Long-term land cover and wild mammal habitat changes in the Caucasus using Corona spy satellite data

By

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"Lift your eyes up and you shall see…"

– Nizami Ganjavi, *Treasury of Mysteries, Khamsa (c. 1173)*

Abstract

The legacy of past human activities strongly affects current landscapes, and current activities will likely have similar legacies in the future. However, predicting future legacies requires understanding past ones, and hence spatially detailed long-term data for large areas. Unfortunately, most land and habitat change studies only start in the 1980s, when 30-m Landsat TM data became available, or in the 2000s when commercial high-resolution satellites were launched. However, 1960s and 1970s US spy satellites from the Corona series provide an opportunity to look at half-a-century of changes at high spatial resolution. This is especially important because the 1960s and '70s were a crucial period for global change when population growth surged post-World War II, the Green Revolution was launched, and climate started to change. My main goal was to advance remote sensing, long-term land change science, and species habitat modeling, focusing on the diverse Caucasus region. Wide variation in elevation, precipitation, ecosystems, plus major historical land use shifts made the Caucasus an ideal setting to study long-term land cover and wildlife habitat changes. I employed object-oriented image analysis techniques to analyze Corona satellite imagery and produced 1964-'65 land cover maps for over 250,000 km^2. I then used these historical land cover maps to evaluate land cover change patterns that occurred before and after the 1991 collapse of the Soviet Union, which the Caucasus region was part of for over seven decades. Finally, I applied these land cover maps to model the relative likelihood of species' presence to assess changes in potential habitats of large ungulates, thereby pioneering habitat change assessments for multiple large mammal species with Corona data. As a result of my successful land cover mapping for the 1960s, I discovered the overall net cropland loss between 1965 and 2015 of about 20%, along with 11% grassland

loss, and 1.5% forest loss. Potential habitats of ungulate species decreased substantially in mountains of Azerbaijan (16-75%) and shifted in lowlands, while increasing for all species within the strictly protected areas, confirming their success for wildlife conservation. My study highlights the feasibility and value of 1960s spy satellite data for long-term land cover and potential habitat change analyses.

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Introduction

The current state of the Earth is strongly linked to the actions and land use choices of previous generations going back millennia (Munteanu et al., 2017). However, current trends in land use by humans raise concerns regarding the sustainability of natural resources (Foley et al., 2011). Continuous environmental degradation decreases ecosystem services, and leads to negative trends in biodiversity, despite conservation efforts globally (Butchart et al., 2010). As humans navigate current environmental challenges, it is important to recognize that current activities will likely have similar legacies in the future as past human activities have today. Hence, it is important to examine historical data to understand the patterns of land use change, which can help inform the development of strategies aimed at preventing further degradation.

A pivotal era that strongly influenced global land use patterns started after the 1960s, a period characterized by post-World War II recovery and population growth (United Nations, 2019). The need to support growing human population prompted large technological advancements in agriculture, the so-called 'Green Revolution' (Evenson and Gollin, 2003), which increased crop yields and food production and greatly improved food supply. Despite its success in mitigating hunger, however, the Green Revolution also contributed to environmental degradation. Agricultural intensification, expansion of crop fields and conversion of grasslands to pastures altered the biophysical characteristics of soils, and caused erosion and soil degradation worldwide (Matson et al., 1997), as well as environmental problems in rivers and wetlands, the loss of natural ecosystems, and alterations of natural disturbance regimes. This degradation had both economic impacts, such as the decrease in yields for farmers, and ecological impacts, such as the wildlife habitat loss. Unfortunately though, most assessments of land and habitat change only start in the 1980s, when 30-m Landsat TM data became available,

or in the 2000s when high-resolution satellites were launched thereby missing the important changes during the mid-20th century.

The 1960s were also the peak of the Cold War between the Soviet Union and the United States, which fueled the space race between both countries (Collins, 1999). During the 1960s, the US launched the Corona Spy satellite program (Peebles, 1997), which aimed to collect high-resolution satellite data to monitor Soviet military capabilities, but in that process captured also the state of the environment at that time. While focused on the Soviet Union, Corona satellites acquired extensive images across all continents (Song et al., 2015), and since these data were declassified in the 1990s (Clinton, 1995), they have been used for science. Despite being captured over half-a century ago, Corona satellite data offer high spatial resolution of 1.8-2.7 m (Song et al., 2015), and great potential to study over 50 years of changes globally.

While holding great potential, Corona data has not been widely used for land cover change studies (Shahbandeh et al., 2023). Furthermore, those studies incorporating Corona data were often either limited to small study area (Chen et al., 2020; Jabs-Sobocińska et al., 2021), or to only one land cover type (e.g., forest, Song et al., 2021), or both (Pan et al., 2020; Song et al., 2015; Stratoulias and Grekousis, 2021). That is unfortunate because Corona data offer a unique opportunity to assess the impacts of mid-20th-century global events on land cover, and can reveal how geopolitical shifts, such as the collapse of the Soviet Union or wars, influenced land use patterns. As such, the historical spy satellite data together with contemporary imagery can be used to compare changes of the Soviet era and the post-Soviet era to assess how land use change trajectories differed between the two periods.

In addition to understanding land change trajectories, Corona data can help assess changes in wildlife habitat after major socio-political shocks. So far, Corona data has been rarely

used to study wildlife species (Klimetzek et al., 2021; Munteanu et al., 2020) and never to map large mammals' potential habitats. However, broad-scale land use changes, such as the agricultural abandonment can create more habitat, while agricultural intensification can lead to its reduction, which is important to record. Similarly, the analysis of long-term data can be used to evaluate whether the protected areas are successful in mitigating habitat loss by examining the periods before and after their establishment. Hence, high-resolution historical satellite imagery acquired by Corona satellites can help understand the relationship between land use and wildlife habitats and identify areas where additional conservation efforts are most needed.

In conclusion, past human activities strongly affect current landscapes and their wildlife habitats, and current activities will likely have similar effects in the future. However, predicting future change trends requires understanding past ones, and hence spatially detailed long-term data for large areas (Foster et al., 2003), such as those obtained by the Corona spy satellites.

The **overarching goal** of my dissertation was to advance remote sensing, long-term land change science, and modeling potential habitat of wildlife. My research helps to unlock the secrets of the US spy satellite image archives to understand long-term changes in land use and in large mammal habitats. My objectives were to:

a) Demonstrate the feasibility of using high-resolution panchromatic historical spy satellite imagery to automatically map the broad-scale land cover classes, such as forest, barren, grassland, cropland, urban, wetland, and water;
b) Quantify long-term land cover changes and compare trends of these changes that occurred through major socio-political events in the Caucasus; and
c) Assess potential habitat changes of wild ungulates, and evaluate how successful protected areas were in conserving those habitats.

Study area

My study area was the Caucasus region (250,000 km^2), which is highly diverse in elevation (-27 to 5,633 m a.s.l.), precipitation (annual average 240-2704 mm) (Coene, 2009), and ecosystems. The Caucasus is one of 36 global biodiversity hotspots, with many rare ecosystems and endemic species of conservation concern. Agriculture has been an essential part of the local economy for many centuries. However, being strategically located between Europe and Asia, the Caucasus has been ruled at different times by every large empire that has existed in the region, which has affected the land use decisions due to different land incentives introduced by each government.

In the 20th century, while under Soviet rule, the Caucasus experienced various land initiatives implemented by the Soviet government and the effects of its collapse, which resulted in unregulated land use practices. Being part of the Soviet Union, the Caucasus was also well captured by the Corona Spy satellites. In addition, major shifts in government and in land use, such as after the collapse of the Soviet Union, make it an ideal location to study land use changes and their effects on wildlife habitat. The diversity of the Caucasus in terms of elevation, and unique biomes means that my new approaches are also applicable in many other parts of the Earth.

Chapter summaries

Chapter 1. Large-area, 1964 land cover classifications of Corona spy satellite imagery for the Caucasus Mountains.

Accelerating human impacts on ecosystems across the globe are raising concerns about its future. Historical data, especially the high-resolution (2.5 m) spy satellite imagery from the 1960s can be invaluable for evaluating ecosystem patterns and understanding the landscape

changes. However, although widely available, Corona data have not been used extensively for change analyses. In this chapter, I developed a method to map large-area land cover using Corona spy satellite imagery for 1964. Specifically, I (a) conducted a comprehensive analysis of both feature selection and parameter setting for large-area classification processes for 2.5-m historical panchromatic Corona imagery for a full suite of land cover classes, (b) compared pixel-based and object-oriented methods to classify land cover, and (c) examined the benefits of adding a digital elevation model for both pixel-based and object-oriented land cover classifications. My study area was a 160,000 km^2 portion of the Caucasus region, covering a large range of elevations, and great variability in land cover types and illumination conditions. I found that for Corona satellite data, the object-oriented land cover classification yielded better results (67.3 ± 4.0%) than the pixel-based classification (63.0 ± 5.0%). The digital elevation model improved overall accuracy to 75.3 ± 3.0% and 78.7 ± 2.5%, for pixel- and object-based approaches, respectively. My results highlight the feasibility of accurately and automatically classifying 1960s land cover for large areas using Corona imagery and demonstrate that Corona data can make important contributions to global change science, predating the earliest 30-m Landsat land cover classifications by two, and high-resolution satellite classifications by four decades.

Related manuscript: Rizayeva, A., Nita, M. D., & Radeloff, V. C. (2023). Large-area, 1964 land cover classifications of Corona spy satellite imagery for the Caucasus Mountains. Remote Sensing of Environment, 284, 113343.

Chapter 2. Half-century of land cover changes in the Caucasus derived from Corona and Landsat satellite data.

Assessments of land cover changes are greatly affected by the chosen baseline, often set at the beginning of the Landsat record in the early 1980s. However, the global events of the mid-20th century, including rapid human population growth, the Cold War between the Soviet Union and the USA, and the green revolution accompanied by the mechanization and industrialization of agriculture, have left a long-lasting impact on current land cover patterns. This is why Corona data is important because it provides an opportunity to revisit a period when these global events had occurred. However, prior studies using Corona data were limited spatially, or only evaluated forest changes. In this chapter, I produced 1964-'65 maps for about 240,000 km^2 for broad land cover classes, including forest, barren, grassland, cropland, urban, wetland, and water in the Caucasus. I compared them to Landsat-based maps from 1987 and 2015 to detect long-term land cover changes during the Soviet era (1965-'87), and after the Soviet collapse (1987-2015). I found that the most widespread changes from 1965 to 2015 occurred in grasslands (+11%) and croplands (-18%). Forests were lost during the Soviet era (-6% 1965-'87) but regained area after 1987 (+5%). Grassland gain was continuous during and after the Soviet era but at different rates (4 and 7%, respectively). On the contrary, croplands were lost continuously but also at different rates, with 3% and 16% loss during and after the Soviet era, respectively. My analyses of the Caucasus region demonstrate the possibility to identify historical changes by extending the time series further into the past and emphasize the importance of this for regions with substantial changes during that time frame.

Related manuscript: Rizayeva, A., Nita, M. D., Yin, H., Buchner, J., Kasraee, N., Rogova, N., Askerov, E., Gavashelishvili, A., Aleksanyan, A., Abbasov, R., & Radeloff, V. C.

Half-century of land cover changes in the Caucasus derived from Corona and Landsat satellite data. Global Change Biology (to be submitted).

Chapter 3. The impact of half-a-century of land cover changes on wild ungulates in Azerbaijan.

Habitat loss due to human activities and global climate change is a major threat to biodiversity especially in hotspots. To identify the causes and prevent further loss, it is necessary to quantify how much habitat has already been lost. Most time series of habitat loss start after the launch of freely available 30-m resolution satellite data, but by then much habitat had already been lost. This is a great example of a shifting baseline syndrome: limited or missing information of past conditions resulting in a gradual change in the understanding of the natural environment. Long-term data from my 1960s land cover maps helped me to extend the baseline of species' potential habitat availability further back in time, which is important because it takes decades to correctly assess habitat changes of large mammals given their relatively long lifespans and low reproduction rates, which can cause extinction debts. In this chapter, I used ensemble models to predict contemporary (2021) and historical (1965) potential habitats and assess 55-year changes for seven ungulate species in Azerbaijan, a core part of the Caucasus biodiversity hotspot. In addition, I assessed whether the protected areas were successful in conserving and restoring wildlife habitat by examining net changes in potential habitat losses and gains within them. I found that potential habitats of wild ungulates in Azerbaijan's mountains decreased by 16-75%, possibly due to forest loss, and potential habitats shifted in location in lowlands, possibly due to abandoned and new agricultural fields from 1965 to 2021. Strictly protected areas were successful in that potential habitat area increased within them, especially within the protected

areas established after the collapse of the Soviet Union (13-214% increase in habitats). The Corona Spy satellite images allowed me to extend understanding of past habitat conditions to the 1960s and thus reduce the shifting baseline syndrome.

Related manuscript: Rizayeva, A., Askerov, E., Babaliyeva, A., Nita, M. D., Sarukhanova, S., Buchner, J., Zazanashvili, N., Zuckerberg, B., & Radeloff, V. C. The impact of half-a-century of land cover changes on wild ungulates in Azerbaijan. Conservation Biology (to be submitted).

Related publications

Throughout my time at UW-Madison, I also co-authored several other papers related to the long-term land change in the Caucasus region and beyond:

- De Leeuw, J., **Rizayeva, A.,** Namazov, E., Bayramov, E., Marshall, M. T., Etzold, J., & Neudert, R. (2019). Application of the MODIS MOD 17 Net Primary Production product in grassland carrying capacity assessment. *International Journal of Applied Earth Observation and Geoinformation*, 78, 66-76.

In this paper, we presented a novel approach for grassland biomass estimation using the MODIS Net Primary Production (NPP) product. We employed it to assess carrying capacity in Azerbaijan's mountain grasslands and identified overgrazing where current livestock densities exceed predicted carrying capacity.

- Buchner, J., Yin, H., Frantz, D., Kuemmerle, T., Askerov, E., Bakuradze, T., Bleyhl, B., Elizbarashvili, N., Komarova, A., Lewińska, K.E., **Rizayeva, A.,** Sayadyan, H., Tan, B., Tepanosyan, G., Zazanashvili, N., & Radeloff, V. C. (2020). Land-cover

change in the Caucasus Mountains since 1987 based on the topographic correction of multi-temporal Landsat composites. *Remote Sensing of Environment*, 248, 111967.

In this paper, we explored the challenges of mapping land cover change in the mountainous Caucasus region, by correcting topographic effects on satellite reflectance data. We demonstrated the benefits of topographic correction, which improved the overall classification accuracy by 2% and helped assess land cover changes since 1987, detecting cropland loss, particularly in Georgia, Armenia, and Azerbaijan, and more stable cropland in the North Caucasus, Russia.

- Yin, H., Brandão Jr, A., Buchner, J., Helmers, D., Iuliano, B. G., Kimambo, N. E., Lewińska, K.E., Razenkova, E., **Rizayeva, A.,** Rogova, N., Spawn, S.A., Xie, Y., & Radeloff, V. C. (2020). Monitoring cropland abandonment with Landsat time series. *Remote Sensing of Environment*, 246, 111873.

In this study, we developed a new approach to accurately map and monitor cropland abandonment and tested it in 14 regions globally. This method allowed us to understand long-term land use changes, using Landsat imagery. We were able to differentiate abandoned cropland, stable cropland, non-cropland, and fallow fields by analyzing land-use trajectories obtained from Landsat time series. Cropland abandonment was common in developing countries and formerly socialist states, indicating the importance of mapping it, and potential implications for the environment, food production, and rural livelihoods.

- Piipponen, J., Jalava, M., De Leeuw, J., **Rizayeva, A.,** Godde, C., Cramer, G., Herrero, M. & Kummu, M. (2022). Global trends in grassland carrying capacity and relative stocking density of livestock. *Global Change Biology*, 28(12), 3902-3919.

In this paper, we developed methods to assess global livestock carrying capacity and relative stocking density across 2001-2015. Our results showed that while livestock carrying capacity decreased in 27% of global grasslands, especially in Europe and southeastern Brazil, it increased in 15%, especially in Sudano-Sahel and parts of South America, with implications for sustainable land management and conservation. Our findings highlight the importance of sustainable land management practices, support conservation initiatives, and offer insights into undergrazed areas for potential intensification or rewilding efforts.

- Farhadinia, M. S., Johnson, P. J., Kamath, V., Eid, E., Hikmani, H. A., Ambarlı, H., Alom, Z., Askerov, E., Buchakiet, P., Buuveibaatar, B., Gavashelishvili, A., Tsiklauri, K., Gritsina, M. A., Haidir, I., Htun, S., Kabir, M., Khanal, G., Kittle, A., Koshkin, M. A., Kulenbekov, R., Kubanychbekov, Z., Lynam, A., Maheshwari, A., Penjor, U., Rasphone, A., Raza, H., Redford, T., **Rizayeva, A.,** Rosen, T., Weinberg, P., Yachmennikova, A., Yamaguchi, N., & Macdonald, D. W. (2023). Economics of conservation law enforcement by rangers across Asia. *Conservation Letters*, e12943.

In this paper, we focused on countries across Asia, including the Caucasus region, to highlight the critical role of rangers in the management and enforcement of protected areas. We found that ranger density in Asian protected areas has declined by 2.4-fold since the 1990s, resulting in a median of 26.4 km^2 per ranger. Rangers generally received payments higher than the minimum wage, but the annual spending on ranger salaries varied among countries. These results present a baseline for ranger-based monitoring to improve conservation performance.

Significance and implications

Despite being declassified for almost three decades, Corona data is rarely employed in environmental research, partly because they are not widely known, and partly because they are not as easy to analyze as later-date multispectral satellite imagery that is already georectified. Nevertheless, the Corona data hold great potential. In my dissertation, I demonstrate the feasibility of integrating Corona data for assessing land and potential habitat changes. By looking into the past in a geographically diverse region with long land-use history, my interdisciplinary research helps to reveal the trajectory of long-term changes in the global Earth system. My results represent a big step towards understanding long-term global ecosystem changes and their effects on biodiversity.

Scientifically, my dissertation contributes to global change science and environmental research. My work advances the understanding of landscape dynamics, particularly in regions with diverse land cover types and complex historical trajectories. I quantified long-term land cover trends in the former Soviet states in the Caucasus region during both the Soviet era and post-Soviet years, which helps to understand how past land use decisions dictate current land cover. By challenging the conventional baseline set in the 1980s and using Corona data to revisit a period right when major mid-20th-century global events took place, my results uncovered important historical patterns of land cover changes. I found that some land cover changes in the Caucasus were continuous in the Soviet era and after the collapse, such as grassland growth and cropland abandonment, but at very different rates. For other land cover classes, such as the forest, even the direction of the trajectories changed, showing first a forest loss and then its gain. Despite the collapse of the Soviet Union and the subsequent wars, cropland abandonment rates in the Caucasus were overall low compared to Eastern Europe or other parts of the former Soviet

Union. Hence, revealed by the 1960s data, the resilience of agriculture in the Caucasus is remarkable. Furthermore, my dissertation extends the understanding of potential habitat availability for ungulate species, and combining historical and contemporary data allowed me to assess the effects of human activities and climate change. I observed a decline in potential habitats for mountain ungulates in Azerbaijan, while those for lowland species increased within and shifted outside of protected areas. This shift in potential habitats may be due to abandonment of existing and the establishment of new croplands in the lowlands of Azerbaijan, which highlights the close relationship between land use and potential habitat changes. Understanding these changes can help develop effective conservation strategies and land management policies.

In terms of **scientific methodology**, my research advances remote sensing by applying and optimizing approaches for processing high-resolution historical satellite imagery. In Chapter 1, I present a novel workflow using 2.5-m Corona spy satellite imagery to map for the first time large-area land cover (250,000 km^2) for broad land cover types, such as forest, barren, grassland, cropland, urban, wetland, and water for the 1960s. This workflow is the result of my research on refining feature selection and parameter setting, exploring the benefits and limitations of pixel-based vs. object-based image analysis techniques, and evaluating the impacts of incorporating a recent digital elevation model on the accuracy of historical land cover classifications. I built a set of codes on a cloud-based processing platform (Google Earth Engine) and demonstrated the feasibility of automatically classifying the 1960s land cover for large and diverse areas. The techniques I present in this work are adaptable for the analyses of other available historical images, such as aerial photographs, and for other areas captured by Corona satellites across all continents, and especially frequently across the former Soviet Union and nearby countries. In Chapter 2, I present the feasibility of extending the historical record by two decades beyond what

had been previously mapped for large areas. I combined multi-resolution satellite imagery, such as Corona and Landsat data to detect 50 years of land cover changes. In Chapter 3, I combined Corona and Sentinel-2-derived land cover data to develop ensemble models with current species presence data and hindcast the potential habitat of wild mammals back by 55 years, facilitating the assessment of potential habitat changes.

From a **management** perspective, my dissertation has important implications for conservation and resource management both globally and in the Caucasus. Globally, the ability to identify and analyze historical land cover changes allows for more informed decision-making in land use planning. My work provides a basis for incorporating 1960s data into present-day environmental management, potentially increasing ecosystem resilience against ongoing anthropogenic impacts. My findings on species potential habitat loss and the success of strictly protected areas are important for biodiversity management, and can inform ongoing plans to create new protected areas and expand existing ones. My results provide support for such efforts, highlighting the successful outcomes of past protected areas. I present here also ways to extend the baseline of species' potential habitat availability, thus helping reduce the shifting baseline syndrome and prevent species' extinction. For the Caucasus, a major biodiversity hotspot, my work provides an important foundation for cross-border conservation and management efforts. The results of my dissertation will be used for further conservation and protected area management by local population, policymakers, stakeholders, and land managers and owners, such as the Ministries of Ecology and of Agriculture, local and international NGOs, such as WWF Caucasus Program, and WWF Azerbaijan.

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Chapter 1. Large-area, 1964 land cover classifications of Corona spy satellite imagery for the Caucasus Mountains

Abstract

Historical land use strongly influences current landscapes and ecosystems making maps of historical land cover an important reference point. However, the earliest satellite-based land cover maps typically date back to the 1980s only, after 30-m Landsat data became available. Our goal was to develop a methodology to automatically map land cover for large areas using high-resolution panchromatic Corona spy satellite imagery for 1964. Specifically, we a) conducted a comprehensive analysis on the feature selection and parameter setting for large-area classification processes for 2.5-m historical panchromatic Corona imagery for a full suite of land cover classes, b) compared the pixel-based and object-oriented methods of classifying the land cover, and c) examined the benefits of adding a digital elevation model for the pixel-based and object-oriented land cover classifications. We mapped land cover in parts of the Caucasus Mountains (158,000 km^2), a study area with great variability in land cover types and illumination conditions. The overall accuracies of our pixel-based and object-oriented land cover maps were 63.0 ± 5.0% and 67.3 ± 4.0%, respectively, showing that object-oriented classifications performed better for Corona satellite data. Incorporating the digital elevation model improved the overall accuracy to 75.3 ± 3.0% and 78.7 ± 2.5%, respectively. The digital elevation model was especially useful for differentiating forest and snow-and-ice from lakes in mountainous areas affected by cast shadows. Our results highlight the feasibility of accurately and automatically classifying land cover for large areas based on Corona spy satellite imagery for the 1960s. Such land cover maps predate the earliest 30-m Landsat land cover classifications by two decades, and

those from high-resolution satellite imagery by four decades. As such, we demonstrate here that Corona imagery can make important contributions to global change science.

Introduction

Current landscape structure is strongly affected by past human activities (Munteanu et al., 2017; Wu et al., 2013) and many vegetation types change slowly over time (Barichivich et al., 2013; White et al., 2009). This means that historical information is valuable when assessing current ecosystem patterns and processes (Foster et al., 2003). Similarly, land cover classifications are essential for environmental science (Altmaier and Kany, 2002), because they provide information on the status of both natural ecosystems and human land use (Balzter et al., 2015; Yin et al., 2020; Zhu and Woodcock, 2014). The earliest land cover maps typically only date back to the 1980s when 30-m satellite data became available. However, images captured by American spy satellites during the 1960s and ‘70s provide an opportunity to obtain land cover data for earlier decades (Saleem et al., 2018; Stratoulias and Kabadayı, 2020).

The earliest high-resolution satellite imagery (< 5 m resolution) dates back to the early 1960s, when the first Corona spy satellites were launched (Peebles, 1997). The Corona satellite missions started a series of US reconnaissance satellites operated by the US Air Force and the US Central Intelligence Agency (CIA) (Altmaier and Kany, 2002; Norris, 2007; Peebles, 1997). While designed and launched for military purposes, Corona satellite images also contain valuable information about the environment and archaeology (Beck et al., 2011; Casana et al., 2012; Conesa et al., 2015). For example, Corona images can reveal historical urban development patterns (Fekete, 2020; Kennedy, 1998; Lasaponara et al., 2018), lithological structures in the Arctic (Lorenz, 2004), and the retreat of glaciers in Nepal (Bolch et al., 2008). Corona data have also been useful in detecting individual wadi trees in Eastern Desert in Egypt (Andersen, 2006),

wild mammal species' occurrences, such as the burrows of the bobak marmot (*Marmota bobak)* in the 1960s (Munteanu et al., 2020). Additionally, Corona has captured long-term dynamics of ant colonies (Klimetzek et al., 2021), and wildlife habitat information, such as recolonization of new growth forests by capercaillie (*Tetrao urogallus*) (Stăncioiu et al., 2021).

Among its many uses, Corona imagery provide especially valuable information on land cover. For example, Corona images capture the reforestation of abandoned agricultural fields (Jabs-Sobocińska et al., 2021), high conservation value forests (Munteanu et al., 2021), widespread logging after the World War II in the Romanian Carpathians (Nita et al., 2018), and 1960s forest cover in parts of the US and Brazil (Song et al., 2015) and Canada (Franklin et al., 2005). The imagery captures forest loss due to agriculture and settlements in Thailand (Kusanagi et al., 2003), Senegal (Tappan et al., 2000), the Ramganga river basin in India (Gurjar and Tare, 2019), and the Tarim river basin in northwestern China (Veroustraete et al., 2011). Corona images have also been used to identify forest loss due to industrial operations in arctic Russia (Rigina, 2003) and eastern China (Zhang et al., 2020), and forest regrowth along the border of Latvia and Russia (Rendenieks et al., 2020). However, most prior studies of Corona imagery analyzed only small study areas, and the question remains how to map land cover accurately for large areas from Corona imagery.

Large-area land cover maps require both efficient georectification of many Corona images and accurate classification algorithms. For the georectification of Corona imagery, the analysis of forests in Romania by Nita et al. (2018) represented a major breakthrough because it provided a new approach to geo-rectify Corona imagery by applying structure-from-motion algorithms (Nita et al., 2018). However, only forest and non-forests were distinguished, and forest patches were hand-digitized (Nita et al., 2018), as was the case for a study based in Canada (Franklin et al.,

2005). Successful pixel-based classifications have been conducted based on image texture metrics (Shahtahmassebi et al., 2017; Song et al., 2015, 2021), unsupervised classification (Kusanagi et al., 2003), and two-dimensional convolutional neural networks (Deshpande et al., 2021). Object-oriented classifications of Corona imagery has only been tested twice: to map forest cover in Latvia (Rendenieks et al., 2020), and agricultural and urban expansion in India (Gurjar and Tare, 2019). However, the former examined forest cover only, not a full suite of land cover classes, and the latter applied considerable manual effort to improve classification accuracy. So, given that prior classifications were either for small areas or classified forests-non-forests only, our first question was how to classify a full suite of land cover classes for a large area automatically from Corona imagery?

Object-oriented classifications, also known as object-based image analysis (OBIA) or geographical object-based image analysis (GEOBIA), typically outperform pixel-level classifications of high-resolution imagery (Blaschke et al., 2000) because objects can be classified based on both spectral and spatial characteristics. Since the first commercial high-resolution satellites were launched in the early 2000s, their images have been widely used for land use and land cover mapping (Lackner and Conway, 2008; Li et al., 2019; Moser et al., 2012). However, large-area (100,000 to 1,000,000 km^2) land cover mapping with high-resolution imagery remains uncommon (Khare & Ghosh, 2016, but see Robinson et al., 2019 [160,000 km^2]), most likely because the imagery is often costly, data volumes are large, and algorithms are computationally intensive. While object-oriented approaches work well for small study areas (Ma et al., 2017), it is less clear how well they perform for large areas in general, and especially for classifications of a full suite of land cover classes for a large area based on Corona imagery.

So, our second question is whether the pixel-based or object-oriented classifications performed better for land-area land cover mapping based on Corona imagery?

Another open question when classifying Corona imagery is if including ancillary data, such as a digital surface model improves classification accuracy. Because Corona images are panchromatic and lack the different spectral bands that 21st century high-resolution satellite sensors provide, elevation information may be especially valuable. One source of elevation information can be the Corona imagery itself, because for many areas the Corona imagery was obtained as stereoscopic that allow extraction of high-resolution historical digital surface models (Altmaier and Kany, 2002; Galiatsatos et al., 2008; Mészáros et al., 2008). However, where Corona data is not fully stereoscopic, such as in our study area, other digital elevation data may improve classification accuracy.

Our main goal was to develop a methodology to map land cover automatically for a large area from panchromatic Corona satellites imagery. Our objectives were to a) conduct a comprehensive analysis on the feature selection and parameter setting for large-area classification processes for 2.5-m historical panchromatic Corona imagery for a full suite of land cover classes; b) compare the pixel-based and object-oriented methods of classifying the land cover; c) examine the benefits of adding a digital elevation model (DEM) for the pixel-based and object-oriented land cover classification. We expected that object-oriented image analysis would outperform pixel-level classifications, and that adding elevation information would improve classification accuracy substantially.

Methods

Study area

We classified 1964 land cover for a 158,000 km^2 study area that included parts of the Greater and Lesser Caucasus, and territories of southern Russia, Armenia, Azerbaijan, Georgia, and eastern Turkey (Figure 1.1). The elevation in the study area ranges from -6 to 5,633 m above sea level, peaking at Mount Elbrus. The Caucasus ecoregion is a global biodiversity hotspot (Myers et al., 2000; Zazanashvili and Mallon, 2009) that includes ecosystems ranging from arid and semi-arid to sub-nival and nival zones. Accordingly, the Caucasus ecoregion has highly heterogeneous landscapes with strong environmental gradients and high variability in elevations and land cover, which makes it a challenging place to map land cover, and a good test site for our study goal.

Data

Our study area was frequently photographed by Corona spy satellites because of its high strategic importance during the Cold War. We selected data from one KH-4A Corona mission number 1011 (October 8, 1964) because it had only sparse cloud cover. The focal length camera was equal to 610 mm. The Petzval f.3/5 panoramic lenses of Corona satellites moved through a 70° arc perpendicular to the direction of orbit. To capture stereoscopic images, both front and back cameras had a 15° tilt forward and backward, respectively. The orbit altitudes were approximately 180-185 km, and the resolution varied across image, ranging from 2.7 to 7.6 m with the finest located in the center. The images are providing 70% overlap between consecutive image frames and were scanned with 7 micrometer resolution. We analyzed both forward- and backward-facing photographs as separate sets, and jointly by concatenating the two images into one with two bands, and tested if the combination of the two bands resulted in an improvement

in classification accuracy. Because our imagery was recorded in October, more than 20,000 km^2 area (about 12.9% of our study area) was covered by snow. During summer, many of these areas, especially right above the treeline are not covered by snow, but by October, winter had already arrived in the mountains. Our source of digital elevation data was the Shuttle Radar Topography Mission (SRTM) (Farr et al., 2007). We present our work-flow in Figure 1.2 and the processing environments for each step in Appendix 1.1.

Orthorectification

We acquired 59 scanned Corona images from the United States Geological Survey (USGS, 2019). Each image covered an area of approximately 17x232 km. To orthorectify the images, we applied Structure from Motion (SfM) algorithms (Song et al., 2015; Ullman, 1979) and the Corona georectification approach developed by Nita et al. (2018) in AgiSoft Metashape software (AgiSoft, 2021). First, we co-aligned the raw strips and generated a point cloud. Second, we assigned coordinates to this point cloud based on high-resolution Google Earth and Bing imagery and generated orthophotos with 2.5 m resolution. During the mosaicking, the processing pipeline implements a data division approach, which splits the data into several frequency domains, which are blended independently. The highest frequency component is blended along the seamline only, and each further step away from the seamline results in a lower number of domains being subject to blending. Therefore, any differences (e.g., due to the effect of the bidirectional reflectance distribution function [BRDF]), which were still persistent after image normalization between overlapping images, were removed by these steps. We grouped the 59 raw images into 30 pairs, given the decreasing overlap between the forward and backward stereo-medium photographs. Unfortunately, because the images were only ‘stereo-medium’, we could not extract a high-resolution continuous digital surface model from the Corona data, but

only the one with gaps in areas where the raw photographs did not overlap, so we used instead the SRTM to generate the orthophotos (Nita et al., 2018). When processing mosaics from a sequence of Corona stereo images, there are two types of overlap: the overlap between successive frames of a Corona camera, and the overlap between the two images of the stereo pair. In our imagery, there was an overlap of approximately 8% between successive frames at the center of the format, which relates directly to the camera scan rate, which is determined by the ratio of the satellite velocity to its height above ground (NRO, 1967). The overlap within the stereo pairs varies somewhat among acquisitions and with orbital elevation but is typically approximately 90% for stereo photographs named in metadata as 'stereo-high' and approximately 70% for 'stereo-medium' (USGS, 2019). Our data were stereo-medium and that meant that the successive stereo images have little overlap, which results in a small overlap between their DEMs (Goerlich et al., 2017). Therefore, only 30 pairs could be formed. However, this did not affect our SfM procedures because the pairs were processed separately and bundle adjusted in the end, according to methodology published by Nita et al (2018). As demonstrated in previous studies (Nita et al., 2018; Rendenieks et al., 2020) an average of 20-26 independent check ground control points (GCP) per strip is sufficient for an accurate orthorectification, but this number depends somewhat on topography, clouds, and image characteristics (e.g., sharpness, illumination, etc.). We selected the GCPs as visible points (e.g., crossroads, visible landmarks etc.) that did not change over time. Accordingly, we assessed the root mean square errors of the resulting images using an average number of 26 GCPs per stereographic pair, for a total of 802 GCPs.

Pixel-based classification

For our pixel-based supervised land cover classification, we calculated the first- and second-order texture metrics. Second-order texture metrics were based on the grey-level co-occurrence matrix (GLCM, *.glcmTexture*). We set the offset distance of the GLCM textures calculated within Google Earth Engine (GEE) platform at the default of one pixel and retained the original quantization of 8 bits. We calculated the second-order texture metrics over east-west and north-south directions and averaged those for each metric to create single multi-directional texture metrics. In order to determine the best window size for the texture calculation, we conducted tests in several smaller subsets of our study area with variety of elevations and land cover types using 3x3 and 7x7 pixel windows. We selected the 7x7 window size because differences between different land cover types were more distinct than for the 3x3 window size. Validation of the classification maps for those subset areas using 3x3 and 7x7 window size resulted in overall accuracies of 69.5 ± 5.0% and 70.2 ± 5.3%, respectively. To compare the pixel-based and object-oriented classifications, we calculated mean and standard deviation as first-order metrics, and angular second moment, entropy, and homogeneity as second-order texture metrics, all within 7x7 pixel windows (Conners et al., 1984; Haralick et al., 1973), and used these for a first classification. To test if they would improve the pixel-based classifications, we also calculated second-order texture metrics of correlation, dissimilarity, and variance (Farwell et al., 2021) for a second classification.

We performed pixel-based Random Forest classifications (*.smileRandomForest*) setting the tree size to 100 and applied a 10-fold Monte Carlo (Picard and Cook, 1984) Random Forest classification with majority voting (Cui et al., 2018). Ten folds are most commonly used (Ruiz Hernandez and Shi, 2017; Song et al., 2017), because it ensures a sufficient number of folds and

sufficient number of training points in each fold (Kuhn and Johnson, 2013; Molinaro et al., 2005). We calculated metrics, and conducted the Random Forest classification in GEE (see below, Gorelick et al., 2017). To determine how important each of the chosen metrics (Appendix 1.2) were for our classification, we ran importance tests within R software (R Core Team, 2013) and calculated the mean decrease in accuracy, which represents the difference in overall accuracy if a given metric is removed.

Object-oriented classification

For our object-oriented supervised classification, we also applied a 10-fold Monte Carlo (Picard and Cook, 1984) Random Forest classification with majority voting (Cui et al., 2018) within GEE (.*smileRandomForest*) setting the tree size to 100. Prior to the classification, we performed the segmentation (described in the following section) and calculated the objects' geometry information: area, perimeter, width, height (Gorelick et al., 2017), shape (Li et al., 2007; Nghi and Mai, 2008), as well as the texture. The width and height were calculated based on the bounding box. We calculated object-oriented first- (mean and standard deviation), and second-order texture metrics (angular second moment, entropy, and homogeneity) by applying the same texture calculation parameters as in pixel-based classification (Conners et al., 1984; Farwell et al., 2021; Haralick et al., 1973), but with a 7x7 pixel moving window within each object obtained from the segmentation. We clipped the original images by the segment borders and applied a 7x7 moving window. Along the edges of segments where the windows extended beyond the segment boundaries, we treated outside pixels as 'no data', and calculated texture metrics for the inside pixels only. We also summarized the elevation data for the objects obtained during the segmentation. We conducted one classification using only the texture metrics so that we could compare that classification with the pixel-based classification, but also performed an

object-oriented land cover classification that also included the object geometry information to test whether it would help improve the final accuracy results. Again, we calculated importance of metrics based on the mean decrease in accuracy for each scenario.

Segmentation

We performed image segmentation in order to outline image objects prior to our classifications (Haralick et al., 1973; Kressler et al., 2003). For the segmentation, we used the Simple Non-Iterative Clustering (.*SNIC*) algorithm (Achanta and Süsstrunk, 2017). The SNIC algorithm is computationally efficient, while allowing control over the number and compactness of output segments (Achanta and Süsstrunk, 2017). The compactness parameter represents the ratio between a segment's perimeter and square root of its area (Happ et al., 2010). We performed the segmentation within GEE.

Classification results of object-oriented classifications depend on the quality of segmentation (Blaschke, 2010; Clinton et al., 2010; Kavzoglu, 2017; Kavzoglu and Tonbul, 2018), and hence how segmentation parameters are set. We selected the segmentation parameters after conducting numerous tests in a variety of altitudes and land cover types. We present the results of these tests in Appendix 1.3. The selected parameters were best in merging the information of each land cover class into a separate segment. We set the distance between the seeds represented by 'seed grid' parameter to 40 pixels, the connectivity parameter to 4 neighbors, and the compactness factor at 0.1, which ensured a low ratio of the area of a segment to its perimeter (Achanta and Süsstrunk, 2017). This avoided overly convoluted segments. We quantified the segmentation results by separating the objects into four categories: homogeneous segments (100% of the dominant class); segments with 75-100% of the dominant class; segments with 50-75% of the dominant class and segments with several classes (no class covering 50%) (Appendix 1.4). The

segments were the objects for our object-based classification, and we use the two terms ‘segment’ and ‘object’ synonymously.

Training and validation data

To collect both our training and our validation data, we applied a systematic sampling design and generated a 5x5 km point grid of 4,828 points for our study area. We opted for a systematic sampling design to limit the effects of spatial autocorrelation by maximizing the distances between points, and to ensure that all countries and ecoregions in our study area had the same sampling density. Our systematic sampling design is comparable to the sampling design for the LUCAS land use dataset of the European Union (LUCAS, 2022). We based our choice of distance between points in the grid on the need to balance the advantage of a higher sample size, with the feasibility of collecting the data. We used Corona data for each point to visually identify the dominant land cover class of the segment the point belonged to, and assigned the dominant class in the segment to the grid point. The high resolution of the Corona imagery allowed unambiguous visual differentiation between the classes in almost all cases (Figure 1.1). All points were labeled by one expert (A.R.) for consistency. The point grid took approximately one month of full-time work to classify into forest, grassland, cropland, barren, wetland, urban, river, lake, and snow-and-ice (Figure 1.1, Appendix 1.5). We also determined if segments included more than one class (e.g., Figure 1.3). We removed grid points in such segments from the training data, but retained them if they were part of the validation dataset (see below). For classes that were rare, or were misclassified in initial runs, we manually added training points (Table 1.1, Appendix 1.4) but did not use these added points for validation. Thus, we had 5,126 points total for training and validation. We used the same training and validation data for both the pixel-based and object-oriented classifications.

For training, we used 80% of the points located in homogeneous segments, as well as the additionally collected training data. For validation, we used the remaining 20% of the points associated with homogeneous segments, plus 20% of the points within heterogeneous – missegmented or shifted objects. Some of the missegmented or shifted objects occurred due to errors in orthorectification so that the two concatenated images captured by forward- and backward-facing camera did not co-align perfectly. For our accuracy assessment, we used 10-fold validation from randomly split training and testing data. We did not manually add points to the validation dataset. These steps resulted in 10 sets, each totalling 3,684 points: 2,719 for training and 965 for validation. In order to determine whether the number of the points was sufficient for our classifications, we ran tests with fewer points. Namely, we selected 66% and 50% of both the training (1,795 and 1,360) and validation (637 and 483) points to classify our land cover and calculate map accuracies. The rationale was that if accuracies for the smaller subsets are similar to that for the full set, then that suggests that the full set was sufficiently large and more points would not have improved classification accuracy greatly. We used the same 10 sets of training and validation points for both the pixel-based and the object-oriented classifications, so that the individual training pixels were only derived from homogeneous segments.

The effect of the DEM

To test the effect of adding elevation data on classification accuracy, we resampled the 30-m SRTM elevation model to 2.5-m to match the remaining metrics using nearest neighbor resampling method, and calculated slope and aspect. To overcome the problem that when calculating aspect, the two opposite ends of the range both refer to North, we normalize the aspect variable by calculating topographic radiation aspect index (TRASP) proposed by Maxwell

and Shobe (Appendix 1.2) (2022). We then added slope and TRASP plus elevation as input metrics for both the pixel-based and object-oriented classifications. For our classifications of the Corona imagery plus the elevation data, we followed all the steps described above, and used the same sets of training and validation data.

Validation, accuracy assessment

We conducted a thorough accuracy assessment of the resulting land cover maps and calculated the overall accuracy, user's accuracy and producer's accuracy following the best practices outlined in Olofsson et al. (2014). To capture variability among classifications, we calculated their standard deviation. Because the barren, wetland, urban, and river classes covered only small portions of our study region and had often only a few validation points, we merged them into one class named 'others' when reporting the accuracies, but retained them as separate classes in our maps for visualization purposes.

Results

We successfully produced high-resolution land cover maps from 1964 Corona imagery for our study area with nine major land cover classes (forest, grassland, cropland, lake, and snow-and-ice), plus four minor land cover classes (barren, wetland, urban, and river), which we grouped into 'others' for our accuracy assessment.

Orthorectification

Our orthorectification of the scanned Corona satellite images from 1964 was highly accurate. Based on our 802 independent check ground control points, our geo-rectification had an absolute root mean square error of 16.3 ± 10.4 m. Co-registration errors were highest in areas with few stable ground features, such as buildings, rivers, and road intersections (Figure 1.4). Contrary to

what we had expected, co-registration errors were not higher in the more mountainous parts of our study area.

Importance tests for metrics

Our importance tests showed that the most important metrics for the classifications were similar for all pixel-based and object-oriented classifications (Table 1.2). The most important were the mean of both panchromatic bands (6.6-9.6% and 7.4-11.3% decrease in overall accuracy if the mean of backward-facing camera and forward-facing camera images were removed), and slope (6.8-12.6%). The least important were the object geometry metrics included for the object-oriented classification (0.9-2.0%), but they still improved the overall accuracy.

Pixel-based classification of Corona imagery

Our supervised pixel-based classification with five texture metrics (Figure 1.5, Figure 1.6) had an overall accuracy of 63.0 ± 5.0% (Figure 1.7, Table 1.3, Appendix 1.6). Classification accuracy was lower for grasslands, croplands and lakes with 57.8 ± 9.0%, 54.7 ± 7.3%, and 41.4 ± 8.1% UA, and 46.4 ± 6.7%, 55.6 ± 8.4%, and 67.5 ± 14.9% PA, respectively. In contrast, the accuracies for forest (68.5 ± 3.8% UA and 78.0 ± 2.4% PA) and snow-and-ice (85.0 ± 4.2% UA and 87.2 ± 3.4% PA) classes were considerably higher but they were sometimes confused with shadows in mountainous areas. The ‘others’ class, which included barren, wetland, urban, and river had low accuracy, but also covered only small areas within our study region.

Object-oriented classification of Corona imagery

Segmentation

Our optimal segmentation parameters resulted in objects of 0.75 ± 0.52 km^2 on average. We checked the quality of segmentation visually (Zhang et al., 2008) and found it overall to be

accurate. We found that approximately 18.4% of the assessed objects (887 out of 4828 total) were missegmented and included more than one land cover class (Table 1.1, Appendix 1.4). Segmentation errors mainly occurred when there was high similarity in spectral signature between different classes, and sometimes when there were mis-registration problems between the forward and backward photos (915 out of 4828 total, Table 1.1, Appendix 1.4).

Classification

The supervised object-oriented classification with five texture metrics using Random Forest algorithm (Figure 1.5, Figure 1.6) yielded an overall accuracy of 67.3 ± 4.0% (Figure 1.7, Table 1.3, Appendix 1.6). The forest, lake and snow-and-ice classes had the highest accuracies (72.6 ± 3.0%, 74.9 ± 9.0% and 88.5 ± 2.5% UA and 80.4 ± 2.2%, 84.1 ± 7.2% and 87.0 ± 2.7% PA, respectively). The grassland and cropland classes had the lowest accuracies (58.9 ± 8.3% and 62.8 ± 6.2% UA and 58.5 ± 4.6% and 55.6 ± 8.8% PA, respectively), largely because those two classes were frequently confused. Again, the 'other' class was not well classified.

As a test, in a subset area we conducted the classifications for each band separately, and for both bands together. We found an improvement of about 2 percentage points in overall accuracies when classifying both bands together (77.6 ± 2.4%), compared to the single-band classifications (75.6 ± 3.2% for forward- and 75.7 ± 2.7% for backward-facing camera image). In all of these comparisons, we conducted object-oriented classifications, and included the DEM and object geometry information.

Pixel-based vs object-oriented classification of Corona imagery

The object-oriented classification had higher overall and user's accuracies for each class than the pixel-based classification (Figure 1.7, Appendix 1.6). The greatest improvement in class-level accuracies were for grassland, cropland, and lake classes. Both the pixel-based and object-

oriented classifications had similar spatial patterns (Figure 1.5). Croplands were dominant in the northeastern portion of our study area in both classifications. However, some classes, such as the snow-and-ice, were noticeably less common in the pixel-based classification. The forest class was better mapped in the object-oriented classification, especially in mountainous areas bordering snow-and-ice.

Classifications of Corona imagery plus DEM

Adding the DEM to both the pixel-based and object-oriented land cover classifications (Figure 1.5, Figure 1.6) increased overall accuracies to 75.3 ± 3.0% and 78.7 ± 2.5%, respectively (Figure 1.7, Table 1.3, Appendix 1.6). Inclusion of the DEM resulted in an increase of UA and PA of almost all land cover classes both for pixel-based and object-oriented classifications. The greatest improvements were in the lake class, which increased in UA from 41.4 ± 8.1% to 89.1 ± 6.0% and in PA from 67.5 ± 14.9% to 92.5 ± 4.1% in pixel-based classifications and from 74.9 ± 9.0% to 94.4 ± 5.2% in UA and from 84.1 ± 7.2% to 95.2 ± 4.9% in object-oriented classifications. Similarly, when including the DEM, the cropland class had an increase in user's accuracy by 19.4 and 13.4 percentage points, and in producer's accuracy by 18.7 and 25.5 percentage points, in the pixel-based and object-oriented classifications, respectively. However, accuracy of snow-and-ice land cover class did not change noticeably (~85-91% in land cover maps from both classifications). Our accuracy assessment using only the grid points associated with homogeneous segments (Table 1.1, Appendix 1.4) yielded overall accuracies of 75.8 ± 2.1% and 81.7 ± 1.7% for pixel-based and object-oriented classifications, respectively.

Our experiments using only 50% and 66% of the training and validation data for the object-oriented classification with DEM resulted in overall accuracies of 74.4% and 75.8%, respectively. This is quite close to the accuracy of 78.7% for the full dataset and suggests that

accuracy had stabilized with our 3,684 points and would not have increased substantially with a larger training dataset.

Our object-oriented classification with the incorporation of the DEM also resulted in the classification that made visually the most sense. The greatest improvement occurred in areas of misclassification among spectrally similar classes, such as forest vs. lake, snow-and-ice vs. urban, as well as in cast shadow areas, which can make snow and grass in the high mountains appear dark. Thus, in our resulting map with highest overall accuracy (object-oriented with five textures and DEM), forest comprised 27.0%, grasslands – 30.4%, croplands – 27.5%, lakes – 1.3%, snow-and-ice – 12.9%, and others – 0.9% of the total study area.

Our additional pixel-based classifications (Figure 1.6, Figure 1.8), with eight texture metrics did not improve our accuracy results by yielding only 62.8 ± 5.0% and 74.4 ± 2.9% with and without DEM (Figure 1.17, Table 1.3, Appendix 1.7). Similarly, we did not observe an improvement in object-oriented classifications when including the object geometry information (Figure 1.6, Figure 1.8). The overall accuracies with and without DEM were 67.9 ± 4.2% and 78.6 ± 2.2%, respectively (Figure 1.7, Table 1.3, Appendix 1.7).

Discussion

We developed a new approach to conduct large-area land cover classifications from single-date, 2.5-m resolution panchromatic Corona satellite imagery for 1964. We calculated both pixel-based and object-oriented metrics, from which we derived our land cover maps. Our object-oriented classification outperformed the pixel-based classification, and classification accuracy was even higher when including a DEM (78.7 ± 2.5% overall accuracy). Ultimately, we showed that it is possible to conduct automated classifications from single-date panchromatic imagery for

a full suite of land cover classes in large areas from high-resolution 1964 spy satellite imagery, thereby providing land cover information several decades prior to what is possible from multi-spectral earth observing satellites.

For the science of land use, it is important to develop robust methods to map land cover from 1960s Corona satellite data in order to expand the length of time series for land cover and land use change detection. Corona satellite images can extend the temporal baseline for land use studies to the mid-20th century. This allows capturing important historical events, such as the peak of the Cold War between the USA and the USSR (McMahon, 2021), the green revolution (Evenson and Gollin, 2003), as well as the continued expansion of mechanization and industrialization of agriculture (Crossley et al., 2021). Our study period also includes the era when human populations grew most rapidly (United Nations, 2019), which resulted in increased food demand and thus agricultural production. Thus, to evaluate the long-term effects of these historical events, Corona satellite images provide unique information for land use science.

There have been a handful of studies using the Corona spy satellite imagery for land cover classification but no study was conducted for a large area and a full suite of land cover classes. Some of the previous studies used pixel-based classification (Song et al., 2015) or object-oriented classification for forest vs. non-forest (Rendenieks et al., 2020) and for smaller study areas (e.g., ~30 km^2 in Shahtahmassebi et al., 2017). The results of our land cover classification (78.7 ± 2.5%, 158,000 km^2) compare favorably with the previous results of Corona imagery classifications for smaller study areas (93% for 22,400 km^2 in Gurjar and Tare, 2019), and forest-non-forest classifications (~95.5% in Song et al., 2015; ~90% in Song et al., 2021; ~92% in Rendenieks et al., 2020). Our pixel-based classification yielded 75.3 ± 3.0%, which is

comparable to accuracies of other studies using a pixel-based approach, but for two land cover classes only and smaller areas (95% for ~770 km^2 and 96% for 1240 km^2 in Song et al., 2015).

In general, there are few automated land cover classifications derived from high-resolution imagery that cover large areas (Khare and Ghosh, 2016). Similarly, automated classifications from Corona imagery are rare, and many of the previous studies applied a considerable amount of manual effort and hand digitization (Dittrich et al., 2010; Ruelland et al., 2011; Zhang et al., 2020). Our methodological advancement allowed for an efficient regional-scale land cover mapping of single-date 2.5-m panchromatic Corona imagery. We automated the classification process deriving a combination of texture and geometry metrics and classification along with the rigorous validation of the resulting maps. By 'automated land cover classification' we refer to the set of codes available freely on Google Earth Engine platform and GitHub (https://github.com/rizayeva/coronaClassification.git). Our codes can be used for a different sets of very high-resolution panchromatic imagery, and parameters that need to be adjusted are noted in the code description. We were able to overcome some issues caused by availability of only the single-date imagery, and we reached a classification accuracy of up to 78.7 ± 2.5%. We attribute the high accuracy to our use of a combination of second-order texture metrics, as well as elevation information. However, because we analyzed only one image, and that image was from October, there was some misclassification between the cropland and grasslands, which we had expected, and also croplands and forests, which surprised us. The reason why grasslands and croplands were not always correctly distinguished from each other is that neither have green vegetation in our study area in October, making it difficult to delineate crop fields from other classes in panchromatic images, especially when compared to spectrally rich satellite images (Wardlow and Egbert, 2003). This was especially a problem in our pixel-based classification,

and we could remedy this issue partly in the object-oriented classification via the objects' geometry information metrics. The confusion of croplands with forests occurred because the pixels with some freshly ploughed winter crop fields had low values, similar to forests. Our work focused on Corona spy satellite data with only two panchromatic images captured, one by forward- and one by backward-facing camera. For the modern era, higher classification accuracies are possible with multi-spectral imagery, but for the 1960s, there are no other data, and that makes Corona imagery and our land cover classification approach valuable. As more high-resolution imagery becomes available with new commercial satellites with comparably rich spectral information, our methods for classifying the large areas with Corona imagery may also be relevant for other high-resolution satellite images.

We found that our pixel-based and object-oriented classifications each had some costs and benefits. The pixel-based classification had considerably lower accuracy, and resulting maps had a 'salt-and-pepper' pattern. This may necessitate a substantial amount of post-classification noise removal (Zheng et al., 2014). However, the pixel-based classifications ran much faster (Duro et al., 2012), and did not require image segmentation and per-object texture calculation. The object-oriented classification had higher accuracy, but accuracies of object-oriented classifications depend highly on segmentation results, and while our segmentation was generally good, there were some over- and under-segmented objects. Ultimately, the selection of image segmentation parameters and the complexity of calculating within-object metrics required approximately ten-times longer processing times. Overall, the advantages of object-oriented classification far outweighed its drawbacks. The segments contextualize grey levels within object parameters, and the resulting map has a more generalized appearance than the 'salt-and-pepper' pattern in the pixel-based classification. This is attractive for end users because a more generalized view adds

to better visual differentiation of land cover types (Dorren et al., 2003; Duro et al., 2012; Stuckens et al., 2000). Interestingly, three studies that compared pixel-based and object-oriented classifications from medium-resolution satellite imagery (Landsat and SPOT) did not find significant differences (Duro et al., 2012; Prudente et al., 2017; Robertson and King, 2011). However, for post-2000 commercial high-resolution imagery, object-oriented classification clearly outperforms pixel-based classification with and without the DEM (Chen and Tian, 2020; Cleve et al., 2008), which is also what we found for classifications of Corona imagery.

Highly heterogeneous mountain areas, such as the Caucasus region (Reinhold et al., 2016), presented a challenging test site for land cover classifications because of reflectance differences introduced by cast shadows in steep terrain, and overall highly variable illumination conditions (Buchner et al., 2020; Chen et al., 2021). Generally, heterogeneous landscapes and land cover transition zones, along with spectrally similar land cover classes tend to result in lower accuracies (Song et al., 2013). We achieved the highest classification accuracy by combining the DEM with our texture metrics. Using only spectral and texture information, our classifications had some confusion between lakes and forests. However, since lakes are flat, the ‘slope’ metric helped differentiate lakes from forests. Confusion between snow-and-ice and urban areas, as well as the barren class were also minimized by adding the DEM. Our results support the findings from other studies that including elevation data when mapping the land cover in mountainous regions can greatly improve land cover classifications (Balzter et al., 2015; Buchner et al., 2020; Chen et al., 2017).

The land cover in our study area in 1964 was diverse. The mountainous areas in Georgia, which were partly covered by snow in our imagery, were heavily forested. Livestock production was historically one of the main sources of food and income in the Caucasus because grasslands were

widespread (Hopkins et al., 2012). Croplands dominated the mostly level areas of our study region in southern Russia. Agricultural policies introduced by the Soviet government in the 1960s resulted in rapid agricultural development in many regions of the Soviet Union (Taff et al., 2010), including the Caucasus region (McCauley, 1976). To this date, similar to many Eastern European countries (Feranec et al., 2016), agriculture remains an important component of the economy in the Caucasus (Worden and de Beurs, 2020). As a result, a large variety of crops are grown and there are many large gardens and orchards, which we included in the forest class because of their woody vegetation.

While our overall classification accuracy was high, there were some notable errors and limitations in our datasets. One source of errors was noise and scanning errors in the Corona images (Gheyle et al., 2011). The accuracy of our image orthorectification depended to some extent on where current high-resolution imagery was available in Google and Bing. Previous studies (e.g., Shortridge and Messina, 2011) found that SRTM error magnitudes are generally larger for sites with higher forest cover and slope, as measured by the standard deviation of error, the RMSE, and the 90% error. The errors rise monotonically with increasing slope and forest cover percent. In our study, the geolocation mismatch between Corona image and SRTM varies from 5.9 to 26.7 m (lower than the size of a SRTM pixel). This can affect the extraction of elevation and slope in highly heterogeneous terrains, due to the rapid changes between neighboring pixels, and therefore the classification of small patches of land cover classes situated in those environments. Fortunately, our study area had slopes steeper than 35 degrees only in 6.8% of the area, and only 0.4% of forested areas occurred in small patches. Furthermore, we gathered our training and validation samples using only visual image interpretation because of the lack of independent data for 1964. However, the high resolution of Corona satellite data

allowed in almost all cases to unambiguously identify the land cover for training and validation data (Pengra et al., 2020; Tarko et al., 2020). Lastly, our DEM was derived from satellite data recorded in 2000 and has a spatial resolution of 30 m, which may have affected the classification accuracy. However, the accuracy assessment showed nevertheless a strong improvement when adding the DEM. For further analyses of Corona images, we suggest extracting the high-resolution digital surface model from the Corona data itself whenever full stereoscopic coverage is available is worth considering (Ghuffar et al., 2022). Furthermore, it would be interesting to explore Corona image classifications using convolutional neural networks methods. We opted against them due to their need for very large training datasets, but high-resolution Corona imagery may be well suited for such deep learning approaches. In summary though, despite all of these challenges, our object-oriented land cover mapping with incorporation of the DEM was successful in mapping land cover in a highly heterogeneous and large area.

Given the high accuracy of our final resulting map and the broad availability of historical Corona imagery, we suggest that our approach can facilitate large-area and long-term land use studies in many other regions across the globe. To map areas larger than our study area would require analyzing imagery from multiple Corona paths, and hence different dates and sometimes camera parameters. The extent to which training data signatures from one Corona path could be extended for use in a neighboring path is unclear, but in principle, even larger areas could be mapped. Our approach can advance long-term land use change analyses by combining Corona-based classifications for the 1960s with more recent land cover classifications derived, for example, Landsat or Sentinel-2 imagery. However, due to differences in spatial and spectral resolution, such comparison of Corona data to more recent satellite images would require

development and application of customized change detection methods, and just overlaying the different land cover classifications would not be valid.

In conclusion, accurate land cover maps are crucial for land management and global change monitoring, and we demonstrated here that single-date panchromatic Corona satellite imagery can be classified accurately resulting in high-resolution land cover maps for the 1960s. Our results indicate that the object-oriented classification is best, and that including a DEM substantially improves classification accuracy. Our map of broad land cover types in a large and highly heterogeneous area shows the potential of our approach and suggests that similar maps could be made in most landscapes globally, thereby extending the temporal baseline for land use studies to the mid-20th century.

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Tables and Figures

Table 1.1: Number of points in our training and validation datasets. For each of our 10 Random Forest classifications, training and testing points were randomly selected from the four different pool of grid points. For the number of points in each land cover class, please see Appendix 1.4

	Total	Training	Testing
Grid points in homogeneous segments	3,026	2,421 (80%)	605 (20%)
Additional points	298	298 (100%)	0 (0%)
Grid points in shifted segments	915	0 (0%)	183 (20%)
Grid points in missegmented objects	887	0 (0%)	177 (20%)
Total	5,126	2,719	965

Table 1.2: Importance of the metrics that we employed for the pixel-based and object-oriented land cover classifications for Corona satellite images captured by backward (B1) and forward (B2) camera. All texture metrics were calculated with a moving window size of 7x7 pixels

Metrics		Mean decrease in accuracy (%) for:							
		Pixel-based classification				Object-oriented classification			
		with five textures	with five textures and DEM	with eight textures	With eight textures and DEM	with five textures	with five textures and DEM	with five textures and object geometry information	with five textures, object geometry information and DEM
First-order textures	Mean Panchromatic B1	9.6	8.6	7.4	6.8	9.4	8.5	7.3	6.6
	Mean Panchromatic B2	11.3	9.8	8.5	7.5	11.0	8.9	8.5	7.4
	Standard deviation B1	3.4	3.7	2.3	2.6	4.5	4.0	3.3	2.7
	Standard deviation B2	2.3	2.6	1.7	1.8	4.2	4.0	3.0	2.7
GLCM-derived second-order textures	Angular second moment B1	2.8	2.9	1.8	2.0	6.5	6.0	4.9	4.4
	Angular second moment B2	2.6	2.6	1.8	2.1	7.2	6.4	5.2	5.0
	Entropy B1	2.8	2.9	1.8	2.1	6.3	6.0	4.9	4.4
	Entropy B2	2.6	2.7	1.9	2.1	6.6	6.5	5.0	5.0
	Homogeneity B1	2.7	2.8	1.9	2.1	6.6	5.7	4.6	4.4
	Homogeneity B2	2.8	3.0	1.9	2.3	6.9	6.5	5.4	4.9
	Correlation B1*			1.1	1.1				
	Correlation B2*			0.6	0.6				
	Dissimilarity B1*			1.9	2.2				
	Dissimilarity B2*			1.8	2.2				
	Variance B1*			2.0	2.3				
	Variance B2*			1.5	1.8				

Elevation data	Elevation		7.8		5.9		8.5		6.6
	Slope		8.6		6.8		12.6		9.8
	TRASP (topographic radiation aspect index)		1.5		1.1		2.8		2.1
Object geometry	Area**	NA	NA	NA	NA			1.8	1.5
	Height**	NA	NA	NA	NA			1.1	0.9
	Width**	NA	NA	NA	NA			1.7	1.3
	Perimeter**	NA	NA	NA	NA			2.0	1.6
	Shape**	NA	NA	NA	NA			1.4	1.2

* Calculated additionally for pixel-based classification

** Object-based metrics not applicable (NA) for pixel-based classification

Table 1.3: Overall classification accuracy with confidence intervals resulting from each of the different sets of input variables

Classification scenarios			Overall accuracy
Pixel-based classifications	1	with five textures	63.0±5.0%
	2	with five textures and DEM	75.3±3.0%
	3	with eight textures	62.8±5.0%
	4	with eight textures and DEM	74.4±2.9%
Object-oriented classifications	5	with five textures	67.3±4.0%
	6	with five textures and DEM	78.7±2.5%
	7	with five textures and object geometry information	67.9±4.2%
	8	with five textures, object geometry information and DEM	78.6±2.2%

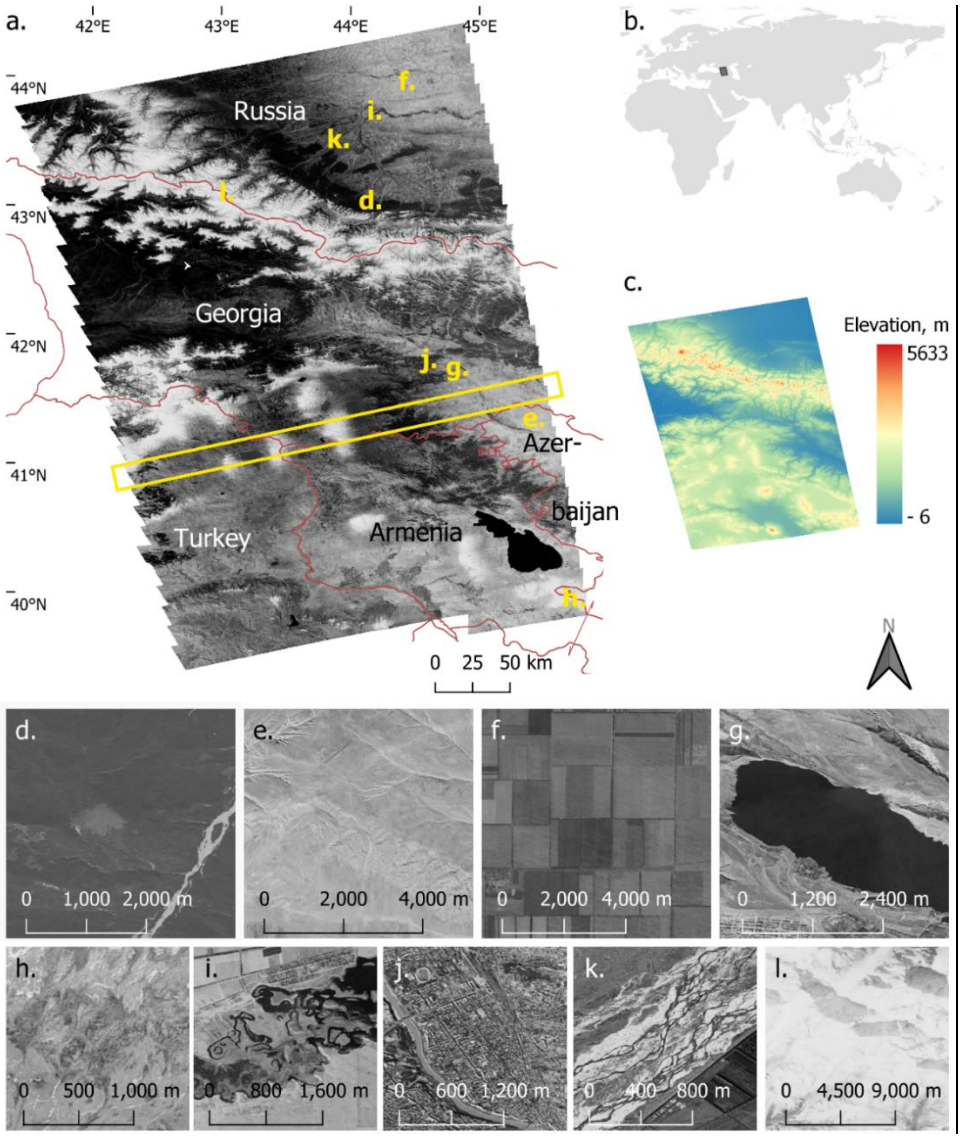


Figure 1.1: a. Study area in the Caucasus ecoregion, which includes parts of Russia, Armenia, Azerbaijan, Georgia and Turkey, with one Corona image strip highlighted in the yellow frame; b. Location of the study area on a world map; c. Elevation map in the study area; and zoomed in examples of our different land cover classes d. forest; e. grassland; f. cropland; g. lake; h. barren; i. wetland; j. urban; k. river; l. snow-and-ice. The location of these examples are indicated with yellow letters in the full Corona image

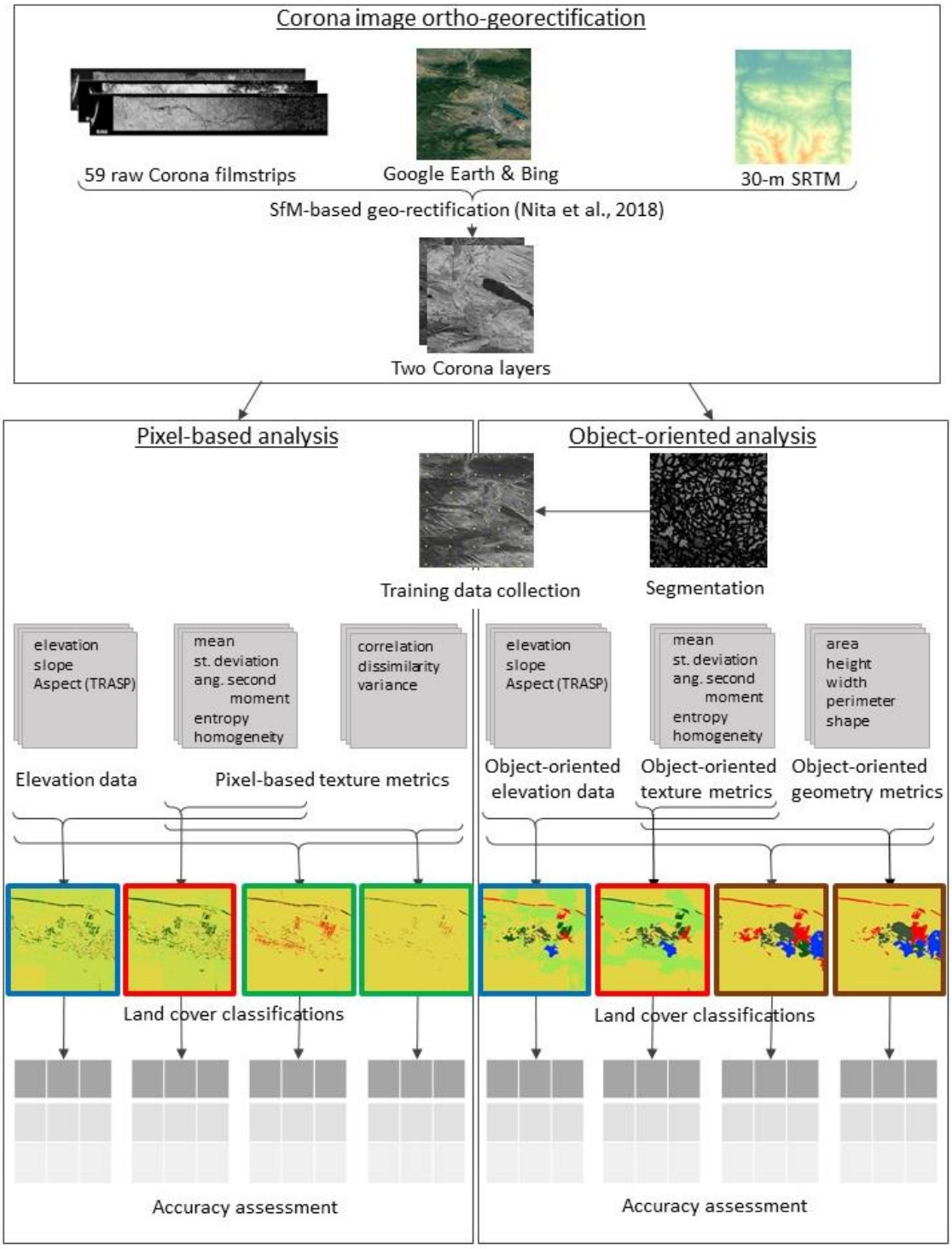


Figure 1.2: Flowchart of the pixel-based and object-oriented land cover classification procedure. In the row of the different land cover classifications we highlight that we compared to each other in different colors. In blue are the pixel-based and object-oriented classifications with five

texture metrics, in red those with five texture metrics and elevation information. We also highlight in green the pixel-based classifications with eight texture metrics with and without elevation information, respectively; and in brown the object-oriented classifications with five texture metrics and five object geometry information metrics with and without elevation information. Additionally, we present the processing environments for each step in Appendix 1.1

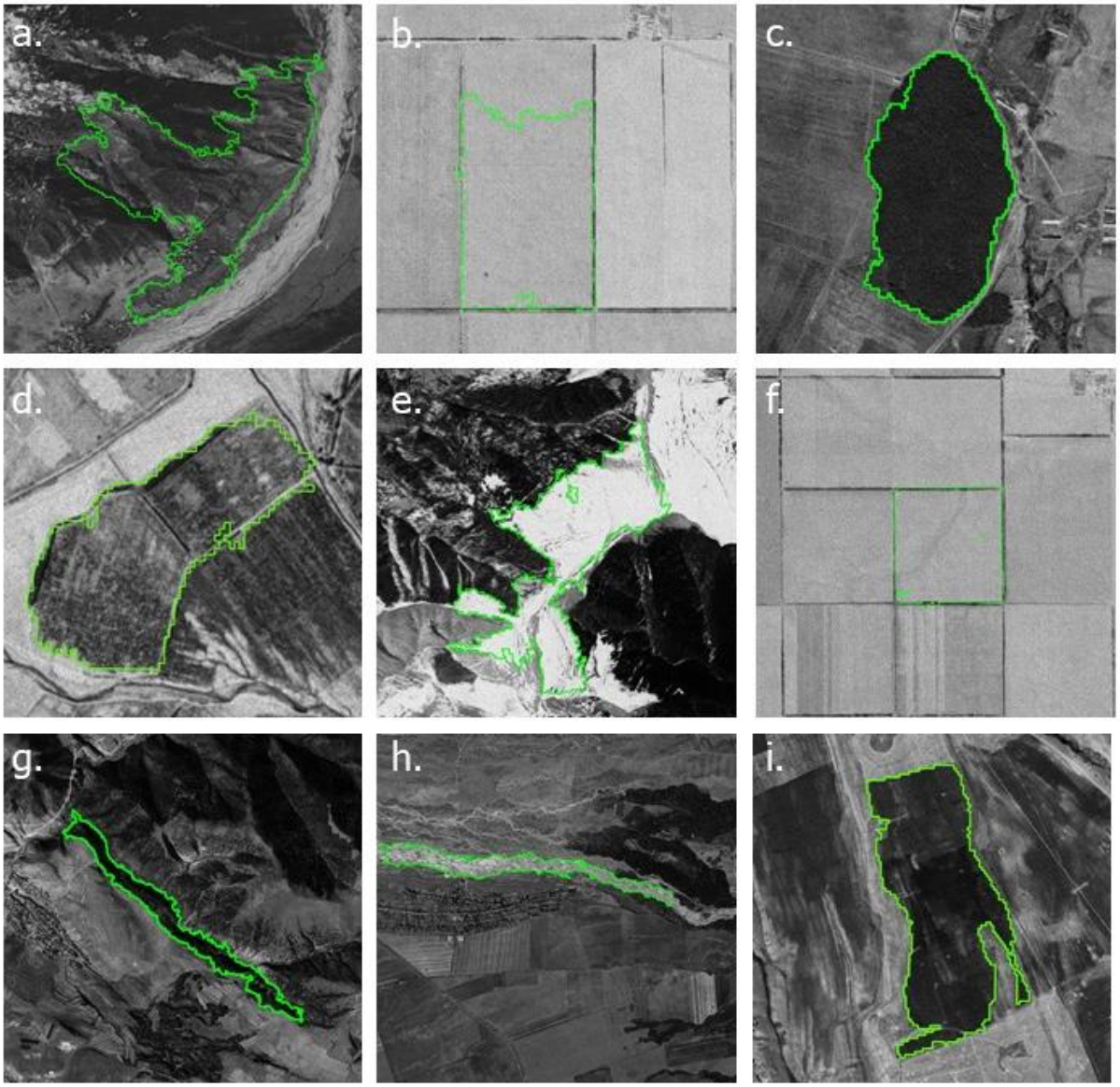


Figure 1.3: Results of the SNIC segmentation algorithm on the panchromatic Corona imagery. Shown are examples of a heterogeneous segment that is over-segmented (a); and homogeneous segments that are under-segmented (b), or correctly segmented (c-i)

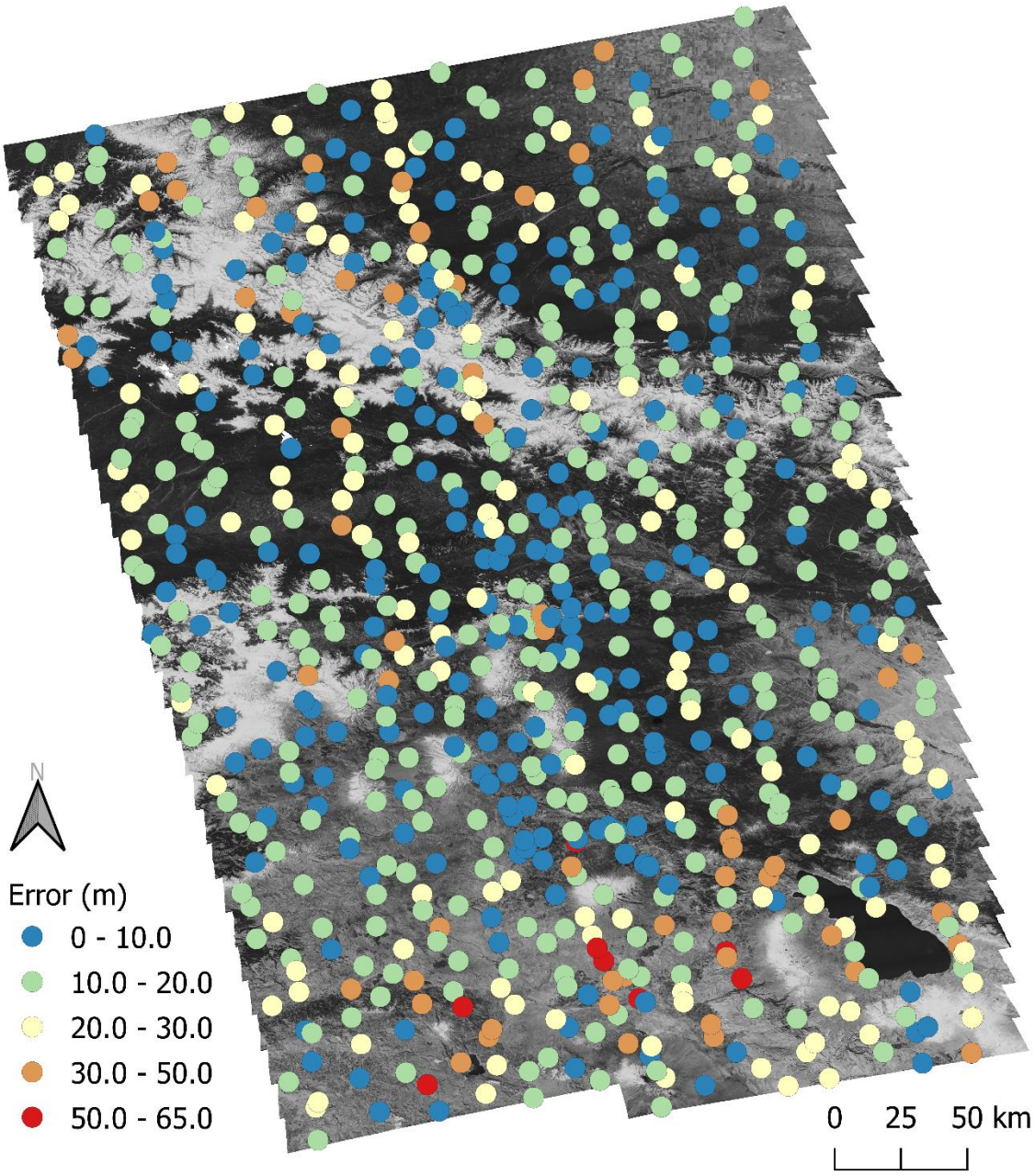


Figure 1.4: Distribution of the ground control points for the orthorectification and their locational error after the rectification

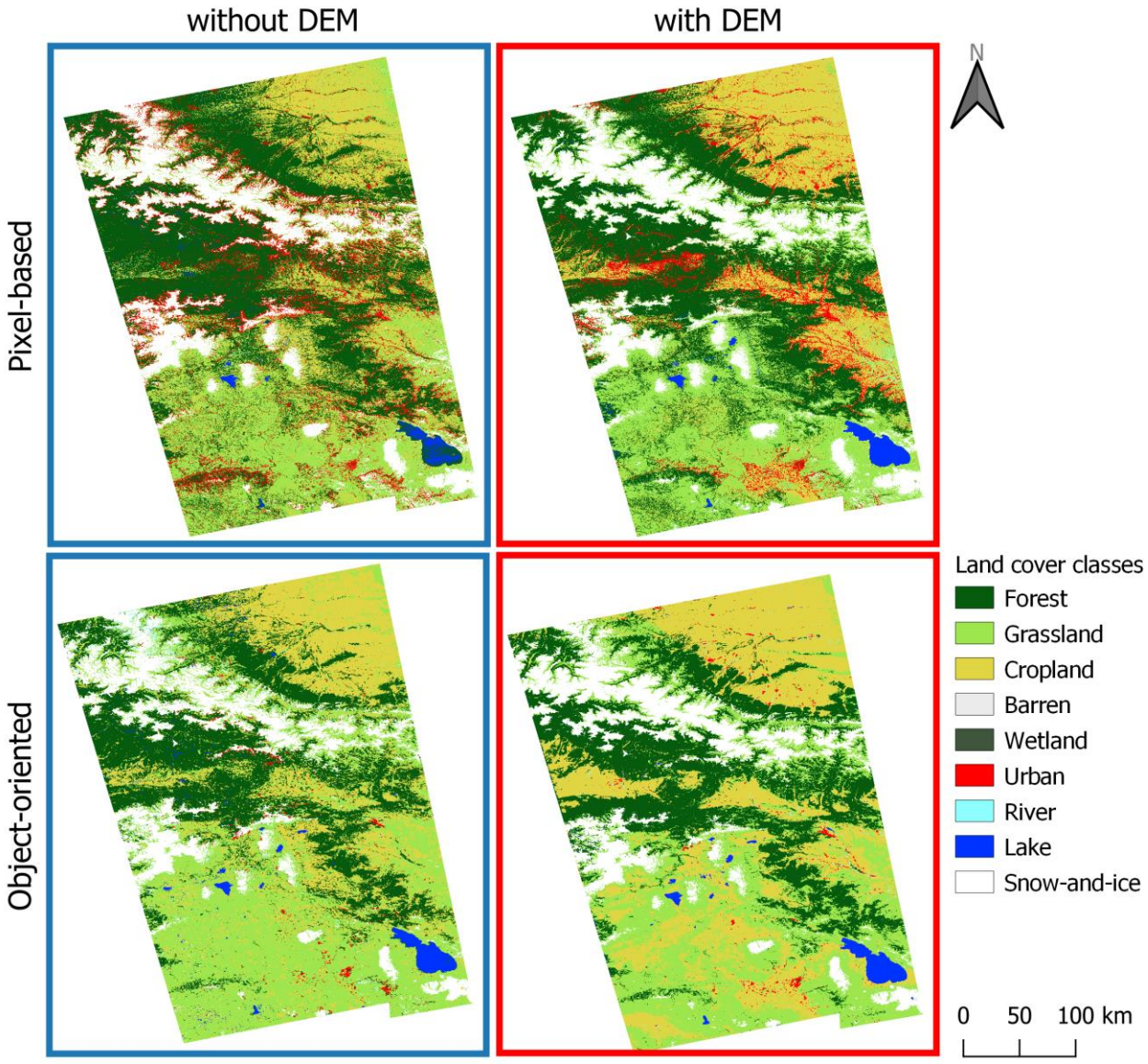


Figure 1.5: Our 1964 land cover maps for comparison of pixel-based and object-oriented classification methods. Highlighted in blue are classifications with five texture metrics, and in red those with five texture metrics and elevation information

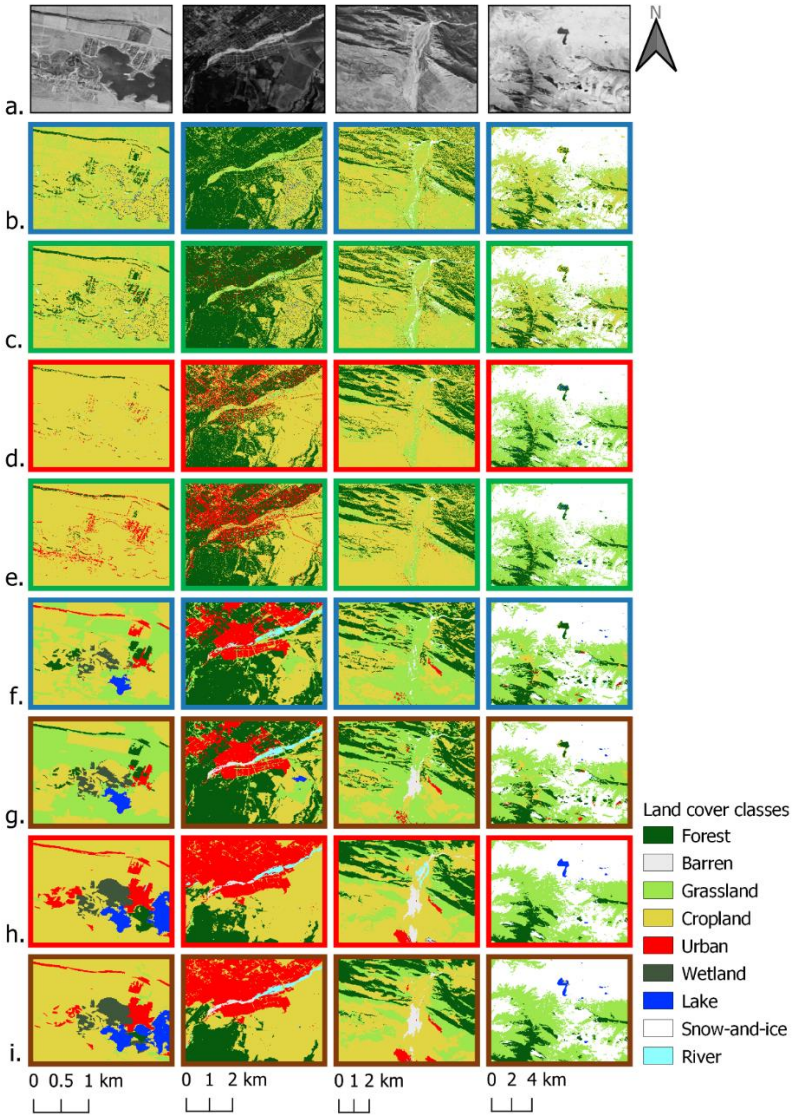
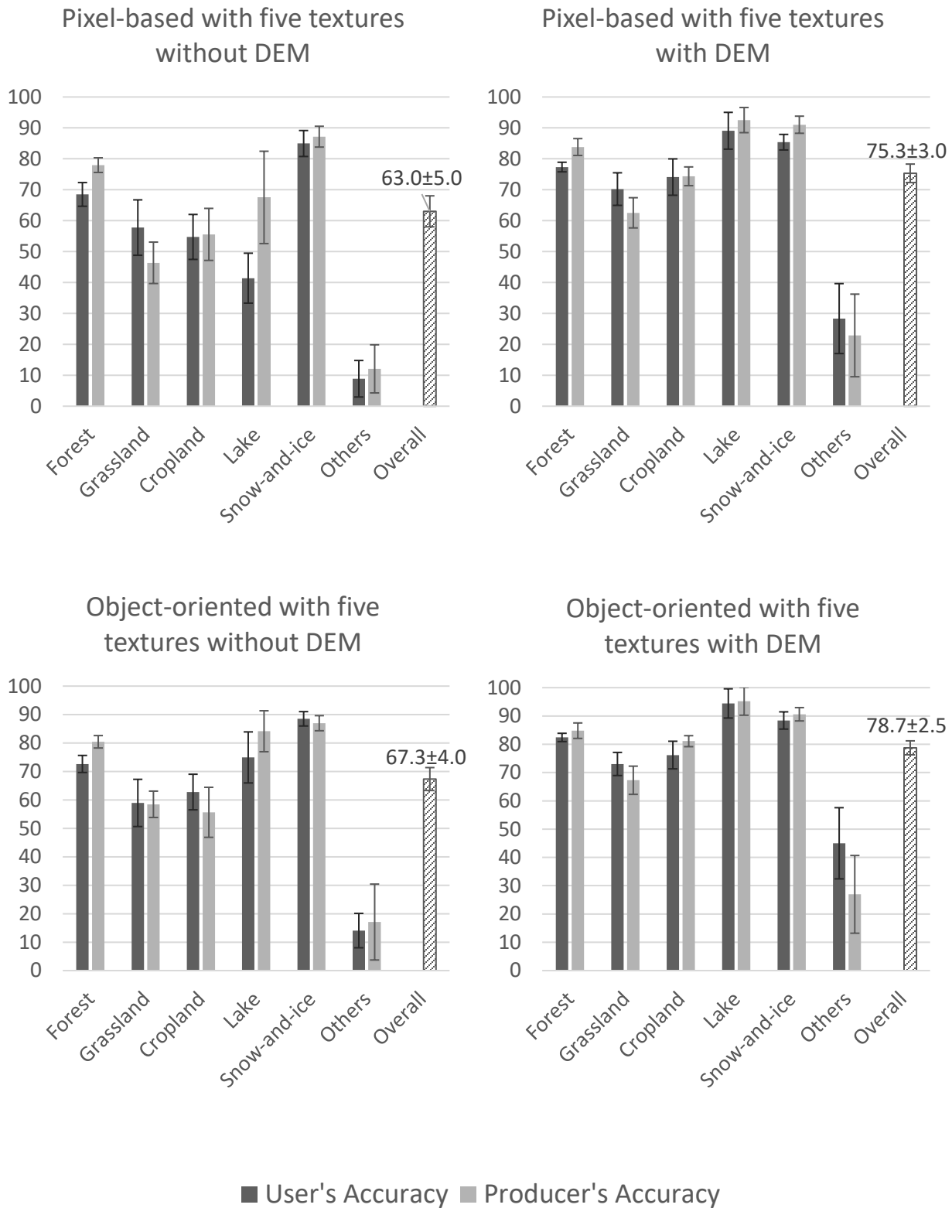


Figure 1.6: Zoomed in examples of a. original Corona imagery followed by the results of pixel-based classifications with: b. five (mean, standard deviation, angular second moment, entropy, homogeneity), and c. eight texture metrics (plus correlation, dissimilarity, variance) without DEM; and d. and e. with DEM; object-oriented classifications with: f. five texture metrics, g. plus object geometry information without DEM; and h. and i. with DEM. We compared the pairs highlighted in red frame to each other, as well as the pairs highlighted in blue frame


Pixel-based with five textures without DEM
63.0±5.0
Pixel-based with five textures with DEM
75.3±3.0
Object-oriented with five textures without DEM
67.3±4.0
Object-oriented with five textures with DEM
78.7±2.5
100
90
80
70
60
50
40
30
20
10
0
Forest
Grassland
Cropland
Lake
Snow-and-ice
Others
Overall
User's Accuracy
Producer's Accuracy

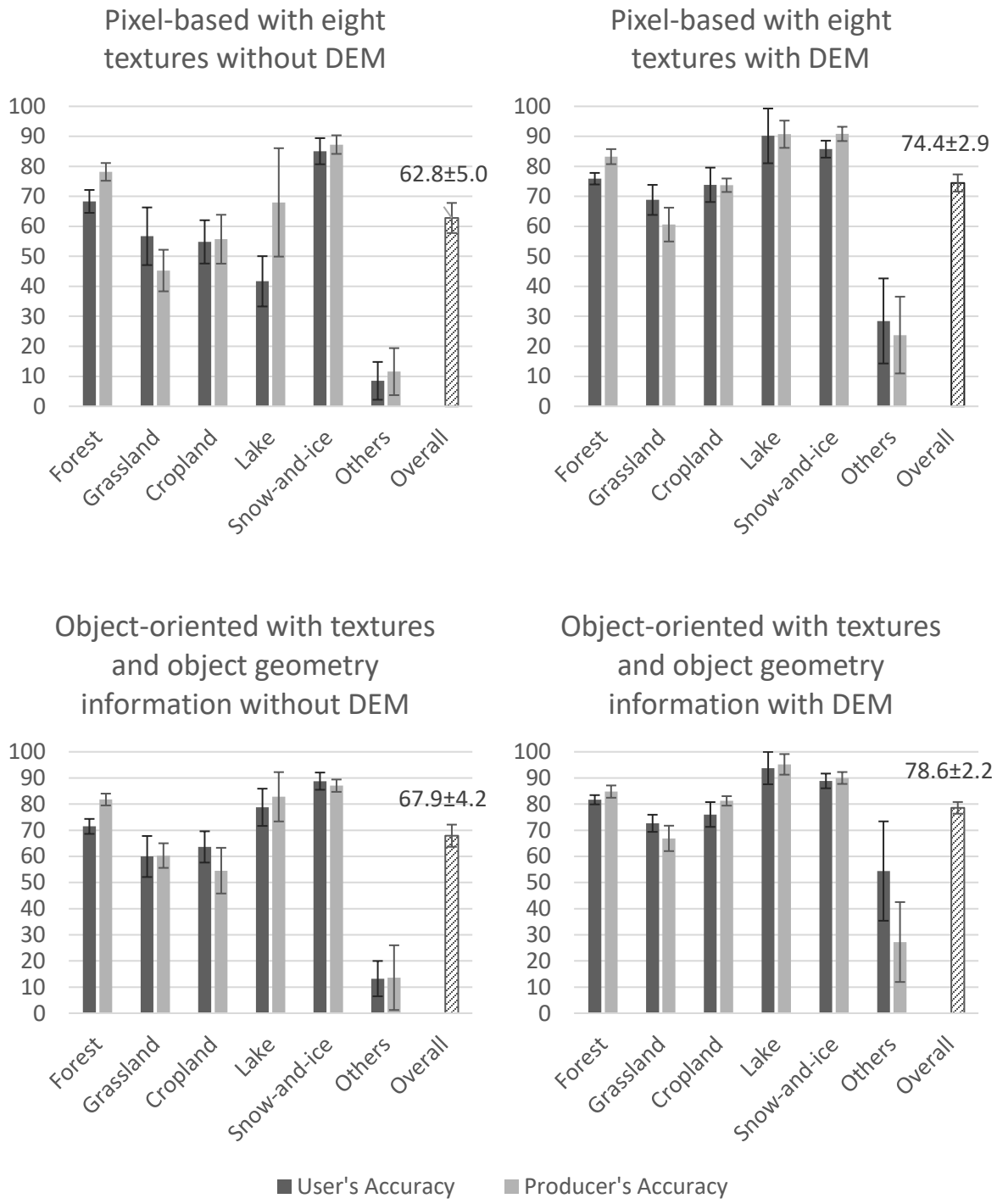


Figure 1.7: Histograms of the user's and producer's accuracy of each land cover class and the overall accuracy for the pixel-based and object-oriented classifications with and without the DEM. The 'error' bars represent the standard deviation

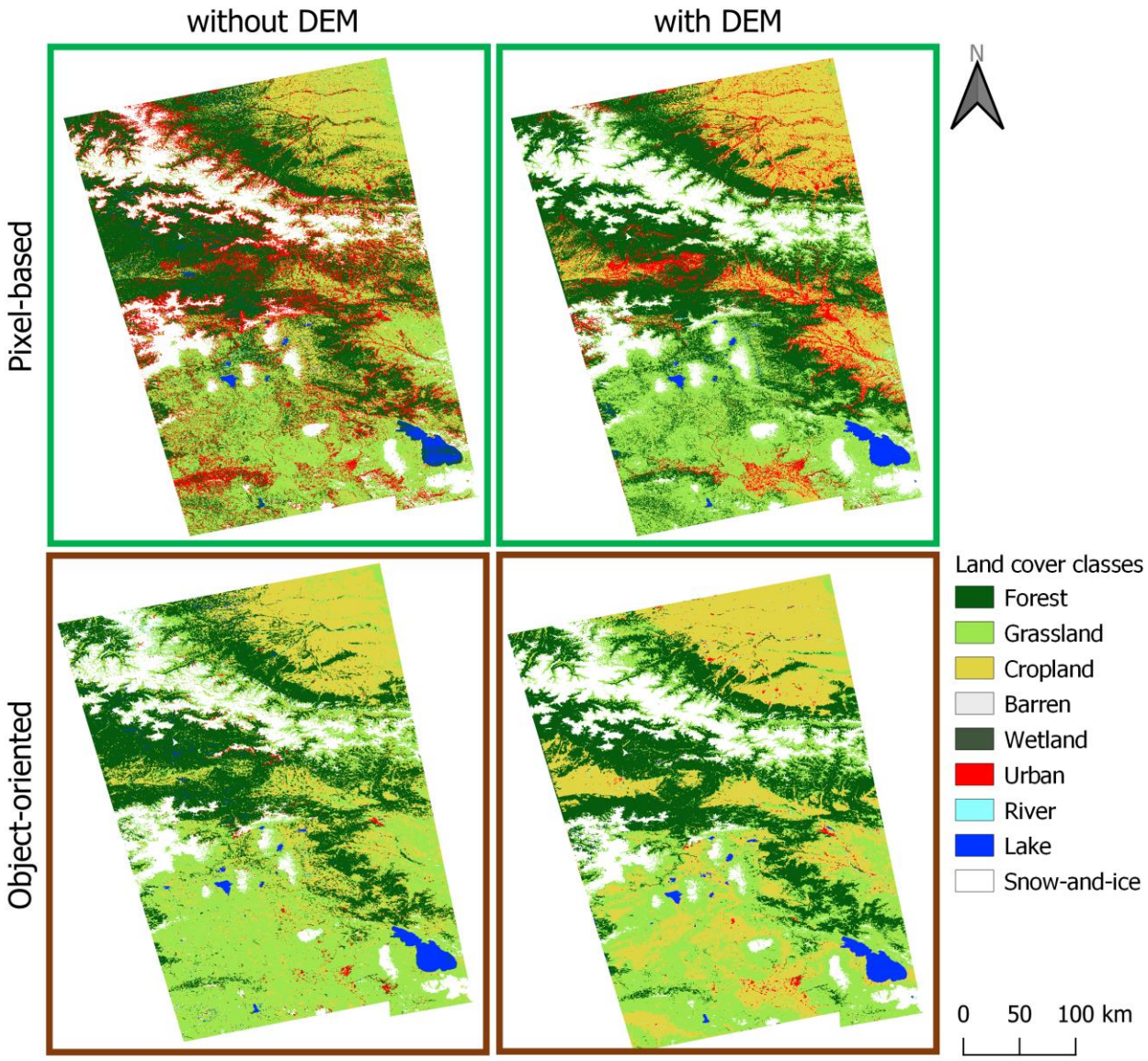


Figure 1.8: Our additional 1964 land cover maps produced in an attempt to improve the classification results for highlighted based on each method. In green are the pixel-based classifications with eight texture metrics with and without elevation information. In brown are the object-oriented classifications with five texture metrics and five object geometry information metrics with and without the elevation information

Appendix

Appendix 1.1: Software packages that we employed in our various steps to analyze the raw Corona images and derive land cover classifications and accuracy assessments

Processing	Software
Ortho-rectification	AgiSoft Metashape, v. 1.7.2
Training and validation point grid generation	QGIS, v. 3.16.10
Extraction of training objects corresponding to point grid	Google earth engine (GEE)
Extraction of point data for importance tests	GEE
Training and validation point labeling	QGIS, v. 3.16.10
Importance tests	R, v. 4.1.1
Access and resampling of the SRTM data	GEE
Segmentation	GEE
Calculation of texture metrics	GEE
Calculation of object geometry properties	GEE
Classification of all maps and test sites	GEE
Validation of all maps and test sites	GEE

Appendix 1.2: Definitions of metrics that we employed for the pixel-based and object-oriented land cover classifications for Corona satellite images

Group	Metrics	Definitions
First-order textures	Mean	Mean of panchromatic Corona satellite image
	Standard deviation	Dispersion of pixel values
GLCM-derived second-order textures	Angular second moment	Orderliness in spatial distribution of neighboring pixel values
	Entropy	Disorderliness in spatial distribution of neighboring pixel values
	Homogeneity	Similarity of values between neighboring pixels
	Correlation	Linear dependency between the pairs of neighboring pixels
	Dissimilarity	Linear difference between the values of neighboring pixels
	Variance	Dispersion of the grey level distribution of neighboring pixel values
Elevation data	Elevation	Terrain DEM
	Slope	Slope in degrees from a terrain DEM
	TRASP (topographic radiation aspect index)	$\frac{1-\cos(\frac{\pi}{180}*(\text{aspect}-30))}{2}$ where aspect is aspect in degrees from a terrain DEM

Object geometry	Area	Objects' total area
	Height	Objects' length from its northernmost point to southernmost point
	Width	Objects' length from its westernmost point to easternmost point
	Perimeter	Objects' perimeter
	Shape	$\sqrt{\text{area}}/\text{perimeter}$

Appendix 1.3: Change in percentage points relative to the best overall classification accuracy for our tests of different segmentation parameters

Parameters					
Compactness					
0.1	1	1.5	20	50	200
best	-0.5	-0.7	-1.1	-1.9	-2.2
Seed grid					
20	30	35	40	45	50
-1.1	-0.7	-0.6	best	-1.6	-0.2
Neighborhood size					
1	16	64	128	192	256
-19.4	-1.2	-0.3	-0.5	-0.3	best
Connectivity					
4				8	
best				-0.5	

Appendix 1.4: Number of training and validation data in each land cover class

Land cover class	Homogeneous segments with 100% of the dominant class	Heterogeneous segments with 76-100% of the dominant class	Heterogeneous segments with 51-75% of the dominant class	Heterogeneous segments with several classes (no class covering 50%)	Heterogeneous – shifted segments	Additional data	Total
Forest	839	128	64	39	251	15	1,336
Grassland	714	197	94	62	331	28	1,426
Cropland	859	86	63	56	220	24	1,308
Barren*	10	3	1	0	4	33	51
Wetland*	0	0	0	0	2	10	12
Urban*	30	10	9	5	12	38	104
River*	3	0	2	0	4	49	58
Lake	59	0	1	0	2	99	161
Snow-and-ice	512	47	15	5	89	2	670
Total	3,026	471	249	167	915	298	5,126

* we did not have many points for the barren, wetland, urban and river classes because they covered a small portion of our study region

Appendix 1.5: Definitions of land cover classes for the study area

Land cover type	Definition
Forest	All woody vegetation, including orchards and gardens
Grassland	Herbaceous vegetation used or not used for grazing
Cropland	Agricultural fields used for growing crops
Barren	Land not covered with vegetation, water or human-made buildings
Wetland	Water covered with vegetation
Urban	Cities, villages and other human settlements
River	Curvilinear areas including river and river bank
Lake	Lakes, water reservoirs
Snow-and-ice	Tops of the mountains and foothills covered in snow and ice

Appendix 1.6: User's and Producer's accuracy (UA and PA) for each land cover class, plus the overall accuracy for our comparisons of pixel-based and object-oriented land cover classifications based on identical sets of texture metrics

	without DEM				with DEM			
	Pixel-based		Object-oriented		Pixel-based		Object-oriented	
Land cover class	UA	PA	UA	PA	UA	PA	UA	PA
Forest	68.5±3.8%	78.0±2.4%	72.6±3.0%	80.4±2.2%	77.3±1.5%	83.8±2.7%	82.4±1.5%	84.8±2.7%
Grassland	57.8±9.0%	46.4±6.7%	58.9±8.3%	58.5±4.6%	70.2±5.3%	62.5±4.9%	73.0±4.1%	67.3±5.0%
Cropland	54.7±7.3%	55.6±8.4%	62.8±6.2%	55.6±8.8%	74.1±5.9%	74.3±3.0%	76.2±4.9%	81.1±1.9%
Lake	41.4±8.1%	67.5±14.9%	74.9±9.0%	84.1±7.2%	89.1±6.0%	92.5±4.1%	94.4±5.2%	95.2±4.9%
Snow-and-ice	85.0±4.2%	87.2±3.4%	88.5±2.5%	87.0±2.7%	85.4±2.5%	91.0±2.8%	88.4±3.0%	90.6±2.4%
Others	8.9±5.9%	12.1±7.8%	14.1±6.0%	17.1±13.3%	28.3±11.3%	22.9±13.4%	45.0±12.6%	26.9±13.7%
Overall	63.0±5.0%		67.3±4.0%		75.3±3.0%		78.7±2.5%	

Appendix 1.7: User's and Producer's accuracy (UA and PA) for each land cover class, plus the overall accuracy for our additional pixel-based and object-oriented land cover classifications. In pixel-based, we added three texture metrics to the original classification and in object-oriented we added the object geometry information to the original classification

	Pixel-based				Object-oriented			
	without DEM		with DEM		without DEM		with DEM	
Land cover class	UA	PA	UA	PA	UA	PA	UA	PA
Forest	68.3±3.8%	78.1±3.0%	75.9±1.9%	83.2±2.5%	71.5±2.9%	81.8±2.3%	81.7±1.8%	84.8±2.3%
Grassland	56.7±9.6%	45.3±6.9%	68.8±5.0%	60.6±5.6%	60.0±7.9%	60.3±4.7%	72.7±3.3%	66.9±4.9%
Cropland	54.8±7.2%	55.7±8.1%	73.8±5.7%	73.7±2.2%	63.6±6.0%	54.5±8.7%	76.0±4.7%	81.2±1.8%
Lake	41.7±8.4%	68.0±18.1%	90.1±9.1%	90.7±4.5%	78.8±7.1%	82.8±9.4%	93.8±6.2%	95.2±3.9%
Snow-and-ice	85.0±4.3%	87.2±3.1%	85.7±2.8%	90.8±2.4%	88.8±3.3%	87.1±2.4%	88.9±2.8%	90.0±2.3%
Others	8.5±6.3%	11.6±7.8%	28.5±14.2%	23.8±12.8%	13.2±6.8%	13.6±12.4%	54.4±19.0%	27.2±15.3%
Overall	62.8±5.0%		74.4±2.9%		67.9±4.2%		78.6±2.2%	

Chapter 2. Half-century of land cover changes in the Caucasus derived from Corona and Landsat satellite data

Abstract

Land cover change has many environmental consequences, and long-term land cover change can exert strong legacies on current patterns and processes. Unfortunately, most land cover change analyses start only in the mid-1980s, when 30-m Landsat satellite imagery became available, missing important changes during the 1960s and '70s, an era of major global change. However, historical spy satellite images may provide data for those decades. Our goal here was to detect long-term land cover change processes in the Caucasus (240,000 km^2) and to quantify the magnitude of both Soviet-era changes (1965-'87), and post-Soviet changes (1987-2015). To achieve that, we (a) produced a land cover map for the Caucasus region based on 1965 Corona spy satellite imagery; and (b) analyzed and quantified long-term changes by comparing the 1965 Corona with 1987 and 2015 Landsat satellite image classifications while accounting for the differences in spatial and spectral resolution of both sensors data. We applied an object-based classification to produce the historical land cover maps, and conducted post-classification change detection. Our Corona-derived map accuracy was 74.4 ± 3.7%, and change accuracies were 66.0 ± 4.2% and 61.6 ± 2.8% for 1965-'87 and 1965-2015, respectively. We found the highest overall gains from 1965 to 2015 in grasslands (+11%), mainly on former croplands (-18%). Change trajectory differed considerably during the Soviet era and thereafter. For example, forest loss was high during the Soviet era (-6% 1965-'87) but followed by forest gain after 1987 (+5%). Grasslands gained continuously in area but at different rates (4% and 7% during and after the Soviet era, respectively), whereas croplands lost area in both eras, but especially after 1987 (3% versus 16%). While the total area of each land cover class was relatively stable, we observed

substantial changes between the classes, resulting in a shift in their locations. There were also stark differences among countries. Post-Soviet cropland gain was especially common in Azerbaijan, whereas forest gain was concentrated in the Russian Caucasus and Georgia. More broadly we show, using the Caucasus as an example, that extending land cover time series deeper in time can reveal substantial historical land cover changes, not adequately captured by recent satellite data alone. Our results highlight both the feasibility and the value of using 1960s and '70s spy satellite data for long-term land cover change analyses, which is especially valuable in regions that experienced substantial land cover changes at the time.

Introduction

Land cover and land use change is widespread (Foley et al., 2005) and has many environmental consequences, such as the loss of ecosystem services (Corvalan et al., 2005), soil degradation (Borrelli et al., 2017), habitat degradation and biodiversity loss (Powers & Jetz, 2019), and climate change (Houghton & Nassikas, 2017). However, assessments of land cover change depend strongly on the baseline, i.e., the earliest year of the analysis. Land use managers often use baseline conditions as the reference to make management decisions about current and future land use, but that entails the risk of a 'shifting baseline syndrome' (Soga & Gaston, 2018) where the choice of recent baselines results in inadequate management decisions because environmental losses prior to the baseline are ignored. Unfortunately, that baseline is typically determined by data availability, and for land cover analyses using remote sensing imagery the baseline is commonly the start of the 30-m resolution Landsat record in the early 1980s, which misses important land cover changes prior.

Mid-20th century global events exert a strong legacy on current land cover. Human population declined during World War II but grew rapidly thereafter, especially from 1960 to ‘75 (United Nations, 2019). In order to meet the growing demand for food, agriculture industrialized (Crossley et al., 2021), and the production of high-yield crop varieties, especially of wheat and maize, increased dramatically during the 1960s’ Green Revolution (Shiferaw et al., 2013). Agricultural intensification required to construct dams and reservoirs for irrigation, which were also used to generate hydroelectric power, and that altered land use patterns in river valleys (Coene, 2009; Cressey, 1953). The Cold War affected the structure of international politics and relations, including global trade (McMahon, 2021), which resulted in economic, technological and environmental changes linked with land management and land use (Greenberg et al., 1997). The question is how to extend the baseline for land cover change studies prior to the 1980s start of the Landsat record, and back to the mid-20th century.

Images from earth-observing satellites, most notably the series of Landsat satellites, are the most common but by no means the only data source to map land cover change. Long-term land cover change can also be derived from historical maps (Kaim et al., 2016; Kraemer et al., 2015; Catalina Munteanu et al., 2014) or historical aerial photographs (Chmielewski et al., 2020; Gonzalez-Abraham et al., 2007; Liu & Tian, 2010). However, in many regions neither historical maps nor aerial photos exist, or they are not accessible for research, or cover only small areas. Cold-war Corona spy satellite imagery, however, has been available globally since the 1960s (Munteanu et al., in press; Song et al., 2015), and presents an alternative data source for change detection. By combining images acquired by historical Corona satellites in the 1960s with more recent satellite data, it becomes possible to map long-term land cover change for large areas.

High-resolution Corona imagery depicts historical land cover accurately, thereby providing novel information about 1960s and ‘70s land cover change. For example, Corona image analysis shows that despite strong incentives by the Soviet Union to farm more land, cropland abandonment in Latvia and in neighboring areas in Russia was more rapid during the Soviet era than after its collapse (Rendenieks et al., 2020). Similarly, Corona images show that in the eastern US forest gains on abandoned farmland during the 1960-‘70s were followed by forest loss due to urban sprawl, whereas in the Amazon, forest loss was continuous since the 1960s (Song et al., 2015). In northern Iraq, Corona images show that around 4,000 km^2 of forests were cut by the Iraqi army following the failure of the Kurdish revolution in 1974, and that was accompanied by an increase in bare land and a decrease in agricultural and built-up areas (Saleem et al., 2018). In Senegal, Corona data shows widespread agricultural expansion into natural areas including bushlands (Ruelland et al., 2011; Tappan et al., 2000). However, Corona-based land cover change studies have either been limited to small study areas (Dong et al., 2012; Shahbandeh et al., 2022) or examined change only in one land cover class, such as forests (Jabs-Sobocińska et al., 2021; Rendenieks et al., 2020; Shahtahmassebi et al., 2017) or urban areas (Nistor et al., 2021; Sandric et al., 2007; Tang et al., 2008). Mapping a full suite of land cover classes for large areas from Corona for large areas has been lacking, but it is possible, as we have shown in a previous paper (Rizayeva et al., 2023). However, what is unclear is how to assess long-term land cover changes for large areas by combining historical Corona and more recent Landsat classifications.

The Caucasus region has a long land use history that extend back several centuries, but land cover changes were especially rapid after the middle of the 20th century (Zazanashvili, 2009). Agriculture, including livestock grazing, was traditionally a major part of rural livelihoods

(Tephnadze et al., 2014). Croplands were well-established even prior to the Soviet revolution in the 1920s, due to market demands from Russia, Iran and Turkey for wheat, silk and meat from the Caucasus (Leviatov, 1948; Osmanov, 1984). Farmland area increased greatly during the Soviet era (Belonovskaya et al., 2016; Wiesmair et al., 2016). During World War II (1939-'45), the Soviet government resettled large population groups, particularly from the Caucasus. While these displaced populations were allowed to return to their native lands after the war, the resettlement, although short-lived, had a strong negative effect on agricultural production (Lyuri et al., 2010). The Soviet Union also embarked on major campaigns to expand agricultural area though, such as "The Great Stalin Plan for the Transformation of Nature" (Smith, 2014), or the "Virgin Lands" introduced by N. Khrushchev (McCauley, 1976), which affected agricultural development (Lyuri et al., 2010). These campaigns had mixed results though, and the lack of essential agricultural infrastructure, such as roads, combined with the goals to meet production goals led to overuse of areas that were more accessible, and the loss of ecosystem services (Prishchepov et al., 2013). After 1991, the collapse of socialism brought another wave of rapid political and socio-economic changes in all formerly socialist countries (Elena Ana et al., 2013; Gutman & Radeloff, 2016), including those in the Caucasus region (Hartvigsen, 2014). Land use was greatly affected by the transition of economy from centralized to market-oriented, and by several military conflicts (Buchner et al., 2020; Yin et al., 2018, 2019) all of which triggered agricultural abandonment. However, prior land cover change studies in the Caucasus were solely based on Landsat data thus missing pre-Landsat changes (Buchner et al., 2020), and often limited in terms of geographical extent (Yin et al., 2018, 2019).

Our major goal was to assess long-term land cover changes in the Caucasus region and to compare the magnitude of Soviet-era changes (appx. 20 years: 1965-'87), and post-Soviet

changes (appx. 20 years: 1987-2015). Our objectives were to: (a) produce a land cover map for the Caucasus region based on 1965 Corona spy satellite imagery; (b) analyze and quantify long-term changes by comparing the 1965 Corona with 1987 and 2015 Landsat satellite image classifications while accounting for the differences in spatial and spectral resolution of both sensors data.

Methods

Study area

We analyzed land cover change across the Caucasus region, spreading from the Black Sea to the Caspian Sea, covering 240,000 km^2. Our study area includes the Greater Caucasus and Lesser Caucasus plus surrounding areas including parts of Armenia (10% of total study area, 82% of the country, 24,300 km^2), Azerbaijan (28%, 79%, 68,300 km^2), Georgia (22%, 77%, 54,000 km^2), and southern Russia (Russian Caucasus, 40%, 0.6%, 93,400 km^2) (Figure 2.1, Appendix 2.1.8). Elevation ranges from -27 to 5,633 m above sea level, and the topography consists of mountain ranges, plains, and uplands in the central areas. Climate ranges from cold alpine to humid subtropical (Dobrynin, 1948), and dominant vegetation types include temperate broad-leaved and mixed forests, dry open woodlands, shrublands, steppes, and semi-deserts (Bohn et al., 2007; Krever et al., 2001; Mancheno et al., 2017).

Since the 1960s the Caucasus experienced several political changes. Due to favorable growing conditions, agriculture has been an essential part of local economy historically (Tephnadze et al., 2014), but intensified under the policies of the Soviet government (Smith, 2014). After 1991, post-socialist land tenure reforms led to the collapse of farming associations and the distribution of private lands to new local owners (Gunya, 2017; Malek et al., 2019). Parcels of agricultural

enterprises (collective farms (*kolkhoz*) and state farms (*sovkhoz*)) were privatized and distributed to families that resided in neighboring settlements at the time of the Soviet collapse (Uzun et al., 2014), which resulted in fragmentation of ownership and small fields (0.9 to 1.6 ha, Hartvigsen, 2014). Animal husbandry and cattle farming (Belonovskaya et al., 2016; Gunya et al., 2019) were historically an important food source (Neudert & Allahverdiyeva, 2009). However, overgrazing of pastures caused their degradation (de Leeuw et al., 2019; Lewińska et al., 2020; Shatberashvili et al., 2015). The major shifts in government and in land use along with high complexity and landscape heterogeneity make the Caucasus region an exciting place to study long-term land cover changes.

Data

Given its strategic importance during the Cold War, the Caucasus region was frequently photographed by Corona spy satellites. We selected data from five Corona missions based on low cloud cover and analyzed high-resolution photographs (1.8-2.7 m) (Song et al., 2015) captured by forward-facing and backward-facing cameras in 1964 and 1965, hereafter referred to as '1965' (Table 2.1, Figure 2.1. We augmented the Corona image classifications with 30-m Shuttle Radar Topography Mission (SRTM) data (Farr et al., 2007).

Since 1985, our study area has been imaged by 30-m Landsat satellite data (Mission 5, 7 and 8). We analyzed medium-resolution (30-m) land cover maps for the Caucasus region derived from topographically corrected Landsat imagery for 1987 and 2015 (Buchner et al., 2020). The overall accuracy for cropland change from 1987 to 2015 was $75.7 \pm 2.6\%$ and for forest change $90.2 \pm 2.7\%$ (Buchner et al., 2020).

Corona land cover classification

We ortho-georectified 198 Corona images using Structure from Motion (SfM) algorithms (Song et al., 2015; Ullman, 1979) and the Corona georectification approach developed by Nita et al., (2018) based on Metashape software (AgiSoft Metashape Professional, Version 1.7.2) (AgiSoft, 2021). We acquired the unprocessed Corona data from the United States Geological Survey (USGS, 2019) and geo-referenced them against recent Google and Bing very-high resolution images, focusing on stable locations. Each Corona image covered approximately 17 x 232 km. To assess the accuracy of the georectification, we selected ca. 20 independent check ground control points (GCP), such as crossroads and visible landmarks that were stable over time and calculated the root mean square errors for each stereographic pair captured by forward- and backward-facing cameras (Nita et al., 2018; Rendenieks et al., 2020) resulting in a total of 1,988 GCPs. Our georectified images had an absolute root mean square positional error of only 12.8 ± 3.2 m (Table 2.1, Appendix 2.1.1, Figure 2.2).

We had previously developed a classification methodology for single-band Corona images, and tested it in a small portion of the Caucasus (Rizayeva et al. (2023). Here, we used that methodology to derive the 1965 land cover maps for our study area using Corona photographs captured by forward- and backward-facing cameras from each mission covering almost the entire Caucasus (Figure 2.3). Specifically, we performed an object-oriented classification after segmentation using the Simple Non-Iterative Clustering (SNIC, *.snic*) algorithm (Achanta & Süsstrunk, 2017) within Google Earth Engine (GEE), to map eleven land cover classes (forest, barren, grassland, cropland, urban, wetland, river, lake, snow-and-ice, clouds, cloud shadows, Appendix 2.1.2). We applied SNIC on the georectified Corona images using segmentation parameters that we fine-tuned during multiple test runs (seed location spacing: 40, connectivity: 4 neighbors, compactness factor: 0.1). We calculated each objects' geometry information: area,

perimeter, width, height (Gorelick et al., 2017), and shape (Li et al., 2007; Nghi & Mai, 2008), as well as the object-based first- (mean and standard deviation) and second-order texture metrics (angular second moment, entropy, and homogeneity) based on the grey-level co-occurrence matrix (GLCM, *.glcmTexture*) by applying a 7 x 7 pixel moving window within each object obtained from the segmentation (Conners et al., 1984; Haralick et al., 1973; Farwell et al., 2020).

For our land cover classification, we applied a 10-fold Monte-Carlo (Picard & Cook, 1984) classification using Random Forest algorithm with majority voting (Cui et al., 2018) within GEE (*.smileRandomForest*), setting the tree size to 100. We included the same digital elevation model (DEM) that we used for the ortho-georectification as classification input after resampling it to 2.5-m (Rizayeva et al., 2023). One of us (A. Rizayeva) digitzed all training and validation information for 10,953 points in total for the eleven classes plus clouds and cloud shadows (Table 2.2). Following the sampling design for the LUCAS land use dataset of the European Union (LUCAS, 2022), we employed a systematic sampling design to ensure that all countries and regions in our study area had the same sampling density. This also aided in limiting the effects of spatial autocorrelation by maximizing the distance between points. We implemented a 5 x 5 km point grid to balance the advantage of a large sample size with the feasibility of collecting the data. Our training and validation data collection took approximately two months of full-time work. We visually assessed Corona data for each point, selected the dominant land cover class of the segment the point belonged to, and assigned the dominant class in the segment to the grid point. We quantified the accuracy of the resulting maps using 10-fold cross-validation. For training, we selected 80% of the grid points from homogeneous segments and added more training points for classes that had less than fifty in the systematic sample to improve the classification accuracy obtained from our initial classification tests (Appendix 2.1.3). In some

areas where the forward- and backward-facing Corona images did not align well, the segments appeared “shifted”. Furthermore, errors from image segmentation led to “missegmented” objects. We ommitted such points from the training dataset, but retained them for validation. Specifically, in each of our cross-validation folds, we selected 20% of the grid points in homogeneous segments, and 20% of the points in shifted and missegmented objects for validation (Appendix 2.1.3) (Rizayeva et al., 2023). We only report accuracies of land cover classes that we used for change detection, that is after combining river and lake to class “water”, and removing cloud, cloud shadow, and snow-and-ice classes (see below). We conducted a thorough area-adjusted accuracy assessment of the 1965 land cover map derived from Corona images and calculated the overall accuracy, user’s accuracy, producer’s accuracy and their confidence intervals and the F1 score following the best practices outlined in Olofsson et al. (2014).

Change detection from 1965 to ‘87 and then 2015

To quantify land cover changes over time, we first matched the classes of the maps derived using Corona and Landsat data by making the class catalog consistent (Table 2.3). Then we resampled the Corona classification to 30-m resolution using the projection of the Landsat classification and majority rule for the area-weighted resampling. Specifically, we applied a *.mode* reducer within GEE (*.reduceResolution*) to ensure that each new 30-m pixel was consistent with the label of majority 2.5-m pixels overlapping with it. We built a set of codes within GEE for change detection between 1965, 1987 and 2015 (https://github.com/rizayeva/changeDetection – will be accessible upon publication). We compared each pair of maps (post-classification comparison) to assess the changes for each period (i.e., 1965-‘87, 1987-2015, and 1965-2015). We selected these three intervals to describe Soviet-era changes (appx. 20 years: 1965-‘87), post-Soviet changes (appx. 20 years: 1987-2015), and net overall changes (50 years: 1965-2015).

We considered any transition from one class to another as a change (Table 2.4) but excluded a few cases. Because we analyzed only single-date Corona images captured in fall, there was already quite a bit of snow and ice in the mountains. Hence, we did not consider changes to or from snow-and-ice as land cover changes and masked out the 1965 snow-and-ice class from the two later time points. Similarly, we categorized clouds and cloud shadows into a separate class in our 1965 map, and masked them from all maps for further change assessment. Overall, we had 42 change classes and 7 stable classes (Table 2.4). For each time interval, we assessed the losses and gains in each land cover class and calculated the total area of each change. We calculated error-adjusted area estimates for the entire study area (Appendix 2.1.5 and 2.1.6), but because they cannot be derived for each country, we report unadjusted area estimates in the text for consistency. For visual purposes, we grouped some of the change classes in the change maps, but the area statistics are for each class separately.

We summarized changes by administrative units within each country in the Caucasus (Appendix 2.1.9). Because our most recent year is 2015, and some administrative units have been renamed after 2015, we used the official names and borders accepted within each country as of 2015 (Appendix 2.1.9). As such, we refer to Abkhazia as Abkhazeti, parts of Racha Lechkhumi, Shida Kartli, and Mtskheta-Mtianeti include South Ossetia in Georgia, and Yukhari Karabakh includes Nagorno-Karabakh in Azerbaijan. Due to Corona data availability and partial cloud cover, some of the administrative units were not entirely covered (Appendix 2.1.9, Appendix 2.2.4) and when reporting changes, we refer to the area covered within each administrative unit or country.

We performed area-adjusted accuracy assessments of our land cover change maps (1965-‘87 and 1965-2015). In addition to overall accuracy, we report the accuracies and confidence intervals for each change class. Using our change maps, we generated a random stratified sample and

validated sampling points for the 1965-‘87 and 1965-2015 change maps, respectively. We aimed for 75 points per change class to validate each change map (Congalton & Green, 2009). Because we used objects as the mapping unit for our 1965 land cover map, we restricted our sampling to only one validation point per object, which is why some of the classes had fewer than 75 points (Table 2.5) and our final number of change validation points were 1,149 and 1,307 points for the 1965-‘87 and 1965-2015 change maps, respectively. For 1987 and 2015, we visually assessed the Landsat and very high-resolution Google Earth imagery and two observers (N. Kasraee and A. Rizayeva) manually labeled each validation point according to its land cover. For 1965, we visually assessed the Corona imagery and referred to the most dominant class within a given object.

Results

Corona land cover classification

The land cover classification based on the 1965 Corona satellite images plus elevation data had an overall area-adjusted accuracy of 74.4 ± 3.7% (Appendix 2.1.4, Figure 2.4, Figure 2.5). The land cover in the Caucasus in 1965 was predominantly forest (25.2%), cropland (38.3%) and grassland (24.7%). The mountainous areas in Georgia and Azerbaijan were highly forested. Croplands were predominant in the north of our study area, the southern parts of Russia in Krasnodarskiy Kraj, but also common in Aran, Sheki-Zagatala and Ganja-Gazakh administrative districts in Azerbaijan, in Kakheti and Kvemo Kartli in Georgia, and in Shirak, Aragatsotn and Armavir in Armenia (see Appendix 2.2 for details about the administrative units). Grasslands were prevalent in Dagestan and in north-eastern Azerbaijan.

Change detection from 1965 to '87 and then 2015

Map accuracies

Our change maps were not quite as accurate as the single-year Corona classification because errors from two land cover classification compounded. However, the overall area-adjusted accuracies of the change maps for the two periods were comparable at 66.0 ± 4.2% for 1965-'87 and 61.6 ± 2.8% for 1965-2015 (Appendix 2.1.5 and 2.1.6, Figures 2.6 and 2.7). For cropland change from 1987 to 2015, the overall accuracy was 75.7 ± 2.6% and for forest change 90.2 ± 2.7% (Buchner et al., 2020). While the overall accuracy was higher for the 1965-'87 change map, it had consistently lower user's accuracies (UA, average 57% vs. 71%) and producer's accuracies (PA, average 48% vs. 55%) than our 1965-2015 change map. Stable classes had an overall higher F1 score for 1965-'87 (average 49% vs. 31%), than for 1965-2015, which had a higher F1 score for change classes (average 61% vs. 53%), mainly due to misclassification of urban (8% and 26%) and barren areas (45% and 16%). Forest loss class had a higher PA for 1965-'87 (92 ± 16%) and a higher UA for 1965-2015 (91 ± 7%), forest gain had the lowest accuracy for 1965-'87 (11 ± 9% UA and 16 ± 52% PA), but a high UA (91 ± 7%) for 1965-2015. The cropland gain class had the highest UA for 1965-2015 (100 ± 0%) and a PA of 73.4 ± 0.1%, while for 1965-'87 it had lower accuracies (28 ± 31% UA, and 34 ± 17% PA).

Land changes

Our results clearly showed that land cover in the Caucasus changed during both the Soviet (1965-'87) and post-Soviet eras (1987-2015) (Appendix 2.1.7, Figure 2.8), but the magnitude and direction of changes differed between the two eras. Changes in the three most dominant classes, namely forest, grassland, and cropland, exceed by area those in all other categories

(Figure 2.9). Of the area covered in croplands in 1965, 33% were lost by 1987 (21,060 km^2, Appendix 2.2.1.1), and 35% of 1987's croplands were lost by 2015 (21,900 km^2, Appendix 2.2.2.1). We also observed 30% cropland gain from 1965 to 1987 (19,167 km^2, Appendix 2.2.1.1), and 19% cropland gain from 1987 to 2015 (12,071 km^2, Appendix 2.2.2.1). Thus, our results show net 3% loss in 1965 croplands by 1987 (1,900 km^2, Appendix 2.2.1.1), and net 16% loss of 1987's croplands by 2015 (9,800 km^2, Appendix 2.2.2.1). Grasslands increased consistently both in the Soviet (net 4% gain relative to 1965 grasslands, 3,300 km^2, Appendix 2.2.1.1), and the post-Soviet era (net 7% gain relative to 1987 grasslands, 7,100 km^2, Appendix 2.2.2.1), and a 1965-2015 net grassland gain of about 11% (10,500 km^2, Appendix 2.2.3.1). For forest, a full 23% (16,800 km^2) of the 1965 forests were lost by 1987, but there was only 7% (4,700 km^2) loss of 1987's forests by 2015. Similarly, we observed 12.2% (8,300 km^2) gain in 1965 forests by 1987 and 17% (12,400 km^2) forests gained from 1987 to 2015. Overall, forest cover remained almost stable with net 1% (800 km^2) less forest cover in 2015 than in 1965. Changes occurred in other classes too (Figure 2.9), but our findings for forest, grassland, and cropland highlight how dynamic the land cover in the Caucasus region was, and has been for a long time (Figure 2.8, Figure 2.9). While land cover changes were widespread throughout the Caucasus, the types of changes differed considerably among the four countries. Land cover in the Russian Caucasus was relatively stable over the 50 years that we analyzed. In the mid-1960s, a large portion of the land in the Russian Caucasus (30%, 28,300 km^2, Appendix 2.2.1.2) was already cultivated as croplands, and moderate cropland loss occurred during the post-Soviet era. Cropland loss resulted often in grassland gain with 67% of 1965-1987 cropland loss (3,800 km^2, Appendix 2.2.1.2) and 64% of 1987-2015 cropland loss (4,600 km^2, Appendix 2.2.2.2) being cropland to grassland change. After the Soviet Union collapsed, cropland loss occurred mainly in

Dagestan (net 14% loss of 1987 croplands, 612 km^2, Appendix 2.2.4.9.2). Grasslands in Dagestan in the post-Soviet era were largely replaced by forests (27% of the 1987-2015 grassland loss, 719 km^2, Appendix 2.2.4.9.2). With only a 0.7% (191 km^2) net increase relative to the area they covered in 1965, grasslands of the Russian Caucasus remained relatively stable during the Soviet era (Appendix 2.2.1.2) but increased slightly after the collapse with a net 7% gain relative to the 1987 grasslands by 2015 (2,000 km^2, Appendix 2.2.2.2). While a net 3% (1,000 km^2) of 1965 forests were lost by 1987 (Appendix 2.2.1.2), in the post-Soviet era, there was net 6% gain (2,000 km^2) relative to the 1987 forests by 2015, mainly in Krasnodarskiy Kraj (5.5% net gain in 1987 forests of Krasnodarskiy Kraj by 2015, 812 km^2, Appendix 2.2.4.1.2), and Dagestan (15% net gain in 1987 forests of Dagestan by 2015, 596 km2, Appendix 2.2.4.9.2).

Georgia experienced the highest forest gain of the four countries: 3% net gain (700 km^2) of 1965 forests by 1987 (Appendix 2.2.1.3), and 6% net gain of 1987 forests (1,500 km^2) by 2015 (Appendix 2.2.2.3). In Abkhazeti, a net of 40% of the 1965 forests (1,967 km^2) were gained by 1987, especially on former grasslands (93% of Abkhazeti's 1965-'87 forest growth, 1,212 km^2) and croplands (5% of Abkhazeti's 1965-'87 forest growth, 60 km^2, Appendix 2.2.4.10.1). In the post-Soviet era, forest gains occurred in especially in the valleys across the south of Georgia with a 6% net gain relative to 1987's forests of Samtskhe-Javakheti by 2015 (90 km^2, Appendix 2.2.4.16.2), and at higher altitudes in the North with a 16% net gain relative to 1987's forests of Shida Kartli (350 km^2, Appendix 2.2.4.17.2), and a 10% net gain relative to 1987's forests of Mtskheta-Mtianeti (275 km^2, Appendix 2.2.4.18.2). By 1987, 56% of the losses of 1965's grasslands in Georgia (3,200 km^2) occurred due to forest gains and 34% (2,000 km^2) due to cropland gains (Appendix 2.2.1.3). Similarly, by 2015, 58% (1,900 km^2) of 1987 grassland loss was due to forest gain and 34% (1,100 km^2) due to cropland gain (Appendix 2.2.2.3). Losses of

1965's croplands by 1987 (net 10%, 1,200 km^2, Appendix 2.2.1.3) and 1987's croplands by 2015 (net 29%, 3,000 km^2, Appendix 2.2.2.3) occurred often close to large cities, such as near Tbilisi, including the Shida Kartli and Mtskheta-Mtianeti regions.

In Armenia, cropland gain was common during the Soviet era (51% gain of 1965 croplands by 1987, 2,500 km^2, Appendix 2.2.1.4). After the collapse, it continued with a 29% gain relative to 1987's croplands (1,500 km^2), but there was more cropland loss then too (44%, 2,300 km^2, Appendix 2.2.2.4). While large portions of croplands established before 1987 were lost thereafter, in Kotayk and Ararat cropland loss was even more widespread during the Soviet era at a net 28% loss (127 km^2, Appendix 2.2.4.26.1) and 61% loss (278 km^2, Appendix 2.2.4.28.1) of each region's 1965's croplands, respectively. Overall, we observed a 18% gain relative to 1987's grasslands by 2015 (2,600 km^2), and this grassland loss was often due to cropland gain (81% of 1987-2015 grassland gain, 2,100 km^2), especially in Tavush (70% of 1987-2015, 140 km^2, Appendix 2.2.4.29.2), and Gegharkunik (89% of 1987-2015 grassland loss, 372 km^2, Appendix 2.2.4.30.2). Forest loss occurred mainly during the Soviet era with a net of 22% less forests (891 km^2) in 1987 than in 1965 (Appendix 2.2.1.4), but a net of 8% forest gain (3,400 km^2) in the post-Soviet period (Appendix 2.2.2.4).

In Azerbaijan, the most widespread changes were cropland loss accompanied by some cropland gain on former grasslands and forests. By 1987, a 40% gain occurred relative to the 1965 croplands (7,700 km^2), especially in Yukhari Karabakh, which had a net gain 86% compared to 1965 croplands (794 km^2, Appendix 2.2.4.36.1) and net 480% gain in Kalbajar-Lachin (519 km^2, Appendix 2.2.4.34.1). However, there large areas of cropland were concomitantly lost in Aran (net 29%, 2,803 km^2, Appendix 2.2.4.38.1), and Guba-Khachmaz (net 12%, 212 km^2, Appendix 2.2.4.39.1). Over time, croplands that were newly farmed during the Soviet era were often

abandoned thereafter. In the post-Soviet era, loss of 1987 croplands was widespread in Yukhari Karabakh (50%, 866 km^2), but there was also considerable cropland gain (40% by 2015 relative to 1987's croplands, 693 km^2, Appendix 2.2.4.36.2). The area covered by croplands in 1965 decreased by a net of 5% (1,000 km^2) during the Soviet era (Appendix 2.2.1.5) and a net of 11% of the 1987 croplands (1,900 km^2) during the post-Soviet period (Appendix 2.2.2.5). Gain in grasslands during the Soviet era (net 7% of 1965 grasslands, 2,400 km^2) was mostly due to cropland loss (65% of 1965-'87 grassland gain, 7,400 km^2, Appendix 2.2.1.5), especially in Aran (94% of Aran's grassland gain, 4,269 km^2, Appendix 2.2.4.38.1). While we observed some forest gain before 1987, for example a net gain of 10% relative to 1965's forests in Guba-Khachmaz (117 km^2, Appendix 2.2.4.39.1), the 1965-'87 and 1965-2015 forest loss were at high net loss of 29% relative to 1965's forests in Azerbaijan (3,200 km^2, Appendix 2.2.1.5, and 3,300 km^2, Appendix 2.2.3.5, respectively).

Discussion

We conducted a long-term land cover change assessment for a large and geographically diverse area by combining 1960s Corona spy satellite imagery with later-date Landsat classifications thereby capturing land cover changes over five decades. We found that many of the land cover changes in the Caucasus occurred already prior to the start of Landsat data, highlighting both the need and the value of extending land cover change analyses further back in time by analyzing Corona spy satellite imagery. Our historical land cover classification for the Caucasus region using single-date panchromatic Corona imagery had an overall accuracy of 74.4 ± 3.7%, and is the first historical land cover map for a large area (over 240,000 km^2) and with a full set of land cover classes obtained from Corona. We were able to obtain distinct land cover change patterns

across the Caucasus region using classifications derived from Corona (1964-1965) and Landsat (1985-1989 and 2013-2017) data, which captured changes with 66.0 ± 4.2% and 61.6 ± 2.8% overall accuracy, respectively. Results were fascinating. For example, we were surprised to find substantial forest loss before 1987 but then forest gain by 2015. Similarly noteworthy was that despite numerous agricultural land initiatives by the Soviet government and post-Soviet countries in the Caucasus region, the total area covered by croplands declined gradually and did so already during the Soviet era, but abandonment rates in the Caucasus were not as high as in other post-Soviet countries (Griffiths et al., 2013; Lesiv et al., 2018; Lyuri et al., 2010).

Land cover and land use change assessments are typically limited to the period following the introduction of Landsat Thematic Mapper data (Hemati et al. 2021). However, considerable changes had already occurred prior in many parts of the world. This phenomenon is known as shifting baseline syndrome, where the understanding of natural conditions relies on established baselines (Soga & Gaston, 2018), which can be misleading. For example, during the 1987-2015 era alone, we observed extensive cropland abandonment, but by adding the 1965 baseline, we discovered that many croplands abandoned after the Soviet collapse were freshly cultivated in the late Soviet era (Figure 2.8.b). It is likely that the reasons for both their late cultivation also fostered their abandonment, such as unfavorable growing conditions, or relative inaccessibility, and the cultivation of these lands may have been due to government subsidies and to meet plans. In contrast, areas more suitable to agriculture that were already cultivated before the 1960s, remained active agriculture throughout the Soviet era and after the collapse (Figure 2.8.c). Similarly, while Landsat data allowed us to capture the gain in forest area post-1987 (+5%), it missed the forest loss during the Soviet era (-6% 1965-‘87). Ultimately, having an extended baseline with Corona data allowed us to detect how both the magnitude and direction of land

cover changes differed during and after the Soviet era. For example, we observed continuous grassland gain during and after the Soviet era but at varying rates (4 and 7%, respectively). On the contrary, croplands were lost continuously but also at different rates (3% and 16% loss, respectively). When compared to other post-Soviet countries, the area of each land cover class was relatively stable, but we observed substantial changes between classes, resulting in a shift in their locations (Figure 2.9). Thus, incorporating Corona data helped us uncover land change processes and trends missed by recent satellite data alone. This extension of baselines further back in time, more exactly, by two decades prior to what had been previously mapped for large areas, can be especially important for regions that experienced substantial changes in the 1960-‘70s.

The most widespread land cover changes in the Soviet and the post-Soviet era, occurred in croplands, forests and grasslands. The main causes for cropland change were Soviet policies, post-collapse changes in the agricultural sector, population migration, and numerous military conflicts that occurred in the region after the collapse. In 1965, croplands accounted for approximately 27% of our study area, with high rates of both losses and gains thereafter. We had expected an increase in cropland area during the Soviet era, due to the agricultural programs, but found a net decrease in cropland from 1987 to 1965. While access to water established during the Soviet era allowed to leach saline soils with fresh water (Iskenderov, 2015; Sastre-Conde et al., 2015), this resulted in rising groundwater levels, waterlogged soils, and subsequent productivity losses. An unofficial race among regions to overachieve the planned Soviet government targets for agricultural production, rooted in receiving government grants and awards, resulted in the expansion of croplands on unfavorable lands, and the loss of natural landscapes across the Soviet Union, including lowlands in the Caucasus region (Lyuri et al., 2010). Many of these new

agricultural areas did not persist though. We found that croplands often converted to wetland or grassland, which we suggest was often due to the combination of improper irrigation and overuse. Cropland loss was widespread in many transitional economies (Alcantara et al., 2012; Feranec et al., 2016; Müller et al., 2013), partly the previously guaranteed market for agricultural goods vanished, leading to a decline in the agricultural sector across most post-Soviet countries (Prishchepov et al., 2012). In most of Eastern Europe, post-Soviet cropland loss exceeded those rates of the Soviet era (Munteanu et al., 2014, but see Rendenieks et al., 2020) and often occurred in unsuitable lands (Alcantara et al., 2013; Catalina Munteanu et al., 2017). However, compared to Eastern Europe, cropland loss was relatively rare in our study area, especially in the Russian Caucasus where croplands were very stable in the post-Soviet era (Buchner et al., 2020; Lesiv et al., 2018; Yin et al., 2018), likely due to more favorable growing conditions (Dragavtseva et al., 2015; Tyurin et al., 2010). Interestingly, lost croplands in our study area did not convert to forest, as occurred in many other areas (Alcantara et al., 2012, 2013; Rendenieks et al., 2020). The most likely reason is that most of the croplands were located in flat areas where forest was rare, having dispersal limitations.

The dynamics of cropland area during the post-Soviet era, both throughout the former Eastern bloc and in the Caucasus, were greatly influenced by migration and refugee movements. In Western Ukraine (Baumann et al., 2011), Slovakia (Pazúr et al., 2020), Romania (Grădinaru et al., 2015), Belarus, and European Russia (Prishchepov et al., 2016), croplands near large cities often had especially high loss rates because agricultural workers chose other types of employment with higher income. Similarly, in the Caucasus, cropland loss was widespread near Tbilisi, in Shida Kartli, and Mtskheta-Mtianeti, Georgia, as well as near Pyatigorsk, Russia. Cropland loss was also partly due to the privatization of agricultural enterprises (*sovkhoz* and

kolkhoz farmlands). Throughout post-Soviet countries, parcels of land were distributed among local populations after the Soviet Union collapse (Uzun et al., 2014), or retributed to pre-collectivism landowners, resulting in fragmented land ownership (Alcantara et al., 2012). However, new landowners who moved to cities or retired had often either limited interest in agriculture or lacked the capacity to continue cultivation, resulting in cropland loss (Alix-Garcia et al., 2012; Muller et al., 2009; Prishchepov et al., 2012). A strong demand for country and holiday houses (*dacha*s) near large cities further contributed to cropland loss. In our study area, widespread cropland loss occurred in Abkhazeti in Georgia during the post-Soviet era, but we found that there was already widespread cropland loss during the Soviet era, which may be related to forced relocation of local population to other regions of Georgia and Türkiye in the pre-Corona era (Lazba & Tsintsadze, 2019; Lerner, 2016), as well as the development of tourism (Salukvadze & Backhaus, 2020; Theissen et al., 2022).

Military conflicts in the region also played an important role in shaping agricultural practices (Buchner et al., 2022; Yin et al., 2019), due to post-war policies and population displacement (Baumann et al., 2015) and higher life-threatening risks near war zones (Yin et al., 2020). In the post-Soviet era, in Russia, Georgia, and Azerbaijan cropland loss was rare except in war-affected regions, such as Ingushskaya respublika, Abkhazeti, Kalbajar-Lachin and Yukhari Garabakh. Outside of the war zones, we observed widespread cropland gain in some parts of Azerbaijan where winter pastures converted into croplands. Wars disrupted croplands along rivers such as Hakari and Bazarchay, which together with the construction of the Khoda Afarin reservoir in the 2000s (Leummens & Matthews, 2013), and resulted in higher ground water levels and wetland expansion, such as in Kalbajar-Lachin.

We did not observe large net changes in forest and grassland area, but these two classes were very dynamic. The main causes for changes in grasslands and forests in the Caucasus were often linked. Among them, were the Soviet policies of human population resettlements, Soviet forest exploitation, and post-Soviet changes in herding practices due to institutional transformations and military conflicts. However, the changes in herding practices had opposite effects in different regions, leading to both grassland and forest gain.

We observed a continuous net increase in grasslands across the Caucasus region. In flat areas, cropland loss occurred mainly in marginal soils and near military conflicts, which contributed to grassland gain (see above). In mountainous areas changes mainly occurred due to changes in herding practices in the post-Soviet era, but direction of these changes differed across regions. For instance, in Ganja-Gazakh, Sheki-Zagatala, and Guba-Khachmaz, grassland area increased, which we suggest was because the post-Soviet wars forced herders to seek alternative summer pastures, intensifying pressure on mountain grasslands afar from war zones (de Leeuw et al., 2019), and sometimes causing forest loss. While the total area covered by grasslands increased, some of the grassland degraded (Lewińska et al., 2020, 2021), possibly due to climate change and overgrazing by displaced populations (de Leeuw et al., 2019). In contrast, in Georgia post-Soviet changes in pasture usage led to grassland loss. Georgian herders who used wintering grounds in Dagestan of Russia during the Soviet era (Raaflaub & Dobry, 2015), lost access after the collapse of the Soviet Union and so Georgia's land was no longer able to support as many sheep (Didebulidze & Plachter, 2002), which reduced grazing pressure in summering grounds (Radvanyi & Muduyev, 2013; Wiesmair et al., 2016), and resulted in the expansion of forests at higher elevations, for example in Shida Kartli and Mtskheta-Mtianeti.

Overall, we found a slight decrease in forest area, but both direction and magnitude of forest changes varied among regions. We found that in Russian Caucasus the forests were stable (Bragina et al., 2015), and only a small forest loss occurred in Georgia throughout the Soviet and post-Soviet eras (Chen et al., 2021; Olofsson et al., 2010; Ozdogan et al., 2016). However, we also found considerable forest loss in Armenia and Azerbaijan during the Soviet era, with the exception of Altiaghaj and Galaalti districits in Azerbaijan, where we observed forest gain, which we suggest occurred because Soviet government encouraged citizens living in mountainous areas to relocate to lowlands or larger cities for easier access to resources (Goff, 2022; Radvanyi, 1987), such as from Guba-Khachmaz to Baku. During the post-Soviet era, we observed forest gain, which is in line with previous research (Buchner et al., 2020). One of the reasons was the Soviet incentives for planting trees yielded results in the post-Soviet era (Zalikhanov, 1978), especially in Imereti (Georgia), Guba-Khachmaz (Azerbaijan). Similarly, forest regrew on Soviet clear-cuts, especially after World War II (Kuemmerle et al., 2011; Turnock, 2002). Forest restoration can take decades, and, in our results, these areas appeared as grassland in 1965 and 1987, but forests in 2015. Forest gain in Georgia and Azerbaijan in the post-Soviet may also be partially due to improved access to energy resources in rural areas, which reduced firewood use, resulting in a rebound effect (Lambin & Meyfroidt, 2011). Furthermore, continuing urbanization and migration to larger cities (Hosner et al., 2018), decreased demand for forest resources due to a remittance effect (Lambin & Meyfroidt, 2011). Some of the forest gains that we observed were due to an increase in orchards, which we mapped as forests (Lesiv et al., 2018), such as in Armavir and Kotayk (Armenia). Additionally, natural factors, such as the major earthquake in the Shirak region of Armenia in 1988 (Rowland, 2007), caused population displacement from rural areas to cities, thus contributing to forest gain there.

Some post-Soviet forest loss occurred around Sochi in Russia likely due to development the Olympic Games infrastructure and recreational mountain ski resorts (Bragina et al., 2015). These varied changes match what occurred during the post-Soviet era across Eastern Europe. Many forests were lost in Eastern European countries within the first decade of the Soviet Union collapse (Potapov et al., 2011), due to political instability and lack of forest protection systems (Catalina Munteanu et al., 2015). However, there were also regions with forest gains (Griffith et al., 2014; Taff et al., 2009). Importantly though, we found that many changes occurred before the Landsat era. Thus, our study highlights the value of long-term Corona imagery for studying land use changes.

Along with our findings, we acknowledge some limitations and challenges. First, we focused on three time points over a 50-year period, which may not reflect the full complexity and variability of land cover change. Similarly, our classification scheme with only nine classes (excluding cloud and cloud shadow) may not have fully captured the diversity and heterogeneity of all land cover types in the Caucasus. Nevertheless, we captured main land cover types in the region. Each of our land cover classifications had some errors affecting our change maps, an inherent problem of post-classification comparisons (Singh, 2010). In our 1965 map, topographic effects, such as the bright illumination on southwesterly slopes and deep shadows on the opposite slopes caused some misclassification between forests as grasslands. While our ortho-georectification was successful, some of the classification errors were due to misalignment between forward- and backward-facing images**.** To generate the 1965 land cover maps, we used a DEM for 2000, and that time difference caused some errors due to new water bodies. Where full stereographic Corona coverage is available, we suggest extracting high-resolution digital surface models from the Corona data itself (Ghuffar et al., 2022), but our imagery did not allow for that. To facilitate

comparison with Landsat data, we resampled the 2.5 m object-based Corona classifications to 30-m resolution, resulting in a loss of details. The use of recent high-resolution satellite data for classifications is an alternative, but we opted against it because there is no such imagery for the end of the Soviet era. Because we analyzed only single-date imagery for the 1960s, we had to exclude areas obscured by snow or clouds. Cloud shadows, haze, and snow in Corona images affected our historical maps especially in Azerbaijan, but also in Abkhazeti in Georgia, and Dagestan in Russia, where some areas with haze were misclassified, as were areas with snow under forest canopies. We also observed the parallax effect, where the placement of clouds changes between the forward- to backward-facing camera photos because the clouds are high above the ground, causing segments located under the clouds to be misclassified. When possible, we recommend analyzing cloudless Corona images. Single-date imagery also resulted in confusion between grasslands and croplands, because these two classes are spectrally similar, especially in fall (Dara et al., 2018; Estel et al., 2015; Teluguntla et al., 2018). We expected higher urbanization rates (Bassullu & Sanchez-Paus Díaz, 2023; Theissen et al., 2019), but did not find that. This may be due to an overestimation of urban areas in Corona-derived maps, caused by the object size set for initial segmentation, as well as overall high heterogeneity in urban areas, which can lead to confusion with grassland and cropland. However, overall accuracies of our classifications and change maps were high enough to capture all of the major land cover changes well.

The Corona satellite data can offer valuable information for scientific, management and conservation application. In the absence of long-term satellite data many land cover and succession studies employ space-for-time substitution (Pickett, 1989), but that does not capture vegetation succession directly. That is a problem when different disturbance regimes lead to

distinct successional trajectories (Franklin et al., 2007), and when information on pre-succession conditions is necessary. By providing access to mid-20th century land cover with high spatial resolution, Corona data allows to detect the areas that were not forested in the 1960s, and identify causes of disturbance, such as clear-cuts from pre-Corona era or agricultural usage, in turn allowing to evaluate long-term successional dynamics relative to initial disturbance. In addition, it is possible to assess the long-term forest structure changes after selective cutting, which is challenging (Mikeladze et al., 2020). Although not the primary focus of our research, high-resolution Corona data can assess the extent of selective logging, by looking into the infrastructure development that indicates forest usage, which is not feasible medium-resolution satellite data, such as Landsat. The highly dynamic changes that we observed between grasslands and forests are typical for mountain ecosystems especially in transitional zones such as subalpine areas and could be driven by either natural or anthropogenic causes (Rogova & Skvortsov, 2020). Extending the baseline for the monitoring of change up to the beginning of the most rapid global changes is necessary for better evaluation of the consequences of climate change (Aulló-Maestro et al., 2023).

Most studies of agricultural abandonment focus on post-Soviet changes, but cropland abandonment was also widespread during soviet time (Lyuri et al., 2010). Corona data allowed us to identify the fields that were abandoned in the Soviet era and remained fallow. Such areas could be potentially valuable for either agricultural re-development (Crawford et al., 2022) or biodiversity restoration (Daskalova & Kamp, 2023), and can have high value for grassland restoration if vegetation succession occurred already for several decades (Pereira & Navarro, 2015). In summary, the Corona data can provide a wealth of information about the past land cover practices offering insights in forest succession and structure, and opportunities for

grassland restoration, and can provide basis for informed decision making and sustainable conservation.

Conclusions

In conclusion, we observed major changes in land cover, specifically in forest, cropland, and grassland throughout the Caucasus since the 1960s, and many of these changes occurred during the Soviet era and hence prior to the first Landsat images. Our findings emphasize the impact of political and economic policies on the environment, highlighting the importance of sustainable development strategies that balance economic growth with environmental conservation. Our study also highlights the feasibility and the value of combining historical spy satellite imagery with Landsat archives for mapping land cover change in large and diverse regions. By pushing the baseline for land cover assessments back to the 1960s, legacies of past land cover on current patterns reveal themselves, land cover change predictions can be more reliable, and land management and conservation actions are better informed.

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Tables and Figures

Table 2.1: Acquisition dates of the Corona images to be used for classification of historical land cover maps of the Caucasus region based on patch numbers in Figure 2.1 and the root mean square errors (RMSE) of orthorectification procedure per mission

	Mission	Revolution	Date	RMSE, m
1	1011-1	040D	October 08, 1964	16.3 ± 10.4
2	1023-2	087D	August 23, 1965	15.0 ± 11.1
3	1024-2	104D	September 29, 1965	8.1 ± 5.7
4	1025-1	072D	October 10, 1965	11.9 ± 8.0

Table 2.2: Corona images and the average number of training and validation points for each corresponding class, used for the 10-fold Monte-Carlo classification to produce the historical land cover maps

			Corona images							
			1011-1040D		1023-2087D		1024-2104D		1025-1072D	
			Training	Validation	Training	Validation	Training	Validation	Training	Validation
LC classes	Forest		686	264	204	101	333	198	294	131
	Barren		41	4	41	17	47	7	47	5
	Grassland		599	280	738	308	44	37	397	201
	Cropland		711	257	410	161	386	144	231	103
	Urban		62	13	47	7	45	9	47	8
	Wetland		10	1	46	6	24	1	7	1
	Water	River	51	2	47	8	49	3	48	4
		Lake	146	12	47	4	49	1	42	11
	Snow-and-ice		412	NA	50	NA	19	NA	41	NA
	Clouds		0	NA	171	NA	42	NA	136	NA
	Cloud shadows		0	NA	47	NA	30	NA	49	NA
	Total		2,718	833	1,848	612	1,068	400	1,339	468

Table 2.3: Matching broad land cover classes for the Landsat and Corona-derived land cover maps

LC classes in Corona-derived maps	LC classes in Landsat-derived maps (Buchner et al., 2020)	Broad-scale LC classes in change maps
Forest	Deciduous forest Coniferous forest Mixed forest	Forest
Barren	Barren	Barren
Grassland	Rangeland	Grassland
Cropland	Cropland	Cropland
Urban	Built up	Urban
Wetland	Wetland	Wetland
River Lake	Water	Water
Snow-and-ice	Snow-and-ice	NA
Cloud	NA	NA
Cloud shadow	NA	NA

Table 2.4: Land cover change processes with colors corresponding to those in our change maps

		Later year						
		Forest	Barren	Grassland	Cropland	Urban	Wetland	Water
Earlier year	Forest	stable	barren gain / forest loss	grassland gain / forest loss	cropland gain / forest loss	urban gain / forest loss	wetland gain / forest loss	water gain / forest loss
	Barren	forest gain / barren loss	stable	grassland gain / barren loss	cropland gain / barren loss	urban gain / barren loss	wetland gain / barren loss	water gain / barren loss
	Grassland	forest gain / grassland loss	barren gain / grassland loss	stable	cropland gain / grassland loss	urban gain / grassland loss	wetland gain / grassland loss	water gain / grassland loss
	Cropland	forest gain / cropland loss	barren gain / cropland loss	grassland gain / cropland loss	stable	urban gain / cropland loss	wetland gain / cropland loss	water gain / cropland loss
	Urban	forest gain / urban loss	barren gain / urban loss	grassland gain / urban loss	cropland gain / urban loss	stable	wetland gain / urban loss	water gain / urban loss
	Wetland	forest gain / wetland loss	barren gain / wetland loss	grassland gain / wetland loss	cropland gain / wetland loss	urban gain / wetland loss	stable	water gain / wetland loss
	Water	forest gain / water loss	barren gain / water loss	grassland gain / water loss	cropland gain / water loss	urban gain / water loss	wetland gain / water loss	stable

Table 2.5: Numbers of validation points for each change class for our 1965-‘87 and 1965-2015 change maps

		Periods	
		1965-‘87	1965-2015
Change classes	Stable forest	47	235
	Forest loss	89	64
	Forest gain	54	64
	Stable barren	15	116
	Stable grassland	73	193
	Grassland loss	29	49
	Stable cropland	57	232
	Cropland loss	87	114
	Cropland gain	97	70
	Stable urban	35	154
	Stable wetland	55	35
	Stable water	56	85
	Stable others	455	88
	Total	1,149	1,307

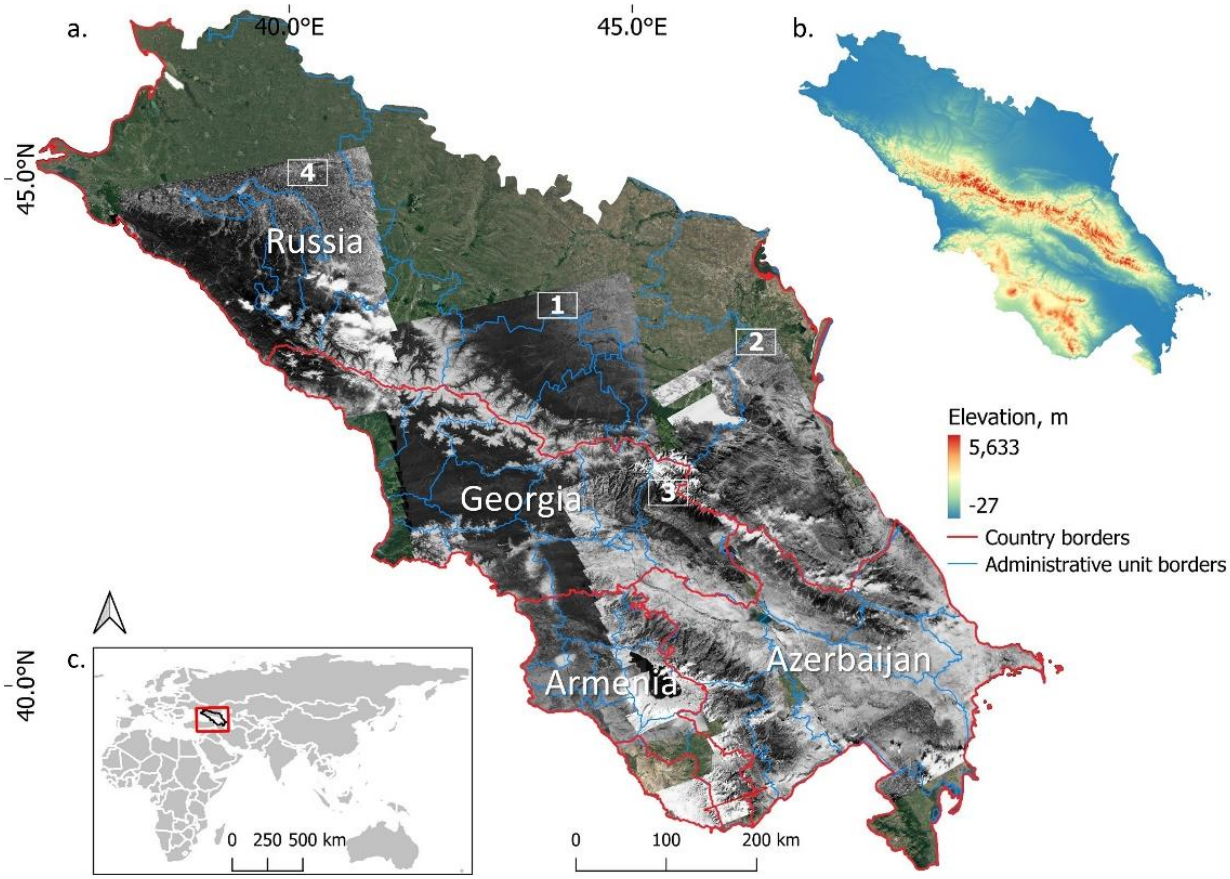


Figure 2.1: a. Study area in the Caucasus ecoregion, which includes parts of Russian Caucasus, Armenia, Azerbaijan and Georgia, with Corona images overlaid. Numbers of Corona images indicated with patch numbers (1, 2, 3, 4) correspond to those in Table 2.4; b. Elevation map in the study area; c. Location of the study area on a world map

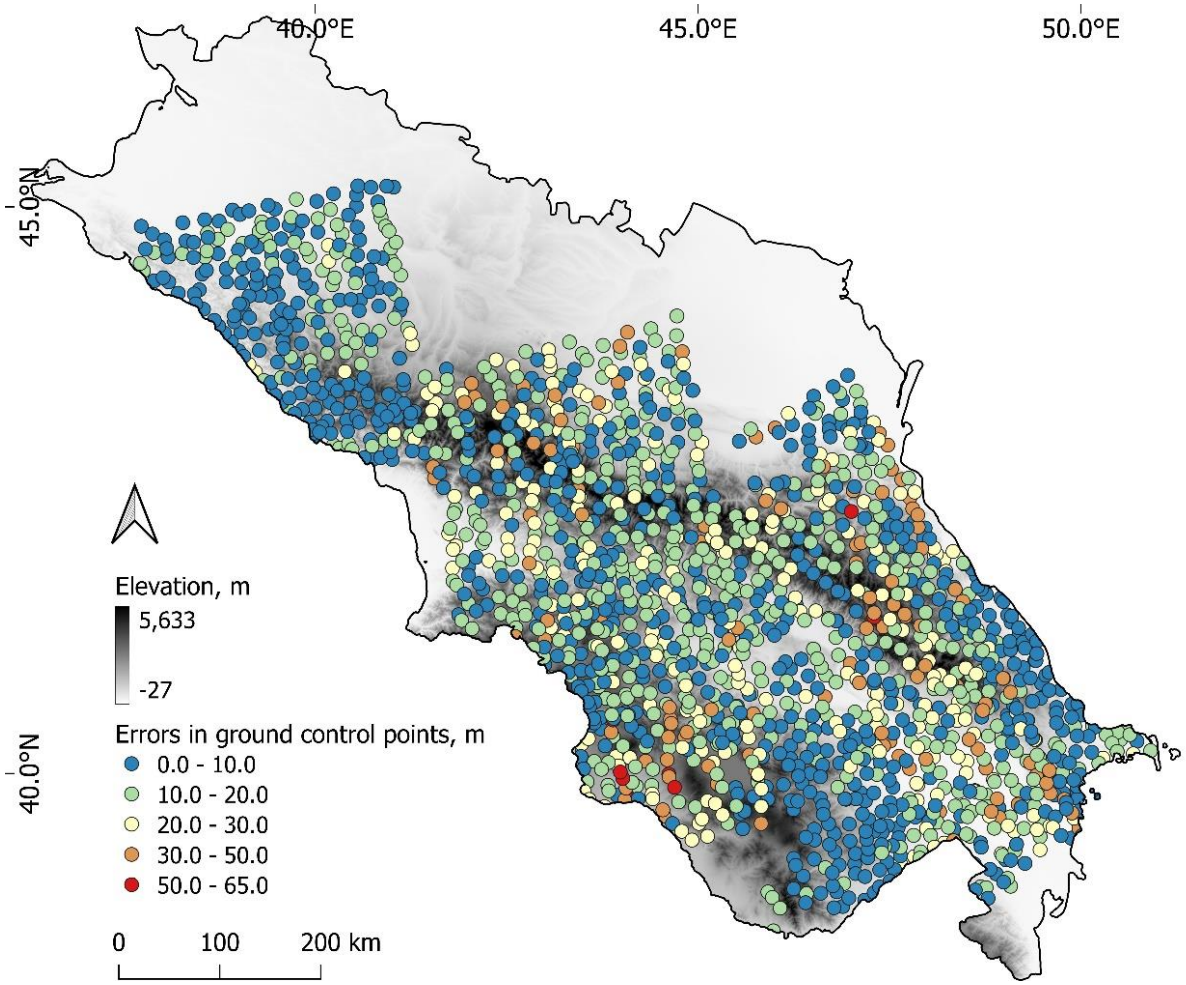


Figure 2.2: Distribution of the ground control points for the ortho-rectification process and their locational error after the rectification

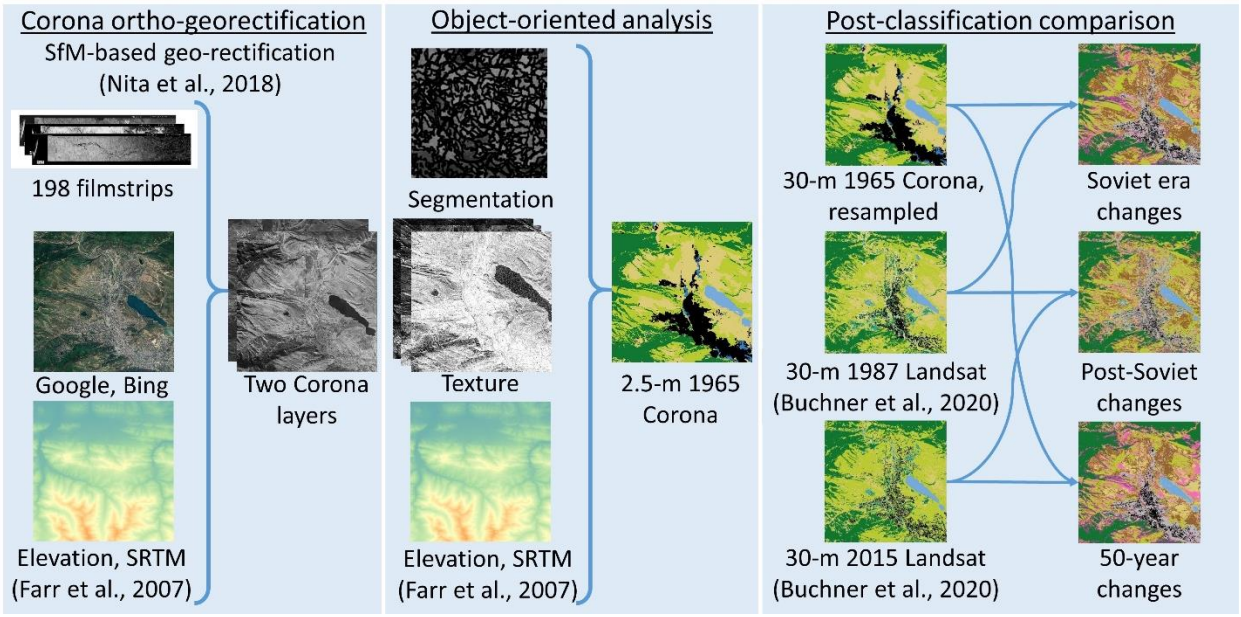


Figure 2.3: Flowchart depicting our full processing from raw Corona images to final change mapping. The maps are for visualization purposes only, the colors match the legends in Figures 2.6 and 2.8

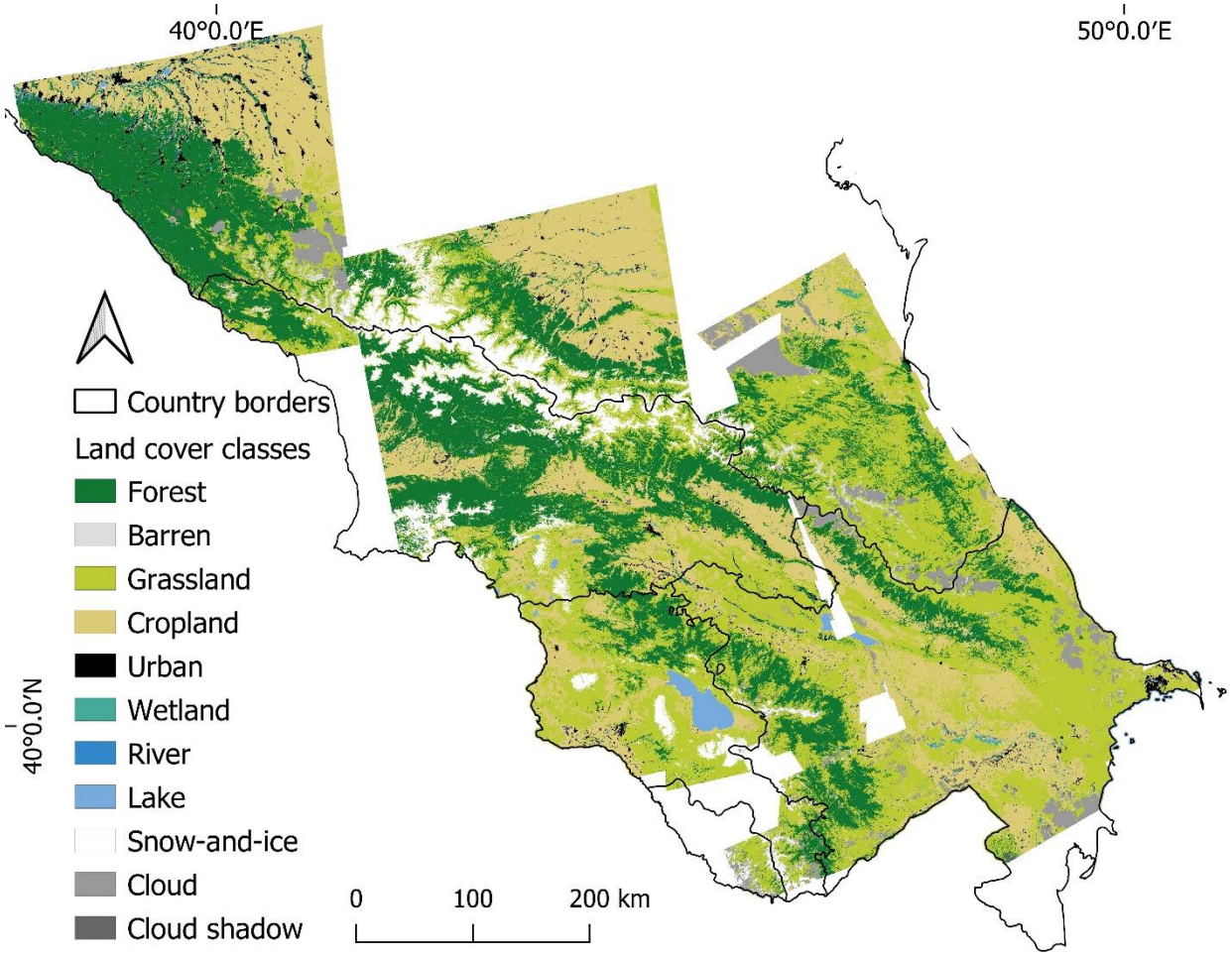


Figure 2.4: Our 1965 land cover map obtained using object-oriented image analyses (methods from Rizayeva et al., 2023)

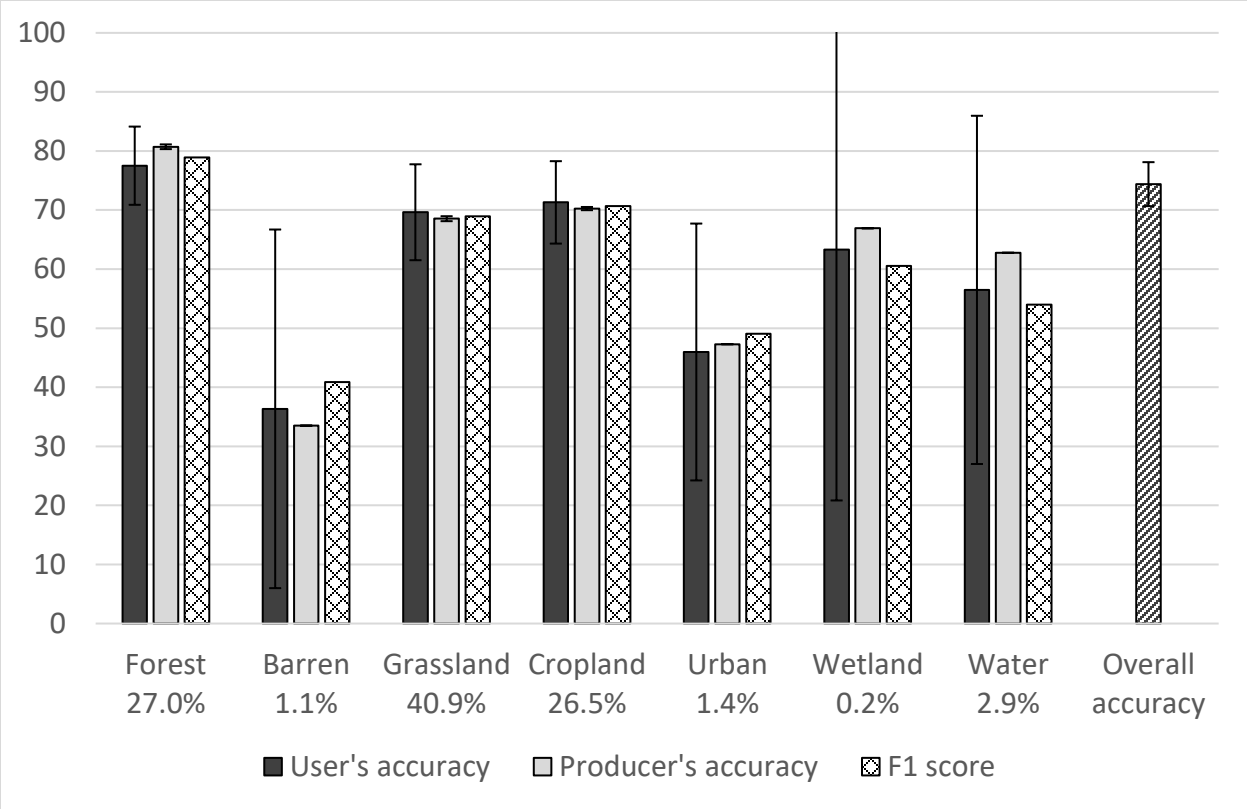


Figure 2.5: The user's and producer's accuracy and F1 score of each land cover class and the overall accuracy for our Corona-derived 1965 land cover classification map. The 'error' bars represent the confidence intervals at a level of 95%. The percent numbers next to the class labels represent the percentage of the total area analyzed that each class covers in 1965 map

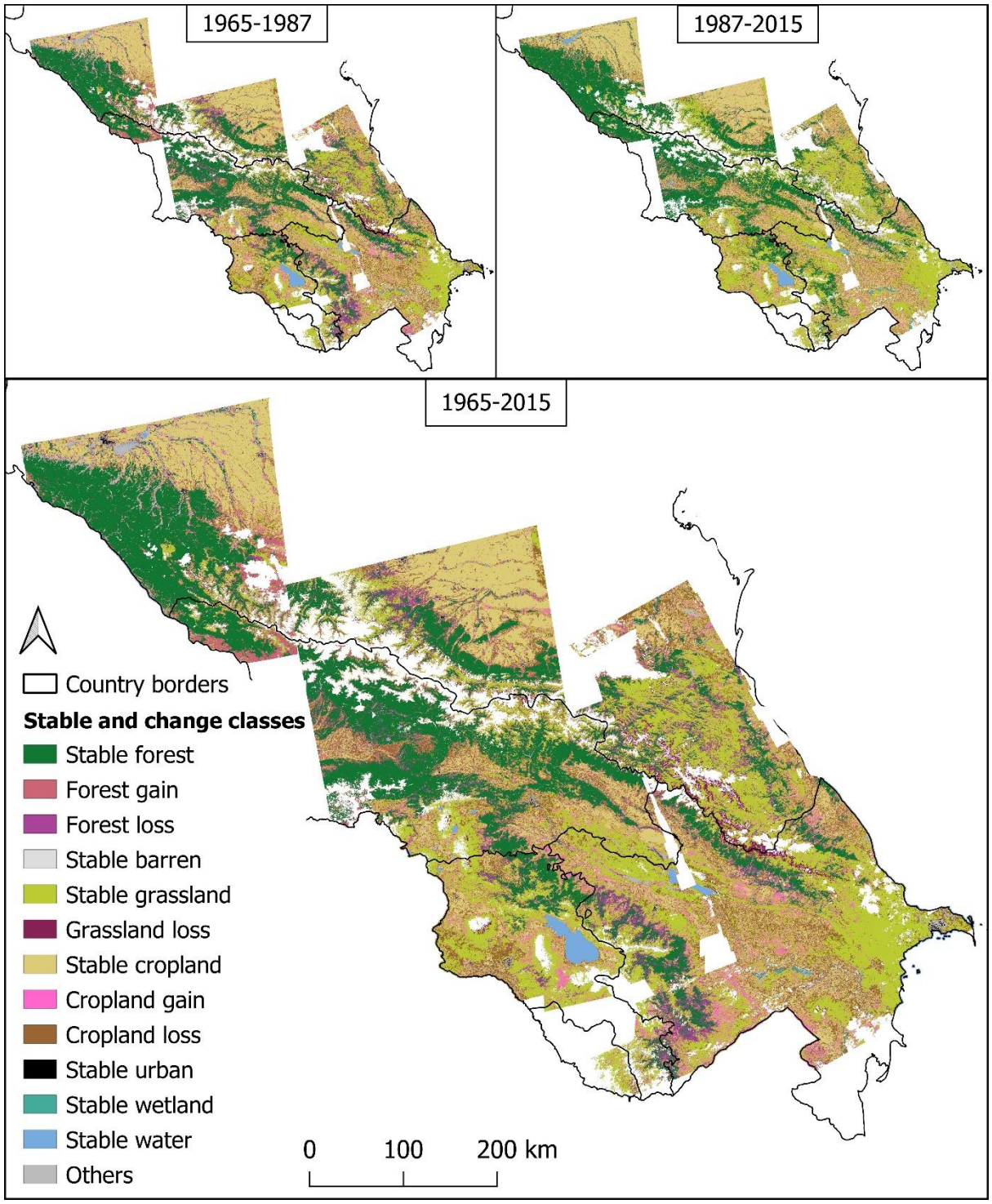
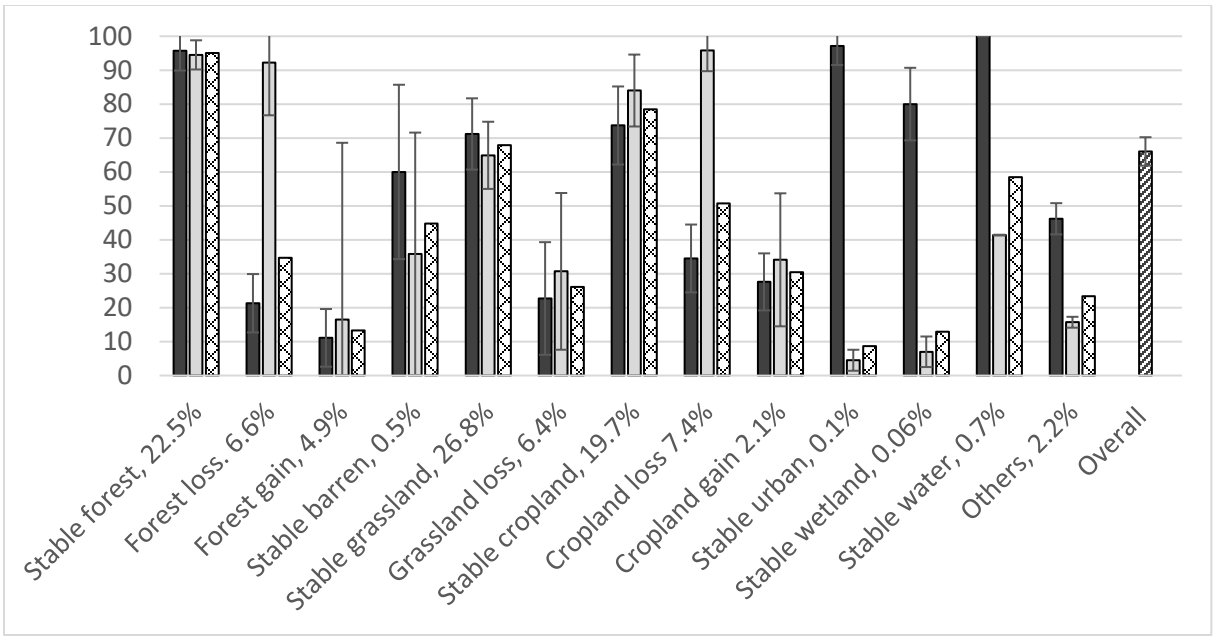


Figure 2.6: Our final maps for Soviet-era changes (1965-‘87), post-Soviet-era changes (1987-2015), and net changes (1965-2015)

a.



b.

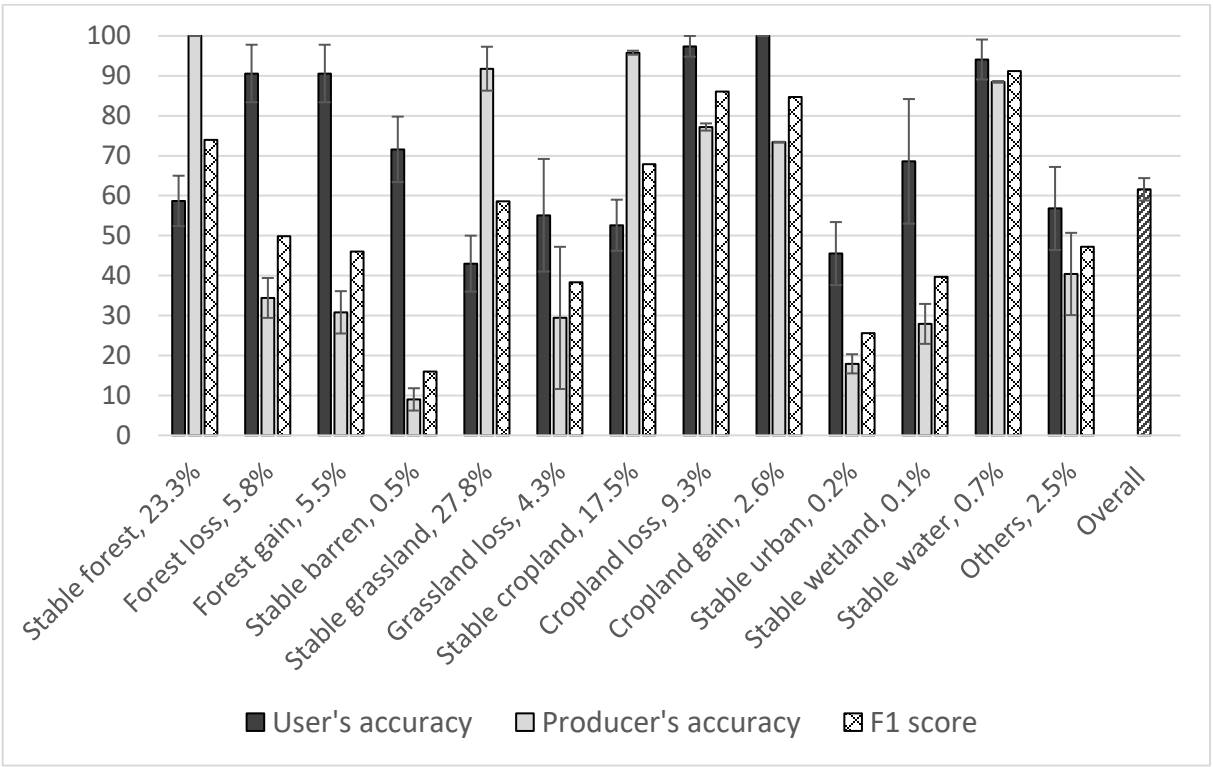


Figure 2.7: The user's and producer's accuracy and F1 score of each class and the overall accuracy for a. 1965-'87 and b. 1965-2015 change maps. The 'error' bars represent the confidence intervals at a level of 95%. The percent numbers next to the class labels represent the percentage of the total area analyzed that each change class covers in the corresponding period

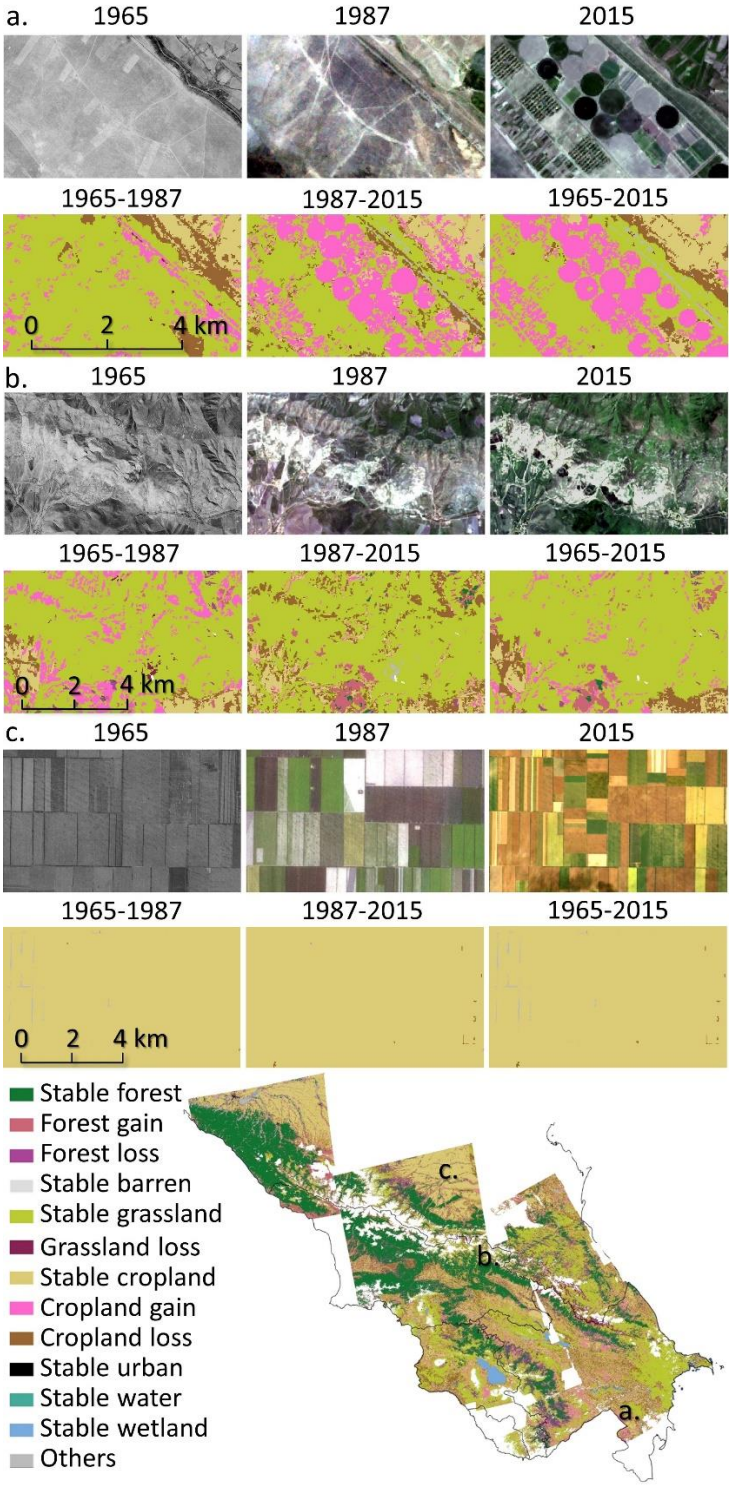


Figure 2.8: Zoomed in examples of change areas for 1965-‘87, 1987-2015, and 1965-2015, and corresponding Corona- and Landsat-derived land cover maps

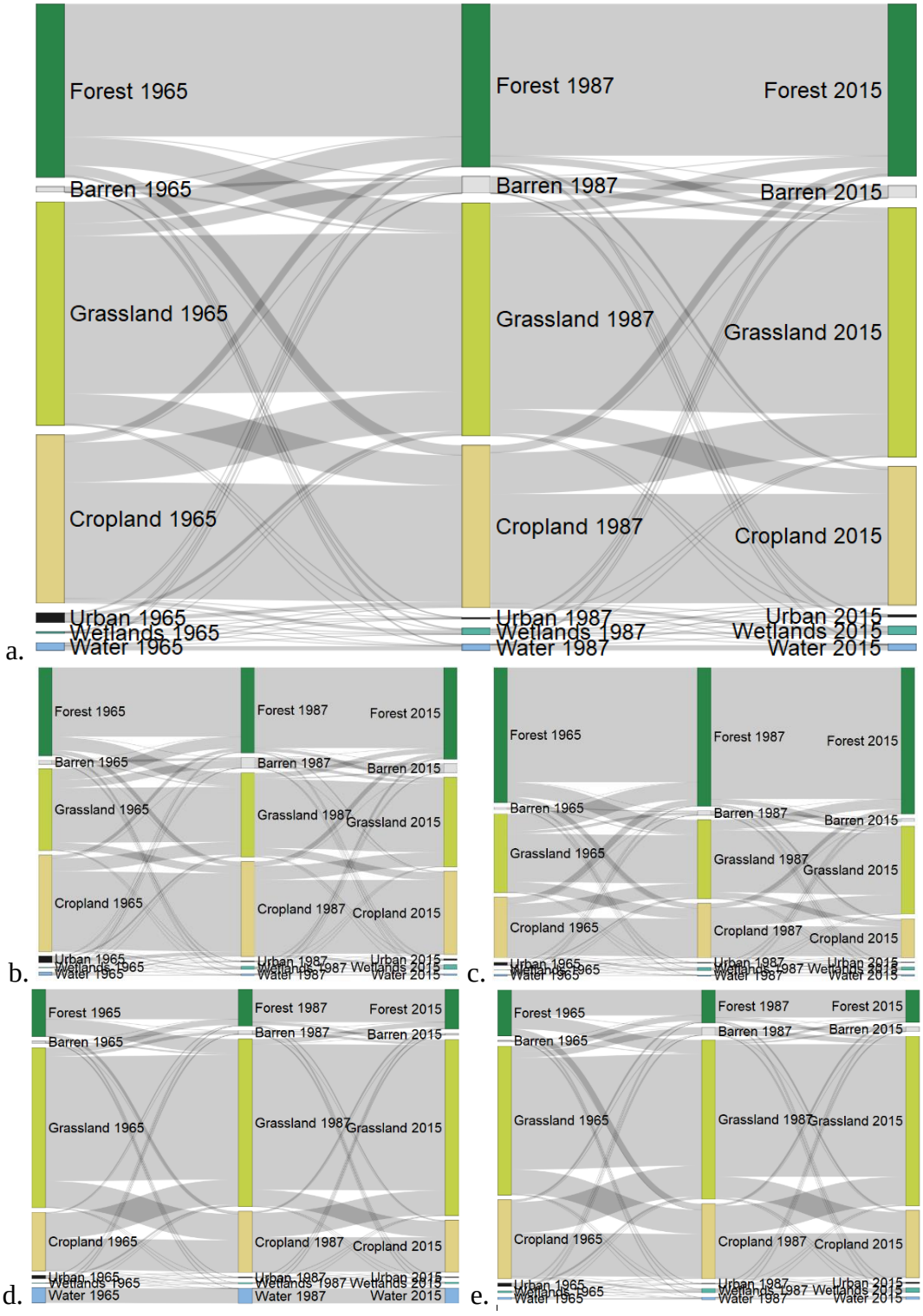


Figure 2.9: Land cover flow (sankey) diagrams for all land cover classes across: a. our entire study area, b. Russian Caucasus, c. Georgia, d. Armenia, and e. Azerbaijan

Appendix

Appendix 2.1.1: Average errors based on per-image errors assessed with ground control points. The patch numbers correspond to those in Figure 2.1

		Average error	Standard deviation
1	DS1011-1040	16.3	
2	DS1023-2087	15.0	
3	DS1025-1072	11.9	
4	DS1024-2104	8.1	
	Overall	12.8	3.2

Appendix 2.1.2: Definitions of land cover classes in the historical Corona imagery

Land cover type	Definition
Forest	All woody vegetation, including orchards and gardens
Barren	Land not covered with vegetation, water or human-made buildings
Grassland	Herbaceous vegetation used or not used for grazing
Cropland	Agricultural fields used for growing crops
Urban	Cities, villages and other human settlements
Wetland	Water covered with vegetation
River	Curvilinear areas including river and river bank
Lake	Lakes, water reservoirs
Snow-and-ice	Tops of the mountains and foothills covered in snow and ice
Cloud	Thick or hazy cloud cover that obscures the underlying land features
Cloud shadow	Areas of reduced light or shading on the land caused by cloud cover

Appendix 2.1.3: Number of points in our training and validation datasets. For each of our 10 Random Forest classifications, training and testing points were randomly selected from the four different pools of grid points

	DS1011-1040			DS1023-2087			DS1024-2104			DS1025-1072		
	Total	Training	Testing	Total	Training	Testing	Total	Training	Testing	Total	Training	Testing
Grid points in homogeneous segments	3,026	2421 (80%)	605 (20%)	2,026	1,620 (80%)	406 (20%)	1,021	816 (80%)	205 (20%)	1,419	1,135 (80%)	284 (20%)
Additional points	470	470 (100%)	0 (0%)	414	414 (100%)	0 (0%)	275	275 (100%)	0 (0%)	335	335 (100%)	0 (0%)
Grid points in shifted segments	915	0 (0%)	183 (20%)	254	0 (0%)	51 (20%)	431	0 (0%)	86 (20%)	NA*	0 (0%)	0 (0%)
Grid points in missegmented objects	887	0 (0%)	177 (20%)	1,058	0 (0%)	212 (20%)	612	0 (0%)	122 (20%)	1,166	0 (0%)	233 (20%)
Total	5,298	2891	965	3,752	2,035	668	2,339	1,092	413	2,920	1,470	517

*NA – Not available due to only one backward-facing Corona image

Appendix 2.1.4: Accuracy assessment results for our final 1965 land cover map with user's accuracies, producer's accuracies for each land cover class and the overall accuracy along with their confidence intervals

	User's accuracy	UA error	Producer's accuracy	PA error	Overall	Overall CI	Area, km^2	% from total
Forest	77.5	6.6	80.7	0.40			75,300	27.0
Barren	36.4	30.4	33.5	0.06			2,940	1.1
Grassland	69.6	8.1	68.5	0.42			114,000	40.9
Cropland	71.3	7.8	70.3	0.27			73,700	26.5
Urban	46.0	21.7	47.3	0.01			3,970	1.4
Wetland	63.3	42.5	66.9	0.00			624	0.2
Water	56.5	29.5	62.8	0.00			8,070	2.9
Overall					74.4	3.7		

Appendix 2.1.5: Accuracy assessment results for our 1965-‘87 change map with user’s and producer’s accuracies for each change class, and the overall accuracy along with their confidence intervals

	User's accuracy	Producer's accuracy	UA error	PA error	F1 score	Area, km^2	Adjusted area, km^2
Stable forest	95.7	94.5	5.8	4.3	95.1	56,600	57,372
Forest loss	21.3	92.2	8.6	15.5	34.7	16,641	3,851
Forest gain	11.1	16.5	8.5	52.1	13.3	1,250	842
Stable barren	60.0	35.8	25.7	35.8	44.8	12,377	20,747
Stable grassland	71.2	64.9	10.5	9.9	67.9	67,400	74,013
Grassland loss	22.7	30.7	16.6	23.1	26.1	16,030	4,249
Stable cropland	73.7	84.0	11.5	10.6	78.5	49,600	43,516
Cropland loss	34.5	95.8	10.0	6.1	50.7	18,730	6,741
Cropland gain	27.6	34.1	16.6	23.1	30.5	5,250	11,836
Stable urban	97.1	4.5	5.6	3.1	8.7	297	6,344
Stable wetland	80.0	7.0	10.7	4.5	12.9	148	1,681
Stable water	100.0	41.4	0.0	0.1	58.5	1,830	4,425
Others	46.2	15.7	4.6	1.6	23.4	5,440	15,978
Overall	66.0		4.2				
Stable classes average	78.0	43.5			48.7	24,211	14,363
Change classes average	23.4	53.9			31.1	11,580	27,804

Appendix 2.1.6: Accuracy assessment results for our 1965-2015 change map with user's and producer's accuracies for each change class, and the overall accuracy along with their confidence intervals

	User's accuracy	Producer's accuracy	UA error	PA error	F1 score	Area, km^2	Adjusted area, km^2
Stable forest	58.7	100.0	6.3	0.0	74.0	59,106	34,709
Forest loss	90.6	34.4	7.2	5.0	49.9	14,713	38,773
Forest gain	90.6	30.8	7.2	5.3	46.0	13,952	10,050
Stable barren	71.6	9.0	8.2	2.8	16.0	1,268	41,039
Stable grassland	43.0	91.8	7.0	5.5	58.6	70,521	33,041
Grassland loss	55.1	29.4	14.1	17.8	38.3	10,908	8,987
Stable cropland	52.6	95.8	6.4	0.5	67.9	44,393	24,373
Cropland loss	97.4	77.2	3.0	0.9	86.1	23,592	29,765
Cropland gain	100.0	73.4	0.0	0.1	84.7	6,595	20,458
Stable urban	45.5	17.9	7.9	2.4	25.6	507	1,292
Stable wetland	68.6	27.9	15.6	5.0	39.7	254	623
Stable water	94.1	88.5	5.0	0.2	91.2	1,776	1,887
Others	56.8	40.4	10.4	10.3	47.2	6,342	8,930
Overall	61.6		2.8				
Stable classes average	61.4	58.9			52.5	23,021	25,521
Change classes average	86.7	49.0			61.0	13,952	9,485

Appendix 2.1.7: Areas of land cover changes in km^2 for 1965-‘87 and 1987-2015 for a. entire study area; b. Russia; c. Georgia; d. Armenia; e. Azerbaijan. The colors are corresponding to those in the change maps

a.

1965 \ 1987	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	55,768.1	414.6	11,718.3	4,031.5	30.2	494.1	144.8	72,601.6
Barren	121.7	1,193.8	863.5	101.7	2.4	13.8	39.1	2,336.0
Grassland	8,896.4	5,231.7	66,158.5	12,495.1	105.9	336.9	138.9	93,363.3
Cropland	2,812.9	272.8	16,022.3	43,054.5	178.3	1,380.1	393.5	64,114.3
Urban	271.9	63.7	1,409.4	1,717.8	295.4	128.5	29.6	3,916.3
Wetland	8.5	3.2	155.8	249.7	1.0	144.9	60.6	623.8
Water	272.6	40.7	367.0	571.6	9.8	193.4	1,832.5	3,287.5
total	68,152.1	7,220.5	96,694.8	62,221.9	622.9	2,691.7	2,638.9	

1987 \ 2015	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	63,433.5	158.2	3,022.9	1,192.9	9.8	306.1	23.5	68,147.0
Barren	168.7	3,910.3	2,884.7	124.0	36.4	24.1	56.9	7,205.0
Grassland	4,548.5	1,027.7	80,034.1	9,933.5	432.9	449.0	130.0	96,555.7
Cropland	2,915.7	92.1	17,052.5	40,269.6	181.6	1,540.3	103.7	62,155.6
Urban	9.7	7.5	297.7	80.1	206.6	16.9	0.8	619.2
Wetland	651.3	8.9	297.9	670.0	11.1	913.5	120.8	2,673.5
Water	32.3	34.0	73.2	71.2	0.6	183.8	2,195.5	2,590.6
total	71,759.8	5,238.6	10,3663.0	52,341.3	879.0	3,433.6	2,631.3	

b.

1965 \ 1987

	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	25,027.7	180.5	4519.7	1,394.4	9.2	312.9	96.2	31,540.6
Barren	66.7	863.4	351.7	69.9	1.1	11.9	31.4	1,396.1
Grassland	3,870.6	2,855.6	19,189.5	2,472.3	22.6	59.0	35.2	28,504.8
Cropland	1,065.3	65.0	3,812.4	22,696.2	57.7	423.4	214.5	28,334.5
Urban	192.9	12.8	581.5	1,275.2	160.9	87.2	22.3	2,332.7
Wetland	5.6	0.2	50.6	115.2	0.5	17.6	44.3	234.0
Water	254.4	22.0	190.0	411.7	5.2	119.2	150.6	1,153.3
total	30,483.3	3,999.4	28,695.4	28,434.8	257.2	1,031.3	594.6	

2015

1987

	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	28,751.4	94.2	1,130.1	334.6	3.5	149.2	15.0	30,477.9
Barren	110.3	2,686.8	1,110.3	44.9	12.5	11.6	20.5	3,996.9
Grassland	1,659.3	493.2	23,645.0	2,469.7	182.7	178.8	39.4	28,668.1
Cropland	1,472.9	45.2	4,638.4	21,199.3	122.2	883.3	38.1	28,399.4
Urban	3.0	2.0	100.4	38.8	105.8	6.2	0.3	256.6
Wetland	421.8	3.5	73.3	184.6	5.5	293.5	46.9	1,029.0
Water	20.2	23.1	14.0	24.0	0.1	112.8	361.7	556.0
total	32,438.8	3,348.1	30,711.5	24,295.9	432.3	1,635.4	521.9	

c.

1965 \ 1987

	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	22,052.4	78.2	2,782.8	930.9	10.9	76.9	12.1	25,944.2
Barren	50.4	186.7	201.9	18.3	1.1	1.7	7.1	467.1
Grassland	3,241.0	545.7	9,213.7	1,986.2	14.4	42.4	12.3	15,055.8
Cropland	1,207.8	52.6	2,638.4	7,256.1	56.4	396.5	40.6	11,648.4
Urban	46.9	13.2	227.9	179.9	38.7	20.7	1.2	528.4
Wetland	0.2	0.0	1.9	2.0	0.1	0.6	0.1	4.8
Water	9.4	7.8	70.1	67.6	2.7	27.5	125.9	311.1
total	26,608.1	884.3	15,136.6	10,441.1	124.2	566.2	199.2	

1987 \ 2015

	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	25,225.4	45.6	898.7	364.3	2.7	69.8	5.4	26,611.9
Barren	40.5	409.4	392.5	12.5	6.0	6.9	13.5	881.3
Grassland	1,871.3	112.8	11,907.1	1,097.2	45.8	67.2	27.0	15,128.5
Cropland	824.7	20.8	3,559.1	5712.4	17.3	282.4	22.7	10,439.4
Urban	5.1	2.3	56.2	25.4	28.7	6.4	0.1	124.2
Wetland	134.4	1.7	63.0	215.4	2.0	129.3	20.0	565.8
Water	9.6	9.3	7.0	7.7	0.2	16.0	146.5	196.2
total	28,111.1	601.9	16,883.5	7,434.8	102.7	578.0	235.2	

d.

1965 \ 1987

	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	2,541.4	10.3	1,223.0	235.9	2.1	5.3	0.2	4,018.2
Barren	0.6	36.8	135.4	6.5	0.0	0.0	0.2	179.6
Grassland	490.4	266.7	10,621.3	2,226.6	15.6	17.2	5.0	13,642.7
Cropland	84.1	10.1	2,134.6	2,675.5	23.9	64.7	14.5	5,007.4
Urban	10.2	3.2	142.8	49.6	39.1	2.8	0.7	248.4
Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water	1.0	0.5	14.2	16.2	0.5	13.1	1,251.0	1,296.6
total	3,127.7	327.6	14,271.4	5,210.5	81.2	103.2	1,271.5	

1987 \ 2015

	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	2,804.8	1.0	223.0	89.6	0.3	7.3	0.2	3,126.3
Barren	1.5	113.8	203.6	4.9	1.6	1.0	0.4	326.7
Grassland	411.9	25.8	12,377.6	1,367.3	33.6	28.4	3.6	14,248.2
Cropland	137.0	3.9	2,072.6	2,928.3	3.4	51.7	6.0	5,202.9
Urban	0.4	0.7	52.9	4.3	21.7	1.1	0.0	81.2
Wetland	12.2	0.1	13.3	22.1	0.1	43.8	11.1	102.6
Water	0.5	0.2	2.4	2.6	0.0	5.6	1,260.0	1,271.2
total	3,368.3	145.5	14,945.4	4,419.1	60.6	138.8	1,281.3	

e.

1965 \ 1987

	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	6,146.7	145.7	3,192.9	1,470.2	8.0	98.9	36.2	11,098.6
Barren	3.9	106.9	174.5	7.0	0.1	0.2	0.5	293.2
Grassland	1,294.4	1,563.7	27,134.0	5,810.0	53.2	218.3	86.4	36,159.9
Cropland	455.6	145.0	7,437.0	10,426.6	40.3	495.6	123.9	19,124.0
Urban	21.9	34.6	457.2	213.1	56.8	17.8	5.4	806.8
Wetland	2.8	3.0	103.3	132.5	0.5	126.7	16.2	385.1
Water	7.7	10.3	92.7	76.0	1.4	33.5	305.0	526.5
total	7,933.0	2,009.3	38,591.5	18,135.6	160.3	991.0	573.5	

1987 \ 2015

	Forest	Barren	Grassland	Cropland	Urban	Wetland	Water	total
Forest	6,651.9	17.5	771.1	404.4	3.3	79.8	2.8	7,930.9
Barren	16.5	700.3	1,178.3	61.7	16.2	4.6	22.6	2,000.1
Grassland	606.0	395.8	32,104.5	4,999.2	170.8	174.5	60.1	38,510.9
Cropland	481.1	22.2	6,782.4	10,429.6	38.7	323.0	36.8	18,113.9
Urban	1.1	2.4	88.1	11.6	50.4	3.1	0.4	157.2
Wetland	82.9	3.6	148.3	248.0	3.5	446.9	42.8	976.1
Water	2.0	1.3	49.8	36.9	0.4	49.4	427.2	567.2
total	7,841.6	1,143.2	41,122.6	16,191.4	283.4	1,081.4	592.8	

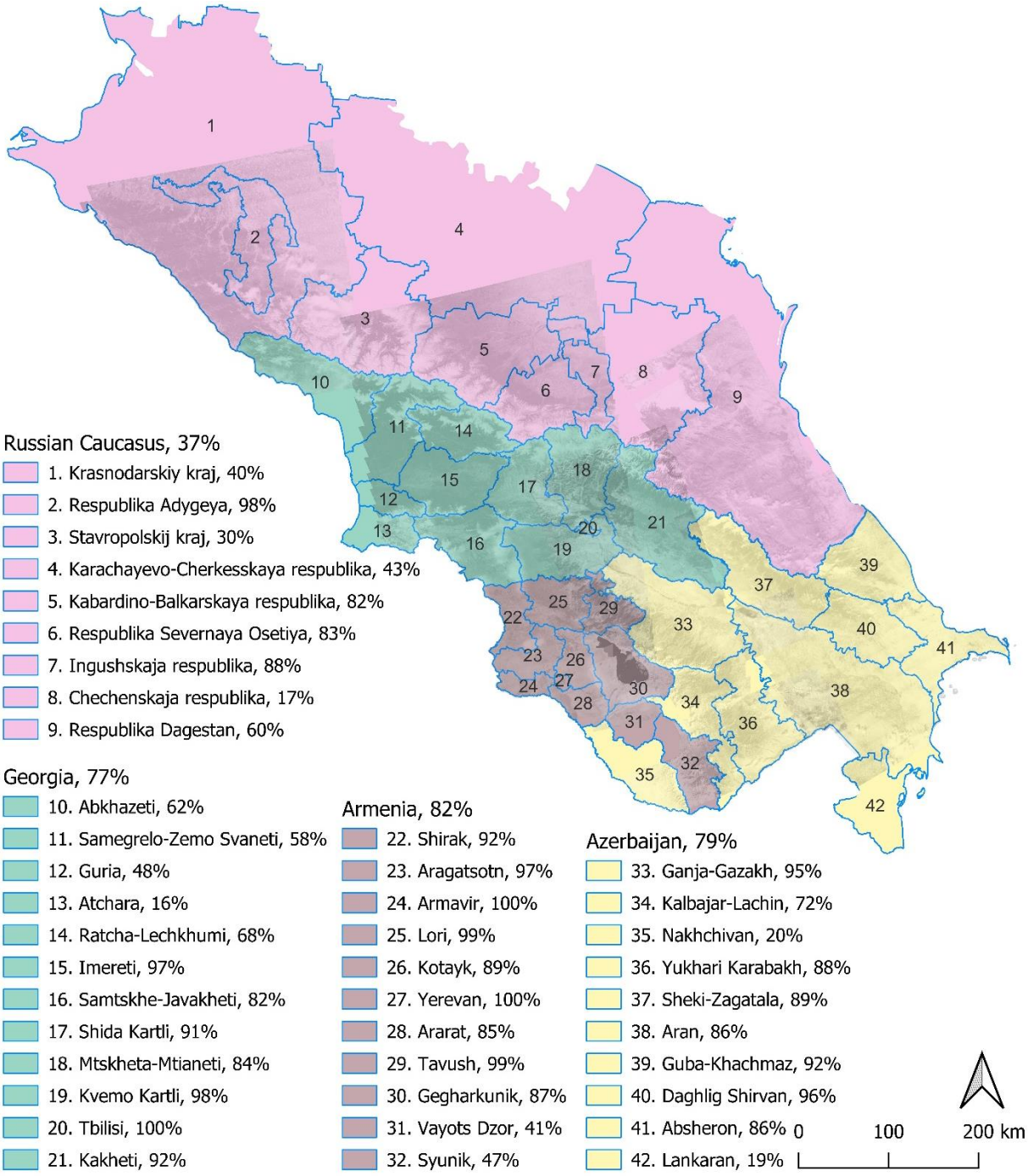
Appendix 2.1.8: Historical and present-day images from Sheki-Zagatala region, Azerbaijan: a) Sarybash Village and fragments of forests; b) Bozdagh ridges (foreground) and the Main Caucasus ridge (background); c) Alpine grasslands on the South-Eastern slopes of Gamzegor ridge, elevation 1,800 m above sea level. *Photo credits: National Archive Department of Azerbaijan (historical photographs) and Azerchin Muradov (present-day photographs)*

a. 

b. 

c. 

Appendix 2.1.9: Administrative units in the Russian Caucasus, Georgia, Armenia and Azerbaijan, overlaid with 20% opacity raw Corona images. The administrative unit names and borders correspond to those in year 2015, and the percentage near their names represent the coverage of our change maps within each unit



Appendix 2.2: Soviet era, post-Soviet era and 50-year area change tables for the entire study area, per country and per region.

Appendix 2.2.1.1. Soviet era changes (1965-'87) in land cover and change percentages within our entire study area.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	5.58E+10	55,768.1	72,601.6	76.8	16,833.5		12,383.9		68,152.1	-4,449.5	-6.1
2	forest	barren	forest loss	barren gain	4.15E+08	414.6		0.6	23.2	2.5	17.1	6.9			
3	forest	grass	forest loss	grassland gain	1.17E+10	11,718.3		16.1		69.6		38.4			
4	forest	crop	forest loss	cropland gain	4.03E+09	4,031.5		5.6		23.9		21.0			
5	forest	urban	forest loss	urban gain	3.02E+07	30.2		0.0		0.2		9.2			
6	forest	wetland	forest loss	wetland gain	4.94E+08	494.1		0.7		2.9		19.4			
7	forest	water	forest loss	water gain	1.45E+08	144.8		0.2		0.9		18.0			
8	barren	forest	barren loss	forest gain	1.22E+08	121.7	2,336.0	5.2	1,142.2	10.7	6,026.7	1.0	7,220.5	4,884.5	209.1
9	barren	barren	stable barren	stable barren	1.19E+09	1,193.8		51.1	48.9		258.0				
10	barren	grass	barren loss	grassland gain	8.63E+08	863.5		37.0		75.6		2.8			
11	barren	crop	barren loss	cropland gain	1.02E+08	101.7		4.4		8.9		0.5			
12	barren	urban	barren loss	urban gain	2.36E+06	2.4		0.1		0.2		0.7			
13	barren	wetland	barren loss	wetland gain	1.38E+07	13.8		0.6		1.2		0.5			
14	barren	water	barren loss	water gain	3.91E+07	39.1		1.7		3.4		4.8			
15	grass	forest	grassland loss	forest gain	8.90E+09	8,896.4	93,363.3	9.5	27,204.8	32.7	30,536.4	71.8	96,694.8	3,331.6	3.6
16	grass	barren	grassland loss	barren gain	5.23E+09	5,231.7		5.6	29.1	19.2	32.7	86.8			
17	grass	grass	stable grassland	stable grass	6.62E+10	66,158.5		70.9							
18	grass	crop	grassland loss	cropland gain	1.25E+10	12,495.1		13.4		45.9		65.2			
19	grass	urban	grassland loss	urban gain	1.06E+08	105.9		0.1		0.4		32.3			
20	grass	wetland	grassland loss	wetland gain	3.37E+08	336.9		0.4		1.2		13.2			
21	grass	water	grassland loss	water gain	1.39E+08	138.9		0.1		0.5		17.2			
22	crop	forest	cropland loss	forest gain	2.81E+09	2,812.9	64,114.3	4.4	21,059.8	13.4	19,167.4	22.7	62,221.9	-1,892.4	-3.0
23	crop	barren	cropland loss	barren gain	2.73E+08	272.8		0.4	32.8	1.3	29.9	4.5			
24	crop	grass	cropland loss	grassland gain	1.60E+10	16,022.3		25.0		76.1		52.5			
25	crop	crop	stable cropland	stable cropland	4.31E+10	43,054.5		67.2							
26	crop	urban	cropland loss	urban gain	1.78E+08	178.3		0.3		0.8		54.4			
27	crop	wetland	cropland loss	wetland gain	1.38E+09	1,380.1		2.2		6.6		54.2			
28	crop	water	cropland loss	water gain	3.93E+08	393.5		0.6		1.9		48.8			
29	urban	forest	urban loss	forest gain	2.72E+08	271.9	3,916.3	6.9	3,620.9	7.5	327.5	2.2	622.9	-3,293.4	-84.1
30	urban	barren	urban loss	barren gain	6.37E+07	63.7		1.6	92.5	1.8	8.4	1.1			
31	urban	grass	urban loss	grass gain	1.41E+09	1,409.4		36.0		38.9		4.6			
32	urban	crop	urban loss	crop gain	1.72E+09	1,717.8		43.9		47.4		9.0			
33	urban	urban	stable urban	stable urban	2.95E+08	295.4		7.5							
34	urban	wetland	urban loss	wetland gain	1.28E+08	128.5		3.3		3.5		5.0			
35	urban	water	urban loss	water gain	2.96E+07	29.6		0.8		0.8		3.7			
36	wetland	forest	wetland loss	forest gain	8.54E+06	8.5	623.8	1.4	478.9	1.8	2,546.7	0.1	2,691.7	2,067.8	331.5
37	wetland	barren	wetland loss	barren gain	3.24E+06	3.2		0.5	76.8	0.7	408.3	0.1			
38	wetland	grass	wetland loss	grassland gain	1.56E+08	155.8		25.0		32.5		0.5			
39	wetland	crop	wetland loss	cropland gain	2.50E+08	249.7		40.0		52.1		1.3			
40	wetland	urban	wetland loss	urban gain	1.04E+06	1.0		0.2		0.2		0.3			
41	wetland	wetland	stable wetland	stable wetland	1.45E+08	144.9		23.2							
42	wetland	water	wetland loss	water gain	6.06E+07	60.6		9.7		12.7		7.5			
43	water	forest	water loss	forest gain	2.73E+08	272.6	3,287.5	8.3	1,455.0	18.7	806.4	2.2	2,638.9	-648.6	-19.7
44	water	barren	water loss	barren gain	4.07E+07	40.7		1.2	44.3	2.8	24.5	0.7			
45	water	grass	water loss	grassland gain	3.67E+08	367.0		11.2		25.2		1.2			
46	water	crop	water loss	cropland gain	5.72E+08	571.6		17.4		39.3		3.0			
47	water	urban	water loss	urban gain	9.82E+06	9.8		0.3		0.7		3.0			
48	water	wetland	water loss	wetland gain	1.93E+08	193.4		5.9		13.3		7.6			
49	water	water	stable water	stable water	1.83E+09	1,832.5		55.7							
	Total					240,242.8									

Appendix 2.2.1.2. Soviet era changes (1965-'87) in land cover and change percentages within Russian Caucasus.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.50E+10	25,027.7	31,540.6	79.4	6,512.8		5,455.6		30,483.3	-1,057.3	-3.4
2	forest	barren	forest loss	barren gain	1.80E+08	180.5		0.6	20.6	2.8	17.3	5.8			
3	forest	grass	forest loss	grassland gain	4.52E+09	4,519.7		14.3		69.4		47.5			
4	forest	crop	forest loss	cropland gain	1.39E+09	1,394.4		4.4		21.4		24.3			
5	forest	urban	forest loss	urban gain	9.16E+06	9.2		0.0		0.1		9.5			
6	forest	wetland	forest loss	wetland gain	3.13E+08	312.9		1.0		4.8		30.9			
7	forest	water	forest loss	water gain	9.62E+07	96.2		0.3		1.5		21.7			
8	barren	forest	barren loss	forest gain	6.67E+07	66.7	1,396.1	4.8	532.8	12.5	3,136.0	1.2	3,999.4	2,603.2	186.5
9	barren	barren	stable barren	stable barren	8.63E+08	863.4		61.8	38.2		224.6				
10	barren	grass	barren loss	grassland gain	3.52E+08	351.7		25.2		66.0		3.7			
11	barren	crop	barren loss	cropland gain	6.99E+07	69.9		5.0		13.1		1.2			
12	barren	urban	barren loss	urban gain	1.14E+06	1.1		0.1		0.2		1.2			
13	barren	wetland	barren loss	wetland gain	1.19E+07	11.9		0.9		2.2		1.2			
14	barren	water	barren loss	water gain	3.14E+07	31.4		2.2		5.9		7.1			
15	grass	forest	grassland loss	forest gain	3.87E+09	3,870.6	28,504.8	13.6	9,315.3	41.6	9,505.9	70.9	28,695.4	190.6	0.7
16	grass	barren	grassland loss	barren gain	2.86E+09	2,855.6		10.0	32.7	30.7	33.3	91.1			
17	grass	grass	stable grasslanc	stable grass	1.92E+10	19,189.5		67.3							
18	grass	crop	grassland loss	cropland gain	2.47E+09	2,472.3		8.7		26.5		43.1			
19	grass	urban	grassland loss	urban gain	2.26E+07	22.6		0.1		0.2		23.5			
20	grass	wetland	grassland loss	wetland gain	5.90E+07	59.0		0.2		0.6		5.8			
21	grass	water	grassland loss	water gain	3.52E+07	35.2		0.1		0.4		7.9			
22	crop	forest	cropland loss	forest gain	1.07E+09	1,065.3	28,334.5	3.8	5,638.3	18.9	5,738.6	19.5	28,434.8	100.3	0.4
23	crop	barren	cropland loss	barren gain	6.50E+07	65.0		0.2	19.9	1.2	20.3	2.1			
24	crop	grass	cropland loss	grassland gain	3.81E+09	3,812.4		13.5		67.6		40.1			
25	crop	crop	stable cropland	stable cropland	2.27E+10	22,696.2		80.1							
26	crop	urban	cropland loss	urban gain	5.77E+07	57.7		0.2		1.0		59.9			
27	crop	wetland	cropland loss	wetland gain	4.23E+08	423.4		1.5		7.5		41.8			
28	crop	water	cropland loss	water gain	2.15E+08	214.5		0.8		3.8		48.3			
29	urban	forest	urban loss	forest gain	1.93E+08	192.9	2,332.7	8.3	2,171.8	8.9	96.3	3.5	257.2	-2,075.5	-89.0
30	urban	barren	urban loss	barren gain	1.28E+07	12.8		0.5	93.1	0.6	4.1	0.4			
31	urban	grass	urban loss	grass gain	5.82E+08	581.5		24.9		26.8		6.1			
32	urban	crop	urban loss	crop gain	1.28E+09	1,275.2		54.7		58.7		22.2			
33	urban	urban	stable urban	stable urban	1.61E+08	160.9		6.9							
34	urban	wetland	urban loss	wetland gain	8.72E+07	87.2		3.7		4.0		8.6			
35	urban	water	urban loss	water gain	2.23E+07	22.3		1.0		1.0		5.0			
36	wetland	forest	wetland loss	forest gain	5.58E+06	5.6	234.0	2.4	216.3	2.6	1,013.6	0.1	1,031.3	797.3	340.8
37	wetland	barren	wetland loss	barren gain	1.76E+05	0.2		0.1	92.5	0.1	433.2	0.0			
38	wetland	grass	wetland loss	grassland gain	5.06E+07	50.6		21.6		23.4		0.5			
39	wetland	crop	wetland loss	cropland gain	1.15E+08	115.2		49.2		53.2		2.0			
40	wetland	urban	wetland loss	urban gain	4.56E+05	0.5		0.2		0.2		0.5			
41	wetland	wetland	stable wetland	stable wetland	1.76E+07	17.6		7.5							
42	wetland	water	wetland loss	water gain	4.43E+07	44.3		19.0		20.5		10.0			
43	water	forest	water loss	forest gain	2.54E+08	254.4	1,153.3	22.1	1,002.6	25.4	444.0	4.7	594.6	-558.6	-48.4
44	water	barren	water loss	barren gain	2.20E+07	22.0		1.9	86.9	2.2	38.5	0.7			
45	water	grass	water loss	grassland gain	1.90E+08	190.0		16.5		18.9		2.0			
46	water	crop	water loss	cropland gain	4.12E+08	411.7		35.7		41.1		7.2			
47	water	urban	water loss	urban gain	5.23E+06	5.2		0.5		0.5		5.4			
48	water	wetland	water loss	wetland gain	1.19E+08	119.2		10.3		11.9		11.8			
49	water	water	stable water	stable water	1.51E+08	150.6		13.1							

Per country total, sq m	9.35E+10
Per country total, sq km	93496.0
Percentage from total	38.9
Total country area	17098242
Percentage from country	0.5

Appendix 2.2.1.3. Soviet era changes (1965-'87) in land cover and change percentages within Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.21E+10	22,052.4	25,944.2	85.0	3,891.8		4,555.7		26,608.1	663.9	2.6
2	forest	barren	forest loss	barren gain	7.82E+07	78.2		0.3	15.0	2.0	17.6	11.2			
3	forest	grass	forest loss	grassland gain	2.78E+09	2,782.8		10.7		71.5		47.0			
4	forest	crop	forest loss	cropland gain	9.31E+08	930.9		3.6		23.9		29.2			
5	forest	urban	forest loss	urban gain	1.09E+07	10.9		0.0		0.3		12.7			
6	forest	wetland	forest loss	wetland gain	7.69E+07	76.9		0.3		2.0		13.6			
7	forest	water	forest loss	water gain	1.21E+07	12.1		0.0		0.3		16.6			
8	barren	forest	barren loss	forest gain	5.04E+07	50.4	467.1	10.8	280.4	18.0	697.6	1.1	884.3	417.2	89.3
9	barren	barren	stable barren	stable barren	1.87E+08	186.7		40.0	60.0		149.3				
10	barren	grass	barren loss	grassland gain	2.02E+08	201.9		43.2		72.0		3.4			
11	barren	crop	barren loss	cropland gain	1.83E+07	18.3		3.9		6.5		0.6			
12	barren	urban	barren loss	urban gain	1.14E+06	1.1		0.2		0.4		1.3			
13	barren	wetland	barren loss	wetland gain	1.66E+06	1.7		0.4		0.6		0.3			
14	barren	water	barren loss	water gain	7.08E+06	7.1		1.5		2.5		9.7			
15	grass	forest	grassland loss	forest gain	3.24E+09	3,241.0	15,055.8	21.5	5,842.1	55.5	5,922.9	71.1	15,136.6	80.8	0.5
16	grass	barren	grassland loss	barren gain	5.46E+08	545.7		3.6	38.8	9.3	39.3	78.2			
17	grass	grass	stable grasslanc	stable grass	9.21E+09	9,213.7		61.2							
18	grass	crop	grassland loss	cropland gain	1.99E+09	1,986.2		13.2		34.0		62.4			
19	grass	urban	grassland loss	urban gain	1.44E+07	14.4		0.1		0.2		16.9			
20	grass	wetland	grassland loss	wetland gain	4.24E+07	42.4		0.3		0.7		7.5			
21	grass	water	grassland loss	water gain	1.23E+07	12.3		0.1		0.2		16.8			
22	crop	forest	cropland loss	forest gain	1.21E+09	1,207.8	11,648.4	10.4	4,392.3	27.5	3,184.9	26.5	10,441.1	-1,207.3	-10.4
23	crop	barren	cropland loss	barren gain	5.26E+07	52.6		0.5	37.7	1.2	27.3	7.5			
24	crop	grass	cropland loss	grassland gain	2.64E+09	2,638.4		22.7		60.1		44.5			
25	crop	crop	stable cropland	stable cropland	7.26E+09	7,256.1		62.3							
26	crop	urban	cropland loss	urban gain	5.64E+07	56.4		0.5		1.3		65.9			
27	crop	wetland	cropland loss	wetland gain	3.96E+08	396.5		3.4		9.0		70.1			
28	crop	water	cropland loss	water gain	4.06E+07	40.6		0.3		0.9		55.3			
29	urban	forest	urban loss	forest gain	4.69E+07	46.9	528.4	8.9	489.7	9.6	85.6	1.0	124.2	-404.2	-76.5
30	urban	barren	urban loss	barren gain	1.32E+07	13.2		2.5	92.7	2.7	16.2	1.9			
31	urban	grass	urban loss	grass gain	2.28E+08	227.9		43.1		46.5		3.8			
32	urban	crop	urban loss	crop gain	1.80E+08	179.9		34.0		36.7		5.6			
33	urban	urban	stable urban	stable urban	3.87E+07	38.7		7.3							
34	urban	wetland	urban loss	wetland gain	2.07E+07	20.7		3.9		4.2		3.7			
35	urban	water	urban loss	water gain	1.20E+06	1.2		0.2		0.2		1.6			
36	wetland	forest	wetland loss	forest gain	1.92E+05	0.2	4.8	4.0	4.2	4.6	565.7	0.0	566.2	561.5	11,820.7
37	wetland	barren	wetland loss	barren gain	2.19E+04	0.0		0.5	88.4	0.5	11,909.1	0.0			
38	wetland	grass	wetland loss	grassland gain	1.88E+06	1.9		39.6		44.8		0.0			
39	wetland	crop	wetland loss	cropland gain	1.96E+06	2.0		41.3		46.7		0.1			
40	wetland	urban	wetland loss	urban gain	5.72E+04	0.1		1.2		1.4		0.1			
41	wetland	wetland	stable wetland	stable wetland	5.53E+05	0.6		11.6							
42	wetland	water	wetland loss	water gain	8.66E+04	0.1		1.8		2.1		0.1			
43	water	forest	water loss	forest gain	9.44E+06	9.4	311.1	3.0	185.3	5.1	73.4	0.2	199.2	-111.9	-36.0
44	water	barren	water loss	barren gain	7.84E+06	7.8		2.5	59.5	4.2	23.6	1.1			
45	water	grass	water loss	grassland gain	7.01E+07	70.1		22.5		37.9		1.2			
46	water	crop	water loss	cropland gain	6.76E+07	67.6		21.7		36.5		2.1			
47	water	urban	water loss	urban gain	2.68E+06	2.7		0.9		1.4		3.1			
48	water	wetland	water loss	wetland gain	2.75E+07	27.5		8.9		14.9		4.9			
49	water	water	stable water	stable water	1.26E+08	125.9		40.5							

Per country total, sq m	5.40E+10
Per country total, sq km	53,959.8
Percentage from total	22.5
Total country area	69681
Percentage from country	77.4

Appendix 2.2.1.4. Soviet era changes (1965-'87) in land cover and change percentages within Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.54E+09	2,541.4	4,018.2	63.2	1,476.9		586.3		3,127.7	-890.6	-22.2
2	forest	barren	forest loss	barren gain	1.03E+07	10.3		0.3	36.8	0.7	14.6	3.5			
3	forest	grass	forest loss	grassland gain	1.22E+09	1,223.0		30.4		82.8		33.5			
4	forest	crop	forest loss	cropland gain	2.36E+08	235.9		5.9		16.0		9.3			
5	forest	urban	forest loss	urban gain	2.08E+06	2.1		0.1		0.1		4.9			
6	forest	wetland	forest loss	wetland gain	5.34E+06	5.3		0.1		0.4		5.2			
7	forest	water	forest loss	water gain	2.45E+05	0.2		0.0		0.0		1.2			
8	barren	forest	barren loss	forest gain	6.08E+05	0.6	179.6	0.3	142.8	0.4	290.7	0.1	327.6	148.0	82.4
9	barren	barren	stable barren	stable barren	3.68E+07	36.8		20.5	79.5		161.9				
10	barren	grass	barren loss	grassland gain	1.35E+08	135.4		75.4		94.9		3.7			
11	barren	crop	barren loss	cropland gain	6.52E+06	6.5		3.6		4.6		0.3			
12	barren	urban	barren loss	urban gain	1.58E+04	0.0		0.0		0.0		0.0			
13	barren	wetland	barren loss	wetland gain	4.94E+04	0.0		0.0		0.0		0.0			
14	barren	water	barren loss	water gain	1.54E+05	0.2		0.1		0.1		0.8			
15	grass	forest	grassland loss	forest gain	4.90E+08	490.4	13,642.7	3.6	3,021.4	16.2	3,650.1	83.6	14,271.4	628.6	4.6
16	grass	barren	grassland loss	barren gain	2.67E+08	266.7		2.0	22.1	8.8	26.8	91.7			
17	grass	grass	stable grasslanc	stable grass	1.06E+10	10,621.3		77.9							
18	grass	crop	grassland loss	cropland gain	2.23E+09	2,226.6		16.3		73.7		87.8			
19	grass	urban	grassland loss	urban gain	1.56E+07	15.6		0.1		0.5		37.0			
20	grass	wetland	grassland loss	wetland gain	1.72E+07	17.2		0.1		0.6		16.6			
21	grass	water	grassland loss	water gain	5.00E+06	5.0		0.0		0.2		24.3			
22	crop	forest	cropland loss	forest gain	8.41E+07	84.1	5,007.4	1.7	2,331.9	3.6	2,535.0	14.3	5,210.5	203.0	4.1
23	crop	barren	cropland loss	barren gain	1.01E+07	10.1		0.2	46.6	0.4	50.6	3.5			
24	crop	grass	cropland loss	grassland gain	2.13E+09	2,134.6		42.6		91.5		58.5			
25	crop	crop	stable cropland	stable cropland	2.68E+09	2,675.5		53.4							
26	crop	urban	cropland loss	urban gain	2.39E+07	23.9		0.5		1.0		56.8			
27	crop	wetland	cropland loss	wetland gain	6.47E+07	64.7		1.3		2.8		62.7			
28	crop	water	cropland loss	water gain	1.45E+07	14.5		0.3		0.6		70.4			
29	urban	forest	urban loss	forest gain	1.02E+07	10.2	248.4	4.1	209.3	4.9	42.1	1.7	81.2	-167.2	-67.3
30	urban	barren	urban loss	barren gain	3.15E+06	3.2		1.3	84.3	1.5	16.9	1.1			
31	urban	grass	urban loss	grass gain	1.43E+08	142.8		57.5		68.2		3.9			
32	urban	crop	urban loss	crop gain	4.96E+07	49.6		20.0		23.7		2.0			
33	urban	urban	stable urban	stable urban	3.91E+07	39.1		15.7							
34	urban	wetland	urban loss	wetland gain	2.83E+06	2.8		1.1		1.4		2.7			
35	urban	water	urban loss	water gain	6.88E+05	0.7		0.3		0.3		3.3			
36	wetland	forest	wetland loss	forest gain	6.88E+02	0.0	0.0	2.9	0.0	2.9	103.2	0.0	103.2	103.2	441,192.9
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0		0.0	100.0	0.0	441,292.9	0.0			
38	wetland	grass	wetland loss	grassland gain	1.93E+04	0.0		82.3		82.3		0.0			
39	wetland	crop	wetland loss	cropland gain	3.44E+03	0.0		14.7		14.7		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0		0.0		0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0		0.0		0.0		0.0			
43	water	forest	water loss	forest gain	1.00E+06	1.0	1,296.6	0.1	45.6	2.2	20.6	0.2	1,271.5	-25.0	-1.9
44	water	barren	water loss	barren gain	5.50E+05	0.5		0.0	3.5	1.2	1.6	0.2			
45	water	grass	water loss	grassland gain	1.42E+07	14.2		1.1		31.2		0.4			
46	water	crop	water loss	cropland gain	1.62E+07	16.2		1.3		35.6		0.6			
47	water	urban	water loss	urban gain	5.00E+05	0.5		0.0		1.1		1.2			
48	water	wetland	water loss	wetland gain	1.31E+07	13.1		1.0		28.7		12.7			
49	water	water	stable water	stable water	1.25E+09	1,251.0		96.5							

Per country total, sq m	2.44E+10
Per country total, sq km	24,393.0
Percentage from total	10.2
Total country area	29743
Percentage from country	82.0

Appendix 2.2.1.5. Soviet era changes (1965-'87) in land cover and change percentages within Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	6.15E+09	6,146.7	11,098.6	55.4	4,951.9		1,786.3		7,933.0	-3,165.6	-28.5
2	forest	barren	forest loss	barren gain	1.46E+08	145.7		1.3	44.6	2.9	16.1	7.7			
3	forest	grass	forest loss	grassland gain	3.19E+09	3,192.9		28.8		64.5		27.9			
4	forest	crop	forest loss	cropland gain	1.47E+09	1,470.2		13.2		29.7		19.1			
5	forest	urban	forest loss	urban gain	8.04E+06	8.0		0.1		0.2		7.8			
6	forest	wetland	forest loss	wetland gain	9.89E+07	98.9		0.9		2.0		11.4			
7	forest	water	forest loss	water gain	3.62E+07	36.2		0.3		0.7		13.5			
8	barren	forest	barren loss	forest gain	3.93E+06	3.9	293.2	1.3	186.2	2.1	1,902.4	0.2	2,009.3	1,716.1	585.4
9	barren	barren	stable barren	stable barren	1.07E+08	106.9		36.5	63.5		648.9				
10	barren	grass	barren loss	grassland gain	1.75E+08	174.5		59.5		93.7		1.5			
11	barren	crop	barren loss	cropland gain	7.03E+06	7.0		2.4		3.8		0.1			
12	barren	urban	barren loss	urban gain	6.35E+04	0.1		0.0		0.0		0.1			
13	barren	wetland	barren loss	wetland gain	2.31E+05	0.2		0.1		0.1		0.0			
14	barren	water	barren loss	water gain	4.74E+05	0.5		0.2		0.3		0.2			
15	grass	forest	grassland loss	forest gain	1.29E+09	1,294.4	36,159.9	3.6	9,025.9	14.3	11,457.5	72.5	38,591.5	2,431.6	6.7
16	grass	barren	grassland loss	barren gain	1.56E+09	1,563.7		4.3	25.0	17.3	31.7	82.2			
17	grass	grass	stable grasslanc	stable grass	2.71E+10	27,134.0		75.0							
18	grass	crop	grassland loss	cropland gain	5.81E+09	5,810.0		16.1		64.4		75.4			
19	grass	urban	grassland loss	urban gain	5.32E+07	53.2		0.1		0.6		51.4			
20	grass	wetland	grassland loss	wetland gain	2.18E+08	218.3		0.6		2.4		25.3			
21	grass	water	grassland loss	water gain	8.64E+07	86.4		0.2		1.0		32.2			
22	crop	forest	cropland loss	forest gain	4.56E+08	455.6	19,124.0	2.4	8,697.3	5.2	7,708.9	25.5	18,135.6	-988.4	-5.2
23	crop	barren	cropland loss	barren gain	1.45E+08	145.0		0.8	45.5	1.7	40.3	7.6			
24	crop	grass	cropland loss	grassland gain	7.44E+09	7,437.0		38.9		85.5		64.9			
25	crop	crop	stable cropland	stable cropland	1.04E+10	10,426.6		54.5							
26	crop	urban	cropland loss	urban gain	4.03E+07	40.3		0.2		0.5		38.9			
27	crop	wetland	cropland loss	wetland gain	4.96E+08	495.6		2.6		5.7		57.3			
28	crop	water	cropland loss	water gain	1.24E+08	123.9		0.6		1.4		46.1			
29	urban	forest	urban loss	forest gain	2.19E+07	21.9	806.8	2.7	750.0	2.9	103.5	1.2	160.3	-646.5	-80.1
30	urban	barren	urban loss	barren gain	3.46E+07	34.6		4.3	93.0	4.6	12.8	1.8			
31	urban	grass	urban loss	grass gain	4.57E+08	457.2		56.7		61.0		4.0			
32	urban	crop	urban loss	crop gain	2.13E+08	213.1		26.4		28.4		2.8			
33	urban	urban	stable urban	stable urban	5.68E+07	56.8		7.0							
34	urban	wetland	urban loss	wetland gain	1.78E+07	17.8		2.2		2.4		2.1			
35	urban	water	urban loss	water gain	5.37E+06	5.4		0.7		0.7		2.0			
36	wetland	forest	wetland loss	forest gain	2.76E+06	2.8	385.1	0.7	258.3	1.1	864.2	0.2	991.0	605.9	157.3
37	wetland	barren	wetland loss	barren gain	3.04E+06	3.0		0.8	67.1	1.2	224.4	0.2			
38	wetland	grass	wetland loss	grassland gain	1.03E+08	103.3		26.8		40.0		0.9			
39	wetland	crop	wetland loss	cropland gain	1.33E+08	132.5		34.4		51.3		1.7			
40	wetland	urban	wetland loss	urban gain	5.27E+05	0.5		0.1		0.2		0.5			
41	wetland	wetland	stable wetland	stable wetland	1.27E+08	126.7		32.9							
42	wetland	water	wetland loss	water gain	1.62E+07	16.2		4.2		6.3		6.0			
43	water	forest	water loss	forest gain	7.67E+06	7.7	526.5	1.5	221.5	3.5	268.5	0.4	573.5	46.9	8.9
44	water	barren	water loss	barren gain	1.03E+07	10.3		2.0	42.1	4.6	51.0	0.5			
45	water	grass	water loss	grassland gain	9.27E+07	92.7		17.6		41.8		0.8			
46	water	crop	water loss	cropland gain	7.60E+07	76.0		14.4		34.3		1.0			
47	water	urban	water loss	urban gain	1.41E+06	1.4		0.3		0.6		1.4			
48	water	wetland	water loss	wetland gain	3.35E+07	33.5		6.4		15.1		3.9			
49	water	water	stable water	stable water	3.05E+08	305.0		57.9							

Per country total, sq m	6.84E+10
Per country total, sq km	68,394.0
Percentage from total	28.5
Total country area	86600
Percentage from country	79.0

Appendix 2.2.2.1. Post-Soviet changes (1987-2015) in land cover and change percentages within our entire study area.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	6.34E+10	63,433.5	68,147.0	93.1	4,713.4		8,326.3		71,759.8	3,612.8	5.3
2	forest	barren	forest loss	barren gain	1.58E+08	158.2		0.2	6.9	3.4	12.2	11.9			
3	forest	grass	forest loss	grassland gain	3.02E+09	3,022.9		4.4		64.1		12.8			
4	forest	crop	forest loss	cropland gain	1.19E+09	1,192.9		1.8		25.3		9.9			
5	forest	urban	forest loss	urban gain	9.80E+06	9.8		0.0		0.2		1.5			
6	forest	wetland	forest loss	wetland gain	3.06E+08	306.1		0.4		6.5		12.1			
7	forest	water	forest loss	water gain	2.35E+07	23.5		0.0		0.5		5.4			
8	barren	forest	barren loss	forest gain	1.69E+08	168.7	7,205.0	2.3	3,294.7	5.1	1,328.3	2.0	5,238.6	-1,966.4	-27.3
9	barren	barren	stable barren	stable barren	3.91E+09	3,910.3		54.3	45.7		18.4				
10	barren	grass	barren loss	grassland gain	2.88E+09	2,884.7		40.0		87.6		12.2			
11	barren	crop	barren loss	cropland gain	1.24E+08	124.0		1.7		3.8		1.0			
12	barren	urban	barren loss	urban gain	3.64E+07	36.4		0.5		1.1		5.4			
13	barren	wetland	barren loss	wetland gain	2.41E+07	24.1		0.3		0.7		1.0			
14	barren	water	barren loss	water gain	5.69E+07	56.9		0.8		1.7		13.1			
15	grass	forest	grassland loss	forest gain	4.55E+09	4,548.5	96,555.7	4.7	16,521.6	27.5	23,628.8	54.6	103,663.0	7,107.2	7.4
16	grass	barren	grassland loss	barren gain	1.03E+09	1,027.7		1.1	17.1	6.2	24.5	77.4			
17	grass	grass	stable grassland	stable grass	8.00E+10	80,034.1		82.9							
18	grass	crop	grassland loss	cropland gain	9.93E+09	9,933.5		10.3		60.1		82.3			
19	grass	urban	grassland loss	urban gain	4.33E+08	432.9		0.4		2.6		64.4			
20	grass	wetland	grassland loss	wetland gain	4.49E+08	449.0		0.5		2.7		17.8			
21	grass	water	grassland loss	water gain	1.30E+08	130.0		0.1		0.8		29.8			
22	crop	forest	cropland loss	forest gain	2.92E+09	2,915.7	62,155.6	4.7	21,886.0	13.3	12,071.7	35.0	52,341.3	-9,814.4	-15.8
23	crop	barren	cropland loss	barren gain	9.21E+07	92.1		0.1	35.2	0.4	19.4	6.9			
24	crop	grass	cropland loss	grassland gain	1.71E+10	17,052.5		27.4		77.9		72.2			
25	crop	crop	stable cropland	stable cropland	4.03E+10	40,269.6		64.8							
26	crop	urban	cropland loss	urban gain	1.82E+08	181.6		0.3		0.8		27.0			
27	crop	wetland	cropland loss	wetland gain	1.54E+09	1,540.3		2.5		7.0		61.1			
28	crop	water	cropland loss	water gain	1.04E+08	103.7		0.2		0.5		23.8			
29	urban	forest	urban loss	forest gain	9.69E+06	9.7	619.2	1.6	412.6	2.3	672.4	0.1	879.0	259.8	42.0
30	urban	barren	urban loss	barren gain	7.45E+06	7.5		1.2	66.6	1.8	108.6	0.6			
31	urban	grass	urban loss	grass gain	2.98E+08	297.7		48.1		72.1		1.3			
32	urban	crop	urban loss	crop gain	8.01E+07	80.1		12.9		19.4		0.7			
33	urban	urban	stable urban	stable urban	2.07E+08	206.6		33.4							
34	urban	wetland	urban loss	wetland gain	1.69E+07	16.9		2.7		4.1		0.7			
35	urban	water	urban loss	water gain	7.98E+05	0.8		0.1		0.2		0.2			
36	wetland	forest	wetland loss	forest gain	6.51E+08	651.3	2,673.5	24.4	1,760.0	37.0	2,520.1	7.8	3,433.6	760.1	28.4
37	wetland	barren	wetland loss	barren gain	8.89E+06	8.9		0.3	65.8	0.5	94.3	0.7			
38	wetland	grass	wetland loss	grassland gain	2.98E+08	297.9		11.1		16.9		1.3			
39	wetland	crop	wetland loss	cropland gain	6.70E+08	670.0		25.1		38.1		5.6			
40	wetland	urban	wetland loss	urban gain	1.11E+07	11.1		0.4		0.6		1.6			
41	wetland	wetland	stable wetland	stable wetland	9.13E+08	913.5		34.2							
42	wetland	water	wetland loss	water gain	1.21E+08	120.8		4.5		6.9		27.7			
43	water	forest	water loss	forest gain	3.23E+07	32.3	2,590.6	1.2	395.1	8.2	435.8	0.4	2,631.3	40.7	1.6
44	water	barren	water loss	barren gain	3.40E+07	34.0		1.3	15.3	8.6	16.8	2.6			
45	water	grass	water loss	grassland gain	7.32E+07	73.2		2.8		18.5		0.3			
46	water	crop	water loss	cropland gain	7.12E+07	71.2		2.7		18.0		0.6			
47	water	urban	water loss	urban gain	6.43E+05	0.6		0.0		0.2		0.1			
48	water	wetland	water loss	wetland gain	1.84E+08	183.8		7.1		46.5		7.3			
49	water	water	stable water	stable water	2.20E+09	2,195.5		84.7							
	Total					239,946.5									

Appendix 2.2.2.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Russian Caucasus.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.88E+10	28,751.4	30,477.9	94.3	1,726.5		3,687.4		32,438.8	1,960.9	6.4
2	forest	barren	forest loss	barren gain	9.42E+07	94.2		0.3	5.7	5.5	12.1	14.2			
3	forest	grass	forest loss	grassland gain	1.13E+09	1,130.1		3.7		65.5		16.0			
4	forest	crop	forest loss	cropland gain	3.35E+08	334.6		1.1		19.4		10.8			
5	forest	urban	forest loss	urban gain	3.49E+06	3.5		0.0		0.2		1.1			
6	forest	wetland	forest loss	wetland gain	1.49E+08	149.2		0.5		8.6		11.1			
7	forest	water	forest loss	water gain	1.50E+07	15.0		0.0		0.9		9.4			
8	barren	forest	barren loss	forest gain	1.10E+08	110.3	3,996.9	2.8	1,310.1	8.4	661.2	3.0	3,348.1	-648.9	-16.2
9	barren	barren	stable barren	stable barren	2.69E+09	2,686.8		67.2	32.8		16.5				
10	barren	grass	barren loss	grassland gain	1.11E+09	1,110.3		27.8		84.7		15.7			
11	barren	crop	barren loss	cropland gain	4.49E+07	44.9		1.1		3.4		1.4			
12	barren	urban	barren loss	urban gain	1.25E+07	12.5		0.3		1.0		3.8			
13	barren	wetland	barren loss	wetland gain	1.16E+07	11.6		0.3		0.9		0.9			
14	barren	water	barren loss	water gain	2.05E+07	20.5		0.5		1.6		12.8			
15	grass	forest	grassland loss	forest gain	1.66E+09	1,659.3	28,668.1	5.8	5,023.1	33.0	7,066.5	45.0	30,711.5	2,043.4	7.1
16	grass	barren	grassland loss	barren gain	4.93E+08	493.2		1.7	17.5	9.8	24.6	74.6			
17	grass	grass	stable grasslanc	stable grass	2.36E+10	23,645.0		82.5							
18	grass	crop	grassland loss	cropland gain	2.47E+09	2,469.7		8.6		49.2		79.8			
19	grass	urban	grassland loss	urban gain	1.83E+08	182.7		0.6		3.6		55.9			
20	grass	wetland	grassland loss	wetland gain	1.79E+08	178.8		0.6		3.6		13.3			
21	grass	water	grassland loss	water gain	3.94E+07	39.4		0.1		0.8		24.6			
22	crop	forest	cropland loss	forest gain	1.47E+09	1,472.9	28,399.4	5.2	7,200.1	20.5	3,096.6	39.9	24,295.9	-4,103.5	-14.4
23	crop	barren	cropland loss	barren gain	4.52E+07	45.2		0.2	25.4	0.6	10.9	6.8			
24	crop	grass	cropland loss	grassland gain	4.64E+09	4,638.4		16.3		64.4		65.6			
25	crop	crop	stable cropland	stable cropland	2.12E+10	21,199.3		74.6							
26	crop	urban	cropland loss	urban gain	1.22E+08	122.2		0.4		1.7		37.4			
27	crop	wetland	cropland loss	wetland gain	8.83E+08	883.3		3.1		12.3		65.8			
28	crop	water	cropland loss	water gain	3.81E+07	38.1		0.1		0.5		23.8			
29	urban	forest	urban loss	forest gain	2.96E+06	3.0	256.6	1.2	150.8	2.0	326.5	0.1	432.3	175.7	68.5
30	urban	barren	urban loss	barren gain	2.03E+06	2.0		0.8	58.8	1.3	127.3	0.3			
31	urban	grass	urban loss	grass gain	1.00E+08	100.4		39.1		66.6		1.4			
32	urban	crop	urban loss	crop gain	3.88E+07	38.8		15.1		25.8		1.3			
33	urban	urban	stable urban	stable urban	1.06E+08	105.8		41.2							
34	urban	wetland	urban loss	wetland gain	6.25E+06	6.2		2.4		4.1		0.5			
35	urban	water	urban loss	water gain	2.61E+05	0.3		0.1		0.2		0.2			
36	wetland	forest	wetland loss	forest gain	4.22E+08	421.8	1,029.0	41.0	735.5	57.3	1,342.0	11.4	1,635.4	606.4	58.9
37	wetland	barren	wetland loss	barren gain	3.50E+06	3.5		0.3	71.5	0.5	130.4	0.5			
38	wetland	grass	wetland loss	grassland gain	7.33E+07	73.3		7.1		10.0		1.0			
39	wetland	crop	wetland loss	cropland gain	1.85E+08	184.6		17.9		25.1		6.0			
40	wetland	urban	wetland loss	urban gain	5.49E+06	5.5		0.5		0.7		1.7			
41	wetland	wetland	stable wetland	stable wetland	2.93E+08	293.5		28.5							
42	wetland	water	wetland loss	water gain	4.69E+07	46.9		4.6		6.4		29.3			
43	water	forest	water loss	forest gain	2.02E+07	20.2	556.0	3.6	194.3	10.4	160.2	0.5	521.9	-34.1	-6.1
44	water	barren	water loss	barren gain	2.31E+07	23.1		4.2	34.9	11.9	28.8	3.5			
45	water	grass	water loss	grassland gain	1.40E+07	14.0		2.5		7.2		0.2			
46	water	crop	water loss	cropland gain	2.40E+07	24.0		4.3		12.4		0.8			
47	water	urban	water loss	urban gain	8.57E+04	0.1		0.0		0.0		0.0			
48	water	wetland	water loss	wetland gain	1.13E+08	112.8		20.3		58.1		8.4			
49	water	water	stable water	stable water	3.62E+08	361.7		65.1							

Per country total, sq m	9.34E+10
Per country total, sq km	93,383.8
Percentage from total	38.9
Total country area	17098242
Percentage from country	0.5

Appendix 2.2.2.3. Post-Soviet changes (1987-2015) in land cover and change percentages within Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.52E+10	25,225.4	26,611.9	94.8	1,386.5		2,885.7		28,111.1	1,499.2	5.6
2	forest	barren	forest loss	barren gain	4.56E+07	45.6		0.2	5.2	3.3	10.8	23.7			
3	forest	grass	forest loss	grassland gain	8.99E+08	898.7		3.4		64.8		18.1			
4	forest	crop	forest loss	cropland gain	3.64E+08	364.3		1.4		26.3		21.1			
5	forest	urban	forest loss	urban gain	2.69E+06	2.7		0.0		0.2		3.6			
6	forest	wetland	forest loss	wetland gain	6.98E+07	69.8		0.3		5.0		15.6			
7	forest	water	forest loss	water gain	5.43E+06	5.4		0.0		0.4		6.1			
8	barren	forest	barren loss	forest gain	4.05E+07	40.5	881.3	4.6	471.9	8.6	192.5	1.4	601.9	-279.4	-31.7
9	barren	barren	stable barren	stable barren	4.09E+08	409.4		46.5	53.5		21.8				
10	barren	grass	barren loss	grassland gain	3.92E+08	392.5		44.5		83.2		7.9			
11	barren	crop	barren loss	cropland gain	1.25E+07	12.5		1.4		2.7		0.7			
12	barren	urban	barren loss	urban gain	6.02E+06	6.0		0.7		1.3		8.1			
13	barren	wetland	barren loss	wetland gain	6.91E+06	6.9		0.8		1.5		1.5			
14	barren	water	barren loss	water gain	1.35E+07	13.5		1.5		2.9		15.2			
15	grass	forest	grassland loss	forest gain	1.87E+09	1,871.3	15,128.5	12.4	3,221.4	58.1	4,976.4	64.8	16,883.5	1,755.0	11.6
16	grass	barren	grassland loss	barren gain	1.13E+08	112.8		0.7	21.3	3.5	32.9	58.6			
17	grass	grass	stable grasslanc	stable grass	1.19E+10	11,907.1		78.7							
18	grass	crop	grassland loss	cropland gain	1.10E+09	1,097.2		7.3		34.1		63.7			
19	grass	urban	grassland loss	urban gain	4.58E+07	45.8		0.3		1.4		61.9			
20	grass	wetland	grassland loss	wetland gain	6.72E+07	67.2		0.4		2.1		15.0			
21	grass	water	grassland loss	water gain	2.70E+07	27.0		0.2		0.8		30.4			
22	crop	forest	cropland loss	forest gain	8.25E+08	824.7	10,439.4	7.9	4,727.1	17.4	1,722.5	28.6	7,434.8	-3,004.6	-28.8
23	crop	barren	cropland loss	barren gain	2.08E+07	20.8		0.2	45.3	0.4	16.5	10.8			
24	crop	grass	cropland loss	grassland gain	3.56E+09	3,559.1		34.1		75.3		71.5			
25	crop	crop	stable cropland	stable cropland	5.71E+09	5,712.4		54.7							
26	crop	urban	cropland loss	urban gain	1.73E+07	17.3		0.2		0.4		23.4			
27	crop	wetland	cropland loss	wetland gain	2.82E+08	282.4		2.7		6.0		62.9			
28	crop	water	cropland loss	water gain	2.27E+07	22.7		0.2		0.5		25.6			
29	urban	forest	urban loss	forest gain	5.15E+06	5.1	124.2	4.1	95.5	5.4	74.0	0.2	102.7	-21.5	-17.3
30	urban	barren	urban loss	barren gain	2.28E+06	2.3		1.8	76.9	2.4	59.6	1.2			
31	urban	grass	urban loss	grass gain	5.62E+07	56.2		45.2		58.8		1.1			
32	urban	crop	urban loss	crop gain	2.54E+07	25.4		20.4		26.5		1.5			
33	urban	urban	stable urban	stable urban	2.87E+07	28.7		23.1							
34	urban	wetland	urban loss	wetland gain	6.44E+06	6.4		5.2		6.7		1.4			
35	urban	water	urban loss	water gain	1.32E+05	0.1		0.1		0.1		0.1			
36	wetland	forest	wetland loss	forest gain	1.34E+08	134.4	565.8	23.8	436.5	30.8	448.7	4.7	578.0	12.2	2.2
37	wetland	barren	wetland loss	barren gain	1.71E+06	1.7		0.3	77.1	0.4	79.3	0.9			
38	wetland	grass	wetland loss	grassland gain	6.30E+07	63.0		11.1		14.4		1.3			
39	wetland	crop	wetland loss	cropland gain	2.15E+08	215.4		38.1		49.3		12.5			
40	wetland	urban	wetland loss	urban gain	2.01E+06	2.0		0.4		0.5		2.7			
41	wetland	wetland	stable wetland	stable wetland	1.29E+08	129.3		22.9							
42	wetland	water	wetland loss	water gain	2.00E+07	20.0		3.5		4.6		22.5			
43	water	forest	water loss	forest gain	9.58E+06	9.6	196.2	4.9	49.6	19.3	88.7	0.3	235.2	39.1	19.9
44	water	barren	water loss	barren gain	9.28E+06	9.3		4.7	25.3	18.7	45.2	4.8			
45	water	grass	water loss	grassland gain	6.97E+06	7.0		3.6		14.0		0.1			
46	water	crop	water loss	cropland gain	7.69E+06	7.7		3.9		15.5		0.4			
47	water	urban	water loss	urban gain	1.68E+05	0.2		0.1		0.3		0.2			
48	water	wetland	water loss	wetland gain	1.60E+07	16.0		8.1		32.2		3.6			
49	water	water	stable water	stable water	1.47E+08	146.5		74.7							

Per country total, sq m	5.39E+10
Per country total, sq km	53,947.3
Percentage from total	22.5
Total country area	69681
Percentage from country	77.4

Appendix 2.2.2.4. Post-Soviet changes (1987-2015) in land cover and change percentages within Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.80E+09	2,804.8	3,126.3	89.7	321.5		563.6		3,368.3	242.1	7.7
2	forest	barren	forest loss	barren gain	9.75E+05	1.0		0.0	10.3	0.3	18.0	3.1			
3	forest	grass	forest loss	grassland gain	2.23E+08	223.0		7.1		69.4		8.7			
4	forest	crop	forest loss	cropland gain	8.96E+07	89.6		2.9		27.9		6.0			
5	forest	urban	forest loss	urban gain	3.07E+05	0.3		0.0		0.1		0.8			
6	forest	wetland	forest loss	wetland gain	7.26E+06	7.3		0.2		2.3		7.6			
7	forest	water	forest loss	water gain	2.48E+05	0.2		0.0		0.1		1.2			
8	barren	forest	barren loss	forest gain	1.46E+06	1.5	326.7	0.4	212.9	0.7	31.7	0.3	145.5	-181.2	-55.5
9	barren	barren	stable barren	stable barren	1.14E+08	113.8		34.8	65.2		9.7				
10	barren	grass	barren loss	grassland gain	2.04E+08	203.6		62.3		95.7		7.9			
11	barren	crop	barren loss	cropland gain	4.87E+06	4.9		1.5		2.3		0.3			
12	barren	urban	barren loss	urban gain	1.61E+06	1.6		0.5		0.8		4.1			
13	barren	wetland	barren loss	wetland gain	9.72E+05	1.0		0.3		0.5		1.0			
14	barren	water	barren loss	water gain	3.52E+05	0.4		0.1		0.2		1.7			
15	grass	forest	grassland loss	forest gain	4.12E+08	411.9	14,248.2	2.9	1,870.7	22.0	2,567.8	73.1	14,945.4	697.1	4.9
16	grass	barren	grassland loss	barren gain	2.58E+07	25.8		0.2	13.1	1.4	18.0	81.5			
17	grass	grass	stable grasslanc	stable grass	1.24E+10	12,377.6		86.9							
18	grass	crop	grassland loss	cropland gain	1.37E+09	1,367.3		9.6		73.1		91.7			
19	grass	urban	grassland loss	urban gain	3.36E+07	33.6		0.2		1.8		86.3			
20	grass	wetland	grassland loss	wetland gain	2.84E+07	28.4		0.2		1.5		29.9			
21	grass	water	grassland loss	water gain	3.56E+06	3.6		0.0		0.2		16.7			
22	crop	forest	cropland loss	forest gain	1.37E+08	137.0	5,202.9	2.6	2,274.6	6.0	1,490.9	24.3	4,419.1	-783.8	-15.1
23	crop	barren	cropland loss	barren gain	3.89E+06	3.9		0.1	43.7	0.2	28.7	12.3			
24	crop	grass	cropland loss	grassland gain	2.07E+09	2,072.6		39.8		91.1		80.7			
25	crop	crop	stable cropland	stable cropland	2.93E+09	2,928.3		56.3							
26	crop	urban	cropland loss	urban gain	3.38E+06	3.4		0.1		0.1		8.7			
27	crop	wetland	cropland loss	wetland gain	5.17E+07	51.7		1.0		2.3		54.5			
28	crop	water	cropland loss	water gain	6.03E+06	6.0		0.1		0.3		28.3			
29	urban	forest	urban loss	forest gain	4.41E+05	0.4	81.2	0.5	59.5	0.7	38.9	0.1	60.6	-20.6	-25.3
30	urban	barren	urban loss	barren gain	7.19E+05	0.7		0.9	73.3	1.2	47.9	2.3			
31	urban	grass	urban loss	grass gain	5.29E+07	52.9		65.2		89.0		2.1			
32	urban	crop	urban loss	crop gain	4.30E+06	4.3		5.3		7.2		0.3			
33	urban	urban	stable urban	stable urban	2.17E+07	21.7		26.7							
34	urban	wetland	urban loss	wetland gain	1.06E+06	1.1		1.3		1.8		1.1			
35	urban	water	urban loss	water gain	2.74E+04	0.0		0.0		0.0		0.1			
36	wetland	forest	wetland loss	forest gain	1.22E+07	12.2	102.6	11.9	58.8	20.7	95.0	2.2	138.8	36.2	35.3
37	wetland	barren	wetland loss	barren gain	7.80E+04	0.1		0.1	57.3	0.1	92.6	0.2			
38	wetland	grass	wetland loss	grassland gain	1.33E+07	13.3		13.0		22.6		0.5			
39	wetland	crop	wetland loss	cropland gain	2.21E+07	22.1		21.6		37.6		1.5			
40	wetland	urban	wetland loss	urban gain	5.55E+04	0.1		0.1		0.1		0.1			
41	wetland	wetland	stable wetland	stable wetland	4.38E+07	43.8		42.7							
42	wetland	water	wetland loss	water gain	1.11E+07	11.1		10.8		18.9		52.0			
43	water	forest	water loss	forest gain	4.96E+05	0.5	1,271.2	0.0	11.2	4.4	21.3	0.1	1,281.3	10.1	0.8
44	water	barren	water loss	barren gain	2.18E+05	0.2		0.0	0.9	1.9	1.7	0.7			
45	water	grass	water loss	grassland gain	2.35E+06	2.4		0.2		21.0		0.1			
46	water	crop	water loss	cropland gain	2.60E+06	2.6		0.2		23.1		0.2			
47	water	urban	water loss	urban gain	1.35E+03	0.0		0.0		0.0		0.0			
48	water	wetland	water loss	wetland gain	5.56E+06	5.6		0.4		49.5		5.9			
49	water	water	stable water	stable water	1.26E+09	1,260.0		99.1							

Per country total, sq m	2.44E+10
Per country total, sq km	24,359.1
Percentage from total	10.2
Total country area	29743
Percentage from country	81.9

Appendix 2.2.2.5. Post-Soviet changes (1987-2015) in land cover and change percentages within Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	6.65E+09	6,651.9	7,930.9	83.9	1,279.0		1,189.6		7,841.6	-89.3	-1.1
2	forest	barren	forest loss	barren gain	1.75E+07	17.5		0.2	16.1	1.4	15.0	3.9			
3	forest	grass	forest loss	grassland gain	7.71E+08	771.1		9.7		60.3		8.6			
4	forest	crop	forest loss	cropland gain	4.04E+08	404.4		5.1		31.6		7.0			
5	forest	urban	forest loss	urban gain	3.31E+06	3.3		0.0		0.3		1.4			
6	forest	wetland	forest loss	wetland gain	7.98E+07	79.8		1.0		6.2		12.6			
7	forest	water	forest loss	water gain	2.84E+06	2.8		0.0		0.2		1.7			
8	barren	forest	barren loss	forest gain	1.65E+07	16.5	2,000.1	0.8	1,299.8	1.3	442.9	1.4	1,143.2	-856.9	-42.8
9	barren	barren	stable barren	stable barren	7.00E+08	700.3		35.0	65.0		22.1				
10	barren	grass	barren loss	grassland gain	1.18E+09	1,178.3		58.9		90.6		13.1			
11	barren	crop	barren loss	cropland gain	6.17E+07	61.7		3.1		4.7		1.1			
12	barren	urban	barren loss	urban gain	1.62E+07	16.2		0.8		1.2		7.0			
13	barren	wetland	barren loss	wetland gain	4.55E+06	4.6		0.2		0.4		0.7			
14	barren	water	barren loss	water gain	2.26E+07	22.6		1.1		1.7		13.6			
15	grass	forest	grassland loss	forest gain	6.06E+08	606.0	38,510.9	1.6	6,406.4	9.5	9,018.1	50.9	41,122.6	2,611.6	6.8
16	grass	barren	grassland loss	barren gain	3.96E+08	395.8		1.0	16.6	6.2	23.4	89.4			
17	grass	grass	stable grasslanc	stable grass	3.21E+10	32,104.5		83.4							
18	grass	crop	grassland loss	cropland gain	5.00E+09	4,999.2		13.0		78.0		86.8			
19	grass	urban	grassland loss	urban gain	1.71E+08	170.8		0.4		2.7		73.3			
20	grass	wetland	grassland loss	wetland gain	1.75E+08	174.5		0.5		2.7		27.5			
21	grass	water	grassland loss	water gain	6.01E+07	60.1		0.2		0.9		36.3			
22	crop	forest	cropland loss	forest gain	4.81E+08	481.1	18,113.9	2.7	7,684.2	6.3	5,761.8	40.4	16,191.4	-1,922.5	-10.6
23	crop	barren	cropland loss	barren gain	2.22E+07	22.2		0.1	42.4	0.3	31.8	5.0			
24	crop	grass	cropland loss	grassland gain	6.78E+09	6,782.4		37.4		88.3		75.2			
25	crop	crop	stable cropland	stable cropland	1.04E+10	10,429.6		57.6							
26	crop	urban	cropland loss	urban gain	3.87E+07	38.7		0.2		0.5		16.6			
27	crop	wetland	cropland loss	wetland gain	3.23E+08	323.0		1.8		4.2		50.9			
28	crop	water	cropland loss	water gain	3.68E+07	36.8		0.2		0.5		22.2			
29	urban	forest	urban loss	forest gain	1.14E+06	1.1	157.2	0.7	106.8	1.1	233.0	0.1	283.4	126.2	80.3
30	urban	barren	urban loss	barren gain	2.43E+06	2.4		1.5	67.9	2.3	148.2	0.5			
31	urban	grass	urban loss	grass gain	8.81E+07	88.1		56.0		82.5		1.0			
32	urban	crop	urban loss	crop gain	1.16E+07	11.6		7.4		10.9		0.2			
33	urban	urban	stable urban	stable urban	5.04E+07	50.4		32.1							
34	urban	wetland	urban loss	wetland gain	3.12E+06	3.1		2.0		2.9		0.5			
35	urban	water	urban loss	water gain	3.78E+05	0.4		0.2		0.4		0.2			
36	wetland	forest	wetland loss	forest gain	8.29E+07	82.9	976.1	8.5	529.2	15.7	634.4	7.0	1,081.4	105.2	10.8
37	wetland	barren	wetland loss	barren gain	3.60E+06	3.6		0.4	54.2	0.7	65.0	0.8			
38	wetland	grass	wetland loss	grassland gain	1.48E+08	148.3		15.2		28.0		1.6			
39	wetland	crop	wetland loss	cropland gain	2.48E+08	248.0		25.4		46.9		4.3			
40	wetland	urban	wetland loss	urban gain	3.53E+06	3.5		0.4		0.7		1.5			
41	wetland	wetland	stable wetland	stable wetland	4.47E+08	446.9		45.8							
42	wetland	water	wetland loss	water gain	4.28E+07	42.8		4.4		8.1		25.9			
43	water	forest	water loss	forest gain	2.04E+06	2.0	567.2	0.4	139.9	1.5	165.6	0.2	592.8	25.7	4.5
44	water	barren	water loss	barren gain	1.35E+06	1.3		0.2	24.7	1.0	29.2	0.3			
45	water	grass	water loss	grassland gain	4.98E+07	49.8		8.8		35.6		0.6			
46	water	crop	water loss	cropland gain	3.69E+07	36.9		6.5		26.4		0.6			
47	water	urban	water loss	urban gain	3.87E+05	0.4		0.1		0.3		0.2			
48	water	wetland	water loss	wetland gain	4.94E+07	49.4		8.7		35.3		7.8			
49	water	water	stable water	stable water	4.27E+08	427.2		75.3							

Per country total, sq m	6.83E+10
Per country total, sq km	68,256.3
Percentage from total	28.4
Total country area	86600
Percentage from country	78.8

Appendix 2.2.3.1. 50-year changes (1965-2015) in land cover and change percentages within our entire study area.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	5.78E+10	57,764.2	72,601.6	79.6	14,837.4		14,001.8		71,766.0	-835.6	-1.2
2	forest	barren	forest loss	barren gain	2.23E+08	222.8		0.3	20.4	1.5	19.3	5.4			
3	forest	grass	forest loss	grassland gain	1.15E+10	11,496.1		15.8		77.5		32.7			
4	forest	crop	forest loss	cropland gain	2.58E+09	2,577.7		3.6		17.4		17.4			
5	forest	urban	forest loss	urban gain	3.55E+07	35.5		0.0		0.2		7.0			
6	forest	wetland	forest loss	wetland gain	3.60E+08	360.2		0.5		2.4		10.9			
7	forest	water	forest loss	water gain	1.45E+08	145.0		0.2		1.0		17.2			
8	barren	forest	barren loss	forest gain	1.21E+08	120.7	2,336.0	5.2	1,180.7	10.2	4,095.0	0.9	5,250.2	2,914.2	124.8
9	barren	barren	stable barren	stable barren	1.16E+09	1,155.2		49.5	50.5		175.3				
10	barren	grass	barren loss	grassland gain	9.48E+08	948.4		40.6		80.3		2.7			
11	barren	crop	barren loss	cropland gain	7.60E+07	76.0		3.3		6.4		0.5			
12	barren	urban	barren loss	urban gain	2.26E+06	2.3		0.1		0.2		0.4			
13	barren	wetland	barren loss	wetland gain	2.20E+07	22.0		0.9		1.9		0.7			
14	barren	water	barren loss	water gain	1.13E+07	11.3		0.5		1.0		1.3			
15	grass	forest	grassland loss	forest gain	9.64E+09	9,641.8	93,363.3	10.3	24,674.7	39.1	35,131.7	68.9	103,820.2	10,456.9	11.2
16	grass	barren	grassland loss	barren gain	3.71E+09	3,714.7		4.0	26.4	15.1	37.6	90.7			
17	grass	grass	stable grassland	stable grass	6.87E+10	68,688.5		73.6							
18	grass	crop	grassland loss	cropland gain	1.05E+10	10,537.9		11.3		42.7		71.3			
19	grass	urban	grassland loss	urban gain	1.65E+08	165.1		0.2		0.7		32.8			
20	grass	wetland	grassland loss	wetland gain	4.83E+08	482.6		0.5		2.0		14.6			
21	grass	water	grassland loss	water gain	1.33E+08	132.8		0.1		0.5		15.7			
22	crop	forest	cropland loss	forest gain	3.39E+09	3,391.8	64,114.3	5.3	26,501.6	12.8	14,778.6	24.2	52,391.4	-11,723.0	-18.3
23	crop	barren	cropland loss	barren gain	9.65E+07	96.5		0.2	41.3	0.4	23.1	2.4			
24	crop	grass	cropland loss	grassland gain	2.03E+10	20,268.4		31.6		76.5		57.7			
25	crop	crop	stable cropland	stable cropland	3.76E+10	37,612.7		58.7							
26	crop	urban	cropland loss	urban gain	2.82E+08	282.0		0.4		1.1		56.0			
27	crop	wetland	cropland loss	wetland gain	2.00E+09	2,004.3		3.1		7.6		60.8			
28	crop	water	cropland loss	water gain	4.59E+08	458.6		0.7		1.7		54.3			
29	urban	forest	urban loss	forest gain	4.10E+08	410.2	3,916.3	10.5	3,535.0	11.6	503.8	2.9	885.1	-3,031.2	-77.4
30	urban	barren	urban loss	barren gain	4.36E+07	43.6		1.1	90.3	1.2	12.9	1.1			
31	urban	grass	urban loss	grass gain	1.82E+09	1,824.4		46.6		51.6		5.2			
32	urban	crop	urban loss	crop gain	1.03E+09	1,027.9		26.2		29.1		7.0			
33	urban	urban	stable urban	stable urban	3.81E+08	381.2		9.7							
34	urban	wetland	urban loss	wetland gain	1.90E+08	189.6		4.8		5.4		5.8			
35	urban	water	urban loss	water gain	3.94E+07	39.4		1.0		1.1		4.7			
36	wetland	forest	wetland loss	forest gain	1.39E+07	13.9	623.8	2.2	469.6	3.0	3,296.4	0.1	3,450.7	2,826.8	453.2
37	wetland	barren	wetland loss	barren gain	1.20E+06	1.2		0.2	75.3	0.3	528.4	0.0			
38	wetland	grass	wetland loss	grassland gain	1.90E+08	190.3		30.5		40.5		0.5			
39	wetland	crop	wetland loss	cropland gain	2.04E+08	204.0		32.7		43.4		1.4			
40	wetland	urban	wetland loss	urban gain	2.43E+06	2.4		0.4		0.5		0.5			
41	wetland	wetland	stable wetland	stable wetland	1.54E+08	154.2		24.7							
42	wetland	water	wetland loss	water gain	5.78E+07	57.8		9.3		12.3		6.8			
43	water	forest	water loss	forest gain	4.23E+08	423.4	3,287.5	12.9	1,453.0	29.1	844.8	3.0	2,679.2	-608.2	-18.5
44	water	barren	water loss	barren gain	1.62E+07	16.2		0.5	44.2	1.1	25.7	0.4			
45	water	grass	water loss	grassland gain	4.04E+08	404.0		12.3		27.8		1.2			
46	water	crop	water loss	cropland gain	3.55E+08	355.1		10.8		24.4		2.4			
47	water	urban	water loss	urban gain	1.65E+07	16.5		0.5		1.1		3.3			
48	water	wetland	water loss	wetland gain	2.38E+08	237.8		7.2		16.4		7.2			
49	water	water	stable water	stable water	1.83E+09	1,834.5		55.8							
	Total					240,242.8									

Appendix 2.2.3.2. 50-year changes (1965-2015) in land cover and change percentages within Russian Caucasus.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.59E+10	25,917.7	31,540.6	82.2	5,622.8		6,526.4		32,444.1	903.6	2.9
2	forest	barren	forest loss	barren gain	1.46E+08	145.5		0.5	17.8	2.6	20.7	5.8			
3	forest	grass	forest loss	grassland gain	4.38E+09	4,378.1		13.9		77.9		39.9			
4	forest	crop	forest loss	cropland gain	8.04E+08	804.0		2.5		14.3		20.3			
5	forest	urban	forest loss	urban gain	1.54E+07	15.4		0.0		0.3		7.2			
6	forest	wetland	forest loss	wetland gain	1.92E+08	192.2		0.6		3.4		11.9			
7	forest	water	forest loss	water gain	8.77E+07	87.7		0.3		1.6		21.2			
8	barren	forest	barren loss	forest gain	6.87E+07	68.7	1,396.1	4.9	554.7	12.4	2,506.4	1.1	3,347.8	1,951.7	139.8
9	barren	barren	stable barren	stable barren	8.41E+08	841.4		60.3	39.7		179.5				
10	barren	grass	barren loss	grassland gain	3.94E+08	394.1		28.2		71.0		3.6			
11	barren	crop	barren loss	cropland gain	6.17E+07	61.7		4.4		11.1		1.6			
12	barren	urban	barren loss	urban gain	1.20E+06	1.2		0.1		0.2		0.6			
13	barren	wetland	barren loss	wetland gain	1.86E+07	18.6		1.3		3.4		1.2			
14	barren	water	barren loss	water gain	1.05E+07	10.5		0.7		1.9		2.5			
15	grass	forest	grassland loss	forest gain	4.12E+09	4,121.8	28,504.8	14.5	8,716.3	47.3	10,960.5	63.2	30,749.0	2,244.2	7.9
16	grass	barren	grassland loss	barren gain	2.30E+09	2,301.1		8.1	30.6	26.4	38.5	91.8			
17	grass	grass	stable grasslanc	stable grass	1.98E+10	19,788.5		69.4							
18	grass	crop	grassland loss	cropland gain	2.10E+09	2,097.1		7.4		24.1		52.9			
19	grass	urban	grassland loss	urban gain	5.09E+07	50.9		0.2		0.6		23.8			
20	grass	wetland	grassland loss	wetland gain	1.15E+08	114.6		0.4		1.3		7.1			
21	grass	water	grassland loss	water gain	3.08E+07	30.8		0.1		0.4		7.5			
22	crop	forest	cropland loss	forest gain	1.60E+09	1,602.4	28,334.5	5.7	7,975.2	20.1	3,960.6	24.6	24,319.9	-4,014.6	-14.2
23	crop	barren	cropland loss	barren gain	3.70E+07	37.0		0.1	28.1	0.5	14.0	1.5			
24	crop	grass	cropland loss	grassland gain	5.00E+09	5,000.4		17.6		62.7		45.6			
25	crop	crop	stable cropland	stable cropland	2.04E+10	20,359.4		71.9							
26	crop	urban	cropland loss	urban gain	1.35E+08	135.3		0.5		1.7		63.4			
27	crop	wetland	cropland loss	wetland gain	9.85E+08	984.9		3.5		12.3		61.2			
28	crop	water	cropland loss	water gain	2.15E+08	215.2		0.8		2.7		52.1			
29	urban	forest	urban loss	forest gain	3.23E+08	323.5	2,332.7	13.9	2,112.1	15.3	213.5	5.0	434.1	-1,898.6	-81.4
30	urban	barren	urban loss	barren gain	1.28E+07	12.8		0.5	90.5	0.6	9.2	0.5			
31	urban	grass	urban loss	grass gain	9.15E+08	914.9		39.2		43.3		8.3			
32	urban	crop	urban loss	crop gain	6.87E+08	687.2		29.5		32.5		17.3			
33	urban	urban	stable urban	stable urban	2.21E+08	220.5		9.5							
34	urban	wetland	urban loss	wetland gain	1.46E+08	145.5		6.2		6.9		9.0			
35	urban	water	urban loss	water gain	2.83E+07	28.3		1.2		1.3		6.9			
36	wetland	forest	wetland loss	forest gain	1.05E+07	10.5	234.0	4.5	205.4	5.1	1,609.5	0.2	1,638.1	1,404.2	600.1
37	wetland	barren	wetland loss	barren gain	1.00E+05	0.1		0.0	87.8	0.0	687.9	0.0			
38	wetland	grass	wetland loss	grassland gain	6.48E+07	64.8		27.7		31.5		0.6			
39	wetland	crop	wetland loss	cropland gain	8.83E+07	88.3		37.8		43.0		2.2			
40	wetland	urban	wetland loss	urban gain	1.35E+06	1.3		0.6		0.7		0.6			
41	wetland	wetland	stable wetland	stable wetland	2.86E+07	28.6		12.2							
42	wetland	water	wetland loss	water gain	4.03E+07	40.3		17.2		19.6		9.8			
43	water	forest	water loss	forest gain	4.00E+08	399.5	1,153.3	34.6	1,003.1	39.8	412.7	6.1	562.9	-590.3	-51.2
44	water	barren	water loss	barren gain	9.87E+06	9.9		0.9	87.0	1.0	35.8	0.4			
45	water	grass	water loss	grassland gain	2.08E+08	208.2		18.1		20.8		1.9			
46	water	crop	water loss	cropland gain	2.22E+08	222.3		19.3		22.2		5.6			
47	water	urban	water loss	urban gain	9.37E+06	9.4		0.8		0.9		4.4			
48	water	wetland	water loss	wetland gain	1.54E+08	153.7		13.3		15.3		9.6			
49	water	water	stable water	stable water	1.50E+08	150.2		13.0							

Per country total, sq m	9.35E+10
Per country total, sq km	93,496.0
Percentage from total	38.9
Total country area	17098242
Percentage from country	0.5

Appendix 2.2.3.3. 50-year changes (1965-2015) in land cover and change percentages within Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.30E+10	22,967.8	25,944.2	88.5	2,976.4		5,139.9		28,107.7	2,163.5	8.3
2	forest	barren	forest loss	barren gain	4.70E+07	47.0		0.2	11.5	1.6	19.8	11.2			
3	forest	grass	forest loss	grassland gain	2.43E+09	2,425.8		9.3		81.5		34.0			
4	forest	crop	forest loss	cropland gain	4.14E+08	414.1		1.6		13.9		23.7			
5	forest	urban	forest loss	urban gain	5.39E+06	5.4		0.0		0.2		9.1			
6	forest	wetland	forest loss	wetland gain	6.61E+07	66.1		0.3		2.2		11.4			
7	forest	water	forest loss	water gain	1.81E+07	18.1		0.1		0.6		16.0			
8	barren	forest	barren loss	forest gain	4.88E+07	48.8	467.1	10.5	283.5	17.2	421.1	0.9	604.7	137.6	29.5
9	barren	barren	stable barren	stable barren	1.84E+08	183.6		39.3	60.7		90.1				
10	barren	grass	barren loss	grassland gain	2.24E+08	224.0		48.0		79.0		3.1			
11	barren	crop	barren loss	cropland gain	5.74E+06	5.7		1.2		2.0		0.3			
12	barren	urban	barren loss	urban gain	8.65E+05	0.9		0.2		0.3		1.5			
13	barren	wetland	barren loss	wetland gain	3.34E+06	3.3		0.7		1.2		0.6			
14	barren	water	barren loss	water gain	6.47E+05	0.6		0.1		0.2		0.6			
15	grass	forest	grassland loss	forest gain	3.71E+09	3,712.4	15,055.8	24.7	5,289.1	70.2	7,124.9	72.2	16,891.6	1,835.8	12.2
16	grass	barren	grassland loss	barren gain	3.57E+08	356.5		2.4	35.1	6.7	47.3	84.7			
17	grass	grass	stable grasslanc	stable grass	9.77E+09	9,766.7		64.9							
18	grass	crop	grassland loss	cropland gain	1.14E+09	1,137.9		7.6		21.5		65.0			
19	grass	urban	grassland loss	urban gain	1.08E+07	10.8		0.1		0.2		18.1			
20	grass	wetland	grassland loss	wetland gain	5.72E+07	57.2		0.4		1.1		9.9			
21	grass	water	grassland loss	water gain	1.43E+07	14.3		0.1		0.3		12.7			
22	crop	forest	cropland loss	forest gain	1.31E+09	1,308.9	11,648.4	11.2	5,963.2	21.9	1,750.5	25.5	7,435.7	-4,212.7	-36.2
23	crop	barren	cropland loss	barren gain	1.04E+07	10.4		0.1	51.2	0.2	15.0	2.5			
24	crop	grass	cropland loss	grassland gain	4.13E+09	4,129.1		35.4		69.2		58.0			
25	crop	crop	stable cropland	stable cropland	5.69E+09	5,685.2		48.8							
26	crop	urban	cropland loss	urban gain	3.88E+07	38.8		0.3		0.7		65.3			
27	crop	wetland	cropland loss	wetland gain	3.99E+08	398.6		3.4		6.7		69.0			
28	crop	water	cropland loss	water gain	7.73E+07	77.3		0.7		1.3		68.5			
29	urban	forest	urban loss	forest gain	5.47E+07	54.7	528.4	10.4	485.2	11.3	59.5	1.1	102.7	-425.7	-80.6
30	urban	barren	urban loss	barren gain	5.75E+06	5.7		1.1	91.8	1.2	11.3	1.4			
31	urban	grass	urban loss	grass gain	2.67E+08	267.0		50.5		55.0		3.7			
32	urban	crop	urban loss	crop gain	1.34E+08	134.4		25.4		27.7		7.7			
33	urban	urban	stable urban	stable urban	4.32E+07	43.2		8.2							
34	urban	wetland	urban loss	wetland gain	2.09E+07	20.9		4.0		4.3		3.6			
35	urban	water	urban loss	water gain	2.50E+06	2.5		0.5		0.5		2.2			
36	wetland	forest	wetland loss	forest gain	2.89E+05	0.3	4.8	6.1	4.2	6.9	577.9	0.0	578.4	573.7	12,077.2
37	wetland	barren	wetland loss	barren gain	2.52E+04	0.0		0.5	88.2	0.6	12,165.4	0.0			
38	wetland	grass	wetland loss	grassland gain	2.44E+06	2.4		51.3		58.2		0.0			
39	wetland	crop	wetland loss	cropland gain	1.35E+06	1.4		28.5		32.3		0.1			
40	wetland	urban	wetland loss	urban gain	4.61E+03	0.0		0.1		0.1		0.0			
41	wetland	wetland	stable wetland	stable wetland	5.61E+05	0.6		11.8							
42	wetland	water	wetland loss	water gain	8.02E+04	0.1		1.7		1.9		0.1			
43	water	forest	water loss	forest gain	1.47E+07	14.7	311.1	4.7	185.1	8.0	112.9	0.3	238.9	-72.2	-23.2
44	water	barren	water loss	barren gain	1.40E+06	1.4		0.5	59.5	0.8	36.3	0.3			
45	water	grass	water loss	grassland gain	7.66E+07	76.6		24.6		41.4		1.1			
46	water	crop	water loss	cropland gain	5.70E+07	57.0		18.3		30.8		3.3			
47	water	urban	water loss	urban gain	3.65E+06	3.7		1.2		2.0		6.1			
48	water	wetland	water loss	wetland gain	3.17E+07	31.7		10.2		17.1		5.5			
49	water	water	stable water	stable water	1.26E+08	126.0		40.5							

Per country total, sq m	5.40E+10
Per country total, sq km	53,959.8
Percentage from total	22.5
Total country area	69681
Percentage from country	77.4

Appendix 2.2.3.4. 50-year changes (1965-2015) in land cover and change percentages within Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.72E+09	2,718.4	4,018.2	67.7	1,299.9		651.7		3,370.1	-648.1	-16.1
2	forest	barren	forest loss	barren gain	2.52E+06	2.5		0.1	32.3	0.2	16.2	2.2			
3	forest	grass	forest loss	grassland gain	1.12E+09	1,119.7		27.9		86.1		28.6			
4	forest	crop	forest loss	cropland gain	1.71E+08	171.0		4.3		13.2		8.2			
5	forest	urban	forest loss	urban gain	2.24E+06	2.2		0.1		0.2		7.1			
6	forest	wetland	forest loss	wetland gain	3.42E+06	3.4		0.1		0.3		2.4			
7	forest	water	forest loss	water gain	1.02E+06	1.0		0.0		0.1		4.5			
8	barren	forest	barren loss	forest gain	6.11E+05	0.6	179.6	0.3	146.1	0.4	112.7	0.1	146.1	-33.5	-18.6
9	barren	barren	stable barren	stable barren	3.35E+07	33.5		18.6	81.4		62.7				
10	barren	grass	barren loss	grassland gain	1.42E+08	141.6		78.9		96.9		3.6			
11	barren	crop	barren loss	cropland gain	3.76E+06	3.8		2.1		2.6		0.2			
12	barren	urban	barren loss	urban gain	5.49E+03	0.0		0.0		0.0		0.0			
13	barren	wetland	barren loss	wetland gain	6.22E+03	0.0		0.0		0.0		0.0			
14	barren	water	barren loss	water gain	1.05E+05	0.1		0.1		0.1		0.5			
15	grass	forest	grassland loss	forest gain	5.91E+08	591.1	13,642.7	4.3	2,586.8	22.8	3,909.7	90.7	14,965.7	1,323.0	9.7
16	grass	barren	grassland loss	barren gain	1.03E+08	103.1		0.8	19.0	4.0	28.7	91.5			
17	grass	grass	stable grasslanc	stable grass	1.11E+10	11,056.0		81.0							
18	grass	crop	grassland loss	cropland gain	1.86E+09	1,855.1		13.6		71.7		89.0			
19	grass	urban	grassland loss	urban gain	1.24E+07	12.4		0.1		0.5		39.3			
20	grass	wetland	grassland loss	wetland gain	2.11E+07	21.1		0.2		0.8		15.1			
21	grass	water	grassland loss	water gain	4.00E+06	4.0		0.0		0.2		17.7			
22	crop	forest	cropland loss	forest gain	5.24E+07	52.4	5,007.4	1.0	2,663.6	2.0	2,084.6	8.0	4,428.4	-579.0	-11.6
23	crop	barren	cropland loss	barren gain	4.09E+06	4.1		0.1	53.2	0.2	41.6	3.6			
24	crop	grass	cropland loss	grassland gain	2.47E+09	2,472.1		49.4		92.8		63.2			
25	crop	crop	stable cropland	stable cropland	2.34E+09	2,343.8		46.8							
26	crop	urban	cropland loss	urban gain	1.65E+07	16.5		0.3		0.6		52.2			
27	crop	wetland	cropland loss	wetland gain	1.02E+08	101.9		2.0		3.8		72.6			
28	crop	water	cropland loss	water gain	1.67E+07	16.7		0.3		0.6		74.1			
29	urban	forest	urban loss	forest gain	7.09E+06	7.1	248.4	2.9	219.3	3.2	31.5	1.1	60.7	-187.7	-75.6
30	urban	barren	urban loss	barren gain	2.69E+06	2.7		1.1	88.3	1.2	12.7	2.4			
31	urban	grass	urban loss	grass gain	1.61E+08	161.5		65.0		73.6		4.1			
32	urban	crop	urban loss	crop gain	4.29E+07	42.9		17.3		19.6		2.1			
33	urban	urban	stable urban	stable urban	2.91E+07	29.1		11.7							
34	urban	wetland	urban loss	wetland gain	4.42E+06	4.4		1.8		2.0		3.1			
35	urban	water	urban loss	water gain	7.17E+05	0.7		0.3		0.3		3.2			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0	0.0	0.0	0.0	140.3	0.0	140.3	140.3	599,953.0
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0		0.0	100.0	0.0	600,053.0	0.0			
38	wetland	grass	wetland loss	grassland gain	1.99E+04	0.0		85.3		85.3		0.0			
39	wetland	crop	wetland loss	cropland gain	2.75E+03	0.0		11.8		11.8		0.0			
40	wetland	urban	wetland loss	urban gain	6.87E+02	0.0		2.9		2.9		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0		0.0		0.0		0.0			
43	water	forest	water loss	forest gain	5.97E+05	0.6	1,296.6	0.0	37.5	1.6	22.6	0.1	1,281.7	-14.9	-1.2
44	water	barren	water loss	barren gain	3.04E+05	0.3		0.0	2.9	0.8	1.7	0.3			
45	water	grass	water loss	grassland gain	1.49E+07	14.9		1.1		39.7		0.4			
46	water	crop	water loss	cropland gain	1.18E+07	11.8		0.9		31.6		0.6			
47	water	urban	water loss	urban gain	4.28E+05	0.4		0.0		1.1		1.4			
48	water	wetland	water loss	wetland gain	9.45E+06	9.4		0.7		25.2		6.7			
49	water	water	stable water	stable water	1.26E+09	1,259.1		97.1							

Per country total, sq m	2.44E+10
Per country total, sq km	24,393.0
Percentage from total	10.2
Total country area	29743
Percentage from country	82.0

Appendix 2.2.3.5. 50-year changes (1965-2015) in land cover and change percentages within Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Percent from total	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	6.16E+09	6,160.3	11,098.6	55.5	4,938.2		1,683.7		7,844.0	-3,254.5	-29.3
2	forest	barren	forest loss	barren gain	2.77E+07	27.7		0.2	44.5	0.6	15.2	2.6			
3	forest	grass	forest loss	grassland gain	3.57E+09	3,572.6		32.2		72.3		27.2			
4	forest	crop	forest loss	cropland gain	1.19E+09	1,188.7		10.7		24.1		17.0			
5	forest	urban	forest loss	urban gain	1.25E+07	12.5		0.1		0.3		6.3			
6	forest	wetland	forest loss	wetland gain	9.85E+07	98.5		0.9		2.0		10.2			
7	forest	water	forest loss	water gain	3.83E+07	38.3		0.3		0.8		12.9			
8	barren	forest	barren loss	forest gain	2.63E+06	2.6	293.2	0.9	196.4	1.3	1,054.9	0.2	1,151.6	858.5	292.8
9	barren	barren	stable barren	stable barren	9.67E+07	96.7		33.0	67.0		359.8				
10	barren	grass	barren loss	grassland gain	1.89E+08	188.6		64.3		96.0		1.4			
11	barren	crop	barren loss	cropland gain	4.87E+06	4.9		1.7		2.5		0.1			
12	barren	urban	barren loss	urban gain	1.84E+05	0.2		0.1		0.1		0.1			
13	barren	wetland	barren loss	wetland gain	6.17E+04	0.1		0.0		0.0		0.0			
14	barren	water	barren loss	water gain	6.35E+04	0.1		0.0		0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.22E+09	1,216.5	36,159.9	3.4	8,082.6	15.1	13,136.5	72.2	41,213.8	5,053.9	14.0
16	grass	barren	grassland loss	barren gain	9.54E+08	954.0		2.6	22.4	11.8	36.3	90.4			
17	grass	grass	stable grasslanc	stable grass	2.81E+10	28,077.3		77.6							
18	grass	crop	grassland loss	cropland gain	5.45E+09	5,447.8		15.1		67.4		78.0			
19	grass	urban	grassland loss	urban gain	9.10E+07	91.0		0.3		1.1		45.7			
20	grass	wetland	grassland loss	wetland gain	2.90E+08	289.6		0.8		3.6		29.9			
21	grass	water	grassland loss	water gain	8.36E+07	83.6		0.2		1.0		28.2			
22	crop	forest	cropland loss	forest gain	4.28E+08	428.2	19,124.0	2.2	9,899.6	4.3	6,983.0	25.4	16,207.4	-2,916.6	-15.3
23	crop	barren	cropland loss	barren gain	4.51E+07	45.1		0.2	51.8	0.5	36.5	4.3			
24	crop	grass	cropland loss	grassland gain	8.67E+09	8,666.8		45.3		87.5		66.0			
25	crop	crop	stable cropland	stable cropland	9.22E+09	9,224.4		48.2							
26	crop	urban	cropland loss	urban gain	9.14E+07	91.4		0.5		0.9		45.9			
27	crop	wetland	cropland loss	wetland gain	5.19E+08	518.8		2.7		5.2		53.6			
28	crop	water	cropland loss	water gain	1.49E+08	149.3		0.8		1.5		50.3			
29	urban	forest	urban loss	forest gain	2.49E+07	24.9	806.8	3.1	718.4	3.5	199.3	1.5	287.6	-519.1	-64.3
30	urban	barren	urban loss	barren gain	2.24E+07	22.4		2.8	89.0	3.1	24.7	2.1			
31	urban	grass	urban loss	grass gain	4.81E+08	481.1		59.6		67.0		3.7			
32	urban	crop	urban loss	crop gain	1.63E+08	163.4		20.3		22.7		2.3			
33	urban	urban	stable urban	stable urban	8.84E+07	88.4		11.0							
34	urban	wetland	urban loss	wetland gain	1.87E+07	18.7		2.3		2.6		1.9			
35	urban	water	urban loss	water gain	7.85E+06	7.9		1.0		1.1		2.6			
36	wetland	forest	wetland loss	forest gain	3.04E+06	3.0	385.1	0.8	260.0	1.2	968.7	0.2	1,093.8	708.7	184.1
37	wetland	barren	wetland loss	barren gain	1.07E+06	1.1		0.3	67.5	0.4	251.6	0.1			
38	wetland	grass	wetland loss	grassland gain	1.23E+08	123.1		32.0		47.3		0.9			
39	wetland	crop	wetland loss	cropland gain	1.14E+08	114.3		29.7		44.0		1.6			
40	wetland	urban	wetland loss	urban gain	1.08E+06	1.1		0.3		0.4		0.5			
41	wetland	wetland	stable wetland	stable wetland	1.25E+08	125.1		32.5							
42	wetland	water	wetland loss	water gain	1.74E+07	17.4		4.5		6.7		5.9			
43	water	forest	water loss	forest gain	8.53E+06	8.5	526.5	1.6	227.4	3.8	296.5	0.5	595.7	69.2	13.1
44	water	barren	water loss	barren gain	4.61E+06	4.6		0.9	43.2	2.0	56.3	0.4			
45	water	grass	water loss	grassland gain	1.04E+08	104.3		19.8		45.9		0.8			
46	water	crop	water loss	cropland gain	6.39E+07	63.9		12.1		28.1		0.9			
47	water	urban	water loss	urban gain	3.08E+06	3.1		0.6		1.4		1.5			
48	water	wetland	water loss	wetland gain	4.29E+07	42.9		8.1		18.9		4.4			
49	water	water	stable water	stable water	2.99E+08	299.2		56.8							

Per country total, sq m	6.84E+10
Per country total, sq km	68,394.0
Percentage from total	28.5
Total country area	86600
Percentage from country	79.0

Appendix 2.2.4. Per-country administrative units within our study area (consistent with Appendix 2.1.9)

						Contents:		
			Total area, sq km	Area within our study region, sq km	% area within our study region	1965-'87	1987-2015	1965-2015
RUS	1	Krasnodarskiy Kraj	75,617.2	30,034.5	39.7	Appendix 2.2.4.1.1	Appendix 2.2.4.1.2	Appendix 2.2.4.1.3
RUS	2	Respublika Adygeya	7,784.3	7,634.4	98.1	Appendix 2.2.4.2.1	Appendix 2.2.4.2.2	Appendix 2.2.4.2.3
RUS	3	Stavropolskij kraj	66,180.3	7,196.9	10.9	Appendix 2.2.4.3.1	Appendix 2.2.4.3.2	Appendix 2.2.4.3.3
RUS	4	Karachayevo-Cherkesskaya respublika	14,278.5	6,171.6	43.2	Appendix 2.2.4.4.1	Appendix 2.2.4.4.2	Appendix 2.2.4.4.3
RUS	5	Kabardino-Balkarskaya respublika	12,455.1	10,269.0	82.4	Appendix 2.2.4.5.1	Appendix 2.2.4.5.2	Appendix 2.2.4.5.3
RUS	6	Respublika Severnaya Osetiya	7,998.5	6,621.6	82.8	Appendix 2.2.4.6.1	Appendix 2.2.4.6.2	Appendix 2.2.4.6.3
RUS	7	Ingushskaja respublika	3,097.9	2,732.3	88.2	Appendix 2.2.4.7.1	Appendix 2.2.4.7.2	Appendix 2.2.4.7.3
RUS	8	Chechenskaja respublika	16,155.4	4,350.2	26.9	Appendix 2.2.4.8.1	Appendix 2.2.4.8.2	Appendix 2.2.4.8.3
RUS	9	Respublika Dagestan	49,932.3	29,919.7	59.9	Appendix 2.2.4.9.1	Appendix 2.2.4.9.2	Appendix 2.2.4.9.3
GEO	10	Abkhazeti	8,671.3	5,356.0	61.8	Appendix 2.2.4.10.1	Appendix 2.2.4.10.2	Appendix 2.2.4.10.3
GEO	11	Samegrelo-Zemo Svaneti	7,549.2	4,343.1	57.5	Appendix 2.2.4.11.1	Appendix 2.2.4.11.2	Appendix 2.2.4.11.3
GEO	12	Guria	2,048.3	982.0	47.9	Appendix 2.2.4.12.1	Appendix 2.2.4.12.2	Appendix 2.2.4.12.3
GEO	13	Atchara	2,894.0	455.6	15.7	Appendix 2.2.4.13.1	Appendix 2.2.4.13.2	Appendix 2.2.4.13.3
GEO	14	Ratcha-Lechkhumi	5,069.7	3,466.7	68.4	Appendix 2.2.4.14.1	Appendix 2.2.4.14.2	Appendix 2.2.4.14.3
GEO	15	Imereti	6,520.1	6,292.6	96.5	Appendix 2.2.4.15.1	Appendix 2.2.4.15.2	Appendix 2.2.4.15.3
GEO	16	Samtskhe-Javakheti	6,437.5	5,286.8	82.1	Appendix 2.2.4.16.1	Appendix 2.2.4.16.2	Appendix 2.2.4.16.3
GEO	17	Shida Kartli	5,686.9	5,152.7	90.6	Appendix 2.2.4.17.1	Appendix 2.2.4.17.2	Appendix 2.2.4.17.3
GEO	18	Mtskheta-Mtianeti	6,791.7	5,669.2	83.5	Appendix 2.2.4.18.1	Appendix 2.2.4.18.2	Appendix 2.2.4.18.3
GEO	19	Kvemo Kartli	6,424.4	6,324.7	98.4	Appendix 2.2.4.19.1	Appendix 2.2.4.19.2	Appendix 2.2.4.19.3
GEO	20	Tbilisi	225.1	224.9	99.9	Appendix 2.2.4.20.1	Appendix 2.2.4.20.2	Appendix 2.2.4.20.3
GEO	21	Kakheti	11,337.7	10,392.8	91.7	Appendix 2.2.4.21.1	Appendix 2.2.4.21.2	Appendix 2.2.4.21.3
ARM	22	Shirak	2,720.2	2,502.5	92.0	Appendix 2.2.4.22.1	Appendix 2.2.4.22.2	Appendix 2.2.4.22.3
ARM	23	Aragatsotn	2,737.8	2,663.0	97.3	Appendix 2.2.4.23.1	Appendix 2.2.4.23.2	Appendix 2.2.4.23.3
ARM	24	Armavir	1,264.5	1,264.3	100.0	Appendix 2.2.4.24.1	Appendix 2.2.4.24.2	Appendix 2.2.4.24.3
ARM	25	Lori	3,765.8	3,719.5	98.8	Appendix 2.2.4.25.1	Appendix 2.2.4.25.2	Appendix 2.2.4.25.3
ARM	26	Kotayk	2,116.4	1,882.6	89.0	Appendix 2.2.4.26.1	Appendix 2.2.4.26.2	Appendix 2.2.4.26.3
ARM	27	Yerevan	233.3	233.3	100.0	Appendix 2.2.4.27.1	Appendix 2.2.4.27.2	Appendix 2.2.4.27.3
ARM	28	Ararat	2,116.7	1,791.5	84.6	Appendix 2.2.4.28.1	Appendix 2.2.4.28.2	Appendix 2.2.4.28.3
ARM	29	Tavush	2,728.4	2,712.4	99.4	Appendix 2.2.4.29.1	Appendix 2.2.4.29.2	Appendix 2.2.4.29.3
ARM	30	Gegharkunik	5,250.7	4,574.2	87.1	Appendix 2.2.4.30.1	Appendix 2.2.4.30.2	Appendix 2.2.4.30.3
ARM	31	Vayots Dzor	2,298.4	952.2	41.4	Appendix 2.2.4.31.1	Appendix 2.2.4.31.2	Appendix 2.2.4.31.3
ARM	32	Syunik	4,495.8	2,097.5	46.7	Appendix 2.2.4.32.1	Appendix 2.2.4.32.2	Appendix 2.2.4.32.3
AZE	33	Ganja-Gazakh	12,289.4	11,705.6	95.2	Appendix 2.2.4.33.1	Appendix 2.2.4.33.2	Appendix 2.2.4.33.3
AZE	34	Kalbajar-Lachin	6,057.4	4,388.3	72.4	Appendix 2.2.4.34.1	Appendix 2.2.4.34.2	Appendix 2.2.4.34.3
AZE	35	Nakhchivan	5,329.8	1,090.8	20.5	Appendix 2.2.4.35.1	Appendix 2.2.4.35.2	Appendix 2.2.4.35.3
AZE	36	Yukhari Karabakh	7,533.5	6,596.5	87.6	Appendix 2.2.4.36.1	Appendix 2.2.4.36.2	Appendix 2.2.4.36.3
AZE	37	Sheki-Zagatala	8,771.4	7,785.8	88.8	Appendix 2.2.4.37.1	Appendix 2.2.4.37.2	Appendix 2.2.4.37.3
AZE	38	Aran	21,605.9	18,506.1	85.7	Appendix 2.2.4.38.1	Appendix 2.2.4.38.2	Appendix 2.2.4.38.3
AZE	39	Guba-Khachmaz	6,882.1	6,317.0	91.8	Appendix 2.2.4.39.1	Appendix 2.2.4.39.2	Appendix 2.2.4.39.3
AZE	40	Daghlig Shirvan	5,965.1	5,741.9	96.3	Appendix 2.2.4.40.1	Appendix 2.2.4.40.2	Appendix 2.2.4.40.3
AZE	41	Absheron	6,024.1	5,197.7	86.3	Appendix 2.2.4.41.1	Appendix 2.2.4.41.2	Appendix 2.2.4.41.3
AZE	42	Lankaran	5,595.7	1,064.2	19.0	Appendix 2.2.4.42.1	Appendix 2.2.4.42.2	Appendix 2.2.4.42.3

Appendix 2.2.4.1.1. Soviet era changes (1965-'87) in land cover and change percentages within Krasnodarskiy Kraj, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.28E+10	12,757.6	13,625.5	93.6	867.9		1,942.1		14,699.8	1,074.3	7.9
2	forest	barren	forest loss	barren gain	9.87E+06	9.9	45.3		6.4	1.1	14.3	7.5			
3	forest	grass	forest loss	grassland gain	2.06E+08	205.7				23.7		16.1			
4	forest	crop	forest loss	cropland gain	4.28E+08	427.5				49.3		20.9			
5	forest	urban	forest loss	urban gain	1.32E+06	1.3				0.2		5.6			
6	forest	wetland	forest loss	wetland gain	2.15E+08	214.9				24.8		36.9			
7	forest	water	forest loss	water gain	8.53E+06	8.5				1.0		11.1			
8	barren	forest	barren loss	forest gain	1.56E+07	15.6	169.8		126.8	12.3	131.9	0.8	174.9	5.1	3.0
9	barren	barren	stable barren	stable barren	4.30E+07	43.0	0.6	25.3	74.7		77.7				
10	barren	grass	barren loss	grassland gain	5.22E+07	52.2				41.2		4.1			
11	barren	crop	barren loss	cropland gain	4.75E+07	47.5				37.5		2.3			
12	barren	urban	barren loss	urban gain	1.07E+06	1.1				0.8		4.5			
13	barren	wetland	barren loss	wetland gain	5.07E+06	5.1				4.0		0.9			
14	barren	water	barren loss	water gain	5.33E+06	5.3				4.2		6.9			
15	grass	forest	grassland loss	forest gain	1.11E+09	1,108.4	2,428.6		1,576.6	70.3	1,274.9	57.1	2,126.9	-301.7	-12.4
16	grass	barren	grassland loss	barren gain	1.01E+08	101.0	8.1		64.9	6.4	52.5	76.6			
17	grass	grass	stable grassland	stable grass	8.52E+08	852.0		35.1							
18	grass	crop	grassland loss	cropland gain	3.42E+08	342.0				21.7		16.7			
19	grass	urban	grassland loss	urban gain	2.37E+06	2.4				0.2		10.0			
20	grass	wetland	grassland loss	wetland gain	2.02E+07	20.2				1.3		3.5			
21	grass	water	grassland loss	water gain	2.60E+06	2.6				0.2		3.4			
22	crop	forest	cropland loss	forest gain	4.53E+08	453.4	11,466.6		1,286.6	35.2	2,046.0	23.3	12,225.9	759.4	6.6
23	crop	barren	cropland loss	barren gain	7.80E+06	7.8	38.1		11.2	0.6	17.8	5.9			
24	crop	grass	cropland loss	grassland gain	5.80E+08	580.4				45.1		45.5			
25	crop	crop	stable cropland	stable cropland	1.02E+10	10,179.9		88.8							
26	crop	urban	cropland loss	urban gain	1.56E+07	15.6				1.2		66.1			
27	crop	wetland	cropland loss	wetland gain	1.94E+08	193.7				15.1		33.3			
28	crop	water	cropland loss	water gain	3.57E+07	35.7				2.8		46.5			
29	urban	forest	urban loss	forest gain	1.49E+08	148.8	1,515.5		1,415.1	10.5	23.7	7.7	124.1	-1,391.4	-91.8
30	urban	barren	urban loss	barren gain	4.42E+06	4.4	5.0		93.4	0.3	1.6	3.4			
31	urban	grass	urban loss	grass gain	3.24E+08	323.9				22.9		25.4			
32	urban	crop	urban loss	crop gain	8.69E+08	868.6				61.4		42.5			
33	urban	urban	stable urban	stable urban	1.00E+08	100.5		6.6							
34	urban	wetland	urban loss	wetland gain	6.45E+07	64.5				4.6		11.1			
35	urban	water	urban loss	water gain	4.87E+06	4.9				0.3		6.3			
36	wetland	forest	wetland loss	forest gain	2.14E+06	2.1	54.4		51.0	4.2	582.0	0.1	585.5	531.0	975.6
37	wetland	barren	wetland loss	barren gain	3.43E+04	0.0	0.2		93.6	0.1	1,069.3	0.0			
38	wetland	grass	wetland loss	grassland gain	2.35E+06	2.3				4.6		0.2			
39	wetland	crop	wetland loss	cropland gain	2.64E+07	26.4				51.7		1.3			
40	wetland	urban	wetland loss	urban gain	2.51E+05	0.3				0.5		1.1			
41	wetland	wetland	stable wetland	stable wetland	3.46E+06	3.5		6.4							
42	wetland	water	wetland loss	water gain	1.98E+07	19.8				38.9		25.8			
43	water	forest	water loss	forest gain	2.14E+08	213.8	816.8		753.5	28.4	76.8	11.0	140.2	-676.6	-82.8
44	water	barren	water loss	barren gain	8.69E+06	8.7	2.7		92.2	1.2	9.4	6.6			
45	water	grass	water loss	grassland gain	1.10E+08	110.3				14.6		8.7			
46	water	crop	water loss	cropland gain	3.34E+08	334.0				44.3		16.3			
47	water	urban	water loss	urban gain	3.02E+06	3.0				0.4		12.7			
48	water	wetland	water loss	wetland gain	8.36E+07	83.6				11.1		14.4			
49	water	water	stable water	stable water	6.33E+07	63.3		7.8							
	Total					30,077.3									

Appendix 2.2.4.1.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Krasnodarskiy Kraj, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.42E+10	14,191.8	14,699.5	96.5	507.8		1,319.5		15,511.2	811.7	5.5
2	forest	barren	forest loss	barren gain	1.19E+07	11.9	48.9		3.5	2.3	9.0	27.7			
3	forest	grass	forest loss	grassland gain	2.88E+08	288.0				56.7		16.8			
4	forest	crop	forest loss	cropland gain	1.11E+08	111.4				21.9		19.6			
5	forest	urban	forest loss	urban gain	1.77E+06	1.8				0.3		1.3			
6	forest	wetland	forest loss	wetland gain	8.87E+07	88.7				17.5		13.5			
7	forest	water	forest loss	water gain	6.04E+06	6.0				1.2		9.8			
8	barren	forest	barren loss	forest gain	6.08E+06	6.1	172.5		87.3	7.0	42.8	0.5	127.9	-44.5	-25.8
9	barren	barren	stable barren	stable barren	8.51E+07	85.1	0.6	49.4	50.6		24.8				
10	barren	grass	barren loss	grassland gain	6.80E+07	68.0				77.9		4.0			
11	barren	crop	barren loss	cropland gain	5.71E+06	5.7				6.5		1.0			
12	barren	urban	barren loss	urban gain	9.81E+05	1.0				1.1		0.7			
13	barren	wetland	barren loss	wetland gain	2.13E+06	2.1				2.4		0.3			
14	barren	water	barren loss	water gain	4.44E+06	4.4				5.1		7.2			
15	grass	forest	grassland loss	forest gain	3.20E+08	320.0	2,125.7		802.4	39.9	1,718.5	24.3	3,041.9	916.1	43.1
16	grass	barren	grassland loss	barren gain	2.19E+07	21.9	7.1		37.7	2.7	80.8	51.3			
17	grass	grass	stable grassland	stable grass	1.32E+09	1,323.4		62.3							
18	grass	crop	grassland loss	cropland gain	3.45E+08	344.8				43.0		60.7			
19	grass	urban	grassland loss	urban gain	5.13E+07	51.3				6.4		38.6			
20	grass	wetland	grassland loss	wetland gain	5.25E+07	52.5				6.5		8.0			
21	grass	water	grassland loss	water gain	1.18E+07	11.8				1.5		19.3			
22	crop	forest	cropland loss	forest gain	7.11E+08	710.5	12,226.9		2,577.8	27.6	567.9	53.9	10,216.9	-2,009.9	-16.4
23	crop	barren	cropland loss	barren gain	4.38E+06	4.4	40.7		21.1	0.2	4.6	10.2			
24	crop	grass	cropland loss	grassland gain	1.28E+09	1,280.4				49.7		74.5			
25	crop	crop	stable cropland	stable cropland	9.65E+09	9,649.0		78.9							
26	crop	urban	cropland loss	urban gain	7.47E+07	74.7				2.9		56.2			
27	crop	wetland	cropland loss	wetland gain	4.91E+08	491.2				19.1		74.7			
28	crop	water	cropland loss	water gain	1.66E+07	16.6				0.6		27.0			
29	urban	forest	urban loss	forest gain	1.12E+06	1.1	124.0		65.5	1.7	133.0	0.1	191.5	67.5	54.4
30	urban	barren	urban loss	barren gain	7.47E+05	0.7	0.4		52.8	1.1	107.2	1.7			
31	urban	grass	urban loss	grass gain	4.72E+07	47.2				72.0		2.7			
32	urban	crop	urban loss	crop gain	1.36E+07	13.6				20.7		2.4			
33	urban	urban	stable urban	stable urban	5.85E+07	58.5		47.2							
34	urban	wetland	urban loss	wetland gain	2.87E+06	2.9				4.4		0.4			
35	urban	water	urban loss	water gain	4.25E+04	0.0				0.1		0.1			
36	wetland	forest	wetland loss	forest gain	2.78E+08	278.0	584.2		427.8	65.0	657.3	21.1	813.7	229.5	39.3
37	wetland	barren	wetland loss	barren gain	5.86E+05	0.6	1.9		73.2	0.1	112.5	1.4			
38	wetland	grass	wetland loss	grassland gain	3.25E+07	32.5				7.6		1.9			
39	wetland	crop	wetland loss	cropland gain	9.00E+07	90.0				21.0		15.8			
40	wetland	urban	wetland loss	urban gain	4.23E+06	4.2				1.0		3.2			
41	wetland	wetland	stable wetland	stable wetland	1.56E+08	156.4		26.8							
42	wetland	water	wetland loss	water gain	2.25E+07	22.5				5.3		36.6			
43	water	forest	water loss	forest gain	3.74E+06	3.7	101.7		31.8	11.8	61.5	0.3	131.3	29.6	29.2
44	water	barren	water loss	barren gain	3.26E+06	3.3	0.3		31.3	10.2	60.4	7.6			
45	water	grass	water loss	grassland gain	2.52E+06	2.5				7.9		0.1			
46	water	crop	water loss	cropland gain	2.43E+06	2.4				7.6		0.4			
47	water	urban	water loss	urban gain	2.14E+04	0.0				0.1		0.0			
48	water	wetland	water loss	wetland gain	1.98E+07	19.8				62.4		3.0			
49	water	water	stable water	stable water	6.99E+07	69.9		68.7							
	Total					30,034.5									

Appendix 2.2.4.1.3. 50-year changes (1965-2015) in land cover and change percentages within Krasnodarskiy Kraj, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.31E+10	13,084.2	13,612.9	96.1	528.7		2,427.0		15,511.2	1,898.3	13.9
2	forest	barren	forest loss	barren gain	1.21E+07	12.1	45.3		3.9	2.3	17.8	13.1			
3	forest	grass	forest loss	grassland gain	2.50E+08	250.1				47.3		12.0			
4	forest	crop	forest loss	cropland gain	1.51E+08	151.0				28.6		14.4			
5	forest	urban	forest loss	urban gain	6.31E+06	6.3				1.2		11.3			
6	forest	wetland	forest loss	wetland gain	9.84E+07	98.4				18.6		12.2			
7	forest	water	forest loss	water gain	1.08E+07	10.8				2.0		12.1			
8	barren	forest	barren loss	forest gain	1.88E+07	18.8	171.3		135.9	13.9	92.6	0.8	127.9	-43.4	-25.3
9	barren	barren	stable barren	stable barren	3.54E+07	35.4	0.6	20.6	79.4		54.0				
10	barren	grass	barren loss	grassland gain	6.19E+07	61.9				45.5		3.0			
11	barren	crop	barren loss	cropland gain	4.10E+07	41.0				30.2		3.9			
12	barren	urban	barren loss	urban gain	1.10E+06	1.1				0.8		2.0			
13	barren	wetland	barren loss	wetland gain	7.61E+06	7.6				5.6		0.9			
14	barren	water	barren loss	water gain	5.46E+06	5.5				4.0		6.1			
15	grass	forest	grassland loss	forest gain	1.12E+09	1,122.3	2,435.5		1,481.5	75.8	2,088.0	46.2	3,041.9	606.4	24.9
16	grass	barren	grassland loss	barren gain	7.08E+07	70.8	8.1		60.8	4.8	85.7	76.5			
17	grass	grass	stable grassland	stable grass	9.54E+08	953.9		39.2							
18	grass	crop	grassland loss	cropland gain	2.55E+08	254.8				17.2		24.3			
19	grass	urban	grassland loss	urban gain	3.95E+06	4.0				0.3		7.1			
20	grass	wetland	grassland loss	wetland gain	2.84E+07	28.4				1.9		3.5			
21	grass	water	grassland loss	water gain	1.24E+06	1.2				0.1		1.4			
22	crop	forest	cropland loss	forest gain	6.91E+08	691.4	11,465.6		2,298.8	30.1	1,050.1	28.5	10,216.9	-1,248.7	-10.9
23	crop	barren	cropland loss	barren gain	3.31E+06	3.3	38.2		20.0	0.1	9.2	3.6			
24	crop	grass	cropland loss	grassland gain	1.04E+09	1,043.6				45.4		50.0			
25	crop	crop	stable cropland	stable cropland	9.17E+09	9,166.8		80.0							
26	crop	urban	cropland loss	urban gain	3.85E+07	38.5				1.7		69.0			
27	crop	wetland	cropland loss	wetland gain	4.79E+08	479.0				20.8		59.4			
28	crop	water	cropland loss	water gain	4.31E+07	43.1				1.9		48.3			
29	urban	forest	urban loss	forest gain	2.56E+08	256.3	1,516.2		1,380.5	18.6	55.8	10.6	191.5	-1,324.7	-87.4
30	urban	barren	urban loss	barren gain	4.73E+06	4.7	5.0		91.0	0.3	3.7	5.1			
31	urban	grass	urban loss	grass gain	5.90E+08	589.7				42.7		28.2			
32	urban	crop	urban loss	crop gain	4.17E+08	417.4				30.2		39.7			
33	urban	urban	stable urban	stable urban	1.36E+08	135.7		9.0							
34	urban	wetland	urban loss	wetland gain	1.03E+08	103.0				7.5		12.8			
35	urban	water	urban loss	water gain	9.28E+06	9.3				0.7		10.4			
36	wetland	forest	wetland loss	forest gain	4.68E+06	4.7	54.6		46.7	10.0	805.8	0.2	813.7	759.1	1,390.2
37	wetland	barren	wetland loss	barren gain	1.34E+04	0.0	0.2		85.5	0.0	1,475.7	0.0			
38	wetland	grass	wetland loss	grassland gain	5.27E+06	5.3				11.3		0.3			
39	wetland	crop	wetland loss	cropland gain	1.66E+07	16.6				35.5		1.6			
40	wetland	urban	wetland loss	urban gain	7.73E+05	0.8				1.7		1.4			
41	wetland	wetland	stable wetland	stable wetland	7.94E+06	7.9		14.5							
42	wetland	water	wetland loss	water gain	1.93E+07	19.3				41.4		21.7			
43	water	forest	water loss	forest gain	3.33E+08	333.4	778.4		736.3	45.3	89.2	13.7	131.3	-647.1	-83.1
44	water	barren	water loss	barren gain	1.53E+06	1.5	2.6		94.6	0.2	11.5	1.7			
45	water	grass	water loss	grassland gain	1.37E+08	137.5				18.7		6.6			
46	water	crop	water loss	cropland gain	1.69E+08	169.3				23.0		16.1			
47	water	urban	water loss	urban gain	5.19E+06	5.2				0.7		9.3			
48	water	wetland	water loss	wetland gain	8.93E+07	89.3				12.1		11.1			
49	water	water	stable water	stable water	4.21E+07	42.1		5.4							
	Total					30,034.5									

Appendix 2.2.4.2.1. Soviet era changes (1965-'87) in land cover and change percentages within Respublika Adygeya, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.60E+09	2,597.2	2,884.9	90.0	287.7		348.5		2,945.8	60.8	2.1
2	forest	barren	forest loss	barren gain	3.97E+06	4.0	37.8		10.0	1.4	12.1	8.1			
3	forest	grass	forest loss	grassland gain	6.46E+07	64.6				22.5		18.9			
4	forest	crop	forest loss	cropland gain	9.27E+07	92.7				32.2		20.2			
5	forest	urban	forest loss	urban gain	8.05E+04	0.1				0.0		1.3			
6	forest	wetland	forest loss	wetland gain	4.46E+07	44.6				15.5		24.6			
7	forest	water	forest loss	water gain	8.17E+07	81.7				28.4		29.2			
8	barren	forest	barren loss	forest gain	4.43E+06	4.4	62.9		49.1	9.0	48.9	1.3	62.7	-0.2	-0.4
9	barren	barren	stable barren	stable barren	1.38E+07	13.8	0.8	21.9	78.1		77.7				
10	barren	grass	barren loss	grassland gain	9.73E+06	9.7				19.8		2.9			
11	barren	crop	barren loss	cropland gain	1.55E+07	15.5				31.6		3.4			
12	barren	urban	barren loss	urban gain	3.84E+04	0.0				0.1		0.6			
13	barren	wetland	barren loss	wetland gain	5.02E+06	5.0				10.2		2.8			
14	barren	water	barren loss	water gain	1.44E+07	14.4				29.3		5.1			
15	grass	forest	grassland loss	forest gain	1.96E+08	196.0	479.8		268.0	73.2	341.1	56.2	553.0	73.1	15.2
16	grass	barren	grassland loss	barren gain	3.95E+07	39.5	6.3		55.8	14.8	71.1	80.9			
17	grass	grass	stable grassland	stable grass	2.12E+08	211.8		44.2							
18	grass	crop	grassland loss	cropland gain	2.94E+07	29.4				11.0		6.4			
19	grass	urban	grassland loss	urban gain	1.92E+04	0.0				0.0		0.3			
20	grass	wetland	grassland loss	wetland gain	1.62E+06	1.6				0.6		0.9			
21	grass	water	grassland loss	water gain	1.32E+06	1.3				0.5		0.5			
22	crop	forest	cropland loss	forest gain	8.34E+07	83.4	3,511.2		475.8	17.5	459.7	23.9	3,495.1	-16.1	-0.5
23	crop	barren	cropland loss	barren gain	1.78E+06	1.8	46.0		13.6	0.4	13.1	3.6			
24	crop	grass	cropland loss	grassland gain	1.58E+08	157.6				33.1		46.2			
25	crop	crop	stable cropland	stable cropland	3.04E+09	3,035.4		86.4							
26	crop	urban	cropland loss	urban gain	5.91E+06	5.9				1.2		92.5			
27	crop	wetland	cropland loss	wetland gain	8.57E+07	85.7				18.0		47.2			
28	crop	water	cropland loss	water gain	1.41E+08	141.3				29.7		50.6			
29	urban	forest	urban loss	forest gain	3.11E+07	31.1	430.5		405.8	7.7	6.4	8.9	31.2	-399.4	-92.8
30	urban	barren	urban loss	barren gain	1.55E+06	1.5	5.6		94.2	0.4	1.5	3.2			
31	urban	grass	urban loss	grass gain	9.05E+07	90.5				22.3		26.5			
32	urban	crop	urban loss	crop gain	2.50E+08	250.0				61.6		54.4			
33	urban	urban	stable urban	stable urban	2.48E+07	24.8		5.8							
34	urban	wetland	urban loss	wetland gain	1.62E+07	16.2				4.0		8.9			
35	urban	water	urban loss	water gain	1.65E+07	16.5				4.1		5.9			
36	wetland	forest	wetland loss	forest gain	1.06E+06	1.1	49.4		44.5	2.4	181.6	0.3	186.5	137.1	277.4
37	wetland	barren	wetland loss	barren gain	3.00E+04	0.0	0.6		90.1	0.1	367.5	0.1			
38	wetland	grass	wetland loss	grassland gain	5.79E+05	0.6				1.3		0.2			
39	wetland	crop	wetland loss	cropland gain	1.85E+07	18.5				41.6		4.0			
40	wetland	urban	wetland loss	urban gain	1.27E+05	0.1				0.3		2.0			
41	wetland	wetland	stable wetland	stable wetland	4.88E+06	4.9		9.9							
42	wetland	water	wetland loss	water gain	2.42E+07	24.2				54.4		8.7			
43	water	forest	water loss	forest gain	3.25E+07	32.5	215.6		134.9	24.1	279.5	9.3	360.2	144.6	67.1
44	water	barren	water loss	barren gain	2.03E+06	2.0	2.8		62.6	1.5	129.6	4.1			
45	water	grass	water loss	grassland gain	1.81E+07	18.1				13.4		5.3			
46	water	crop	water loss	cropland gain	5.35E+07	53.5				39.7		11.6			
47	water	urban	water loss	urban gain	2.16E+05	0.2				0.2		3.4			
48	water	wetland	water loss	wetland gain	2.85E+07	28.5				21.2		15.7			
49	water	water	stable water	stable water	8.07E+07	80.7		37.4							
	Total					7,634.4									

Appendix 2.2.4.2.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Respublika Adygeya, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.87E+09	2,866.0	2,945.8	97.3	79.8		280.2		3,146.2	200.4	6.8
2	forest	barren	forest loss	barren gain	3.13E+06	3.1	38.6		2.7	3.9	9.5	24.5			
3	forest	grass	forest loss	grassland gain	4.28E+07	42.8				53.7		10.3			
4	forest	crop	forest loss	cropland gain	1.41E+07	14.1				17.6		9.2			
5	forest	urban	forest loss	urban gain	7.35E+04	0.1				0.1		0.4			
6	forest	wetland	forest loss	wetland gain	1.70E+07	17.0				21.3		5.4			
7	forest	water	forest loss	water gain	2.65E+06	2.7				3.3		8.5			
8	barren	forest	barren loss	forest gain	3.20E+06	3.2	62.7		25.5	12.5	12.8	1.1	50.0	-12.8	-20.3
9	barren	barren	stable barren	stable barren	3.72E+07	37.2	0.8	59.3	40.7		20.4				
10	barren	grass	barren loss	grassland gain	1.80E+07	18.0				70.5		4.3			
11	barren	crop	barren loss	cropland gain	9.43E+05	0.9				3.7		0.6			
12	barren	urban	barren loss	urban gain	3.01E+04	0.0				0.1		0.1			
13	barren	wetland	barren loss	wetland gain	1.62E+06	1.6				6.3		0.5			
14	barren	water	barren loss	water gain	1.74E+06	1.7				6.8		5.6			
15	grass	forest	grassland loss	forest gain	7.49E+07	74.9	552.9		205.2	36.5	416.1	26.7	763.8	210.8	38.1
16	grass	barren	grassland loss	barren gain	6.43E+06	6.4	7.2		37.1	3.1	75.2	50.3			
17	grass	grass	stable grassland	stable grass	3.48E+08	347.7		62.9							
18	grass	crop	grassland loss	cropland gain	8.54E+07	85.4				41.6		55.7			
19	grass	urban	grassland loss	urban gain	9.33E+06	9.3				4.5		45.2			
20	grass	wetland	grassland loss	wetland gain	2.42E+07	24.2				11.8		7.7			
21	grass	water	grassland loss	water gain	4.96E+06	5.0				2.4		15.9			
22	crop	forest	cropland loss	forest gain	1.39E+08	138.6	3,495.1		681.9	20.3	153.3	49.5	2,966.5	-528.6	-15.1
23	crop	barren	cropland loss	barren gain	1.22E+06	1.2	45.8		19.5	0.2	4.4	9.5			
24	crop	grass	cropland loss	grassland gain	3.33E+08	333.0				48.8		80.0			
25	crop	crop	stable cropland	stable cropland	2.81E+09	2,813.2		80.5							
26	crop	urban	cropland loss	urban gain	1.09E+07	10.9				1.6		53.0			
27	crop	wetland	cropland loss	wetland gain	1.91E+08	191.3				28.1		60.5			
28	crop	water	cropland loss	water gain	6.85E+06	6.9				1.0		22.0			
29	urban	forest	urban loss	forest gain	1.91E+05	0.2	31.2		12.4	1.5	20.6	0.1	39.4	8.2	26.3
30	urban	barren	urban loss	barren gain	1.34E+04	0.0	0.4		39.9	0.1	66.2	0.1			
31	urban	grass	urban loss	grass gain	7.97E+06	8.0				64.1		1.9			
32	urban	crop	urban loss	crop gain	3.38E+06	3.4				27.2		2.2			
33	urban	urban	stable urban	stable urban	1.87E+07	18.7		60.1							
34	urban	wetland	urban loss	wetland gain	8.71E+05	0.9				7.0		0.3			
35	urban	water	urban loss	water gain	8.29E+03	0.0				0.1		0.0			
36	wetland	forest	wetland loss	forest gain	5.96E+07	59.6	186.5		117.0	51.0	316.3	21.3	385.8	199.3	106.8
37	wetland	barren	wetland loss	barren gain	1.18E+05	0.1	2.4		62.7	0.1	169.6	0.9			
38	wetland	grass	wetland loss	grassland gain	8.24E+06	8.2				7.0		2.0			
39	wetland	crop	wetland loss	cropland gain	3.39E+07	33.9				29.0		22.1			
40	wetland	urban	wetland loss	urban gain	2.58E+05	0.3				0.2		1.2			
41	wetland	wetland	stable wetland	stable wetland	6.95E+07	69.5		37.3							
42	wetland	water	wetland loss	water gain	1.49E+07	14.9				12.7		47.9			
43	water	forest	water loss	forest gain	3.78E+06	3.8	360.2		108.5	3.5	31.1	1.3	282.8	-77.4	-21.5
44	water	barren	water loss	barren gain	1.87E+06	1.9	4.7		30.1	1.7	8.6	14.6			
45	water	grass	water loss	grassland gain	6.06E+06	6.1				5.6		1.5			
46	water	crop	water loss	cropland gain	1.55E+07	15.5				14.3		10.1			
47	water	urban	water loss	urban gain	7.01E+03	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	8.12E+07	81.2				74.9		25.7			
49	water	water	stable water	stable water	2.52E+08	251.7		69.9							
	Total					7,634.4									

Appendix 2.2.4.2.3. 50-year changes (1965-2015) in land cover and change percentages within Respublika Adygeya, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.66E+09	2,658.7	2,882.2	92.2	223.5		487.5		3,146.2	264.0	9.2
2	forest	barren	forest loss	barren gain	3.01E+06	3.0	37.8		7.8	1.3	16.9	8.3			
3	forest	grass	forest loss	grassland gain	5.63E+07	56.3				25.2		10.6			
4	forest	crop	forest loss	cropland gain	4.64E+07	46.4				20.7		17.4			
5	forest	urban	forest loss	urban gain	1.77E+05	0.2				0.1		1.5			
6	forest	wetland	forest loss	wetland gain	4.86E+07	48.6				21.8		13.0			
7	forest	water	forest loss	water gain	6.90E+07	69.0				30.9		30.6			
8	barren	forest	barren loss	forest gain	6.83E+06	6.8	63.3		49.4	13.8	36.1	1.4	50.0	-13.3	-21.1
9	barren	barren	stable barren	stable barren	1.39E+07	13.9	0.8	22.0	78.0		57.0				
10	barren	grass	barren loss	grassland gain	9.41E+06	9.4				19.1		1.8			
11	barren	crop	barren loss	cropland gain	1.78E+07	17.8				36.0		6.7			
12	barren	urban	barren loss	urban gain	3.84E+04	0.0				0.1		0.3			
13	barren	wetland	barren loss	wetland gain	1.07E+07	10.7				21.6		2.8			
14	barren	water	barren loss	water gain	4.64E+06	4.6				9.4		2.1			
15	grass	forest	grassland loss	forest gain	1.98E+08	198.4	481.0		250.2	79.3	533.0	40.7	763.8	282.8	58.8
16	grass	barren	grassland loss	barren gain	3.22E+07	32.2	6.3		52.0	12.9	110.8	89.3			
17	grass	grass	stable grassland	stable grass	2.31E+08	230.8		48.0							
18	grass	crop	grassland loss	cropland gain	1.55E+07	15.5				6.2		5.8			
19	grass	urban	grassland loss	urban gain	3.66E+04	0.0				0.0		0.3			
20	grass	wetland	grassland loss	wetland gain	3.58E+06	3.6				1.4		1.0			
21	grass	water	grassland loss	water gain	5.50E+05	0.6				0.2		0.2			
22	crop	forest	cropland loss	forest gain	1.74E+08	174.3	3,510.2		810.8	21.5	267.1	35.7	2,966.5	-543.7	-15.5
23	crop	barren	cropland loss	barren gain	6.28E+05	0.6	46.0		23.1	0.1	7.6	1.7			
24	crop	grass	cropland loss	grassland gain	2.91E+08	290.7				35.9		54.5			
25	crop	crop	stable cropland	stable cropland	2.70E+09	2,699.4		76.9							
26	crop	urban	cropland loss	urban gain	1.08E+07	10.8				1.3		92.1			
27	crop	wetland	cropland loss	wetland gain	2.21E+08	221.0				27.3		59.0			
28	crop	water	cropland loss	water gain	1.13E+08	113.3				14.0		50.2			
29	urban	forest	urban loss	forest gain	5.27E+07	52.7	431.2		403.5	13.1	11.8	10.8	39.4	-391.8	-90.9
30	urban	barren	urban loss	barren gain	1.49E+05	0.1	5.6		93.6	0.0	2.7	0.4			
31	urban	grass	urban loss	grass gain	1.55E+08	154.5				38.3		29.0			
32	urban	crop	urban loss	crop gain	1.43E+08	143.2				35.5		53.6			
33	urban	urban	stable urban	stable urban	2.76E+07	27.6		6.4							
34	urban	wetland	urban loss	wetland gain	3.56E+07	35.6				8.8		9.5			
35	urban	water	urban loss	water gain	1.74E+07	17.4				4.3		7.7			
36	wetland	forest	wetland loss	forest gain	2.59E+06	2.6	49.7		38.3	6.8	374.4	0.5	385.8	336.1	676.4
37	wetland	barren	wetland loss	barren gain	1.40E+04	0.0	0.7		77.2	0.0	753.6	0.0			
38	wetland	grass	wetland loss	grassland gain	3.61E+06	3.6				9.4		0.7			
39	wetland	crop	wetland loss	cropland gain	1.09E+07	10.9				28.5		4.1			
40	wetland	urban	wetland loss	urban gain	3.67E+05	0.4				1.0		3.1			
41	wetland	wetland	stable wetland	stable wetland	1.14E+07	11.4		22.8							
42	wetland	water	wetland loss	water gain	2.08E+07	20.8				54.4		9.2			
43	water	forest	water loss	forest gain	5.27E+07	52.7	216.8		159.7	33.0	225.7	10.8	282.8	66.0	30.4
44	water	barren	water loss	barren gain	6.53E+04	0.1	2.8		73.7	0.0	104.1	0.2			
45	water	grass	water loss	grassland gain	1.84E+07	18.4				11.5		3.4			
46	water	crop	water loss	cropland gain	3.34E+07	33.4				20.9		12.5			
47	water	urban	water loss	urban gain	3.13E+05	0.3				0.2		2.7			
48	water	wetland	water loss	wetland gain	5.49E+07	54.9				34.4		14.7			
49	water	water	stable water	stable water	5.71E+07	57.1		26.3							
	Total					7,634.4									

Appendix 2.2.4.3.1. Soviet era changes (1965-'87) in land cover and change percentages within Stavropolskij kraj, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.62E+07	96.2	336.3	28.6	240.1		84.6		180.8	-155.5	-46.2
2	forest	barren	forest loss	barren gain	2.72E+05	0.3	4.7		71.4	0.1	25.2	6.0			
3	forest	grass	forest loss	grassland gain	1.36E+08	136.5				56.8		17.0			
4	forest	crop	forest loss	cropland gain	9.78E+07	97.8				40.7		40.7			
5	forest	urban	forest loss	urban gain	6.21E+05	0.6				0.3		20.0			
6	forest	wetland	forest loss	wetland gain	4.67E+06	4.7				1.9		8.4			
7	forest	water	forest loss	water gain	2.34E+05	0.2				0.1		1.8			
8	barren	forest	barren loss	forest gain	8.67E+04	0.1	4.4		4.4	2.0	4.5	0.1	4.5	0.1	2.9
9	barren	barren	stable barren	stable barren	1.63E+04	0.0	0.1	0.4	99.6		102.6				
10	barren	grass	barren loss	grassland gain	4.49E+05	0.4				10.3		0.1			
11	barren	crop	barren loss	cropland gain	3.64E+06	3.6				83.1		1.5			
12	barren	urban	barren loss	urban gain	4.43E+03	0.0				0.1		0.1			
13	barren	wetland	barren loss	wetland gain	1.77E+05	0.2				4.0		0.3			
14	barren	water	barren loss	water gain	2.27E+04	0.0				0.5		0.2			
15	grass	forest	grassland loss	forest gain	1.52E+07	15.2	384.4		90.0	16.9	804.8	18.0	1,099.2	714.8	185.9
16	grass	barren	grassland loss	barren gain	3.73E+05	0.4	5.3		23.4	0.4	209.3	8.3			
17	grass	grass	stable grassland	stable grass	2.94E+08	294.4		76.6							
18	grass	crop	grassland loss	cropland gain	7.09E+07	70.9				78.8		29.5			
19	grass	urban	grassland loss	urban gain	3.26E+05	0.3				0.4		10.5			
20	grass	wetland	grassland loss	wetland gain	2.71E+06	2.7				3.0		4.8			
21	grass	water	grassland loss	water gain	4.75E+05	0.5				0.5		3.6			
22	crop	forest	cropland loss	forest gain	6.04E+07	60.4	6,328.2		740.7	8.2	240.5	71.4	5,827.9	-500.3	-7.9
23	crop	barren	cropland loss	barren gain	3.03E+06	3.0	87.9		11.7	0.4	3.8	67.2			
24	crop	grass	cropland loss	grassland gain	6.22E+08	621.8				84.0		77.3			
25	crop	crop	stable cropland	stable cropland	5.59E+09	5,587.5		88.3							
26	crop	urban	cropland loss	urban gain	2.06E+06	2.1				0.3		66.5			
27	crop	wetland	cropland loss	wetland gain	4.19E+07	41.9				5.7		74.9			
28	crop	water	cropland loss	water gain	1.15E+07	11.5				1.6		87.7			
29	urban	forest	urban loss	forest gain	3.24E+06	3.2	96.9		94.0	3.4	3.1	3.8	6.0	-90.9	-93.8
30	urban	barren	urban loss	barren gain	2.86E+05	0.3	1.3		97.0	0.3	3.2	6.3			
31	urban	grass	urban loss	grass gain	3.55E+07	35.5				37.8		4.4			
32	urban	crop	urban loss	crop gain	5.23E+07	52.3				55.7		21.8			
33	urban	urban	stable urban	stable urban	2.90E+06	2.9		3.0							
34	urban	wetland	urban loss	wetland gain	2.15E+06	2.2				2.3		3.9			
35	urban	water	urban loss	water gain	4.76E+05	0.5				0.5		3.6			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	1.6		1.1	0.0	55.9	0.0	56.5	54.9	3,418.2
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		66.6	0.0	3,484.9	0.0			
38	wetland	grass	wetland loss	grassland gain	6.60E+04	0.1				6.2		0.0			
39	wetland	crop	wetland loss	cropland gain	6.00E+05	0.6				56.1		0.2			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	5.36E+05	0.5		33.4							
42	wetland	water	wetland loss	water gain	4.03E+05	0.4				37.7		3.1			
43	water	forest	water loss	forest gain	5.65E+06	5.6	45.0		36.2	15.6	13.1	6.7	21.9	-23.1	-51.3
44	water	barren	water loss	barren gain	5.46E+05	0.5	0.6		80.4	1.5	29.1	12.1			
45	water	grass	water loss	grassland gain	1.04E+07	10.4				28.9		1.3			
46	water	crop	water loss	cropland gain	1.51E+07	15.1				41.8		6.3			
47	water	urban	water loss	urban gain	8.74E+04	0.1				0.2		2.8			
48	water	wetland	water loss	wetland gain	4.35E+06	4.3				12.0		7.8			
49	water	water	stable water	stable water	8.84E+06	8.8		19.6							
	Total					7,196.9									

Appendix 2.2.4.3.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Stavropolskij kraj, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.57E+08	157.3	180.8	87.0	23.5		116.1		273.3	92.5	51.2
2	forest	barren	forest loss	barren gain	2.72E+04	0.0	2.5		13.0	0.1	64.2	0.5			
3	forest	grass	forest loss	grassland gain	7.26E+06	7.3				30.9		2.5			
4	forest	crop	forest loss	cropland gain	9.46E+06	9.5				40.3		3.1			
5	forest	urban	forest loss	urban gain	1.15E+05	0.1				0.5		0.5			
6	forest	wetland	forest loss	wetland gain	5.96E+06	6.0				25.4		9.2			
7	forest	water	forest loss	water gain	6.82E+05	0.7				2.9		9.4			
8	barren	forest	barren loss	forest gain	3.53E+05	0.4	4.5		4.4	8.0	5.6	0.3	5.8	1.2	27.2
9	barren	barren	stable barren	stable barren	1.29E+05	0.1	0.1	2.9	97.1		124.3				
10	barren	grass	barren loss	grassland gain	1.18E+06	1.2				26.8		0.4			
11	barren	crop	barren loss	cropland gain	1.25E+06	1.3				28.5		0.4			
12	barren	urban	barren loss	urban gain	2.81E+05	0.3				6.4		1.1			
13	barren	wetland	barren loss	wetland gain	3.82E+05	0.4				8.7		0.6			
14	barren	water	barren loss	water gain	9.51E+05	1.0				21.6		13.1			
15	grass	forest	grassland loss	forest gain	3.73E+07	37.3	1,099.5		351.0	10.6	284.8	32.1	1,033.3	-66.3	-6.0
16	grass	barren	grassland loss	barren gain	2.77E+06	2.8	15.3		31.9	0.8	25.9	49.3			
17	grass	grass	stable grassland	stable grass	7.48E+08	748.5		68.1							
18	grass	crop	grassland loss	cropland gain	2.86E+08	285.8				81.4		92.2			
19	grass	urban	grassland loss	urban gain	1.31E+07	13.1				3.7		52.2			
20	grass	wetland	grassland loss	wetland gain	1.13E+07	11.3				3.2		17.4			
21	grass	water	grassland loss	water gain	8.42E+05	0.8				0.2		11.6			
22	crop	forest	cropland loss	forest gain	6.24E+07	62.4	5,828.2		389.9	16.0	309.8	53.8	5,748.1	-80.1	-1.4
23	crop	barren	cropland loss	barren gain	2.69E+06	2.7	81.0		6.7	0.7	5.3	47.7			
24	crop	grass	cropland loss	grassland gain	2.72E+08	272.1				69.8		95.6			
25	crop	crop	stable cropland	stable cropland	5.44E+09	5,438.3		93.3							
26	crop	urban	cropland loss	urban gain	1.15E+07	11.5				3.0		46.0			
27	crop	wetland	cropland loss	wetland gain	3.91E+07	39.1				10.0		60.5			
28	crop	water	cropland loss	water gain	2.04E+06	2.0				0.5		28.1			
29	urban	forest	urban loss	forest gain	1.00E+05	0.1	6.0		3.3	3.1	25.0	0.1	27.8	21.7	361.8
30	urban	barren	urban loss	barren gain	1.31E+05	0.1	0.1		54.3	4.0	416.2	2.3			
31	urban	grass	urban loss	grass gain	1.99E+06	2.0				61.0		0.7			
32	urban	crop	urban loss	crop gain	8.36E+05	0.8				25.6		0.3			
33	urban	urban	stable urban	stable urban	2.74E+06	2.7		45.7							
34	urban	wetland	urban loss	wetland gain	2.04E+05	0.2				6.3		0.3			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.54E+07	15.4	56.5		31.6	48.7	64.7	13.3	89.6	33.2	58.7
37	wetland	barren	wetland loss	barren gain	8.43E+03	0.0	0.8		55.9	0.0	114.6	0.1			
38	wetland	grass	wetland loss	grassland gain	1.90E+06	1.9				6.0		0.7			
39	wetland	crop	wetland loss	cropland gain	1.15E+07	11.5				36.3		3.7			
40	wetland	urban	wetland loss	urban gain	4.98E+04	0.0				0.2		0.2			
41	wetland	wetland	stable wetland	stable wetland	2.49E+07	24.9		44.1							
42	wetland	water	wetland loss	water gain	2.75E+06	2.8				8.7		37.8			
43	water	forest	water loss	forest gain	5.09E+05	0.5	21.9		9.6	5.3	7.3	0.4	19.6	-2.3	-10.5
44	water	barren	water loss	barren gain	1.30E+03	0.0	0.3		43.7	0.0	33.1	0.0			
45	water	grass	water loss	grassland gain	2.87E+05	0.3				3.0		0.1			
46	water	crop	water loss	cropland gain	1.03E+06	1.0				10.7		0.3			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	7.76E+06	7.8				81.0		12.0			
49	water	water	stable water	stable water	1.24E+07	12.4		56.3							
	Total					7,197.5									

Appendix 2.2.4.3.3. 50-year changes (1965-2015) in land cover and change percentages within Stavropolskij kraj, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.18E+08	117.9	336.3	35.1	218.4		155.4		273.3	-63.0	-18.7
2	forest	barren	forest loss	barren gain	3.50E+05	0.4	4.7		64.9	0.2	46.2	6.1			
3	forest	grass	forest loss	grassland gain	1.51E+08	150.5				68.9		20.3			
4	forest	crop	forest loss	cropland gain	5.89E+07	58.9				27.0		34.5			
5	forest	urban	forest loss	urban gain	2.10E+06	2.1				1.0		14.2			
6	forest	wetland	forest loss	wetland gain	5.87E+06	5.9				2.7		6.6			
7	forest	water	forest loss	water gain	6.77E+05	0.7				0.3		5.8			
8	barren	forest	barren loss	forest gain	1.03E+05	0.1	4.4		4.4	2.3	5.7	0.1	5.8	1.4	31.0
9	barren	barren	stable barren	stable barren	1.03E+04	0.0	0.1	0.2	99.8		130.7				
10	barren	grass	barren loss	grassland gain	3.88E+05	0.4				8.8		0.1			
11	barren	crop	barren loss	cropland gain	3.53E+06	3.5				80.6		2.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	2.98E+05	0.3				6.8		0.3			
14	barren	water	barren loss	water gain	6.30E+04	0.1				1.4		0.5			
15	grass	forest	grassland loss	forest gain	2.64E+07	26.4	384.4		92.2	28.6	740.7	17.0	1,032.9	648.5	168.7
16	grass	barren	grassland loss	barren gain	2.50E+05	0.3	5.3		24.0	0.3	192.7	4.3			
17	grass	grass	stable grassland	stable grass	2.92E+08	292.2		76.0							
18	grass	crop	grassland loss	cropland gain	5.78E+07	57.8				62.7		33.9			
19	grass	urban	grassland loss	urban gain	6.29E+05	0.6				0.7		4.3			
20	grass	wetland	grassland loss	wetland gain	6.90E+06	6.9				7.5		7.8			
21	grass	water	grassland loss	water gain	2.54E+05	0.3				0.3		2.2			
22	crop	forest	cropland loss	forest gain	1.17E+08	116.6	6,328.2		750.7	15.5	170.4	75.1	5,747.9	-580.3	-9.2
23	crop	barren	cropland loss	barren gain	4.18E+06	4.2	87.9		11.9	0.6	2.7	72.8			
24	crop	grass	cropland loss	grassland gain	5.44E+08	544.3				72.5		73.5			
25	crop	crop	stable cropland	stable cropland	5.58E+09	5,577.5		88.1							
26	crop	urban	cropland loss	urban gain	1.16E+07	11.6				1.5		78.6			
27	crop	wetland	cropland loss	wetland gain	6.39E+07	63.9				8.5		72.1			
28	crop	water	cropland loss	water gain	1.00E+07	10.0				1.3		86.0			
29	urban	forest	urban loss	forest gain	5.59E+06	5.6	96.9		83.9	6.7	14.8	3.6	27.7	-69.2	-71.4
30	urban	barren	urban loss	barren gain	7.77E+05	0.8	1.3		86.6	0.9	15.2	13.5			
31	urban	grass	urban loss	grass gain	3.63E+07	36.3				43.2		4.9			
32	urban	crop	urban loss	crop gain	3.68E+07	36.8				43.9		21.6			
33	urban	urban	stable urban	stable urban	1.30E+07	13.0		13.4							
34	urban	wetland	urban loss	wetland gain	3.97E+06	4.0				4.7		4.5			
35	urban	water	urban loss	water gain	4.50E+05	0.5				0.5		3.9			
36	wetland	forest	wetland loss	forest gain	3.12E+04	0.0	1.6		0.6	5.0	88.6	0.0	89.6	88.0	5,483.4
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		38.7	0.0	5,522.1	0.0			
38	wetland	grass	wetland loss	grassland gain	8.22E+04	0.1				13.2		0.0			
39	wetland	crop	wetland loss	cropland gain	3.12E+05	0.3				50.2		0.2			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	9.83E+05	1.0		61.3							
42	wetland	water	wetland loss	water gain	1.96E+05	0.2				31.5		1.7			
43	water	forest	water loss	forest gain	6.65E+06	6.7	45.0		37.1	17.9	11.7	4.3	19.6	-25.4	-56.4
44	water	barren	water loss	barren gain	1.87E+05	0.2	0.6		82.4	0.5	25.9	3.3			
45	water	grass	water loss	grassland gain	9.09E+06	9.1				24.5		1.2			
46	water	crop	water loss	cropland gain	1.31E+07	13.1				35.2		7.7			
47	water	urban	water loss	urban gain	4.33E+05	0.4				1.2		2.9			
48	water	wetland	water loss	wetland gain	7.67E+06	7.7				20.7		8.7			
49	water	water	stable water	stable water	7.95E+06	7.9		17.6							
	Total					7,196.9									

Appendix 2.2.4.4.1. Soviet era changes (1965-'87) in land cover and change percentages within Karachayevo-Cherkesskaya respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.07E+09	2,065.6	2,363.3	87.4	297.7		1,499.6		3,565.2	1,201.9	50.9
2	forest	barren	forest loss	barren gain	2.48E+07	24.8	38.3		12.6	8.3	63.5	8.8			
3	forest	grass	forest loss	grassland gain	2.39E+08	238.8				80.2		47.8			
4	forest	crop	forest loss	cropland gain	2.91E+07	29.1				9.8		24.1			
5	forest	urban	forest loss	urban gain	2.99E+04	0.0				0.0		4.4			
6	forest	wetland	forest loss	wetland gain	4.11E+06	4.1				1.4		27.8			
7	forest	water	forest loss	water gain	8.77E+05	0.9				0.3		8.4			
8	barren	forest	barren loss	forest gain	2.56E+07	25.6	446.3		240.3	10.7	281.6	1.7	487.6	41.3	9.3
9	barren	barren	stable barren	stable barren	2.06E+08	206.0	7.2	46.2	53.8		63.1				
10	barren	grass	barren loss	grassland gain	2.07E+08	207.4				86.3		41.5			
11	barren	crop	barren loss	cropland gain	1.85E+06	1.8				0.8		1.5			
12	barren	urban	barren loss	urban gain	2.03E+04	0.0				0.0		3.0			
13	barren	wetland	barren loss	wetland gain	5.69E+05	0.6				0.2		3.8			
14	barren	water	barren loss	water gain	4.84E+06	4.8				2.0		46.2			
15	grass	forest	grassland loss	forest gain	1.43E+09	1,429.8	3,196.3		1,779.7	80.3	500.0	95.3	1,916.7	-1,279.6	-40.0
16	grass	barren	grassland loss	barren gain	2.52E+08	251.7	51.8		55.7	14.1	15.6	89.4			
17	grass	grass	stable grassland	stable grass	1.42E+09	1,416.6		44.3							
18	grass	crop	grassland loss	cropland gain	8.60E+07	86.0				4.8		71.4			
19	grass	urban	grassland loss	urban gain	1.66E+05	0.2				0.0		24.3			
20	grass	wetland	grassland loss	wetland gain	7.79E+06	7.8				0.4		52.7			
21	grass	water	grassland loss	water gain	4.26E+06	4.3				0.2		40.7			
22	crop	forest	cropland loss	forest gain	3.87E+07	38.7	149.2		94.9	40.8	120.4	2.6	174.7	25.5	17.1
23	crop	barren	cropland loss	barren gain	4.34E+06	4.3	2.4		63.6	4.6	80.7	1.5			
24	crop	grass	cropland loss	grassland gain	4.93E+07	49.3				52.0		9.9			
25	crop	crop	stable cropland	stable cropland	5.43E+07	54.3		36.4							
26	crop	urban	cropland loss	urban gain	4.67E+05	0.5				0.5		68.3			
27	crop	wetland	cropland loss	wetland gain	1.58E+06	1.6				1.7		10.7			
28	crop	water	cropland loss	water gain	4.82E+05	0.5				0.5		4.6			
29	urban	forest	urban loss	forest gain	4.28E+06	4.3	11.8		11.7	36.6	0.7	0.3	0.8	-11.0	-93.4
30	urban	barren	urban loss	barren gain	4.25E+05	0.4	0.2		99.2	3.6	5.8	0.2			
31	urban	grass	urban loss	grass gain	3.75E+06	3.7				32.1		0.7			
32	urban	crop	urban loss	crop gain	2.60E+06	2.6				22.2		2.2			
33	urban	urban	stable urban	stable urban	8.94E+04	0.1		0.8							
34	urban	wetland	urban loss	wetland gain	6.23E+05	0.6				5.3		4.2			
35	urban	water	urban loss	water gain	9.76E+03	0.0				0.1		0.1			
36	wetland	forest	wetland loss	forest gain	2.87E+04	0.0	0.1		0.1	30.9	14.8	0.0	14.8	14.7	15,857.2
37	wetland	barren	wetland loss	barren gain	2.29E+04	0.0	0.0		100.0	24.7	15,957.2	0.0			
38	wetland	grass	wetland loss	grassland gain	4.05E+04	0.0				43.7		0.0			
39	wetland	crop	wetland loss	cropland gain	6.54E+02	0.0				0.7		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.15E+06	1.2	3.2		3.2	35.7	10.5	0.1	10.5	7.2	224.4
44	water	barren	water loss	barren gain	2.74E+05	0.3	0.1		99.9	8.5	324.3	0.1			
45	water	grass	water loss	grassland gain	7.48E+05	0.7				23.2		0.1			
46	water	crop	water loss	cropland gain	9.39E+05	0.9				29.1		0.8			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.12E+05	0.1				3.5		0.8			
49	water	water	stable water	stable water	2.61E+03	0.0		0.1							
	Total					6,170.2									

Appendix 2.2.4.4.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Karachayevo-Cherkesskaya respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.22E+09	3,222.9	3,566.8	90.4	343.8		162.9		3,385.9	-180.9	-5.1
2	forest	barren	forest loss	barren gain	1.04E+07	10.4	57.8		9.6	3.0	4.6	19.4			
3	forest	grass	forest loss	grassland gain	3.05E+08	305.0				88.7		49.7			
4	forest	crop	forest loss	cropland gain	1.84E+07	18.4				5.3		36.4			
5	forest	urban	forest loss	urban gain	4.11E+04	0.0				0.0		3.5			
6	forest	wetland	forest loss	wetland gain	9.35E+06	9.3				2.7		54.8			
7	forest	water	forest loss	water gain	6.58E+05	0.7				0.2		27.7			
8	barren	forest	barren loss	forest gain	2.46E+07	24.6	487.7		222.9	11.0	53.6	15.1	318.4	-169.3	-34.7
9	barren	barren	stable barren	stable barren	2.65E+08	264.8	7.9	54.3	45.7		11.0				
10	barren	grass	barren loss	grassland gain	1.90E+08	190.4				85.4		31.0			
11	barren	crop	barren loss	cropland gain	5.28E+06	5.3				2.4		10.5			
12	barren	urban	barren loss	urban gain	3.62E+05	0.4				0.2		30.7			
13	barren	wetland	barren loss	wetland gain	1.77E+06	1.8				0.8		10.4			
14	barren	water	barren loss	water gain	4.78E+05	0.5				0.2		20.1			
15	grass	forest	grassland loss	forest gain	1.09E+08	109.3	1,916.4		173.1	63.1	614.2	67.1	2,357.5	441.1	23.0
16	grass	barren	grassland loss	barren gain	3.48E+07	34.8	31.1		9.0	20.1	32.0	64.9			
17	grass	grass	stable grassland	stable grass	1.74E+09	1,743.4		91.0							
18	grass	crop	grassland loss	cropland gain	2.51E+07	25.1				14.5		49.8			
19	grass	urban	grassland loss	urban gain	6.29E+05	0.6				0.4		53.2			
20	grass	wetland	grassland loss	wetland gain	2.80E+06	2.8				1.6		16.4			
21	grass	water	grassland loss	water gain	4.60E+05	0.5				0.3		19.4			
22	crop	forest	cropland loss	forest gain	1.91E+07	19.1	174.7		138.8	13.7	50.5	11.7	86.3	-88.4	-50.6
23	crop	barren	cropland loss	barren gain	1.75E+06	1.7	2.8		79.5	1.3	28.9	3.3			
24	crop	grass	cropland loss	grassland gain	1.14E+08	114.4				82.4		18.6			
25	crop	crop	stable cropland	stable cropland	3.59E+07	35.9		20.5							
26	crop	urban	cropland loss	urban gain	9.94E+04	0.1				0.1		8.4			
27	crop	wetland	cropland loss	wetland gain	3.02E+06	3.0				2.2		17.7			
28	crop	water	cropland loss	water gain	4.72E+05	0.5				0.3		19.9			
29	urban	forest	urban loss	forest gain	2.79E+04	0.0	0.8		0.5	5.8	1.2	0.0	1.5	0.7	90.6
30	urban	barren	urban loss	barren gain	3.19E+04	0.0	0.0		62.3	6.6	152.9	0.1			
31	urban	grass	urban loss	grass gain	2.54E+05	0.3				52.9		0.0			
32	urban	crop	urban loss	crop gain	1.49E+05	0.1				31.1		0.3			
33	urban	urban	stable urban	stable urban	2.92E+05	0.3		37.7							
34	urban	wetland	urban loss	wetland gain	1.75E+04	0.0				3.6		0.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	7.72E+06	7.7	14.8		12.7	60.9	17.1	4.7	19.2	4.4	29.6
37	wetland	barren	wetland loss	barren gain	2.34E+05	0.2	0.2		85.8	1.8	115.3	0.4			
38	wetland	grass	wetland loss	grassland gain	2.96E+06	3.0				23.3		0.5			
39	wetland	crop	wetland loss	cropland gain	1.41E+06	1.4				11.1		2.8			
40	wetland	urban	wetland loss	urban gain	5.01E+04	0.1				0.4		4.2			
41	wetland	wetland	stable wetland	stable wetland	2.11E+06	2.1		14.2							
42	wetland	water	wetland loss	water gain	3.06E+05	0.3				2.4		12.9			
43	water	forest	water loss	forest gain	2.23E+06	2.2	10.5		10.0	22.2	2.4	1.4	2.8	-7.7	-73.3
44	water	barren	water loss	barren gain	6.42E+06	6.4	0.2		96.0	63.9	22.7	12.0			
45	water	grass	water loss	grassland gain	1.17E+06	1.2				11.6		0.2			
46	water	crop	water loss	cropland gain	1.18E+05	0.1				1.2		0.2			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.12E+05	0.1				1.1		0.7			
49	water	water	stable water	stable water	4.15E+05	0.4		4.0							
	Total					6,171.6									

Appendix 2.2.4.4.3. 50-year changes (1965-2015) in land cover and change percentages within Karachayevo-Cherkesskaya respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.01E+09	2,013.2	2,362.2	85.2	349.0		1,372.7		3,385.9	1,023.7	43.3
2	forest	barren	forest loss	barren gain	1.02E+07	10.2	38.3		14.8	2.9	58.1	6.6			
3	forest	grass	forest loss	grassland gain	3.16E+08	315.8				90.5		47.3			
4	forest	crop	forest loss	cropland gain	1.57E+07	15.7				4.5		27.0			
5	forest	urban	forest loss	urban gain	1.03E+05	0.1				0.0		7.6			
6	forest	wetland	forest loss	wetland gain	6.44E+06	6.4				1.8		33.6			
7	forest	water	forest loss	water gain	7.06E+05	0.7				0.2		25.7			
8	barren	forest	barren loss	forest gain	2.52E+07	25.2	446.4		283.7	8.9	155.7	1.8	318.4	-128.0	-28.7
9	barren	barren	stable barren	stable barren	1.63E+08	162.7	7.2	36.4	63.6		34.9				
10	barren	grass	barren loss	grassland gain	2.57E+08	256.8				90.5		38.4			
11	barren	crop	barren loss	cropland gain	1.34E+06	1.3				0.5		2.3			
12	barren	urban	barren loss	urban gain	3.60E+04	0.0				0.0		2.7			
13	barren	wetland	barren loss	wetland gain	1.78E+05	0.2				0.1		0.9			
14	barren	water	barren loss	water gain	2.14E+05	0.2				0.1		7.8			
15	grass	forest	grassland loss	forest gain	1.32E+09	1,315.7	3,198.0		1,508.5	87.2	668.0	95.9	2,357.5	-840.4	-26.3
16	grass	barren	grassland loss	barren gain	1.44E+08	144.2	51.8		47.2	9.6	20.9	92.6			
17	grass	grass	stable grassland	stable grass	1.69E+09	1,689.5		52.8							
18	grass	crop	grassland loss	cropland gain	3.86E+07	38.6				2.6		66.3			
19	grass	urban	grassland loss	urban gain	2.63E+05	0.3				0.0		19.5			
20	grass	wetland	grassland loss	wetland gain	8.74E+06	8.7				0.6		45.6			
21	grass	water	grassland loss	water gain	9.67E+05	1.0				0.1		35.2			
22	crop	forest	cropland loss	forest gain	2.67E+07	26.7	149.6		121.5	22.0	58.2	1.9	86.3	-63.3	-42.3
23	crop	barren	cropland loss	barren gain	7.88E+05	0.8	2.4		81.2	0.6	38.9	0.5			
24	crop	grass	cropland loss	grassland gain	8.93E+07	89.3				73.5		13.4			
25	crop	crop	stable cropland	stable cropland	2.81E+07	28.1		18.8							
26	crop	urban	cropland loss	urban gain	9.46E+05	0.9				0.8		70.2			
27	crop	wetland	cropland loss	wetland gain	2.97E+06	3.0				2.4		15.5			
28	crop	water	cropland loss	water gain	7.94E+05	0.8				0.7		28.9			
29	urban	forest	urban loss	forest gain	3.42E+06	3.4	11.9		11.8	29.0	1.3	0.2	1.5	-10.4	-87.6
30	urban	barren	urban loss	barren gain	2.46E+05	0.2	0.2		99.0	2.1	11.3	0.2			
31	urban	grass	urban loss	grass gain	5.21E+06	5.2				44.1		0.8			
32	urban	crop	urban loss	crop gain	2.28E+06	2.3				19.4		3.9			
33	urban	urban	stable urban	stable urban	1.25E+05	0.1		1.0							
34	urban	wetland	urban loss	wetland gain	5.71E+05	0.6				4.8		3.0			
35	urban	water	urban loss	water gain	7.00E+04	0.1				0.6		2.5			
36	wetland	forest	wetland loss	forest gain	4.04E+04	0.0	0.1		0.1	31.9	19.2	0.0	19.2	19.0	14,958.8
37	wetland	barren	wetland loss	barren gain	2.68E+04	0.0	0.0		99.5	21.2	15,058.2	0.0			
38	wetland	grass	wetland loss	grassland gain	5.75E+04	0.1				45.4		0.0			
39	wetland	crop	wetland loss	cropland gain	1.96E+03	0.0				1.5		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	6.52E+02	0.0		0.5							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.58E+06	1.6	3.3		3.3	48.0	2.8	0.1	2.8	-0.5	-16.0
44	water	barren	water loss	barren gain	2.07E+05	0.2	0.1		98.9	6.3	82.9	0.1			
45	water	grass	water loss	grassland gain	9.59E+05	1.0				29.2		0.1			
46	water	crop	water loss	cropland gain	2.71E+05	0.3				8.3		0.5			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	2.70E+05	0.3				8.2		1.4			
49	water	water	stable water	stable water	3.82E+04	0.0		1.1							
	Total					6,171.6									

Appendix 2.2.4.5.1. Soviet era changes (1965-'87) in land cover and change percentages within Kabardino-Balkarskaya respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.88E+09	1,875.2	3,305.9	56.7	1,430.7		320.5		2,195.7	-1,110.2	-33.6
2	forest	barren	forest loss	barren gain	2.58E+07	25.8	32.2		43.3	1.8	9.7	10.3			
3	forest	grass	forest loss	grassland gain	1.16E+09	1,155.1				80.7		62.9			
4	forest	crop	forest loss	cropland gain	2.38E+08	238.1				16.6		53.0			
5	forest	urban	forest loss	urban gain	6.80E+05	0.7				0.0		9.8			
6	forest	wetland	forest loss	wetland gain	9.64E+06	9.6				0.7		18.4			
7	forest	water	forest loss	water gain	1.37E+06	1.4				0.1		10.4			
8	barren	forest	barren loss	forest gain	1.91E+05	0.2	12.3		4.5	4.2	251.8	0.1	259.7	247.3	2,003.0
9	barren	barren	stable barren	stable barren	7.85E+06	7.8	0.1	63.6	36.4		2,039.4				
10	barren	grass	barren loss	grassland gain	4.14E+06	4.1				92.1		0.2			
11	barren	crop	barren loss	cropland gain	7.12E+04	0.1				1.6		0.0			
12	barren	urban	barren loss	urban gain	1.24E+04	0.0				0.3		0.2			
13	barren	wetland	barren loss	wetland gain	3.98E+04	0.0				0.9		0.1			
14	barren	water	barren loss	water gain	4.25E+04	0.0				0.9		0.3			
15	grass	forest	grassland loss	forest gain	1.56E+08	155.8	2,271.2		490.8	31.7	1,835.0	48.6	3,615.4	1,344.2	59.2
16	grass	barren	grassland loss	barren gain	2.04E+08	203.7	22.1		21.6	41.5	80.8	80.9			
17	grass	grass	stable grassland	stable grass	1.78E+09	1,780.4		78.4							
18	grass	crop	grassland loss	cropland gain	1.27E+08	127.5				26.0		28.4			
19	grass	urban	grassland loss	urban gain	3.13E+04	0.0				0.0		0.5			
20	grass	wetland	grassland loss	wetland gain	1.22E+06	1.2				0.2		2.3			
21	grass	water	grassland loss	water gain	2.53E+06	2.5				0.5		19.2			
22	crop	forest	cropland loss	forest gain	1.59E+08	158.9	4,457.7		792.0	20.1	449.2	49.6	4,115.0	-342.7	-7.7
23	crop	barren	cropland loss	barren gain	1.41E+07	14.1	43.4		17.8	1.8	10.1	5.6			
24	crop	grass	cropland loss	grassland gain	5.66E+08	566.4				71.5		30.9			
25	crop	crop	stable cropland	stable cropland	3.67E+09	3,665.7		82.2							
26	crop	urban	cropland loss	urban gain	5.95E+06	5.9				0.8		85.4			
27	crop	wetland	cropland loss	wetland gain	3.76E+07	37.6				4.7		71.5			
28	crop	water	cropland loss	water gain	8.95E+06	8.9				1.1		67.9			
29	urban	forest	urban loss	forest gain	3.43E+06	3.4	169.1		160.7	2.1	7.0	1.1	15.4	-153.7	-90.9
30	urban	barren	urban loss	barren gain	3.42E+06	3.4	1.6		95.0	2.1	4.1	1.4			
31	urban	grass	urban loss	grass gain	7.89E+07	78.9				49.1		4.3			
32	urban	crop	urban loss	crop gain	7.23E+07	72.3				45.0		16.1			
33	urban	urban	stable urban	stable urban	8.43E+06	8.4		5.0							
34	urban	wetland	urban loss	wetland gain	2.29E+06	2.3				1.4		4.4			
35	urban	water	urban loss	water gain	3.00E+05	0.3				0.2		2.3			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	52.5	0.0	52.5	52.5	783,936.1
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		60.1	0.0	783,996.1	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				0.0		0.0			
39	wetland	crop	wetland loss	cropland gain	4.02E+03	0.0				100.0		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	2.68E+03	0.0		39.9							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	2.19E+06	2.2	52.3		50.6	4.3	13.2	0.7	14.9	-37.4	-71.5
44	water	barren	water loss	barren gain	4.69E+06	4.7	0.5		96.8	9.3	25.2	1.9			
45	water	grass	water loss	grassland gain	3.04E+07	30.4				60.2		1.7			
46	water	crop	water loss	cropland gain	1.12E+07	11.2				22.1		2.5			
47	water	urban	water loss	urban gain	2.92E+05	0.3				0.6		4.2			
48	water	wetland	water loss	wetland gain	1.78E+06	1.8				3.5		3.4			
49	water	water	stable water	stable water	1.69E+06	1.7		3.2							
	Total					10,268.5									

Appendix 2.2.4.5.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Kabardino-Balkarskaya respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.07E+09	2,067.2	2,196.2	94.1	129.0		421.0		2,488.2	292.0	13.3
2	forest	barren	forest loss	barren gain	8.81E+06	8.8	21.4		5.9	6.8	19.2	13.4			
3	forest	grass	forest loss	grassland gain	8.74E+07	87.4				67.7		12.7			
4	forest	crop	forest loss	cropland gain	2.29E+07	22.9				17.8		7.8			
5	forest	urban	forest loss	urban gain	1.89E+05	0.2				0.1		0.4			
6	forest	wetland	forest loss	wetland gain	7.76E+06	7.8				6.0		12.3			
7	forest	water	forest loss	water gain	1.92E+06	1.9				1.5		12.0			
8	barren	forest	barren loss	forest gain	2.26E+07	22.6	260.4		117.4	19.2	65.8	5.4	208.8	-51.6	-19.8
9	barren	barren	stable barren	stable barren	1.43E+08	143.0	2.5	54.9	45.1		25.3				
10	barren	grass	barren loss	grassland gain	8.50E+07	85.0				72.4		12.4			
11	barren	crop	barren loss	cropland gain	4.61E+06	4.6				3.9		1.6			
12	barren	urban	barren loss	urban gain	9.08E+05	0.9				0.8		2.1			
13	barren	wetland	barren loss	wetland gain	1.96E+06	2.0				1.7		3.1			
14	barren	water	barren loss	water gain	2.37E+06	2.4				2.0		14.9			
15	grass	forest	grassland loss	forest gain	2.33E+08	233.2	3,614.7		577.8	40.4	686.3	55.4	3,723.2	108.5	3.0
16	grass	barren	grassland loss	barren gain	4.86E+07	48.6	35.2		16.0	8.4	19.0	73.8			
17	grass	grass	stable grassland	stable grass	3.04E+09	3,036.9		84.0							
18	grass	crop	grassland loss	cropland gain	2.48E+08	248.3				43.0		84.7			
19	grass	urban	grassland loss	urban gain	2.99E+07	29.9				5.2		69.3			
20	grass	wetland	grassland loss	wetland gain	1.34E+07	13.4				2.3		21.4			
21	grass	water	grassland loss	water gain	4.36E+06	4.4				0.8		27.4			
22	crop	forest	cropland loss	forest gain	1.41E+08	141.3	4,114.9		702.7	20.1	293.0	33.6	3,705.3	-409.7	-10.0
23	crop	barren	cropland loss	barren gain	6.27E+06	6.3	40.1		17.1	0.9	7.1	9.5			
24	crop	grass	cropland loss	grassland gain	5.03E+08	503.1				71.6		73.3			
25	crop	crop	stable cropland	stable cropland	3.41E+09	3,412.3		82.9							
26	crop	urban	cropland loss	urban gain	1.19E+07	11.9				1.7		27.6			
27	crop	wetland	cropland loss	wetland gain	3.57E+07	35.7				5.1		56.7			
28	crop	water	cropland loss	water gain	4.44E+06	4.4				0.6		27.9			
29	urban	forest	urban loss	forest gain	2.20E+05	0.2	15.4		8.9	2.5	43.2	0.1	49.7	34.3	222.7
30	urban	barren	urban loss	barren gain	4.00E+05	0.4	0.1		58.1	4.5	280.8	0.6			
31	urban	grass	urban loss	grass gain	4.45E+06	4.4				49.7		0.6			
32	urban	crop	urban loss	crop gain	3.43E+06	3.4				38.4		1.2			
33	urban	urban	stable urban	stable urban	6.44E+06	6.4		41.9							
34	urban	wetland	urban loss	wetland gain	4.28E+05	0.4				4.8		0.7			
35	urban	water	urban loss	water gain	2.22E+04	0.0				0.2		0.1			
36	wetland	forest	wetland loss	forest gain	2.09E+07	20.9	52.5		40.8	51.4	62.9	5.0	74.7	22.1	42.1
37	wetland	barren	wetland loss	barren gain	2.54E+05	0.3	0.5		77.6	0.6	119.7	0.4			
38	wetland	grass	wetland loss	grassland gain	4.95E+06	4.9				12.1		0.7			
39	wetland	crop	wetland loss	cropland gain	1.16E+07	11.6				28.4		3.9			
40	wetland	urban	wetland loss	urban gain	2.42E+05	0.2				0.6		0.6			
41	wetland	wetland	stable wetland	stable wetland	1.18E+07	11.8		22.4							
42	wetland	water	wetland loss	water gain	2.82E+06	2.8				6.9		17.7			
43	water	forest	water loss	forest gain	2.79E+06	2.8	14.9		11.6	24.1	15.9	0.7	19.2	4.4	29.4
44	water	barren	water loss	barren gain	1.48E+06	1.5	0.1		77.9	12.8	107.2	2.2			
45	water	grass	water loss	grassland gain	1.49E+06	1.5				12.9		0.2			
46	water	crop	water loss	cropland gain	2.18E+06	2.2				18.8		0.7			
47	water	urban	water loss	urban gain	1.04E+04	0.0				0.1		0.0			
48	water	wetland	water loss	wetland gain	3.62E+06	3.6				31.3		5.8			
49	water	water	stable water	stable water	3.29E+06	3.3		22.1							
	Total					10,269.0									

Appendix 2.2.4.5.3. 50-year changes (1965-2015) in land cover and change percentages within Kabardino-Balkarskaya respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.01E+09	2,011.2	3,304.2	60.9	1,293.0		477.0		2,488.2	-816.0	-24.7
2	forest	barren	forest loss	barren gain	1.52E+07	15.2	32.2		39.1	1.2	14.4	7.6			
3	forest	grass	forest loss	grassland gain	1.14E+09	1,139.6				88.1		60.0			
4	forest	crop	forest loss	cropland gain	1.24E+08	123.6				9.6		45.9			
5	forest	urban	forest loss	urban gain	2.53E+06	2.5				0.2		9.7			
6	forest	wetland	forest loss	wetland gain	1.00E+07	10.0				0.8		13.4			
7	forest	water	forest loss	water gain	2.05E+06	2.0				0.2		12.2			
8	barren	forest	barren loss	forest gain	3.03E+05	0.3	12.5		5.2	5.9	201.4	0.1	208.8	196.3	1,567.2
9	barren	barren	stable barren	stable barren	7.37E+06	7.4	0.1	58.9	41.1		1,608.4				
10	barren	grass	barren loss	grassland gain	4.65E+06	4.7				90.3		0.2			
11	barren	crop	barren loss	cropland gain	1.50E+05	0.2				2.9		0.1			
12	barren	urban	barren loss	urban gain	2.68E+04	0.0				0.5		0.1			
13	barren	wetland	barren loss	wetland gain	1.31E+04	0.0				0.3		0.0			
14	barren	water	barren loss	water gain	5.21E+03	0.0				0.1		0.0			
15	grass	forest	grassland loss	forest gain	2.06E+08	206.2	2,274.1		449.2	45.9	1,898.3	43.2	3,723.2	1,449.1	63.7
16	grass	barren	grassland loss	barren gain	1.62E+08	162.2	22.1		19.8	36.1	83.5	80.5			
17	grass	grass	stable grassland	stable grass	1.82E+09	1,824.9		80.2							
18	grass	crop	grassland loss	cropland gain	7.84E+07	78.4				17.4		29.1			
19	grass	urban	grassland loss	urban gain	3.72E+05	0.4				0.1		1.4			
20	grass	wetland	grassland loss	wetland gain	1.74E+06	1.7				0.4		2.3			
21	grass	water	grassland loss	water gain	4.27E+05	0.4				0.1		2.5			
22	crop	forest	cropland loss	forest gain	2.60E+08	260.0	4,456.0		1,019.8	25.5	269.0	54.5	3,705.3	-750.8	-16.8
23	crop	barren	cropland loss	barren gain	1.25E+07	12.5	43.4		22.9	1.2	6.0	6.2			
24	crop	grass	cropland loss	grassland gain	6.53E+08	653.2				64.0		34.4			
25	crop	crop	stable cropland	stable cropland	3.44E+09	3,436.2		77.1							
26	crop	urban	cropland loss	urban gain	2.18E+07	21.8				2.1		83.6			
27	crop	wetland	cropland loss	wetland gain	5.82E+07	58.2				5.7		78.0			
28	crop	water	cropland loss	water gain	1.41E+07	14.1				1.4		83.8			
29	urban	forest	urban loss	forest gain	5.98E+06	6.0	170.0		146.4	4.1	26.1	1.3	49.7	-120.3	-70.8
30	urban	barren	urban loss	barren gain	5.26E+06	5.3	1.7		86.1	3.6	15.4	2.6			
31	urban	grass	urban loss	grass gain	7.72E+07	77.2				52.7		4.1			
32	urban	crop	urban loss	crop gain	5.55E+07	55.5				37.9		20.6			
33	urban	urban	stable urban	stable urban	2.36E+07	23.6		13.9							
34	urban	wetland	urban loss	wetland gain	2.20E+06	2.2				1.5		2.9			
35	urban	water	urban loss	water gain	2.48E+05	0.2				0.2		1.5			
36	wetland	forest	wetland loss	forest gain	1.13E+03	0.0	0.0		0.0	15.3	74.7	0.0	74.7	74.7	851,531.1
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		83.8	0.0	851,614.9	0.0			
38	wetland	grass	wetland loss	grassland gain	5.81E+02	0.0				7.9		0.0			
39	wetland	crop	wetland loss	cropland gain	5.64E+03	0.0				76.8		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	1.42E+03	0.0		16.2							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	4.53E+06	4.5	52.2		49.7	9.1	16.8	1.0	19.2	-32.9	-63.1
44	water	barren	water loss	barren gain	6.26E+06	6.3	0.5		95.3	12.6	32.2	3.1			
45	water	grass	water loss	grassland gain	2.37E+07	23.7				47.7		1.2			
46	water	crop	water loss	cropland gain	1.14E+07	11.4				22.9		4.2			
47	water	urban	water loss	urban gain	1.36E+06	1.4				2.7		5.2			
48	water	wetland	water loss	wetland gain	2.47E+06	2.5				5.0		3.3			
49	water	water	stable water	stable water	2.44E+06	2.4		4.7							
	Total					10,269.0									

Appendix 2.2.4.6.1 Soviet era changes (1965-'87) in land cover and change percentages within Respublika Severnaya Osetiya, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.77E+09	1,767.9	2,046.3	86.4	278.5		380.3		2,148.2	101.9	5.0
2	forest	barren	forest loss	barren gain	9.14E+06	9.1	30.9		13.6	3.3	18.6	6.3			
3	forest	grass	forest loss	grassland gain	2.01E+08	201.4				72.3		29.9			
4	forest	crop	forest loss	cropland gain	6.18E+07	61.8				22.2		29.3			
5	forest	urban	forest loss	urban gain	1.12E+06	1.1				0.4		3.7			
6	forest	wetland	forest loss	wetland gain	3.70E+06	3.7				1.3		6.8			
7	forest	water	forest loss	water gain	1.24E+06	1.2				0.4		9.3			
8	barren	forest	barren loss	forest gain	3.08E+06	3.1	21.7		8.3	37.2	145.0	0.8	158.4	136.7	630.8
9	barren	barren	stable barren	stable barren	1.34E+07	13.4	0.3	61.8	38.2		668.9				
10	barren	grass	barren loss	grassland gain	3.96E+06	4.0				47.8		0.6			
11	barren	crop	barren loss	cropland gain	4.24E+05	0.4				5.1		0.2			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	7.99E+04	0.1				1.0		0.1			
14	barren	water	barren loss	water gain	7.30E+05	0.7				8.8		5.5			
15	grass	forest	grassland loss	forest gain	2.03E+08	203.1	1,261.6		407.7	49.8	673.3	53.4	1,527.3	265.7	21.1
16	grass	barren	grassland loss	barren gain	1.12E+08	111.6	19.1		32.3	27.4	53.4	77.0			
17	grass	grass	stable grassland	stable grass	8.54E+08	854.0		67.7							
18	grass	crop	grassland loss	cropland gain	8.38E+07	83.8				20.6		39.7			
19	grass	urban	grassland loss	urban gain	2.45E+06	2.4				0.6		8.0			
20	grass	wetland	grassland loss	wetland gain	1.86E+06	1.9				0.5		3.4			
21	grass	water	grassland loss	water gain	4.78E+06	4.8				1.2		35.9			
22	crop	forest	cropland loss	forest gain	1.67E+08	167.5	3,138.8		683.8	24.5	211.2	44.0	2,666.3	-472.6	-15.1
23	crop	barren	cropland loss	barren gain	1.91E+07	19.1	47.4		21.8	2.8	6.7	13.2			
24	crop	grass	cropland loss	grassland gain	4.22E+08	421.9				61.7		62.7			
25	crop	crop	stable cropland	stable cropland	2.46E+09	2,455.0		78.2							
26	crop	urban	cropland loss	urban gain	2.54E+07	25.4				3.7		83.3			
27	crop	wetland	cropland loss	wetland gain	4.35E+07	43.5				6.4		80.2			
28	crop	water	cropland loss	water gain	6.46E+06	6.5				0.9		48.5			
29	urban	forest	urban loss	forest gain	3.29E+06	3.3	117.4		95.9	3.4	30.5	0.9	52.1	-65.3	-55.7
30	urban	barren	urban loss	barren gain	2.25E+06	2.3	1.8		81.7	2.4	26.0	1.6			
31	urban	grass	urban loss	grass gain	2.99E+07	29.9				31.2		4.4			
32	urban	crop	urban loss	crop gain	5.76E+07	57.6				60.1		27.3			
33	urban	urban	stable urban	stable urban	2.15E+07	21.5		18.3							
34	urban	wetland	urban loss	wetland gain	2.75E+06	2.8				2.9		5.1			
35	urban	water	urban loss	water gain	9.71E+04	0.1				0.1		0.7			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	54.3	0.0	54.3	54.3	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	3.38E+06	3.4	34.8		33.9	10.0	13.3	0.9	14.2	-20.6	-59.3
44	water	barren	water loss	barren gain	2.89E+06	2.9	0.5		97.5	8.5	38.2	2.0			
45	water	grass	water loss	grassland gain	1.62E+07	16.2				47.7		2.4			
46	water	crop	water loss	cropland gain	7.56E+06	7.6				22.3		3.6			
47	water	urban	water loss	urban gain	1.53E+06	1.5				4.5		5.0			
48	water	wetland	water loss	wetland gain	2.38E+06	2.4				7.0		4.4			
49	water	water	stable water	stable water	8.64E+05	0.9		2.5							
	Total					6,620.6									

Appendix 2.2.4.6.2 Post-Soviet changes (1987-2015) in land cover and change percentages within Respublika Severnaya Osetiya, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.06E+09	2,058.3	2,149.4	95.8	91.0		302.5		2,360.9	211.5	9.8
2	forest	barren	forest loss	barren gain	1.28E+07	12.8	32.5		4.2	14.0	14.1	23.2			
3	forest	grass	forest loss	grassland gain	4.74E+07	47.4				52.0		11.8			
4	forest	crop	forest loss	cropland gain	2.33E+07	23.3				25.6		10.7			
5	forest	urban	forest loss	urban gain	2.81E+05	0.3				0.3		0.8			
6	forest	wetland	forest loss	wetland gain	5.66E+06	5.7				6.2		7.2			
7	forest	water	forest loss	water gain	1.70E+06	1.7				1.9		10.6			
8	barren	forest	barren loss	forest gain	1.33E+07	13.3	158.8		62.3	21.3	55.1	4.4	151.6	-7.2	-4.6
9	barren	barren	stable barren	stable barren	9.65E+07	96.5	2.4	60.8	39.2		34.7				
10	barren	grass	barren loss	grassland gain	3.48E+07	34.8				55.9		8.7			
11	barren	crop	barren loss	cropland gain	4.18E+06	4.2				6.7		1.9			
12	barren	urban	barren loss	urban gain	2.81E+06	2.8				4.5		8.2			
13	barren	wetland	barren loss	wetland gain	2.05E+06	2.0				3.3		2.6			
14	barren	water	barren loss	water gain	5.20E+06	5.2				8.3		32.4			
15	grass	forest	grassland loss	forest gain	1.55E+08	155.5	1,526.6		379.5	41.0	401.2	51.4	1,548.3	21.7	1.4
16	grass	barren	grassland loss	barren gain	3.11E+07	31.1	23.1		24.9	8.2	26.3	56.6			
17	grass	grass	stable grassland	stable grass	1.15E+09	1,147.1		75.1							
18	grass	crop	grassland loss	cropland gain	1.57E+08	157.3				41.4		72.1			
19	grass	urban	grassland loss	urban gain	2.16E+07	21.6				5.7		62.9			
20	grass	wetland	grassland loss	wetland gain	1.08E+07	10.8				2.8		13.8			
21	grass	water	grassland loss	water gain	3.29E+06	3.3				0.9		20.5			
22	crop	forest	cropland loss	forest gain	1.14E+08	114.0	2,666.3		485.0	23.5	218.1	37.7	2,399.4	-266.9	-10.0
23	crop	barren	cropland loss	barren gain	7.48E+06	7.5	40.3		18.2	1.5	8.2	13.6			
24	crop	grass	cropland loss	grassland gain	2.95E+08	295.0				60.8		73.5			
25	crop	crop	stable cropland	stable cropland	2.18E+09	2,181.3		81.8							
26	crop	urban	cropland loss	urban gain	9.28E+06	9.3				1.9		27.1			
27	crop	wetland	cropland loss	wetland gain	5.59E+07	55.9				11.5		71.6			
28	crop	water	cropland loss	water gain	3.29E+06	3.3				0.7		20.5			
29	urban	forest	urban loss	forest gain	7.52E+05	0.8	52.1		36.9	2.0	34.3	0.2	49.4	-2.6	-5.1
30	urban	barren	urban loss	barren gain	5.44E+05	0.5	0.8		70.9	1.5	65.8	1.0			
31	urban	grass	urban loss	grass gain	1.85E+07	18.5				50.2		4.6			
32	urban	crop	urban loss	crop gain	1.56E+07	15.6				42.2		7.1			
33	urban	urban	stable urban	stable urban	1.52E+07	15.2		29.1							
34	urban	wetland	urban loss	wetland gain	1.38E+06	1.4				3.7		1.8			
35	urban	water	urban loss	water gain	1.41E+05	0.1				0.4		0.9			
36	wetland	forest	wetland loss	forest gain	1.51E+07	15.1	54.3		39.4	38.3	78.1	5.0	93.0	38.7	71.3
37	wetland	barren	wetland loss	barren gain	5.84E+05	0.6	0.8		72.7	1.5	143.9	1.1			
38	wetland	grass	wetland loss	grassland gain	4.57E+06	4.6				11.6		1.1			
39	wetland	crop	wetland loss	cropland gain	1.64E+07	16.4				41.7		7.5			
40	wetland	urban	wetland loss	urban gain	3.35E+05	0.3				0.8		1.0			
41	wetland	wetland	stable wetland	stable wetland	1.48E+07	14.8		27.3							
42	wetland	water	wetland loss	water gain	2.42E+06	2.4				6.1		15.1			
43	water	forest	water loss	forest gain	3.96E+06	4.0	14.1		11.2	35.5	16.1	1.3	19.0	4.9	34.5
44	water	barren	water loss	barren gain	2.55E+06	2.5	0.2		79.0	22.8	113.5	4.6			
45	water	grass	water loss	grassland gain	9.45E+05	0.9				8.5		0.2			
46	water	crop	water loss	cropland gain	1.37E+06	1.4				12.2		0.6			
47	water	urban	water loss	urban gain	1.84E+04	0.0				0.2		0.1			
48	water	wetland	water loss	wetland gain	2.33E+06	2.3				20.9		3.0			
49	water	water	stable water	stable water	2.97E+06	3.0		21.0							
	Total					6,621.6									

Appendix 2.2.4.6.3 50-year changes (1965-2015) in land cover and change percentages within Respublika Severnaya Osetiya, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.82E+09	1,824.9	2,046.0	89.2	221.1		535.9		2,360.9	314.9	15.4
2	forest	barren	forest loss	barren gain	9.63E+06	9.6	30.9		10.8	4.4	26.2	7.0			
3	forest	grass	forest loss	grassland gain	1.74E+08	174.4				78.9		24.0			
4	forest	crop	forest loss	cropland gain	3.25E+07	32.5				14.7		20.8			
5	forest	urban	forest loss	urban gain	2.49E+05	0.2				0.1		0.8			
6	forest	wetland	forest loss	wetland gain	3.27E+06	3.3				1.5		3.5			
7	forest	water	forest loss	water gain	1.07E+06	1.1				0.5		6.4			
8	barren	forest	barren loss	forest gain	3.40E+06	3.4	21.6		8.2	41.6	138.2	0.6	151.6	130.0	602.9
9	barren	barren	stable barren	stable barren	1.34E+07	13.4	0.3	62.0	38.0		640.9				
10	barren	grass	barren loss	grassland gain	4.08E+06	4.1				49.8		0.6			
11	barren	crop	barren loss	cropland gain	6.60E+05	0.7				8.1		0.4			
12	barren	urban	barren loss	urban gain	3.95E+03	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	2.71E+04	0.0				0.3		0.0			
14	barren	water	barren loss	water gain	1.32E+04	0.0				0.2		0.1			
15	grass	forest	grassland loss	forest gain	2.54E+08	254.0	1,263.6		440.9	57.6	725.5	47.4	1,548.3	284.7	22.5
16	grass	barren	grassland loss	barren gain	1.17E+08	117.4	19.1		34.9	26.6	57.4	84.9			
17	grass	grass	stable grassland	stable grass	8.23E+08	822.8		65.1							
18	grass	crop	grassland loss	cropland gain	6.35E+07	63.5				14.4		40.6			
19	grass	urban	grassland loss	urban gain	1.13E+06	1.1				0.3		3.5			
20	grass	wetland	grassland loss	wetland gain	3.33E+06	3.3				0.8		3.6			
21	grass	water	grassland loss	water gain	1.57E+06	1.6				0.4		9.4			
22	crop	forest	cropland loss	forest gain	2.66E+08	266.5	3,137.9		894.9	29.8	156.5	49.7	2,399.4	-738.5	-23.5
23	crop	barren	cropland loss	barren gain	8.87E+06	8.9	47.4		28.5	1.0	5.0	6.4			
24	crop	grass	cropland loss	grassland gain	4.96E+08	496.0				55.4		68.4			
25	crop	crop	stable cropland	stable cropland	2.24E+09	2,242.9		71.5							
26	crop	urban	cropland loss	urban gain	2.90E+07	29.0				3.2		90.1			
27	crop	wetland	cropland loss	wetland gain	8.08E+07	80.8				9.0		86.9			
28	crop	water	cropland loss	water gain	1.39E+07	13.9				1.5		82.5			
29	urban	forest	urban loss	forest gain	5.14E+06	5.1	117.8		100.6	5.1	32.2	1.0	49.4	-68.4	-58.0
30	urban	barren	urban loss	barren gain	1.38E+06	1.4	1.8		85.4	1.4	27.3	1.0			
31	urban	grass	urban loss	grass gain	3.71E+07	37.1				36.9		5.1			
32	urban	crop	urban loss	crop gain	5.36E+07	53.6				53.3		34.3			
33	urban	urban	stable urban	stable urban	1.72E+07	17.2		14.6							
34	urban	wetland	urban loss	wetland gain	3.03E+06	3.0				3.0		3.3			
35	urban	water	urban loss	water gain	2.88E+05	0.3				0.3		1.7			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	93.0	0.0	93.0	93.0	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	6.96E+06	7.0	34.6		32.4	21.5	16.8	1.3	19.0	-15.6	-45.1
44	water	barren	water loss	barren gain	9.49E+05	0.9	0.5		93.6	2.9	48.5	0.7			
45	water	grass	water loss	grassland gain	1.39E+07	13.9				43.0		1.9			
46	water	crop	water loss	cropland gain	6.23E+06	6.2				19.2		4.0			
47	water	urban	water loss	urban gain	1.81E+06	1.8				5.6		5.6			
48	water	wetland	water loss	wetland gain	2.53E+06	2.5				7.8		2.7			
49	water	water	stable water	stable water	2.22E+06	2.2		6.4							
	Total					6,621.6									

Appendix 2.2.4.7.1. Soviet era changes (1965-'87) in land cover and change percentages within Ingushskaja respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	6.54E+08	653.9	718.3	91.0	64.4		202.4		856.3	138.0	19.2
2	forest	barren	forest loss	barren gain	7.03E+05	0.7	26.3		9.0	1.1	28.2	2.6			
3	forest	grass	forest loss	grassland gain	4.49E+07	44.9				69.7		16.9			
4	forest	crop	forest loss	cropland gain	1.79E+07	17.9				27.8		10.7			
5	forest	urban	forest loss	urban gain	1.88E+05	0.2				0.3		13.8			
6	forest	wetland	forest loss	wetland gain	3.51E+05	0.4				0.5		9.3			
7	forest	water	forest loss	water gain	3.77E+05	0.4				0.6		14.0			
8	barren	forest	barren loss	forest gain	1.32E+06	1.3	3.9		1.9	68.0	27.0	0.7	29.0	25.1	641.8
9	barren	barren	stable barren	stable barren	1.97E+06	2.0	0.1	50.4	49.6		691.4				
10	barren	grass	barren loss	grassland gain	3.40E+05	0.3				17.5		0.1			
11	barren	crop	barren loss	cropland gain	5.75E+04	0.1				3.0		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	2.25E+05	0.2				11.6		8.4			
15	grass	forest	grassland loss	forest gain	1.54E+08	154.1	698.3		320.4	48.1	265.0	76.2	642.9	-55.4	-7.9
16	grass	barren	grassland loss	barren gain	2.50E+07	25.0	25.6		45.9	7.8	38.0	92.5			
17	grass	grass	stable grassland	stable grass	3.78E+08	377.9		54.1							
18	grass	crop	grassland loss	cropland gain	1.39E+08	138.9				43.3		83.2			
19	grass	urban	grassland loss	urban gain	8.56E+05	0.9				0.3		62.8			
20	grass	wetland	grassland loss	wetland gain	2.40E+05	0.2				0.1		6.4			
21	grass	water	grassland loss	water gain	1.28E+06	1.3				0.4		47.5			
22	crop	forest	cropland loss	forest gain	4.65E+07	46.5	1,292.2		263.0	17.7	166.9	23.0	1,196.1	-96.1	-7.4
23	crop	barren	cropland loss	barren gain	1.22E+06	1.2	47.3		20.4	0.5	12.9	4.5			
24	crop	grass	cropland loss	grassland gain	2.11E+08	211.1				80.3		79.7			
25	crop	crop	stable cropland	stable cropland	1.03E+09	1,029.1		79.6							
26	crop	urban	cropland loss	urban gain	2.96E+05	0.3				0.1		21.7			
27	crop	wetland	cropland loss	wetland gain	3.08E+06	3.1				1.2		81.7			
28	crop	water	cropland loss	water gain	8.12E+05	0.8				0.3		30.1			
29	urban	forest	urban loss	forest gain	3.57E+05	0.4	17.5		17.4	2.0	1.4	0.2	1.5	-16.1	-91.6
30	urban	barren	urban loss	barren gain	3.93E+04	0.0	0.6		99.4	0.2	7.8	0.1			
31	urban	grass	urban loss	grass gain	7.76E+06	7.8				44.5		2.9			
32	urban	crop	urban loss	crop gain	9.17E+06	9.2				52.6		5.5			
33	urban	urban	stable urban	stable urban	1.03E+05	0.1		0.6							
34	urban	wetland	urban loss	wetland gain	9.56E+04	0.1				0.5		2.5			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	3.8	0.0	3.8	3.8	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	1.16E+05	0.1	2.1		2.1	5.6	2.7	0.1	2.7	0.6	30.8
44	water	barren	water loss	barren gain	7.46E+04	0.1	0.1		100.0	3.6	130.8	0.3			
45	water	grass	water loss	grassland gain	9.07E+05	0.9				44.1		0.3			
46	water	crop	water loss	cropland gain	9.32E+05	0.9				45.2		0.6			
47	water	urban	water loss	urban gain	2.42E+04	0.0				1.2		1.8			
48	water	wetland	water loss	wetland gain	5.25E+03	0.0				0.3		0.1			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					2,732.3									

Appendix 2.2.4.7.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Ingushskaja respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	8.05E+08	804.6	856.9	93.9	52.2		82.4		887.0	30.1	3.5
2	forest	barren	forest loss	barren gain	3.77E+06	3.8	31.4		6.1	7.2	9.6	26.1			
3	forest	grass	forest loss	grassland gain	3.27E+07	32.7				62.7		10.7			
4	forest	crop	forest loss	cropland gain	1.39E+07	13.9				26.6		11.2			
5	forest	urban	forest loss	urban gain	7.83E+04	0.1				0.1		0.5			
6	forest	wetland	forest loss	wetland gain	1.67E+06	1.7				3.2		23.9			
7	forest	water	forest loss	water gain	9.27E+04	0.1				0.2		12.2			
8	barren	forest	barren loss	forest gain	5.75E+05	0.6	29.0		6.8	8.4	14.4	0.7	36.6	7.6	26.2
9	barren	barren	stable barren	stable barren	2.22E+07	22.2	1.1	76.5	23.5		49.7				
10	barren	grass	barren loss	grassland gain	5.80E+06	5.8				85.0		1.9			
11	barren	crop	barren loss	cropland gain	3.12E+05	0.3				4.6		0.3			
12	barren	urban	barren loss	urban gain	1.00E+05	0.1				1.5		0.7			
13	barren	wetland	barren loss	wetland gain	2.44E+04	0.0				0.4		0.3			
14	barren	water	barren loss	water gain	1.25E+04	0.0				0.2		1.6			
15	grass	forest	grassland loss	forest gain	4.73E+07	47.3	642.9		170.6	27.7	304.6	57.5	776.9	134.0	20.8
16	grass	barren	grassland loss	barren gain	6.71E+06	6.7	23.5		26.5	3.9	47.4	46.4			
17	grass	grass	stable grassland	stable grass	4.72E+08	472.2		73.5							
18	grass	crop	grassland loss	cropland gain	1.08E+08	107.6				63.0		86.7			
19	grass	urban	grassland loss	urban gain	8.42E+06	8.4				4.9		55.9			
20	grass	wetland	grassland loss	wetland gain	5.72E+05	0.6				0.3		8.2			
21	grass	water	grassland loss	water gain	4.99E+04	0.0				0.0		6.6			
22	crop	forest	cropland loss	forest gain	3.25E+07	32.5	1,196.3		311.9	10.4	124.0	39.4	1,008.4	-187.9	-15.7
23	crop	barren	cropland loss	barren gain	2.96E+06	3.0	43.8		26.1	1.0	10.4	20.5			
24	crop	grass	cropland loss	grassland gain	2.65E+08	264.9				84.9		87.0			
25	crop	crop	stable cropland	stable cropland	8.84E+08	884.4		73.9							
26	crop	urban	cropland loss	urban gain	6.41E+06	6.4				2.1		42.5			
27	crop	wetland	cropland loss	wetland gain	4.58E+06	4.6				1.5		65.6			
28	crop	water	cropland loss	water gain	5.12E+05	0.5				0.2		67.6			
29	urban	forest	urban loss	forest gain	9.83E+04	0.1	1.5		1.0	9.8	15.1	0.1	15.5	14.1	959.6
30	urban	barren	urban loss	barren gain	9.82E+04	0.1	0.1		68.3	9.8	1,027.9	0.7			
31	urban	grass	urban loss	grass gain	5.29E+05	0.5				52.8		0.2			
32	urban	crop	urban loss	crop gain	2.43E+05	0.2				24.2		0.2			
33	urban	urban	stable urban	stable urban	4.64E+05	0.5		31.7							
34	urban	wetland	urban loss	wetland gain	3.37E+04	0.0				3.4		0.5			
35	urban	water	urban loss	water gain	6.60E+02	0.0				0.1		0.1			
36	wetland	forest	wetland loss	forest gain	8.46E+05	0.8	3.8		3.2	26.6	7.0	1.0	7.6	3.8	100.9
37	wetland	barren	wetland loss	barren gain	5.53E+04	0.1	0.1		83.9	1.7	184.8	0.4			
38	wetland	grass	wetland loss	grassland gain	5.79E+05	0.6				18.2		0.2			
39	wetland	crop	wetland loss	cropland gain	1.54E+06	1.5				48.5		1.2			
40	wetland	urban	wetland loss	urban gain	6.42E+04	0.1				2.0		0.4			
41	wetland	wetland	stable wetland	stable wetland	6.08E+05	0.6		16.1							
42	wetland	water	wetland loss	water gain	8.98E+04	0.1				2.8		11.9			
43	water	forest	water loss	forest gain	1.04E+06	1.0	2.7		2.5	41.4	0.8	1.3	0.9	-1.8	-66.0
44	water	barren	water loss	barren gain	8.45E+05	0.8	0.1		94.3	33.5	28.3	5.9			
45	water	grass	water loss	grassland gain	7.28E+04	0.1				2.9		0.0			
46	water	crop	water loss	cropland gain	4.57E+05	0.5				18.1		0.4			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.05E+05	0.1				4.1		1.5			
49	water	water	stable water	stable water	1.53E+05	0.2		5.7							
	Total					2,733.0									

Appendix 2.2.4.7.3. 50-year changes (1965-2015) in land cover and change percentages within Ingushskaja respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	6.60E+08	660.2	718.3	91.9	58.1		226.2		886.5	168.2	23.4
2	forest	barren	forest loss	barren gain	1.49E+06	1.5	26.3		8.1	2.6	31.5	4.4			
3	forest	grass	forest loss	grassland gain	4.75E+07	47.5				81.9		12.8			
4	forest	crop	forest loss	cropland gain	8.23E+06	8.2				14.2		7.9			
5	forest	urban	forest loss	urban gain	1.29E+05	0.1				0.2		1.0			
6	forest	wetland	forest loss	wetland gain	6.38E+05	0.6				1.1		8.4			
7	forest	water	forest loss	water gain	4.22E+04	0.0				0.1		4.6			
8	barren	forest	barren loss	forest gain	5.69E+05	0.6	3.9		1.1	50.5	33.8	0.3	36.6	32.7	835.7
9	barren	barren	stable barren	stable barren	2.79E+06	2.8	0.1	71.2	28.8		864.5				
10	barren	grass	barren loss	grassland gain	5.08E+05	0.5				45.1		0.1			
11	barren	crop	barren loss	cropland gain	5.01E+04	0.1				4.4		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.76E+08	175.8	698.3		294.2	59.8	372.8	77.7	776.9	78.6	11.3
16	grass	barren	grassland loss	barren gain	2.76E+07	27.6	25.6		42.1	9.4	53.4	81.6			
17	grass	grass	stable grassland	stable grass	4.04E+08	404.1		57.9							
18	grass	crop	grassland loss	cropland gain	8.96E+07	89.6				30.5		86.2			
19	grass	urban	grassland loss	urban gain	7.53E+05	0.8				0.3		6.1			
20	grass	wetland	grassland loss	wetland gain	4.30E+05	0.4				0.1		5.7			
21	grass	water	grassland loss	water gain	5.16E+04	0.1				0.0		5.7			
22	crop	forest	cropland loss	forest gain	4.94E+07	49.4	1,292.2		387.8	12.7	103.9	21.9	1,008.2	-283.9	-22.0
23	crop	barren	cropland loss	barren gain	4.20E+06	4.2	47.3		30.0	1.1	8.0	12.4			
24	crop	grass	cropland loss	grassland gain	3.16E+08	315.9				81.4		84.7			
25	crop	crop	stable cropland	stable cropland	9.04E+08	904.4		70.0							
26	crop	urban	cropland loss	urban gain	1.12E+07	11.2				2.9		90.3			
27	crop	wetland	cropland loss	wetland gain	6.34E+06	6.3				1.6		83.4			
28	crop	water	cropland loss	water gain	7.94E+05	0.8				0.2		87.3			
29	urban	forest	urban loss	forest gain	3.81E+05	0.4	17.5		14.4	2.7	12.4	0.2	15.5	-2.0	-11.4
30	urban	barren	urban loss	barren gain	5.13E+05	0.5	0.6		81.9	3.6	70.6	1.5			
31	urban	grass	urban loss	grass gain	7.92E+06	7.9				55.1		2.1			
32	urban	crop	urban loss	crop gain	5.42E+06	5.4				37.7		5.2			
33	urban	urban	stable urban	stable urban	3.17E+06	3.2		18.1							
34	urban	wetland	urban loss	wetland gain	1.14E+05	0.1				0.8		1.5			
35	urban	water	urban loss	water gain	2.17E+04	0.0				0.2		2.4			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	7.6	0.0	7.6	7.6	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	7.68E+04	0.1	2.1		2.1	3.7	0.9	0.0	0.9	-1.1	-55.8
44	water	barren	water loss	barren gain	3.21E+04	0.0	0.1		99.9	1.6	44.2	0.1			
45	water	grass	water loss	grassland gain	9.71E+05	1.0				47.2		0.3			
46	water	crop	water loss	cropland gain	5.84E+05	0.6				28.4		0.6			
47	water	urban	water loss	urban gain	3.16E+05	0.3				15.4		2.6			
48	water	wetland	water loss	wetland gain	7.79E+04	0.1				3.8		1.0			
49	water	water	stable water	stable water	1.31E+03	0.0		0.1							
	Total					2,732.3									

Appendix 2.2.4.8.1. Soviet era changes (1965-'87) in land cover and change percentages within Chechenskaja respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	7.70E+08	770.0	1,094.5	70.4	324.5		472.8		1,242.8	148.3	13.5
2	forest	barren	forest loss	barren gain	8.84E+06	8.8	25.2		29.6	2.7	43.2	27.5			
3	forest	grass	forest loss	grassland gain	2.38E+08	237.6				73.2		37.3			
4	forest	crop	forest loss	cropland gain	7.04E+07	70.4				21.7		20.2			
5	forest	urban	forest loss	urban gain	2.35E+05	0.2				0.1		4.4			
6	forest	wetland	forest loss	wetland gain	6.88E+06	6.9				2.1		17.0			
7	forest	water	forest loss	water gain	4.95E+05	0.5				0.2		3.9			
8	barren	forest	barren loss	forest gain	5.71E+06	5.7	104.8		42.6	13.4	32.2	1.2	94.4	-10.4	-9.9
9	barren	barren	stable barren	stable barren	6.22E+07	62.2	2.4	59.4	40.6		30.7				
10	barren	grass	barren loss	grassland gain	3.17E+07	31.7				74.4		5.0			
11	barren	crop	barren loss	cropland gain	1.80E+06	1.8				4.2		0.5			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	4.65E+05	0.5				1.1		1.1			
14	barren	water	barren loss	water gain	2.93E+06	2.9				6.9		23.0			
15	grass	forest	grassland loss	forest gain	3.60E+08	359.5	1,655.9		649.2	55.4	636.5	76.0	1,643.3	-12.6	-0.8
16	grass	barren	grassland loss	barren gain	1.81E+07	18.1	38.1		39.2	2.8	38.4	56.2			
17	grass	grass	stable grassland	stable grass	1.01E+09	1,006.8		60.8							
18	grass	crop	grassland loss	cropland gain	2.68E+08	268.4				41.3		76.9			
19	grass	urban	grassland loss	urban gain	8.33E+05	0.8				0.1		15.5			
20	grass	wetland	grassland loss	wetland gain	1.67E+06	1.7				0.3		4.1			
21	grass	water	grassland loss	water gain	6.72E+05	0.7				0.1		5.3			
22	crop	forest	cropland loss	forest gain	9.44E+07	94.4	1,463.2		505.4	18.7	349.0	20.0	1,306.9	-156.3	-10.7
23	crop	barren	cropland loss	barren gain	4.18E+06	4.2	33.6		34.5	0.8	23.9	13.0			
24	crop	grass	cropland loss	grassland gain	3.64E+08	363.6				71.9		57.1			
25	crop	crop	stable cropland	stable cropland	9.58E+08	957.9		65.5							
26	crop	urban	cropland loss	urban gain	4.31E+06	4.3				0.9		79.9			
27	crop	wetland	cropland loss	wetland gain	3.02E+07	30.2				6.0		74.7			
28	crop	water	cropland loss	water gain	8.63E+06	8.6				1.7		67.7			
29	urban	forest	urban loss	forest gain	1.51E+04	0.0	1.8		1.8	0.8	5.4	0.0	5.4	3.6	195.0
30	urban	barren	urban loss	barren gain	1.50E+04	0.0	0.0		97.4	0.8	292.3	0.0			
31	urban	grass	urban loss	grass gain	1.27E+06	1.3				70.5		0.2			
32	urban	crop	urban loss	crop gain	4.55E+05	0.5				25.4		0.1			
33	urban	urban	stable urban	stable urban	4.85E+04	0.0		2.6							
34	urban	wetland	urban loss	wetland gain	4.32E+04	0.0				2.4		0.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	8.11E+06	8.1	13.7		11.9	68.0	40.5	1.7	42.3	28.6	208.1
37	wetland	barren	wetland loss	barren gain	6.68E+03	0.0	0.3		86.9	0.1	295.0	0.0			
38	wetland	grass	wetland loss	grassland gain	3.19E+05	0.3				2.7		0.1			
39	wetland	crop	wetland loss	cropland gain	3.48E+06	3.5				29.2		1.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	1.80E+06	1.8		13.1							
42	wetland	water	wetland loss	water gain	9.12E+03	0.0				0.1		0.1			
43	water	forest	water loss	forest gain	4.96E+06	5.0	16.2		13.8	35.9	12.7	1.0	15.1	-1.1	-6.6
44	water	barren	water loss	barren gain	1.06E+06	1.1	0.4		85.1	7.7	78.5	3.3			
45	water	grass	water loss	grassland gain	2.10E+06	2.1				15.2		0.3			
46	water	crop	water loss	cropland gain	4.47E+06	4.5				32.4		1.3			
47	water	urban	water loss	urban gain	1.37E+04	0.0				0.1		0.3			
48	water	wetland	water loss	wetland gain	1.19E+06	1.2				8.7		3.0			
49	water	water	stable water	stable water	2.42E+06	2.4		14.9							
	Total					4,350.2									

Appendix 2.2.4.8.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Chechenskaja respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.18E+09	1,177.5	1,242.9	94.7	65.5		331.2		1,508.7	265.8	21.4
2	forest	barren	forest loss	barren gain	6.64E+06	6.6	28.6		5.3	10.1	26.6	20.7			
3	forest	grass	forest loss	grassland gain	4.29E+07	42.9				65.5		12.0			
4	forest	crop	forest loss	cropland gain	1.02E+07	10.2				15.6		7.0			
5	forest	urban	forest loss	urban gain	5.50E+04	0.1				0.1		0.2			
6	forest	wetland	forest loss	wetland gain	3.54E+06	3.5				5.4		10.3			
7	forest	water	forest loss	water gain	2.18E+06	2.2				3.3		16.5			
8	barren	forest	barren loss	forest gain	3.18E+06	3.2	93.2		14.8	21.5	32.1	1.0	110.6	17.3	18.6
9	barren	barren	stable barren	stable barren	7.84E+07	78.4	2.1	84.1	15.9		34.5				
10	barren	grass	barren loss	grassland gain	7.14E+06	7.1				48.3		2.0			
11	barren	crop	barren loss	cropland gain	1.06E+06	1.1				7.2		0.7			
12	barren	urban	barren loss	urban gain	9.29E+04	0.1				0.6		0.4			
13	barren	wetland	barren loss	wetland gain	4.64E+05	0.5				3.1		1.3			
14	barren	water	barren loss	water gain	2.85E+06	2.9				19.3		21.6			
15	grass	forest	grassland loss	forest gain	1.82E+08	182.0	1,643.0		350.3	52.0	356.5	54.9	1,649.2	6.2	0.4
16	grass	barren	grassland loss	barren gain	1.79E+07	17.9	37.8		21.3	5.1	21.7	55.8			
17	grass	grass	stable grassland	stable grass	1.29E+09	1,292.7		78.7							
18	grass	crop	grassland loss	cropland gain	1.26E+08	126.2				36.0		86.7			
19	grass	urban	grassland loss	urban gain	1.45E+07	14.5				4.2		65.2			
20	grass	wetland	grassland loss	wetland gain	6.39E+06	6.4				1.8		18.6			
21	grass	water	grassland loss	water gain	3.28E+06	3.3				0.9		24.8			
22	crop	forest	cropland loss	forest gain	1.26E+08	125.9	1,307.2		462.7	27.2	145.5	38.0	990.0	-317.1	-24.3
23	crop	barren	cropland loss	barren gain	4.23E+06	4.2	30.1		35.4	0.9	11.1	13.2			
24	crop	grass	cropland loss	grassland gain	3.00E+08	299.8				64.8		84.1			
25	crop	crop	stable cropland	stable cropland	8.44E+08	844.5		64.6							
26	crop	urban	cropland loss	urban gain	7.43E+06	7.4				1.6		33.3			
27	crop	wetland	cropland loss	wetland gain	2.23E+07	22.3				4.8		64.8			
28	crop	water	cropland loss	water gain	2.93E+06	2.9				0.6		22.2			
29	urban	forest	urban loss	forest gain	1.24E+04	0.0	5.4		4.1	0.3	22.3	0.0	23.6	18.2	335.4
30	urban	barren	urban loss	barren gain	3.98E+04	0.0	0.1		75.9	1.0	411.3	0.1			
31	urban	grass	urban loss	grass gain	2.94E+06	2.9				71.3		0.8			
32	urban	crop	urban loss	crop gain	1.10E+06	1.1				26.7		0.8			
33	urban	urban	stable urban	stable urban	1.31E+06	1.3		24.1							
34	urban	wetland	urban loss	wetland gain	2.88E+04	0.0				0.7		0.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.89E+07	18.9	42.3		30.5	61.8	34.4	5.7	46.2	3.9	9.2
37	wetland	barren	wetland loss	barren gain	4.72E+05	0.5	1.0		72.2	1.5	81.4	1.5			
38	wetland	grass	wetland loss	grassland gain	3.10E+06	3.1				10.1		0.9			
39	wetland	crop	wetland loss	cropland gain	5.94E+06	5.9				19.5		4.1			
40	wetland	urban	wetland loss	urban gain	1.81E+05	0.2				0.6		0.8			
41	wetland	wetland	stable wetland	stable wetland	1.18E+07	11.8		27.8							
42	wetland	water	wetland loss	water gain	1.97E+06	2.0				6.5		14.9			
43	water	forest	water loss	forest gain	1.22E+06	1.2	15.1		7.5	16.4	13.2	0.4	20.9	5.7	37.9
44	water	barren	water loss	barren gain	2.82E+06	2.8	0.3		49.4	37.7	87.3	8.8			
45	water	grass	water loss	grassland gain	6.75E+05	0.7				9.0		0.2			
46	water	crop	water loss	cropland gain	1.06E+06	1.1				14.2		0.7			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.70E+06	1.7				22.7		4.9			
49	water	water	stable water	stable water	7.67E+06	7.7		50.6							
	Total					4,349.2									

Appendix 2.2.4.8.3. 50-year changes (1965-2015) in land cover and change percentages within Chechenskaja respublika, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	8.38E+08	838.3	1,094.5	76.6	256.2		670.4		1,508.6	414.1	37.8
2	forest	barren	forest loss	barren gain	1.13E+07	11.3	25.2		23.4	4.4	61.2	29.6			
3	forest	grass	forest loss	grassland gain	2.11E+08	211.3				82.5		30.9			
4	forest	crop	forest loss	cropland gain	2.91E+07	29.1				11.3		16.3			
5	forest	urban	forest loss	urban gain	1.39E+05	0.1				0.1		0.6			
6	forest	wetland	forest loss	wetland gain	2.52E+06	2.5				1.0		5.6			
7	forest	water	forest loss	water gain	1.84E+06	1.8				0.7		10.6			
8	barren	forest	barren loss	forest gain	4.16E+06	4.2	104.8		31.4	13.3	38.4	0.6	111.8	7.0	6.7
9	barren	barren	stable barren	stable barren	7.34E+07	73.4	2.4	70.1	29.9		36.6				
10	barren	grass	barren loss	grassland gain	2.66E+07	26.6				85.0		3.9			
11	barren	crop	barren loss	cropland gain	5.13E+05	0.5				1.6		0.3			
12	barren	urban	barren loss	urban gain	1.76E+04	0.0				0.1		0.1			
13	barren	wetland	barren loss	wetland gain	4.63E+03	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	1.33E+04	0.0				0.0		0.1			
15	grass	forest	grassland loss	forest gain	5.18E+08	517.7	1,655.9		691.0	74.9	684.6	77.2	1,649.5	-6.5	-0.4
16	grass	barren	grassland loss	barren gain	2.57E+07	25.7	38.1		41.7	3.7	41.3	67.0			
17	grass	grass	stable grassland	stable grass	9.65E+08	964.9		58.3							
18	grass	crop	grassland loss	cropland gain	1.42E+08	141.8				20.5		79.6			
19	grass	urban	grassland loss	urban gain	2.44E+06	2.4				0.4		10.5			
20	grass	wetland	grassland loss	wetland gain	2.08E+06	2.1				0.3		4.6			
21	grass	water	grassland loss	water gain	1.32E+06	1.3				0.2		7.5			
22	crop	forest	cropland loss	forest gain	1.33E+08	133.3	1,463.2		651.8	20.5	178.2	19.9	989.6	-473.6	-32.4
23	crop	barren	cropland loss	barren gain	1.17E+06	1.2	33.6		44.5	0.2	12.2	3.0			
24	crop	grass	cropland loss	grassland gain	4.43E+08	443.2				68.0		64.7			
25	crop	crop	stable cropland	stable cropland	8.11E+08	811.5		55.5							
26	crop	urban	cropland loss	urban gain	2.06E+07	20.6				3.2		88.6			
27	crop	wetland	cropland loss	wetland gain	3.93E+07	39.3				6.0		87.5			
28	crop	water	cropland loss	water gain	1.42E+07	14.2				2.2		81.5			
29	urban	forest	urban loss	forest gain	2.56E+04	0.0	1.8		1.4	1.8	23.2	0.0	23.6	21.8	1,181.5
30	urban	barren	urban loss	barren gain	2.49E+04	0.0	0.0		78.0	1.7	1,259.4	0.1			
31	urban	grass	urban loss	grass gain	1.04E+06	1.0				72.0		0.2			
32	urban	crop	urban loss	crop gain	3.50E+05	0.4				24.4		0.2			
33	urban	urban	stable urban	stable urban	4.06E+05	0.4		22.0							
34	urban	wetland	urban loss	wetland gain	1.30E+03	0.0				0.1		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	8.96E+06	9.0	13.7		12.5	71.6	45.0	1.3	46.2	32.5	236.4
37	wetland	barren	wetland loss	barren gain	7.40E+03	0.0	0.3		91.1	0.1	327.6	0.0			
38	wetland	grass	wetland loss	grassland gain	3.88E+05	0.4				3.1		0.1			
39	wetland	crop	wetland loss	cropland gain	3.10E+06	3.1				24.8		1.7			
40	wetland	urban	wetland loss	urban gain	1.05E+04	0.0				0.1		0.0			
41	wetland	wetland	stable wetland	stable wetland	1.22E+06	1.2		8.9							
42	wetland	water	wetland loss	water gain	4.90E+04	0.0				0.4		0.3			
43	water	forest	water loss	forest gain	6.21E+06	6.2	16.2		12.7	48.7	17.4	0.9	20.9	4.7	28.9
44	water	barren	water loss	barren gain	1.15E+05	0.1	0.4		78.6	0.9	107.5	0.3			
45	water	grass	water loss	grassland gain	1.99E+06	2.0				15.6		0.3			
46	water	crop	water loss	cropland gain	3.36E+06	3.4				26.4		1.9			
47	water	urban	water loss	urban gain	3.93E+04	0.0				0.3		0.2			
48	water	wetland	water loss	wetland gain	1.03E+06	1.0				8.1		2.3			
49	water	water	stable water	stable water	3.47E+06	3.5		21.4							
	Total					4,350.2									

Appendix 2.2.4.9.1. Soviet era changes (1965-'87) in land cover and change percentages within Respublika Dagestan, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.31E+09	3,310.3	6,596.3	50.2	3,286.0		762.1		4,072.3	-2,524.0	-38.3
2	forest	barren	forest loss	barren gain	1.06E+08	106.1	22.0		49.8	3.2	11.6	4.7			
3	forest	grass	forest loss	grassland gain	2.61E+09	2,609.2				79.4		56.5			
4	forest	crop	forest loss	cropland gain	5.27E+08	527.3				16.0		23.1			
5	forest	urban	forest loss	urban gain	5.74E+06	5.7				0.2		21.5			
6	forest	wetland	forest loss	wetland gain	3.56E+07	35.6				1.1		28.6			
7	forest	water	forest loss	water gain	2.06E+06	2.1				0.1		4.3			
8	barren	forest	barren loss	forest gain	1.65E+07	16.5	679.2		101.9	16.2	2,249.9	2.2	2,827.2	2,148.0	316.3
9	barren	barren	stable barren	stable barren	5.77E+08	577.3	2.3	85.0	15.0		331.3				
10	barren	grass	barren loss	grassland gain	7.40E+07	74.0				72.6		1.6			
11	barren	crop	barren loss	cropland gain	4.41E+06	4.4				4.3		0.2			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	1.11E+06	1.1				1.1		0.9			
14	barren	water	barren loss	water gain	5.84E+06	5.8				5.7		12.2			
15	grass	forest	grassland loss	forest gain	6.23E+08	623.3	18,168.9		4,472.2	13.9	4,616.5	81.8	18,313.2	144.3	0.8
16	grass	barren	grassland loss	barren gain	2.12E+09	2,122.9	60.6		24.6	47.5	25.4	94.4			
17	grass	grass	stable grassland	stable grass	1.37E+10	13,696.8		75.4							
18	grass	crop	grassland loss	cropland gain	1.66E+09	1,664.7				37.2		72.9			
19	grass	urban	grassland loss	urban gain	1.67E+07	16.7				0.4		62.6			
20	grass	wetland	grassland loss	wetland gain	2.61E+07	26.1				0.6		20.9			
21	grass	water	grassland loss	water gain	1.85E+07	18.5				0.4		38.5			
22	crop	forest	cropland loss	forest gain	1.17E+08	116.9	4,318.9		2,042.2	5.7	2,285.1	15.3	4,561.8	242.9	5.6
23	crop	barren	cropland loss	barren gain	1.67E+07	16.7	14.4		47.3	0.8	52.9	0.7			
24	crop	grass	cropland loss	grassland gain	1.83E+09	1,825.6				89.4		39.5			
25	crop	crop	stable cropland	stable cropland	2.28E+09	2,276.7		52.7							
26	crop	urban	cropland loss	urban gain	4.01E+06	4.0				0.2		15.0			
27	crop	wetland	cropland loss	wetland gain	5.82E+07	58.2				2.9		46.7			
28	crop	water	cropland loss	water gain	2.08E+07	20.8				1.0		43.4			
29	urban	forest	urban loss	forest gain	1.65E+06	1.7	70.8		65.4	2.5	26.7	0.2	32.2	-38.7	-54.6
30	urban	barren	urban loss	barren gain	6.64E+05	0.7	0.2		92.3	1.0	37.7	0.0			
31	urban	grass	urban loss	grass gain	4.69E+07	46.9				71.7		1.0			
32	urban	crop	urban loss	crop gain	1.49E+07	14.9				22.8		0.7			
33	urban	urban	stable urban	stable urban	5.45E+06	5.5		7.7							
34	urban	wetland	urban loss	wetland gain	7.64E+05	0.8				1.2		0.6			
35	urban	water	urban loss	water gain	4.95E+05	0.5				0.8		1.0			
36	wetland	forest	wetland loss	forest gain	2.35E+06	2.4	130.0		120.7	1.9	124.6	0.3	133.9	3.9	3.0
37	wetland	barren	wetland loss	barren gain	8.88E+04	0.1	0.4		92.9	0.1	95.8	0.0			
38	wetland	grass	wetland loss	grassland gain	4.76E+07	47.6				39.5		1.0			
39	wetland	crop	wetland loss	cropland gain	7.03E+07	70.3				58.2		3.1			
40	wetland	urban	wetland loss	urban gain	7.82E+04	0.1				0.1		0.3			
41	wetland	wetland	stable wetland	stable wetland	9.29E+06	9.3		7.1							
42	wetland	water	wetland loss	water gain	3.01E+05	0.3				0.2		0.6			
43	water	forest	water loss	forest gain	1.27E+06	1.3	28.5		24.4	5.2	47.9	0.2	52.0	23.6	82.7
44	water	barren	water loss	barren gain	3.37E+06	3.4	0.1		85.6	13.8	168.4	0.1			
45	water	grass	water loss	grassland gain	1.32E+07	13.2				54.3		0.3			
46	water	crop	water loss	cropland gain	3.51E+06	3.5				14.4		0.2			
47	water	urban	water loss	urban gain	1.57E+05	0.2				0.6		0.6			
48	water	wetland	water loss	wetland gain	2.84E+06	2.8				11.6		2.3			
49	water	water	stable water	stable water	4.09E+06	4.1		14.4							
	Total					29,992.6									

Appendix 2.2.4.9.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Respublika Dagestan, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.54E+09	3,540.5	4,063.4	87.1	523.0		1,118.9		4,659.4	596.0	14.7
2	forest	barren	forest loss	barren gain	4.35E+07	43.5	13.6		12.9	8.3	27.5	10.4			
3	forest	grass	forest loss	grassland gain	3.27E+08	326.8				62.5		11.2			
4	forest	crop	forest loss	cropland gain	1.31E+08	130.6				25.0		7.7			
5	forest	urban	forest loss	urban gain	1.07E+06	1.1				0.2		1.3			
6	forest	wetland	forest loss	wetland gain	1.91E+07	19.1				3.6		9.4			
7	forest	water	forest loss	water gain	1.92E+06	1.9				0.4		5.9			
8	barren	forest	barren loss	forest gain	4.00E+07	40.0	2,825.9		787.9	5.1	416.8	3.6	2,454.8	-371.1	-13.1
9	barren	barren	stable barren	stable barren	2.04E+09	2,038.0	9.4	72.1	27.9		14.7				
10	barren	grass	barren loss	grassland gain	7.08E+08	708.3				89.9		24.2			
11	barren	crop	barren loss	cropland gain	2.38E+07	23.8				3.0		1.4			
12	barren	urban	barren loss	urban gain	7.31E+06	7.3				0.9		9.2			
13	barren	wetland	barren loss	wetland gain	2.10E+06	2.1				0.3		1.0			
14	barren	water	barren loss	water gain	6.23E+06	6.2				0.8		19.2			
15	grass	forest	grassland loss	forest gain	7.19E+08	719.1	18,288.8		2,714.5	26.5	2,925.6	64.3	18,499.9	211.1	1.2
16	grass	barren	grassland loss	barren gain	3.44E+08	343.6	61.1		14.8	12.7	16.0	82.5			
17	grass	grass	stable grassland	stable grass	1.56E+10	15,574.3		85.2							
18	grass	crop	grassland loss	cropland gain	1.50E+09	1,501.3				55.3		88.8			
19	grass	urban	grassland loss	urban gain	6.15E+07	61.5				2.3		77.7			
20	grass	wetland	grassland loss	wetland gain	7.45E+07	74.5				2.7		36.6			
21	grass	water	grassland loss	water gain	1.44E+07	14.4				0.5		44.4			
22	crop	forest	cropland loss	forest gain	3.17E+08	317.0	4,525.2		2,302.0	13.8	1,689.9	28.3	3,913.1	-612.1	-13.5
23	crop	barren	cropland loss	barren gain	2.11E+07	21.1	15.1		50.9	0.9	37.3	5.1			
24	crop	grass	cropland loss	grassland gain	1.85E+09	1,847.6				80.3		63.2			
25	crop	crop	stable cropland	stable cropland	2.22E+09	2,223.2		49.1							
26	crop	urban	cropland loss	urban gain	8.88E+06	8.9				0.4		11.2			
27	crop	wetland	cropland loss	wetland gain	1.01E+08	101.5				4.4		49.9			
28	crop	water	cropland loss	water gain	5.99E+06	6.0				0.3		18.4			
29	urban	forest	urban loss	forest gain	5.51E+05	0.6	31.6		25.5	2.2	79.1	0.0	85.2	53.6	169.3
30	urban	barren	urban loss	barren gain	1.94E+05	0.2	0.1		80.5	0.8	249.9	0.0			
31	urban	grass	urban loss	grass gain	2.15E+07	21.5				84.5		0.7			
32	urban	crop	urban loss	crop gain	2.51E+06	2.5				9.8		0.1			
33	urban	urban	stable urban	stable urban	6.16E+06	6.2		19.5							
34	urban	wetland	urban loss	wetland gain	6.48E+05	0.6				2.5		0.3			
35	urban	water	urban loss	water gain	4.57E+04	0.0				0.2		0.1			
36	wetland	forest	wetland loss	forest gain	3.96E+07	39.6	132.8		94.7	41.8	203.4	3.5	241.5	108.7	81.8
37	wetland	barren	wetland loss	barren gain	1.66E+06	1.7	0.4		71.3	1.8	153.1	0.4			
38	wetland	grass	wetland loss	grassland gain	1.95E+07	19.5				20.6		0.7			
39	wetland	crop	wetland loss	cropland gain	2.97E+07	29.7				31.4		1.8			
40	wetland	urban	wetland loss	urban gain	3.09E+05	0.3				0.3		0.4			
41	wetland	wetland	stable wetland	stable wetland	3.82E+07	38.2		28.7							
42	wetland	water	wetland loss	water gain	3.90E+06	3.9				4.1		12.0			
43	water	forest	water loss	forest gain	2.67E+06	2.7	52.0		18.7	14.3	32.5	0.2	65.8	13.9	26.7
44	water	barren	water loss	barren gain	6.72E+06	6.7	0.2		36.0	36.0	62.6	1.6			
45	water	grass	water loss	grassland gain	1.79E+06	1.8				9.6		0.1			
46	water	crop	water loss	cropland gain	1.93E+06	1.9				10.3		0.1			
47	water	urban	water loss	urban gain	2.84E+04	0.0				0.2		0.0			
48	water	wetland	water loss	wetland gain	5.55E+06	5.5				29.7		2.7			
49	water	water	stable water	stable water	3.33E+07	33.3		64.0							
	Total					29,919.7									

Appendix 2.2.4.9.3. 50-year changes (1965-2015) in land cover and change percentages within Respublika Dagestan, Russia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.65E+09	3,651.1	6,591.5	55.4	2,940.4		1,008.3		4,659.4	-1,932.1	-29.3
2	forest	barren	forest loss	barren gain	9.39E+07	93.9	22.0		44.6	3.2	15.3	5.1			
3	forest	grass	forest loss	grassland gain	2.38E+09	2,379.9				80.9		51.3			
4	forest	crop	forest loss	cropland gain	4.33E+08	432.7				14.7		21.1			
5	forest	urban	forest loss	urban gain	5.94E+06	5.9				0.2		8.1			
6	forest	wetland	forest loss	wetland gain	2.45E+07	24.5				0.8		10.6			
7	forest	water	forest loss	water gain	3.34E+06	3.3				0.1		5.7			
8	barren	forest	barren loss	forest gain	1.37E+07	13.7	678.0		73.5	18.7	1,850.2	1.4	2,454.8	1,776.7	262.0
9	barren	barren	stable barren	stable barren	6.05E+08	604.5	2.3	89.2	10.8		272.9				
10	barren	grass	barren loss	grassland gain	5.82E+07	58.2				79.1		1.3			
11	barren	crop	barren loss	cropland gain	1.39E+06	1.4				1.9		0.1			
12	barren	urban	barren loss	urban gain	9.92E+03	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	1.17E+05	0.1				0.2		0.1			
14	barren	water	barren loss	water gain	1.19E+05	0.1				0.2		0.2			
15	grass	forest	grassland loss	forest gain	8.53E+08	852.7	18,142.2		4,283.0	19.9	4,640.7	84.6	18,499.9	357.7	2.0
16	grass	barren	grassland loss	barren gain	1.75E+09	1,748.2	60.6		23.6	40.8	25.6	94.5			
17	grass	grass	stable grassland	stable grass	1.39E+10	13,859.2		76.4							
18	grass	crop	grassland loss	cropland gain	1.54E+09	1,543.8				36.0		75.2			
19	grass	urban	grassland loss	urban gain	4.34E+07	43.4				1.0		59.5			
20	grass	wetland	grassland loss	wetland gain	6.87E+07	68.7				1.6		29.6			
21	grass	water	grassland loss	water gain	2.61E+07	26.1				0.6		44.8			
22	crop	forest	cropland loss	forest gain	1.35E+08	135.1	4,278.6		2,418.3	5.6	2,052.7	13.4	3,913.1	-365.5	-8.5
23	crop	barren	cropland loss	barren gain	6.68E+06	6.7	14.3		56.5	0.3	48.0	0.4			
24	crop	grass	cropland loss	grassland gain	2.09E+09	2,091.9				86.5		45.1			
25	crop	crop	stable cropland	stable cropland	1.86E+09	1,860.3		43.5							
26	crop	urban	cropland loss	urban gain	2.30E+07	23.0				1.0		31.6			
27	crop	wetland	cropland loss	wetland gain	1.34E+08	133.8				5.5		57.7			
28	crop	water	cropland loss	water gain	2.78E+07	27.8				1.1		47.6			
29	urban	forest	urban loss	forest gain	1.55E+06	1.6	70.9		58.6	2.7	72.9	0.2	85.2	14.3	20.2
30	urban	barren	urban loss	barren gain	5.56E+05	0.6	0.2		82.7	0.9	102.9	0.0			
31	urban	grass	urban loss	grass gain	4.32E+07	43.2				73.7		0.9			
32	urban	crop	urban loss	crop gain	1.12E+07	11.2				19.1		0.5			
33	urban	urban	stable urban	stable urban	1.23E+07	12.3		17.3							
34	urban	wetland	urban loss	wetland gain	1.22E+06	1.2				2.1		0.5			
35	urban	water	urban loss	water gain	8.89E+05	0.9				1.5		1.5			
36	wetland	forest	wetland loss	forest gain	3.34E+06	3.3	130.1		120.6	2.8	232.1	0.3	241.5	111.5	85.7
37	wetland	barren	wetland loss	barren gain	5.68E+04	0.1	0.4		92.7	0.0	178.5	0.0			
38	wetland	grass	wetland loss	grassland gain	5.59E+07	55.9				46.4		1.2			
39	wetland	crop	wetland loss	cropland gain	6.10E+07	61.0				50.6		3.0			
40	wetland	urban	wetland loss	urban gain	2.18E+05	0.2				0.2		0.3			
41	wetland	wetland	stable wetland	stable wetland	9.44E+06	9.4		7.3							
42	wetland	water	wetland loss	water gain	6.21E+04	0.1				0.1		0.1			
43	water	forest	water loss	forest gain	1.90E+06	1.9	28.4		20.9	9.1	58.4	0.2	65.8	37.4	131.8
44	water	barren	water loss	barren gain	8.06E+05	0.8	0.1		73.7	3.8	205.6	0.0			
45	water	grass	water loss	grassland gain	1.16E+07	11.6				55.4		0.2			
46	water	crop	water loss	cropland gain	2.60E+06	2.6				12.4		0.1			
47	water	urban	water loss	urban gain	3.73E+05	0.4				1.8		0.5			
48	water	wetland	water loss	wetland gain	3.66E+06	3.7				17.5		1.6			
49	water	water	stable water	stable water	7.45E+06	7.5		26.3							
	Total					29,919.7									

Appendix 2.2.4.10.1. Soviet era changes (1965-'87) in land cover and change percentages within Abkhazeti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.90E+09	2,897.5	3,006.2	96.4	108.8		1,305.3		4,202.8	1,196.5	39.8
2	forest	barren	forest loss	barren gain	1.86E+07	18.6	56.1		3.6	17.1	43.4	13.3			
3	forest	grass	forest loss	grassland gain	6.80E+07	68.0				62.6		34.1			
4	forest	crop	forest loss	cropland gain	1.52E+07	15.2				14.0		15.1			
5	forest	urban	forest loss	urban gain	5.01E+04	0.1				0.0		0.7			
6	forest	wetland	forest loss	wetland gain	4.27E+06	4.3				3.9		11.8			
7	forest	water	forest loss	water gain	2.59E+06	2.6				2.4		18.6			
8	barren	forest	barren loss	forest gain	2.22E+07	22.2	202.1		122.9	18.1	140.1	1.7	219.3	17.2	8.5
9	barren	barren	stable barren	stable barren	7.92E+07	79.2	3.8	39.2	60.8		69.3				
10	barren	grass	barren loss	grassland gain	8.54E+07	85.4				69.5		42.7			
11	barren	crop	barren loss	cropland gain	7.32E+06	7.3				6.0		7.3			
12	barren	urban	barren loss	urban gain	1.08E+06	1.1				0.9		14.9			
13	barren	wetland	barren loss	wetland gain	1.33E+06	1.3				1.1		3.7			
14	barren	water	barren loss	water gain	5.58E+06	5.6				4.5		40.0			
15	grass	forest	grassland loss	forest gain	1.21E+09	1,212.0	1,923.9		1,412.5	85.8	199.7	92.9	711.1	-1,212.8	-63.0
16	grass	barren	grassland loss	barren gain	1.20E+08	119.8	35.9		73.4	8.5	10.4	85.5			
17	grass	grass	stable grassland	stable grass	5.11E+08	511.3		26.6							
18	grass	crop	grassland loss	cropland gain	6.63E+07	66.3				4.7		66.0			
19	grass	urban	grassland loss	urban gain	1.75E+06	1.7				0.1		24.2			
20	grass	wetland	grassland loss	wetland gain	8.97E+06	9.0				0.6		24.7			
21	grass	water	grassland loss	water gain	3.66E+06	3.7				0.3		26.2			
22	crop	forest	cropland loss	forest gain	6.02E+07	60.2	180.9		117.3	51.4	100.4	4.6	164.0	-16.9	-9.3
23	crop	barren	cropland loss	barren gain	1.02E+06	1.0	3.4		64.8	0.9	55.5	0.7			
24	crop	grass	cropland loss	grassland gain	3.35E+07	33.5				28.6		16.8			
25	crop	crop	stable cropland	stable cropland	6.36E+07	63.6		35.2							
26	crop	urban	cropland loss	urban gain	4.18E+06	4.2				3.6		57.9			
27	crop	wetland	cropland loss	wetland gain	1.64E+07	16.4				14.0		45.3			
28	crop	water	cropland loss	water gain	1.89E+06	1.9				1.6		13.6			
29	urban	forest	urban loss	forest gain	9.16E+06	9.2	40.1		35.5	25.8	7.2	0.7	11.8	-28.3	-70.6
30	urban	barren	urban loss	barren gain	3.59E+05	0.4	0.7		88.6	1.0	18.0	0.3			
31	urban	grass	urban loss	grass gain	1.06E+07	10.6				29.8		5.3			
32	urban	crop	urban loss	crop gain	1.06E+07	10.6				29.9		10.6			
33	urban	urban	stable urban	stable urban	4.59E+06	4.6		11.4							
34	urban	wetland	urban loss	wetland gain	4.65E+06	4.6				13.1		12.8			
35	urban	water	urban loss	water gain	1.55E+05	0.2				0.4		1.1			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.2		0.2	0.0	36.3	0.0	36.3	36.1	17,701.7
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		99.7	0.0	17,801.4	0.0			
38	wetland	grass	wetland loss	grassland gain	4.84E+04	0.0				23.8		0.0			
39	wetland	crop	wetland loss	cropland gain	1.78E+04	0.0				8.7		0.0			
40	wetland	urban	wetland loss	urban gain	5.72E+04	0.1				28.2		0.8			
41	wetland	wetland	stable wetland	stable wetland	6.58E+02	0.0		0.3							
42	wetland	water	wetland loss	water gain	7.99E+04	0.1				39.3		0.6			
43	water	forest	water loss	forest gain	1.63E+06	1.6	6.1		5.8	28.3	13.9	0.1	14.3	8.2	133.7
44	water	barren	water loss	barren gain	2.85E+05	0.3	0.1		94.7	4.9	228.5	0.2			
45	water	grass	water loss	grassland gain	2.14E+06	2.1				37.0		1.1			
46	water	crop	water loss	cropland gain	9.67E+05	1.0				16.7		1.0			
47	water	urban	water loss	urban gain	1.06E+05	0.1				1.8		1.5			
48	water	wetland	water loss	wetland gain	6.51E+05	0.7				11.3		1.8			
49	water	water	stable water	stable water	3.22E+05	0.3		5.3							
	Total					5,359.6									

Appendix 2.2.4.10.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Abkhazeti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	4.03E+09	4,032.4	4,202.5	96.0	170.1		229.1		4,261.5	59.0	1.4
2	forest	barren	forest loss	barren gain	1.14E+07	11.4	78.5		4.0	6.7	5.5	27.6			
3	forest	grass	forest loss	grassland gain	1.39E+08	139.3				81.9		46.0			
4	forest	crop	forest loss	cropland gain	1.16E+07	11.6				6.8		31.9			
5	forest	urban	forest loss	urban gain	2.61E+05	0.3				0.2		10.6			
6	forest	wetland	forest loss	wetland gain	7.27E+06	7.3				4.3		21.1			
7	forest	water	forest loss	water gain	2.62E+05	0.3				0.2		10.1			
8	barren	forest	barren loss	forest gain	1.17E+07	11.7	219.1		124.0	9.4	41.3	5.1	136.4	-82.6	-37.7
9	barren	barren	stable barren	stable barren	9.51E+07	95.1	4.1	43.4	56.6		18.9				
10	barren	grass	barren loss	grassland gain	1.10E+08	110.0				88.7		36.3			
11	barren	crop	barren loss	cropland gain	1.63E+06	1.6				1.3		4.5			
12	barren	urban	barren loss	urban gain	3.48E+04	0.0				0.0		1.4			
13	barren	wetland	barren loss	wetland gain	3.30E+05	0.3				0.3		1.0			
14	barren	water	barren loss	water gain	2.85E+05	0.3				0.2		11.0			
15	grass	forest	grassland loss	forest gain	1.25E+08	125.0	710.4		171.0	73.1	302.7	54.6	842.1	131.7	18.5
16	grass	barren	grassland loss	barren gain	2.16E+07	21.6	13.3		24.1	12.6	42.6	52.2			
17	grass	grass	stable grassland	stable grass	5.39E+08	539.4		75.9							
18	grass	crop	grassland loss	cropland gain	1.20E+07	12.0				7.0		33.0			
19	grass	urban	grassland loss	urban gain	1.53E+06	1.5				0.9		62.1			
20	grass	wetland	grassland loss	wetland gain	9.82E+06	9.8				5.7		28.5			
21	grass	water	grassland loss	water gain	9.74E+05	1.0				0.6		37.4			
22	crop	forest	cropland loss	forest gain	7.33E+07	73.3	163.9		134.1	54.6	36.5	32.0	66.2	-97.6	-59.6
23	crop	barren	cropland loss	barren gain	1.55E+06	1.5	3.1		81.9	1.2	22.3	3.7			
24	crop	grass	cropland loss	grassland gain	4.34E+07	43.4				32.4		14.4			
25	crop	crop	stable cropland	stable cropland	2.97E+07	29.7		18.1							
26	crop	urban	cropland loss	urban gain	4.49E+05	0.4				0.3		18.3			
27	crop	wetland	cropland loss	wetland gain	1.51E+07	15.1				11.3		43.9			
28	crop	water	cropland loss	water gain	2.91E+05	0.3				0.2		11.2			
29	urban	forest	urban loss	forest gain	4.25E+05	0.4	11.8		10.2	4.2	2.5	0.2	4.1	-7.7	-65.4
30	urban	barren	urban loss	barren gain	2.10E+04	0.0	0.2		86.2	0.2	20.8	0.1			
31	urban	grass	urban loss	grass gain	4.32E+06	4.3				42.5		1.4			
32	urban	crop	urban loss	crop gain	3.63E+06	3.6				35.7		9.9			
33	urban	urban	stable urban	stable urban	1.63E+06	1.6		13.8							
34	urban	wetland	urban loss	wetland gain	1.74E+06	1.7				17.1		5.1			
35	urban	water	urban loss	water gain	2.99E+04	0.0				0.3		1.1			
36	wetland	forest	wetland loss	forest gain	1.59E+07	15.9	36.0		28.6	55.5	34.5	6.9	41.9	5.9	16.4
37	wetland	barren	wetland loss	barren gain	1.31E+05	0.1	0.7		79.4	0.5	95.8	0.3			
38	wetland	grass	wetland loss	grassland gain	4.17E+06	4.2				14.6		1.4			
39	wetland	crop	wetland loss	cropland gain	7.47E+06	7.5				26.1		20.5			
40	wetland	urban	wetland loss	urban gain	1.71E+05	0.2				0.6		7.0			
41	wetland	wetland	stable wetland	stable wetland	7.41E+06	7.4		20.6							
42	wetland	water	wetland loss	water gain	7.63E+05	0.8				2.7		29.3			
43	water	forest	water loss	forest gain	2.82E+06	2.8	12.4		11.2	25.3	2.6	1.2	3.9	-8.6	-68.7
44	water	barren	water loss	barren gain	6.64E+06	6.6	0.2		89.6	59.6	20.9	16.1			
45	water	grass	water loss	grassland gain	1.44E+06	1.4				12.9		0.5			
46	water	crop	water loss	cropland gain	8.07E+04	0.1				0.7		0.2			
47	water	urban	water loss	urban gain	1.51E+04	0.0				0.1		0.6			
48	water	wetland	water loss	wetland gain	1.62E+05	0.2				1.4		0.5			
49	water	water	stable water	stable water	1.29E+06	1.3		10.4							
	Total					5,356.0									

Appendix 2.2.4.10.3. 50-year changes (1965-2015) in land cover and change percentages within Abkhazeti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.91E+09	2,908.5	3,005.4	96.8	96.9		1,353.0		4,261.5	1,256.1	41.8
2	forest	barren	forest loss	barren gain	1.16E+07	11.6	56.1		3.2	12.0	45.0	15.6			
3	forest	grass	forest loss	grassland gain	7.81E+07	78.1				80.7		31.5			
4	forest	crop	forest loss	cropland gain	3.38E+06	3.4				3.5		11.3			
5	forest	urban	forest loss	urban gain	8.05E+04	0.1				0.1		3.8			
6	forest	wetland	forest loss	wetland gain	2.91E+06	2.9				3.0		7.0			
7	forest	water	forest loss	water gain	7.82E+05	0.8				0.8		21.7			
8	barren	forest	barren loss	forest gain	2.07E+07	20.7	202.2		140.2	14.8	74.4	1.5	136.4	-65.8	-32.5
9	barren	barren	stable barren	stable barren	6.20E+07	62.0	3.8	30.7	69.3		36.8				
10	barren	grass	barren loss	grassland gain	1.12E+08	111.9				79.8		45.1			
11	barren	crop	barren loss	cropland gain	3.90E+06	3.9				2.8		13.0			
12	barren	urban	barren loss	urban gain	4.23E+05	0.4				0.3		19.8			
13	barren	wetland	barren loss	wetland gain	2.79E+06	2.8				2.0		6.7			
14	barren	water	barren loss	water gain	4.20E+05	0.4				0.3		11.6			
15	grass	forest	grassland loss	forest gain	1.24E+09	1,242.8	1,923.7		1,329.9	93.5	248.2	91.9	842.1	-1,081.7	-56.2
16	grass	barren	grassland loss	barren gain	6.25E+07	62.5	35.9		69.1	4.7	12.9	84.0			
17	grass	grass	stable grassland	stable grass	5.94E+08	593.9		30.9							
18	grass	crop	grassland loss	cropland gain	1.35E+07	13.5				1.0		44.9			
19	grass	urban	grassland loss	urban gain	6.83E+05	0.7				0.1		32.1			
20	grass	wetland	grassland loss	wetland gain	9.71E+06	9.7				0.7		23.2			
21	grass	water	grassland loss	water gain	6.56E+05	0.7				0.0		18.2			
22	crop	forest	cropland loss	forest gain	7.48E+07	74.8	178.8		142.6	52.5	30.1	5.5	66.2	-112.6	-63.0
23	crop	barren	cropland loss	barren gain	1.96E+05	0.2	3.3		79.8	0.1	16.8	0.3			
24	crop	grass	cropland loss	grassland gain	4.56E+07	45.6				31.9		18.4			
25	crop	crop	stable cropland	stable cropland	3.62E+07	36.2		20.2							
26	crop	urban	cropland loss	urban gain	8.55E+05	0.9				0.6		40.1			
27	crop	wetland	cropland loss	wetland gain	1.96E+07	19.6				13.8		46.9			
28	crop	water	cropland loss	water gain	1.54E+06	1.5				1.1		42.8			
29	urban	forest	urban loss	forest gain	1.22E+07	12.2	40.0		38.0	32.2	2.1	0.9	4.1	-35.9	-89.8
30	urban	barren	urban loss	barren gain	3.27E+04	0.0	0.7		95.1	0.1	5.3	0.0			
31	urban	grass	urban loss	grass gain	1.06E+07	10.6				28.0		4.3			
32	urban	crop	urban loss	crop gain	8.78E+06	8.8				23.1		29.2			
33	urban	urban	stable urban	stable urban	1.96E+06	2.0		4.9							
34	urban	wetland	urban loss	wetland gain	6.12E+06	6.1				16.1		14.6			
35	urban	water	urban loss	water gain	2.01E+05	0.2				0.5		5.6			
36	wetland	forest	wetland loss	forest gain	1.32E+03	0.0	0.1		0.1	1.2	41.8	0.0	41.9	41.7	33,252.0
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		85.3	0.0	33,337.3	0.0			
38	wetland	grass	wetland loss	grassland gain	1.32E+04	0.0				12.3		0.0			
39	wetland	crop	wetland loss	cropland gain	8.62E+04	0.1				80.5		0.3			
40	wetland	urban	wetland loss	urban gain	5.92E+03	0.0				5.5		0.3			
41	wetland	wetland	stable wetland	stable wetland	1.84E+04	0.0		14.7							
42	wetland	water	wetland loss	water gain	5.29E+02	0.0				0.5		0.0			
43	water	forest	water loss	forest gain	2.38E+06	2.4	5.9		5.6	42.7	3.6	0.2	3.9	-2.0	-33.6
44	water	barren	water loss	barren gain	7.27E+04	0.1	0.1		95.1	1.3	61.5	0.1			
45	water	grass	water loss	grassland gain	1.94E+06	1.9				34.7		0.8			
46	water	crop	water loss	cropland gain	4.20E+05	0.4				7.5		1.4			
47	water	urban	water loss	urban gain	8.34E+04	0.1				1.5		3.9			
48	water	wetland	water loss	wetland gain	6.79E+05	0.7				12.2		1.6			
49	water	water	stable water	stable water	2.90E+05	0.3		4.9							
	Total					5,356.0									

Appendix 2.2.4.11.1. Soviet era changes (1965-'87) in land cover and change percentages within Samegrelo-Zemo Svaneti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.40E+09	2,404.5	2,781.5	86.4	377.0		494.3		2,898.8	117.3	4.2
2	forest	barren	forest loss	barren gain	1.61E+07	16.1	64.0		13.6	4.3	17.8	35.6			
3	forest	grass	forest loss	grassland gain	1.97E+08	197.0				52.3		56.9			
4	forest	crop	forest loss	cropland gain	1.47E+08	146.9				39.0		86.1			
5	forest	urban	forest loss	urban gain	2.10E+05	0.2				0.1		7.6			
6	forest	wetland	forest loss	wetland gain	1.18E+07	11.8				3.1		10.5			
7	forest	water	forest loss	water gain	4.98E+06	5.0				1.3		35.5			
8	barren	forest	barren loss	forest gain	1.78E+05	0.2	0.8		0.5	34.2	45.4	0.0	45.7	44.9	5,594.0
9	barren	barren	stable barren	stable barren	2.83E+05	0.3	0.0	35.3	64.7		5,658.7				
10	barren	grass	barren loss	grassland gain	3.30E+05	0.3				63.5		0.1			
11	barren	crop	barren loss	cropland gain	3.30E+03	0.0				0.6		0.0			
12	barren	urban	barren loss	urban gain	8.54E+03	0.0				1.6		0.3			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.69E+08	269.3	484.5		307.9	87.5	346.1	54.5	522.7	38.2	7.9
16	grass	barren	grassland loss	barren gain	2.37E+07	23.7	11.2		63.6	7.7	71.4	52.2			
17	grass	grass	stable grassland	stable grass	1.77E+08	176.6		36.4							
18	grass	crop	grassland loss	cropland gain	1.37E+07	13.7				4.5		8.0			
19	grass	urban	grassland loss	urban gain	1.19E+05	0.1				0.0		4.3			
20	grass	wetland	grassland loss	wetland gain	7.69E+05	0.8				0.2		0.7			
21	grass	water	grassland loss	water gain	3.16E+05	0.3				0.1		2.3			
22	crop	forest	cropland loss	forest gain	2.24E+08	223.6	1,043.1		469.1	47.7	170.6	45.2	744.6	-298.5	-28.6
23	crop	barren	cropland loss	barren gain	3.88E+06	3.9	24.0		45.0	0.8	16.4	8.5			
24	crop	grass	cropland loss	grassland gain	1.34E+08	133.6				28.5		38.6			
25	crop	crop	stable cropland	stable cropland	5.74E+08	574.0		55.0							
26	crop	urban	cropland loss	urban gain	2.27E+06	2.3				0.5		82.1			
27	crop	wetland	cropland loss	wetland gain	9.72E+07	97.2				20.7		86.6			
28	crop	water	cropland loss	water gain	8.54E+06	8.5				1.8		60.9			
29	urban	forest	urban loss	forest gain	7.56E+05	0.8	14.5		14.2	5.3	2.8	0.2	3.1	-11.4	-78.8
30	urban	barren	urban loss	barren gain	3.84E+05	0.4	0.3		97.9	2.7	19.1	0.8			
31	urban	grass	urban loss	grass gain	6.45E+06	6.4				45.4		1.9			
32	urban	crop	urban loss	crop gain	5.61E+06	5.6				39.5		3.3			
33	urban	urban	stable urban	stable urban	3.09E+05	0.3		2.1							
34	urban	wetland	urban loss	wetland gain	8.10E+05	0.8				5.7		0.7			
35	urban	water	urban loss	water gain	1.90E+05	0.2				1.3		1.4			
36	wetland	forest	wetland loss	forest gain	5.31E+03	0.0	0.1		0.1	8.2	112.3	0.0	112.3	112.2	172,481.1
37	wetland	barren	wetland loss	barren gain	6.64E+02	0.0	0.0		100.0	1.0	172,581.1	0.0			
38	wetland	grass	wetland loss	grassland gain	3.32E+03	0.0				5.1		0.0			
39	wetland	crop	wetland loss	cropland gain	5.51E+04	0.1				84.7		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	6.64E+02	0.0				1.0		0.0			
43	water	forest	water loss	forest gain	4.74E+05	0.5	18.8		16.7	2.8	14.0	0.1	16.2	-2.6	-14.0
44	water	barren	water loss	barren gain	1.28E+06	1.3	0.4		88.7	7.7	74.7	2.8			
45	water	grass	water loss	grassland gain	8.71E+06	8.7				52.3		2.5			
46	water	crop	water loss	cropland gain	4.35E+06	4.4				26.1		2.6			
47	water	urban	water loss	urban gain	1.60E+05	0.2				1.0		5.8			
48	water	wetland	water loss	wetland gain	1.69E+06	1.7				10.1		1.5			
49	water	water	stable water	stable water	2.13E+06	2.1		11.3							
	Total					4,343.2									

Appendix 2.2.4.11.2 Post-Soviet changes (1987-2015) in land cover and change percentages within Samegrelo-Zemo Svaneti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.69E+09	2,693.7	2,898.8	92.9	205.1		302.3		2,995.9	97.1	3.4
2	forest	barren	forest loss	barren gain	5.07E+06	5.1	66.7		7.1	2.5	10.4	48.8			
3	forest	grass	forest loss	grassland gain	1.28E+08	128.0				62.4		35.0			
4	forest	crop	forest loss	cropland gain	5.76E+07	57.6				28.1		43.5			
5	forest	urban	forest loss	urban gain	4.24E+04	0.0				0.0		3.3			
6	forest	wetland	forest loss	wetland gain	1.37E+07	13.7				6.7		15.5			
7	forest	water	forest loss	water gain	7.33E+05	0.7				0.4		7.2			
8	barren	forest	barren loss	forest gain	9.06E+06	9.1	45.9		31.4	28.9	10.4	3.0	24.9	-21.0	-45.7
9	barren	barren	stable barren	stable barren	1.45E+07	14.5	1.1	31.7	68.3		22.6				
10	barren	grass	barren loss	grassland gain	1.93E+07	19.3				61.6		5.3			
11	barren	crop	barren loss	cropland gain	1.18E+06	1.2				3.8		0.9			
12	barren	urban	barren loss	urban gain	4.79E+04	0.0				0.2		3.7			
13	barren	wetland	barren loss	wetland gain	7.34E+05	0.7				2.3		0.8			
14	barren	water	barren loss	water gain	1.02E+06	1.0				3.3		10.0			
15	grass	forest	grassland loss	forest gain	1.30E+08	130.1	522.4		170.4	76.4	365.8	43.0	717.8	195.4	37.4
16	grass	barren	grassland loss	barren gain	3.76E+06	3.8	12.0		32.6	2.2	70.0	36.3			
17	grass	grass	stable grassland	stable grass	3.52E+08	352.0		67.4							
18	grass	crop	grassland loss	cropland gain	2.75E+07	27.5				16.1		20.8			
19	grass	urban	grassland loss	urban gain	5.82E+05	0.6				0.3		45.3			
20	grass	wetland	grassland loss	wetland gain	6.55E+06	6.6				3.8		7.4			
21	grass	water	grassland loss	water gain	1.86E+06	1.9				1.1		18.2			
22	crop	forest	cropland loss	forest gain	1.39E+08	138.9	744.5		415.1	33.5	132.4	46.0	461.8	-282.7	-38.0
23	crop	barren	cropland loss	barren gain	6.29E+05	0.6	17.1		55.8	0.2	17.8	6.1			
24	crop	grass	cropland loss	grassland gain	2.07E+08	206.7				49.8		56.5			
25	crop	crop	stable cropland	stable cropland	3.29E+08	329.4		44.2							
26	crop	urban	cropland loss	urban gain	4.96E+05	0.5				0.1		38.6			
27	crop	wetland	cropland loss	wetland gain	6.52E+07	65.2				15.7		74.0			
28	crop	water	cropland loss	water gain	3.08E+06	3.1				0.7		30.1			
29	urban	forest	urban loss	forest gain	9.96E+04	0.1	3.1		2.8	3.5	1.3	0.0	1.5	-1.5	-50.3
30	urban	barren	urban loss	barren gain	1.71E+04	0.0	0.1		92.0	0.6	41.7	0.2			
31	urban	grass	urban loss	grass gain	1.38E+06	1.4				48.9		0.4			
32	urban	crop	urban loss	crop gain	1.04E+06	1.0				36.8		0.8			
33	urban	urban	stable urban	stable urban	2.47E+05	0.2		8.0							
34	urban	wetland	urban loss	wetland gain	2.72E+05	0.3				9.6		0.3			
35	urban	water	urban loss	water gain	1.46E+04	0.0				0.5		0.1			
36	wetland	forest	wetland loss	forest gain	2.33E+07	23.3	112.3		80.7	28.8	88.2	7.7	119.7	7.5	6.6
37	wetland	barren	wetland loss	barren gain	7.36E+05	0.7	2.6		71.9	0.9	78.5	7.1			
38	wetland	grass	wetland loss	grassland gain	8.68E+06	8.7				10.8		2.4			
39	wetland	crop	wetland loss	cropland gain	4.44E+07	44.4				55.0		33.5			
40	wetland	urban	wetland loss	urban gain	7.44E+04	0.1				0.1		5.8			
41	wetland	wetland	stable wetland	stable wetland	3.16E+07	31.6		28.1							
42	wetland	water	wetland loss	water gain	3.53E+06	3.5				4.4		34.5			
43	water	forest	water loss	forest gain	7.73E+05	0.8	16.2		5.0	15.4	10.2	0.3	21.4	5.2	32.2
44	water	barren	water loss	barren gain	1.68E+05	0.2	0.4		31.1	3.3	63.4	1.6			
45	water	grass	water loss	grassland gain	1.71E+06	1.7				33.9		0.5			
46	water	crop	water loss	cropland gain	6.85E+05	0.7				13.6		0.5			
47	water	urban	water loss	urban gain	4.12E+04	0.0				0.8		3.2			
48	water	wetland	water loss	wetland gain	1.66E+06	1.7				33.0		1.9			
49	water	water	stable water	stable water	1.11E+07	11.1		68.9							
	Total					4,343.1									

Appendix 2.2.4.11.3. 50-year changes (1965-2015) in land cover and change percentages within Samegrelo-Zemo Svaneti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.45E+09	2,452.3	2,778.8	88.3	326.4		543.6		2,995.9	217.2	7.8
2	forest	barren	forest loss	barren gain	6.54E+06	6.5	64.0		11.7	2.0	19.6	26.5			
3	forest	grass	forest loss	grassland gain	2.40E+08	240.4				73.7		44.5			
4	forest	crop	forest loss	cropland gain	5.95E+07	59.5				18.2		85.8			
5	forest	urban	forest loss	urban gain	9.00E+04	0.1				0.0		7.0			
6	forest	wetland	forest loss	wetland gain	1.30E+07	13.0				4.0		10.9			
7	forest	water	forest loss	water gain	6.81E+06	6.8				2.1		36.0			
8	barren	forest	barren loss	forest gain	3.36E+05	0.3	0.8		0.6	60.6	24.7	0.1	24.9	24.1	3,022.1
9	barren	barren	stable barren	stable barren	2.44E+05	0.2	0.0	30.5	69.5		3,091.6				
10	barren	grass	barren loss	grassland gain	1.63E+05	0.2				29.3		0.0			
11	barren	crop	barren loss	cropland gain	4.73E+04	0.0				8.5		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	8.54E+03	0.0				1.5		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.86E+08	286.1	486.8		309.0	92.6	540.0	52.6	717.8	231.0	47.4
16	grass	barren	grassland loss	barren gain	1.67E+07	16.7	11.2		63.5	5.4	110.9	67.5			
17	grass	grass	stable grassland	stable grass	1.78E+08	177.8		36.5							
18	grass	crop	grassland loss	cropland gain	5.09E+06	5.1				1.6		7.3			
19	grass	urban	grassland loss	urban gain	7.83E+04	0.1				0.0		6.0			
20	grass	wetland	grassland loss	wetland gain	7.11E+05	0.7				0.2		0.6			
21	grass	water	grassland loss	water gain	3.39E+05	0.3				0.1		1.8			
22	crop	forest	cropland loss	forest gain	2.55E+08	254.6	1,043.1		650.6	39.1	69.4	46.8	461.8	-581.3	-55.7
23	crop	barren	cropland loss	barren gain	1.25E+06	1.2	24.0		62.4	0.2	6.6	5.1			
24	crop	grass	cropland loss	grassland gain	2.81E+08	280.7				43.1		52.0			
25	crop	crop	stable cropland	stable cropland	3.92E+08	392.5		37.6							
26	crop	urban	cropland loss	urban gain	1.01E+06	1.0				0.2		77.7			
27	crop	wetland	cropland loss	wetland gain	1.02E+08	101.7				15.6		85.0			
28	crop	water	cropland loss	water gain	1.14E+07	11.4				1.8		60.4			
29	urban	forest	urban loss	forest gain	1.16E+06	1.2	14.8		14.5	8.0	1.3	0.2	1.5	-13.2	-89.6
30	urban	barren	urban loss	barren gain	6.47E+04	0.1	0.3		98.4	0.4	8.8	0.3			
31	urban	grass	urban loss	grass gain	8.59E+06	8.6				59.1		1.6			
32	urban	crop	urban loss	crop gain	2.99E+06	3.0				20.6		4.3			
33	urban	urban	stable urban	stable urban	2.36E+05	0.2		1.6							
34	urban	wetland	urban loss	wetland gain	1.39E+06	1.4				9.6		1.2			
35	urban	water	urban loss	water gain	3.36E+05	0.3				2.3		1.8			
36	wetland	forest	wetland loss	forest gain	4.00E+03	0.0	0.1		0.1	5.7	119.7	0.0	119.7	119.6	160,881.1
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		93.7	0.0	160,974.8	0.0			
38	wetland	grass	wetland loss	grassland gain	2.99E+04	0.0				42.8		0.0			
39	wetland	crop	wetland loss	cropland gain	3.58E+04	0.0				51.4		0.1			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	4.65E+03	0.0		6.3							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.40E+06	1.4	18.8		16.3	8.6	18.9	0.3	21.4	2.6	13.8
44	water	barren	water loss	barren gain	1.67E+05	0.2	0.4		86.9	1.0	100.7	0.7			
45	water	grass	water loss	grassland gain	1.01E+07	10.1				62.1		1.9			
46	water	crop	water loss	cropland gain	1.68E+06	1.7				10.3		2.4			
47	water	urban	water loss	urban gain	1.21E+05	0.1				0.7		9.3			
48	water	wetland	water loss	wetland gain	2.82E+06	2.8				17.3		2.4			
49	water	water	stable water	stable water	2.46E+06	2.5		13.1							
	Total					4,343.1									

Appendix 2.2.4.12.1. Soviet era changes (1965-'87) in land cover and change percentages within Guria, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	7.39E+08	739.2	770.5	95.9	31.3		94.8		834.1	63.6	8.2
2	forest	barren	forest loss	barren gain	5.22E+04	0.1	78.5		4.1	0.2	12.3	29.2			
3	forest	grass	forest loss	grassland gain	1.36E+07	13.6				43.6		64.0			
4	forest	crop	forest loss	cropland gain	1.54E+07	15.4				49.1		90.6			
5	forest	urban	forest loss	urban gain	4.68E+04	0.0				0.1		13.3			
6	forest	wetland	forest loss	wetland gain	2.18E+06	2.2				7.0		15.6			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	1.36E+06	1.4	1.4		1.4	94.5	0.2	1.4	0.2	-1.3	-87.6
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.1	0.0	100.0		12.4				
10	barren	grass	barren loss	grassland gain	7.84E+04	0.1				5.5		0.4			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				0.0		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	4.09E+07	40.9	44.4		42.3	96.7	21.3	43.2	23.4	-21.0	-47.2
16	grass	barren	grassland loss	barren gain	6.36E+04	0.1	4.5		95.3	0.2	48.0	35.6			
17	grass	grass	stable grassland	stable grass	2.10E+06	2.1		4.7							
18	grass	crop	grassland loss	cropland gain	1.27E+06	1.3				3.0		7.5			
19	grass	urban	grassland loss	urban gain	3.34E+03	0.0				0.0		1.0			
20	grass	wetland	grassland loss	wetland gain	4.21E+04	0.0				0.1		0.3			
21	grass	water	grassland loss	water gain	0.00E+00	0.0				0.0		0.0			
22	crop	forest	cropland loss	forest gain	5.25E+07	52.5	164.3		72.1	72.7	17.0	55.3	109.1	-55.2	-33.6
23	crop	barren	cropland loss	barren gain	6.28E+04	0.1	16.7		43.9	0.1	10.3	35.2			
24	crop	grass	cropland loss	grassland gain	7.46E+06	7.5				10.3		35.0			
25	crop	crop	stable cropland	stable cropland	9.22E+07	92.2		56.1							
26	crop	urban	cropland loss	urban gain	3.01E+05	0.3				0.4		85.7			
27	crop	wetland	cropland loss	wetland gain	1.17E+07	11.7				16.2		83.5			
28	crop	water	cropland loss	water gain	1.57E+05	0.2				0.2		100.0			
29	urban	forest	urban loss	forest gain	6.68E+03	0.0	0.0		0.0	17.2	0.4	0.0	0.4	0.3	805.1
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	905.1	0.0			
31	urban	grass	urban loss	grass gain	1.14E+04	0.0				29.3		0.1			
32	urban	crop	urban loss	crop gain	2.07E+04	0.0				53.4		0.1			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	0.00E+00	0.0				0.0		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	3.97E+04	0.0	0.5		0.2	19.5	14.0	0.0	14.2	13.8	3,010.5
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		44.5	0.0	3,055.0	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				0.0		0.0			
39	wetland	crop	wetland loss	cropland gain	1.64E+05	0.2				80.5		1.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	2.54E+05	0.3		55.5							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	2.27E+04	0.0	0.6		0.4	6.1	0.2	0.0	0.3	-0.2	-39.1
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.1		67.4	0.0	28.3	0.0			
45	water	grass	water loss	grassland gain	1.30E+05	0.1				34.9		0.6			
46	water	crop	water loss	cropland gain	1.34E+05	0.1				35.9		0.8			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	8.65E+04	0.1				23.1		0.6			
49	water	water	stable water	stable water	1.81E+05	0.2		32.6							
	Total					981.8									

Appendix 2.2.4.12.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Guria, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	7.86E+08	786.4	834.5	94.2	48.1		48.0		834.4	-0.1	0.0
2	forest	barren	forest loss	barren gain	3.48E+04	0.0	85.0		5.8	0.1	5.8	60.5			
3	forest	grass	forest loss	grassland gain	2.97E+07	29.7				61.6		60.5			
4	forest	crop	forest loss	cropland gain	1.46E+07	14.6				30.4		66.3			
5	forest	urban	forest loss	urban gain	6.02E+03	0.0				0.0		12.2			
6	forest	wetland	forest loss	wetland gain	3.81E+06	3.8				7.9		27.2			
7	forest	water	forest loss	water gain	1.33E+03	0.0				0.0		1.5			
8	barren	forest	barren loss	forest gain	4.62E+04	0.0	0.2		0.2	26.0	0.1	0.1	0.1	-0.1	-66.8
9	barren	barren	stable barren	stable barren	2.01E+03	0.0	0.0	1.1	98.9		32.1				
10	barren	grass	barren loss	grassland gain	1.11E+05	0.1				62.6		0.2			
11	barren	crop	barren loss	cropland gain	1.40E+04	0.0				7.9		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	6.02E+03	0.0				3.4		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	9.68E+06	9.7	23.4		12.1	79.8	49.0	20.1	60.4	36.9	157.5
16	grass	barren	grassland loss	barren gain	7.36E+03	0.0	2.4		51.8	0.1	209.3	12.8			
17	grass	grass	stable grassland	stable grass	1.13E+07	11.3		48.2							
18	grass	crop	grassland loss	cropland gain	2.03E+06	2.0				16.7		9.2			
19	grass	urban	grassland loss	urban gain	6.01E+03	0.0				0.0		12.2			
20	grass	wetland	grassland loss	wetland gain	3.99E+05	0.4				3.3		2.9			
21	grass	water	grassland loss	water gain	1.42E+04	0.0				0.1		15.7			
22	crop	forest	cropland loss	forest gain	3.50E+07	35.0	109.1		62.9	55.6	22.0	72.8	68.3	-40.9	-37.4
23	crop	barren	cropland loss	barren gain	1.54E+04	0.0	11.1		57.7	0.0	20.2	26.7			
24	crop	grass	cropland loss	grassland gain	1.81E+07	18.1				28.9		37.0			
25	crop	crop	stable cropland	stable cropland	4.62E+07	46.2		42.3							
26	crop	urban	cropland loss	urban gain	3.34E+04	0.0				0.1		67.6			
27	crop	wetland	cropland loss	wetland gain	9.69E+06	9.7				15.4		69.1			
28	crop	water	cropland loss	water gain	2.54E+04	0.0				0.0		28.1			
29	urban	forest	urban loss	forest gain	3.14E+04	0.0	0.3		0.3	9.2	0.0	0.1	0.1	-0.3	-83.6
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		97.7	0.0	14.1	0.0			
31	urban	grass	urban loss	grass gain	1.55E+05	0.2				45.3		0.3			
32	urban	crop	urban loss	crop gain	1.24E+05	0.1				36.1		0.6			
33	urban	urban	stable urban	stable urban	8.01E+03	0.0		2.3							
34	urban	wetland	urban loss	wetland gain	3.21E+04	0.0				9.4		0.2			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	3.29E+06	3.3	14.2		9.5	34.5	14.0	6.9	18.7	4.5	31.4
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	1.5		66.9	0.0	98.4	0.0			
38	wetland	grass	wetland loss	grassland gain	9.37E+05	0.9				9.8		1.9			
39	wetland	crop	wetland loss	cropland gain	5.25E+06	5.2				55.1		23.8			
40	wetland	urban	wetland loss	urban gain	4.01E+03	0.0				0.0		8.1			
41	wetland	wetland	stable wetland	stable wetland	4.71E+06	4.7		33.1							
42	wetland	water	wetland loss	water gain	4.93E+04	0.0				0.5		54.7			
43	water	forest	water loss	forest gain	4.68E+03	0.0	0.3		0.1	3.7	0.1	0.0	0.3	0.0	-10.8
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		37.5	0.0	26.7	0.0			
45	water	grass	water loss	grassland gain	2.14E+04	0.0				16.8		0.0			
46	water	crop	water loss	cropland gain	2.34E+04	0.0				18.4		0.1			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	7.75E+04	0.1				61.0		0.6			
49	water	water	stable water	stable water	2.11E+05	0.2		62.5							
	Total					982.2									

Appendix 2.2.4.12.3. 50-year changes (1965-2015) in land cover and change percentages within Guria, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	7.27E+08	727.2	769.4	94.5	42.2		107.4		834.6	65.2	8.5
2	forest	barren	forest loss	barren gain	3.68E+04	0.0	78.3		5.5	0.1	14.0	61.8			
3	forest	grass	forest loss	grassland gain	3.01E+07	30.1				71.5		52.6			
4	forest	crop	forest loss	cropland gain	9.45E+06	9.4				22.4		95.8			
5	forest	urban	forest loss	urban gain	1.94E+04	0.0				0.0		34.1			
6	forest	wetland	forest loss	wetland gain	2.52E+06	2.5				6.0		13.6			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	1.37E+06	1.4	1.4		1.4	95.5	0.1	1.3	0.1	-1.4	-95.8
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.1	0.0	100.0		4.2				
10	barren	grass	barren loss	grassland gain	6.50E+04	0.1				4.5		0.1			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				0.0		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	4.24E+07	42.4	45.8		42.7	99.3	57.2	39.5	60.4	14.6	31.9
16	grass	barren	grassland loss	barren gain	4.02E+03	0.0	4.7		93.2	0.0	125.1	6.7			
17	grass	grass	stable grassland	stable grass	3.11E+06	3.1		6.8							
18	grass	crop	grassland loss	cropland gain	1.60E+05	0.2				0.4		1.6			
19	grass	urban	grassland loss	urban gain	0.00E+00	0.0				0.0		0.0			
20	grass	wetland	grassland loss	wetland gain	1.33E+05	0.1				0.3		0.7			
21	grass	water	grassland loss	water gain	0.00E+00	0.0				0.0		0.0			
22	crop	forest	cropland loss	forest gain	6.33E+07	63.3	164.5		106.2	59.6	9.9	59.0	68.3	-96.3	-58.5
23	crop	barren	cropland loss	barren gain	1.87E+04	0.0	16.8		64.5	0.0	6.0	31.4			
24	crop	grass	cropland loss	grassland gain	2.69E+07	26.9				25.3		47.0			
25	crop	crop	stable cropland	stable cropland	5.84E+07	58.4		35.5							
26	crop	urban	cropland loss	urban gain	3.74E+04	0.0				0.0		65.9			
27	crop	wetland	cropland loss	wetland gain	1.58E+07	15.8				14.9		85.1			
28	crop	water	cropland loss	water gain	1.11E+05	0.1				0.1		100.0			
29	urban	forest	urban loss	forest gain	7.34E+03	0.0	0.0		0.0	16.9	0.1	0.0	0.1	0.0	30.3
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		98.5	0.0	128.8	0.0			
31	urban	grass	urban loss	grass gain	2.00E+04	0.0				46.2		0.0			
32	urban	crop	urban loss	crop gain	1.54E+04	0.0				35.4		0.2			
33	urban	urban	stable urban	stable urban	6.68E+02	0.0		1.5							
34	urban	wetland	urban loss	wetland gain	6.68E+02	0.0				1.5		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	3.14E+05	0.3	0.6		0.4	71.5	18.6	0.3	18.7	18.1	2,979.7
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.1		72.3	0.0	3,052.0	0.0			
38	wetland	grass	wetland loss	grassland gain	4.68E+03	0.0				1.1		0.0			
39	wetland	crop	wetland loss	cropland gain	1.20E+05	0.1				27.4		1.2			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	1.68E+05	0.2		27.7							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.74E+04	0.0	0.6		0.4	4.7	0.1	0.0	0.3	-0.3	-46.2
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.1		66.0	0.0	19.8	0.0			
45	water	grass	water loss	grassland gain	1.27E+05	0.1				34.4		0.2			
46	water	crop	water loss	cropland gain	1.16E+05	0.1				31.5		1.2			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.09E+05	0.1				29.5		0.6			
49	water	water	stable water	stable water	1.91E+05	0.2		34.0							
	Total					982.3									

Appendix 2.2.4.13.1. Soviet era changes (1965-'87) in land cover and change percentages within Atchara, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.56E+08	255.8	268.1	95.4	12.3		162.3		418.1	150.0	56.0
2	forest	barren	forest loss	barren gain	3.79E+05	0.4	59.0		4.6	3.1	60.5	57.9			
3	forest	grass	forest loss	grassland gain	7.80E+06	7.8				63.7		79.4			
4	forest	crop	forest loss	cropland gain	3.99E+06	4.0				32.6		30.2			
5	forest	urban	forest loss	urban gain	7.39E+03	0.0				0.1		10.3			
6	forest	wetland	forest loss	wetland gain	6.59E+04	0.1				0.5		20.2			
7	forest	water	forest loss	water gain	4.03E+03	0.0				0.0		28.5			
8	barren	forest	barren loss	forest gain	5.63E+06	5.6	8.5		8.4	66.8	0.7	3.5	0.7	-7.8	-91.7
9	barren	barren	stable barren	stable barren	4.91E+04	0.0	1.9	0.6	99.4		7.7				
10	barren	grass	barren loss	grassland gain	1.99E+06	2.0				23.6		20.3			
11	barren	crop	barren loss	cropland gain	8.04E+05	0.8				9.5		6.1			
12	barren	urban	barren loss	urban gain	2.69E+03	0.0				0.0		3.7			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	6.05E+03	0.0				0.1		42.8			
15	grass	forest	grassland loss	forest gain	1.57E+08	156.6	177.5		165.6	94.5	9.8	96.5	21.7	-155.8	-87.8
16	grass	barren	grassland loss	barren gain	2.75E+05	0.3	39.1		93.3	0.2	5.5	42.1			
17	grass	grass	stable grassland	stable grass	1.19E+07	11.9		6.7							
18	grass	crop	grassland loss	cropland gain	8.43E+06	8.4				5.1		63.7			
19	grass	urban	grassland loss	urban gain	6.18E+04	0.1				0.0		86.0			
20	grass	wetland	grassland loss	wetland gain	2.61E+05	0.3				0.2		79.8			
21	grass	water	grassland loss	water gain	4.04E+03	0.0				0.0		28.6			
22	crop	forest	cropland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	13.2	0.0	13.2	13.2	140,292.5
23	crop	barren	cropland loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	140,392.5	0.0			
24	crop	grass	cropland loss	grassland gain	9.42E+03	0.0				100.0		0.1			
25	crop	crop	stable cropland	stable cropland	0.00E+00	0.0		0.0							
26	crop	urban	cropland loss	urban gain	0.00E+00	0.0				0.0		0.0			
27	crop	wetland	cropland loss	wetland gain	0.00E+00	0.0				0.0		0.0			
28	crop	water	cropland loss	water gain	0.00E+00	0.0				0.0		0.0			
29	urban	forest	urban loss	forest gain	2.15E+04	0.0	0.0		0.0	49.2	0.1	0.0	0.1	0.0	64.5
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	164.5	0.0			
31	urban	grass	urban loss	grass gain	2.22E+04	0.0				50.8		0.2			
32	urban	crop	urban loss	crop gain	0.00E+00	0.0				0.0		0.0			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	0.00E+00	0.0				0.0		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.3	0.0	0.3	0.3	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.0	0.0	0.0	0.0	NA
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
45	water	grass	water loss	grassland gain	0.00E+00	0.0				NA		0.0			
46	water	crop	water loss	cropland gain	0.00E+00	0.0				NA		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				NA		0.0			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				NA		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		NA							
	Total					454.1									

Appendix 2.2.4.13.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Atchara, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	4.13E+08	412.9	419.5	98.4	6.6		18.6		431.5	12.0	2.9
2	forest	barren	forest loss	barren gain	3.23E+04	0.0	92.1		1.6	0.5	4.4	81.4			
3	forest	grass	forest loss	grassland gain	5.53E+06	5.5				83.7		48.6			
4	forest	crop	forest loss	cropland gain	4.34E+05	0.4				6.6		61.6			
5	forest	urban	forest loss	urban gain	0.00E+00	0.0				0.0		0.0			
6	forest	wetland	forest loss	wetland gain	6.09E+05	0.6				9.2		61.7			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		NA			
8	barren	forest	barren loss	forest gain	3.52E+05	0.4	0.7		0.7	50.3	0.0	1.9	0.1	-0.7	-92.6
9	barren	barren	stable barren	stable barren	1.34E+04	0.0	0.2	1.9	98.1		5.6				
10	barren	grass	barren loss	grassland gain	3.14E+05	0.3				44.8		2.8			
11	barren	crop	barren loss	cropland gain	2.49E+04	0.0				3.5		3.5			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	9.42E+03	0.0				1.3		1.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		NA			
15	grass	forest	grassland loss	forest gain	1.09E+07	10.9	21.7		11.3	96.6	11.4	58.8	21.7	0.0	0.2
16	grass	barren	grassland loss	barren gain	3.37E+03	0.0	4.8		52.2	0.0	52.5	8.5			
17	grass	grass	stable grassland	stable grass	1.04E+07	10.4		47.8							
18	grass	crop	grassland loss	cropland gain	2.38E+05	0.2				2.1		33.8			
19	grass	urban	grassland loss	urban gain	6.72E+02	0.0				0.0		12.5			
20	grass	wetland	grassland loss	wetland gain	1.47E+05	0.1				1.3		14.9			
21	grass	water	grassland loss	water gain	0.00E+00	0.0				0.0		NA			
22	crop	forest	cropland loss	forest gain	7.09E+06	7.1	13.2		12.7	55.9	0.7	38.1	1.3	-12.0	-90.4
23	crop	barren	cropland loss	barren gain	4.04E+03	0.0	2.9		95.7	0.0	5.3	10.2			
24	crop	grass	cropland loss	grassland gain	5.37E+06	5.4				42.3		47.2			
25	crop	crop	stable cropland	stable cropland	5.71E+05	0.6		4.3							
26	crop	urban	cropland loss	urban gain	0.00E+00	0.0				0.0		0.0			
27	crop	wetland	cropland loss	wetland gain	2.21E+05	0.2				1.7		22.4			
28	crop	water	cropland loss	water gain	0.00E+00	0.0				0.0		NA			
29	urban	forest	urban loss	forest gain	5.38E+03	0.0	0.1		0.1	7.7	0.0	0.0	0.0	-0.1	-92.3
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	7.7	0.0			
31	urban	grass	urban loss	grass gain	6.39E+04	0.1				91.3		0.6			
32	urban	crop	urban loss	crop gain	0.00E+00	0.0				0.0		0.0			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	6.72E+02	0.0				1.0		0.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		NA			
36	wetland	forest	wetland loss	forest gain	2.05E+05	0.2	0.3		0.3	64.5	1.0	1.1	1.0	0.7	204.3
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.1		97.1	0.0	301.4	0.0			
38	wetland	grass	wetland loss	grassland gain	1.01E+05	0.1				31.7		0.9			
39	wetland	crop	wetland loss	cropland gain	7.40E+03	0.0				2.3		1.0			
40	wetland	urban	wetland loss	urban gain	4.71E+03	0.0				1.5		87.5			
41	wetland	wetland	stable wetland	stable wetland	9.41E+03	0.0		2.9							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		NA			
43	water	forest	water loss	forest gain	8.07E+03	0.0	0.0		0.0	100.0	0.0	0.0	0.0	0.0	-100.0
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	0.0	0.0			
45	water	grass	water loss	grassland gain	0.00E+00	0.0				0.0		0.0			
46	water	crop	water loss	cropland gain	0.00E+00	0.0				0.0		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				0.0		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					455.6									

Appendix 2.2.4.13.3. 50-year changes (1965-2015) in land cover and change percentages within Atchara, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.61E+08	260.9	267.6	97.5	6.7		170.6		431.5	163.9	61.2
2	forest	barren	forest loss	barren gain	1.88E+04	0.0	58.7		2.5	0.3	63.7	35.4			
3	forest	grass	forest loss	grassland gain	6.15E+06	6.2				91.9		76.0			
4	forest	crop	forest loss	cropland gain	3.05E+05	0.3				4.6		23.9			
5	forest	urban	forest loss	urban gain	0.00E+00	0.0				0.0		0.0			
6	forest	wetland	forest loss	wetland gain	2.19E+05	0.2				3.3		21.9			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		NA			
8	barren	forest	barren loss	forest gain	6.58E+06	6.6	8.6		8.6	76.2	0.1	3.9	0.1	-8.6	-99.4
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	1.9	0.0	100.0		0.6				
10	barren	grass	barren loss	grassland gain	1.92E+06	1.9				22.2		23.7			
11	barren	crop	barren loss	cropland gain	1.14E+05	0.1				1.3		8.9			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	2.02E+04	0.0				0.2		2.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		NA			
15	grass	forest	grassland loss	forest gain	1.64E+08	164.0	179.3		165.6	99.0	8.1	96.1	21.7	-157.6	-87.9
16	grass	barren	grassland loss	barren gain	3.43E+04	0.0	39.4		92.4	0.0	4.5	64.6			
17	grass	grass	stable grassland	stable grass	1.36E+07	13.6		7.6							
18	grass	crop	grassland loss	cropland gain	8.57E+05	0.9				0.5		67.2			
19	grass	urban	grassland loss	urban gain	5.38E+03	0.0				0.0		100.0			
20	grass	wetland	grassland loss	wetland gain	7.57E+05	0.8				0.5		76.0			
21	grass	water	grassland loss	water gain	0.00E+00	0.0				0.0		NA			
22	crop	forest	cropland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	1.3	0.0	1.3	1.3	13,441.9
23	crop	barren	cropland loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	13,541.9	0.0			
24	crop	grass	cropland loss	grassland gain	9.42E+03	0.0				100.0		0.1			
25	crop	crop	stable cropland	stable cropland	0.00E+00	0.0		0.0							
26	crop	urban	cropland loss	urban gain	0.00E+00	0.0				0.0		0.0			
27	crop	wetland	cropland loss	wetland gain	0.00E+00	0.0				0.0		0.0			
28	crop	water	cropland loss	water gain	0.00E+00	0.0				0.0		NA			
29	urban	forest	urban loss	forest gain	2.62E+04	0.0	0.0		0.0	61.9	0.0	0.0	0.0	0.0	-87.3
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	12.7	0.0			
31	urban	grass	urban loss	grass gain	1.61E+04	0.0				38.1		0.2			
32	urban	crop	urban loss	crop gain	0.00E+00	0.0				0.0		0.0			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	0.00E+00	0.0				0.0		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		NA			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	1.0	0.0	1.0	1.0	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		NA			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.0	0.0	0.0	0.0	NA
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
45	water	grass	water loss	grassland gain	0.00E+00	0.0				NA		0.0			
46	water	crop	water loss	cropland gain	0.00E+00	0.0				NA		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				NA		0.0			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				NA		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		NA							
	Total					455.6									

Appendix 2.2.4.14.1. Soviet era changes (1965-'87) in land cover and change percentages within Ratcha-Lechkhumi, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.48E+09	2,476.6	2,862.6	86.5	386.0		264.8		2,741.4	-121.2	-4.2
2	forest	barren	forest loss	barren gain	1.14E+07	11.4	82.6		13.5	3.0	9.3	24.3			
3	forest	grass	forest loss	grassland gain	3.20E+08	319.6				82.8		95.8			
4	forest	crop	forest loss	cropland gain	5.05E+07	50.5				13.1		68.1			
5	forest	urban	forest loss	urban gain	3.57E+05	0.4				0.1		27.0			
6	forest	wetland	forest loss	wetland gain	2.65E+06	2.7				0.7		40.1			
7	forest	water	forest loss	water gain	1.49E+06	1.5				0.4		27.8			
8	barren	forest	barren loss	forest gain	1.07E+06	1.1	1.5		1.5	71.7	47.0	0.4	47.0	45.5	3,042.8
9	barren	barren	stable barren	stable barren	7.26E+03	0.0	0.0	0.5	99.5		3,142.3				
10	barren	grass	barren loss	grassland gain	3.66E+05	0.4				24.6		0.1			
11	barren	crop	barren loss	cropland gain	5.56E+04	0.1				3.7		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.55E+08	254.8	550.6		312.7	81.5	333.4	96.2	571.3	20.8	3.8
16	grass	barren	grassland loss	barren gain	3.29E+07	32.9	15.9		56.8	10.5	60.6	70.1			
17	grass	grass	stable grassland	stable grass	2.38E+08	237.9		43.2							
18	grass	crop	grassland loss	cropland gain	2.27E+07	22.7				7.2		30.5			
19	grass	urban	grassland loss	urban gain	5.33E+05	0.5				0.2		40.3			
20	grass	wetland	grassland loss	wetland gain	9.97E+05	1.0				0.3		15.1			
21	grass	water	grassland loss	water gain	7.78E+05	0.8				0.2		14.5			
22	crop	forest	cropland loss	forest gain	7.99E+06	8.0	38.7		27.7	28.9	74.2	3.0	85.2	46.5	120.1
23	crop	barren	cropland loss	barren gain	2.02E+06	2.0	1.1		71.5	7.3	191.6	4.3			
24	crop	grass	cropland loss	grassland gain	1.19E+07	11.9				43.2		3.6			
25	crop	crop	stable cropland	stable cropland	1.10E+07	11.0		28.5							
26	crop	urban	cropland loss	urban gain	4.14E+05	0.4				1.5		31.4			
27	crop	wetland	cropland loss	wetland gain	2.21E+06	2.2				8.0		33.5			
28	crop	water	cropland loss	water gain	3.08E+06	3.1				11.1		57.4			
29	urban	forest	urban loss	forest gain	5.37E+05	0.5	1.8		1.6	32.6	1.3	0.2	1.5	-0.3	-18.2
30	urban	barren	urban loss	barren gain	8.14E+04	0.1	0.1		91.4	4.9	73.2	0.2			
31	urban	grass	urban loss	grass gain	6.41E+05	0.6				38.9		0.2			
32	urban	crop	urban loss	crop gain	2.89E+05	0.3				17.6		0.4			
33	urban	urban	stable urban	stable urban	1.55E+05	0.2		8.6							
34	urban	wetland	urban loss	wetland gain	8.41E+04	0.1				5.1		1.3			
35	urban	water	urban loss	water gain	1.46E+04	0.0				0.9		0.3			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	6.6	0.0	6.6	6.6	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	4.85E+05	0.5	10.4		3.2	15.0	5.4	0.2	12.5	2.1	20.3
44	water	barren	water loss	barren gain	5.14E+05	0.5	0.3		31.1	15.9	51.3	1.1			
45	water	grass	water loss	grassland gain	9.07E+05	0.9				28.0		0.3			
46	water	crop	water loss	cropland gain	6.48E+05	0.6				20.0		0.9			
47	water	urban	water loss	urban gain	1.72E+04	0.0				0.5		1.3			
48	water	wetland	water loss	wetland gain	6.68E+05	0.7				20.6		10.1			
49	water	water	stable water	stable water	7.19E+06	7.2		68.9							
	Total					3,465.6									

Appendix 2.2.4.14.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Ratcha-Lechkhumi, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.69E+09	2,689.9	2,742.1	98.1	52.2		305.1		2,995.0	252.9	9.2
2	forest	barren	forest loss	barren gain	7.58E+06	7.6	79.1		1.9	14.5	11.1	55.5			
3	forest	grass	forest loss	grassland gain	3.74E+07	37.4				71.6		42.9			
4	forest	crop	forest loss	cropland gain	3.99E+06	4.0				7.6		32.0			
5	forest	urban	forest loss	urban gain	2.91E+04	0.0				0.1		4.2			
6	forest	wetland	forest loss	wetland gain	2.51E+06	2.5				4.8		31.4			
7	forest	water	forest loss	water gain	7.30E+05	0.7				1.4		14.6			
8	barren	forest	barren loss	forest gain	5.46E+06	5.5	47.2		25.3	21.6	13.6	1.8	35.6	-11.7	-24.7
9	barren	barren	stable barren	stable barren	2.19E+07	21.9	1.4	46.4	53.6		28.9				
10	barren	grass	barren loss	grassland gain	1.71E+07	17.1				67.7		19.7			
11	barren	crop	barren loss	cropland gain	8.26E+05	0.8				3.3		6.6			
12	barren	urban	barren loss	urban gain	1.08E+05	0.1				0.4		15.8			
13	barren	wetland	barren loss	wetland gain	6.15E+05	0.6				2.4		7.7			
14	barren	water	barren loss	water gain	1.16E+06	1.2				4.6		23.2			
15	grass	forest	grassland loss	forest gain	2.54E+08	253.7	571.5		268.0	94.6	87.0	83.1	390.5	-181.0	-31.7
16	grass	barren	grassland loss	barren gain	4.73E+06	4.7	16.5		46.9	1.8	15.2	34.7			
17	grass	grass	stable grassland	stable grass	3.03E+08	303.5		53.1							
18	grass	crop	grassland loss	cropland gain	6.15E+06	6.1				2.3		49.3			
19	grass	urban	grassland loss	urban gain	3.49E+05	0.3				0.1		50.7			
20	grass	wetland	grassland loss	wetland gain	1.98E+06	2.0				0.7		24.8			
21	grass	water	grassland loss	water gain	1.13E+06	1.1				0.4		22.6			
22	crop	forest	cropland loss	forest gain	4.20E+07	42.0	85.2		76.6	54.9	12.5	13.8	21.1	-64.1	-75.2
23	crop	barren	cropland loss	barren gain	7.84E+05	0.8	2.5		89.9	1.0	14.6	5.7			
24	crop	grass	cropland loss	grassland gain	3.03E+07	30.3				39.5		34.8			
25	crop	crop	stable cropland	stable cropland	8.63E+06	8.6		10.1							
26	crop	urban	cropland loss	urban gain	1.44E+05	0.1				0.2		21.0			
27	crop	wetland	cropland loss	wetland gain	2.51E+06	2.5				3.3		31.4			
28	crop	water	cropland loss	water gain	8.76E+05	0.9				1.1		17.5			
29	urban	forest	urban loss	forest gain	1.18E+05	0.1	1.5		1.4	8.5	0.7	0.0	0.8	-0.7	-47.0
30	urban	barren	urban loss	barren gain	4.70E+04	0.0	0.0		93.6	3.4	46.6	0.3			
31	urban	grass	urban loss	grass gain	7.86E+05	0.8				56.9		0.9			
32	urban	crop	urban loss	crop gain	3.14E+05	0.3				22.7		2.5			
33	urban	urban	stable urban	stable urban	9.40E+04	0.1		6.4							
34	urban	wetland	urban loss	wetland gain	1.12E+05	0.1				8.1		1.4			
35	urban	water	urban loss	water gain	4.62E+03	0.0				0.3		0.1			
36	wetland	forest	wetland loss	forest gain	2.36E+06	2.4	6.6		5.5	42.5	8.0	0.8	9.1	2.4	37.0
37	wetland	barren	wetland loss	barren gain	1.55E+05	0.2	0.2		83.9	2.8	120.9	1.1			
38	wetland	grass	wetland loss	grassland gain	1.16E+06	1.2				20.8		1.3			
39	wetland	crop	wetland loss	cropland gain	7.26E+05	0.7				13.1		5.8			
40	wetland	urban	wetland loss	urban gain	5.16E+04	0.1				0.9		7.5			
41	wetland	wetland	stable wetland	stable wetland	1.06E+06	1.1		16.1							
42	wetland	water	wetland loss	water gain	1.10E+06	1.1				19.8		22.0			
43	water	forest	water loss	forest gain	1.46E+06	1.5	12.6		2.9	50.6	5.0	0.5	14.7	2.1	16.8
44	water	barren	water loss	barren gain	3.49E+05	0.3	0.4		23.0	12.1	39.9	2.6			
45	water	grass	water loss	grassland gain	3.38E+05	0.3				11.7		0.4			
46	water	crop	water loss	cropland gain	4.75E+05	0.5				16.4		3.8			
47	water	urban	water loss	urban gain	5.96E+03	0.0				0.2		0.9			
48	water	wetland	water loss	wetland gain	2.60E+05	0.3				9.0		3.3			
49	water	water	stable water	stable water	9.66E+06	9.7		77.0							
	Total					3,466.7									

Appendix 2.2.4.14.3. 50-year changes (1965-2015) in land cover and change percentages within Ratcha-Lechkhumi, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.66E+09	2,659.3	2,857.1	93.1	197.8		335.7		2,995.0	137.9	4.8
2	forest	barren	forest loss	barren gain	7.32E+06	7.3	82.4		6.9	3.7	11.8	20.6			
3	forest	grass	forest loss	grassland gain	1.74E+08	173.8				87.8		91.7			
4	forest	crop	forest loss	cropland gain	1.02E+07	10.2				5.2		64.2			
5	forest	urban	forest loss	urban gain	1.07E+05	0.1				0.1		15.2			
6	forest	wetland	forest loss	wetland gain	4.34E+06	4.3				2.2		47.9			
7	forest	water	forest loss	water gain	2.08E+06	2.1				1.1		27.0			
8	barren	forest	barren loss	forest gain	1.19E+06	1.2	1.5		1.5	80.5	35.6	0.4	35.6	34.1	2,304.7
9	barren	barren	stable barren	stable barren	1.32E+03	0.0	0.0	0.1	99.9		2,404.6				
10	barren	grass	barren loss	grassland gain	2.88E+05	0.3				19.5		0.2			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				0.0		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	3.21E+08	321.3	557.0		356.1	90.2	189.6	95.7	390.5	-166.6	-29.9
16	grass	barren	grassland loss	barren gain	2.72E+07	27.2	16.1		63.9	7.6	34.0	76.3			
17	grass	grass	stable grassland	stable grass	2.01E+08	200.9		36.1							
18	grass	crop	grassland loss	cropland gain	4.58E+06	4.6				1.3		28.8			
19	grass	urban	grassland loss	urban gain	1.74E+05	0.2				0.0		24.7			
20	grass	wetland	grassland loss	wetland gain	2.08E+06	2.1				0.6		22.9			
21	grass	water	grassland loss	water gain	8.25E+05	0.8				0.2		10.7			
22	crop	forest	cropland loss	forest gain	1.16E+07	11.6	38.8		33.6	34.5	15.9	3.4	21.1	-17.7	-45.6
23	crop	barren	cropland loss	barren gain	7.62E+05	0.8	1.1		86.6	2.3	41.0	2.1			
24	crop	grass	cropland loss	grassland gain	1.39E+07	13.9				41.5		7.4			
25	crop	crop	stable cropland	stable cropland	5.21E+06	5.2		13.4							
26	crop	urban	cropland loss	urban gain	4.10E+05	0.4				1.2		58.2			
27	crop	wetland	cropland loss	wetland gain	2.21E+06	2.2				6.6		24.3			
28	crop	water	cropland loss	water gain	4.70E+06	4.7				14.0		61.0			
29	urban	forest	urban loss	forest gain	6.59E+05	0.7	1.9		1.8	36.8	0.7	0.2	0.8	-1.1	-58.1
30	urban	barren	urban loss	barren gain	6.48E+04	0.1	0.1		95.8	3.6	37.6	0.2			
31	urban	grass	urban loss	grass gain	6.58E+05	0.7				36.8		0.3			
32	urban	crop	urban loss	crop gain	2.43E+05	0.2				13.6		1.5			
33	urban	urban	stable urban	stable urban	7.88E+04	0.1		4.2							
34	urban	wetland	urban loss	wetland gain	6.49E+04	0.1				3.6		0.7			
35	urban	water	urban loss	water gain	1.00E+05	0.1				5.6		1.3			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	9.1	0.0	9.1	9.1	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	9.77E+05	1.0	10.4		3.4	28.5	7.7	0.3	14.7	4.3	41.2
44	water	barren	water loss	barren gain	2.71E+05	0.3	0.3		33.0	7.9	74.2	0.8			
45	water	grass	water loss	grassland gain	9.24E+05	0.9				26.9		0.5			
46	water	crop	water loss	cropland gain	8.73E+05	0.9				25.4		5.5			
47	water	urban	water loss	urban gain	1.32E+04	0.0				0.4		1.9			
48	water	wetland	water loss	wetland gain	3.73E+05	0.4				10.9		4.1			
49	water	water	stable water	stable water	6.95E+06	7.0		67.0							
	Total					3,466.7									

Appendix 2.2.4.15.1. Soviet era changes (1965-'87) in land cover and change percentages within Imereti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.76E+09	3,763.2	4,325.7	87.0	562.5		412.2		4,175.4	-150.3	-3.5
2	forest	barren	forest loss	barren gain	2.01E+06	2.0	68.7		13.0	0.4	9.5	17.3			
3	forest	grass	forest loss	grassland gain	3.89E+08	388.7				69.1		44.9			
4	forest	crop	forest loss	cropland gain	1.57E+08	157.1				27.9		72.5			
5	forest	urban	forest loss	urban gain	1.99E+06	2.0				0.4		9.3			
6	forest	wetland	forest loss	wetland gain	1.25E+07	12.5				2.2		11.1			
7	forest	water	forest loss	water gain	2.54E+05	0.3				0.0		3.4			
8	barren	forest	barren loss	forest gain	1.65E+06	1.7	2.4		2.4	67.4	11.6	0.4	11.6	9.2	373.8
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	0.0	100.0		473.8				
10	barren	grass	barren loss	grassland gain	6.77E+05	0.7				27.7		0.1			
11	barren	crop	barren loss	cropland gain	1.20E+05	0.1				4.9		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	9.59E+07	95.9	265.2		130.5	73.5	866.4	23.3	1,001.2	736.0	277.5
16	grass	barren	grassland loss	barren gain	1.23E+06	1.2	4.2		49.2	0.9	326.7	10.6			
17	grass	grass	stable grassland	stable grass	1.35E+08	134.8		50.8							
18	grass	crop	grassland loss	cropland gain	3.11E+07	31.1				23.8		14.3			
19	grass	urban	grassland loss	urban gain	5.67E+05	0.6				0.4		2.7			
20	grass	wetland	grassland loss	wetland gain	1.26E+06	1.3				1.0		1.1			
21	grass	water	grassland loss	water gain	4.73E+05	0.5				0.4		6.3			
22	crop	forest	cropland loss	forest gain	3.08E+08	308.3	1,615.6		885.7	34.8	216.8	74.8	946.7	-669.0	-41.4
23	crop	barren	cropland loss	barren gain	5.84E+06	5.8	25.7		54.8	0.7	13.4	50.4			
24	crop	grass	cropland loss	grassland gain	4.53E+08	453.2				51.2		52.3			
25	crop	crop	stable cropland	stable cropland	7.30E+08	729.9		45.2							
26	crop	urban	cropland loss	urban gain	1.84E+07	18.4				2.1		86.5			
27	crop	wetland	cropland loss	wetland gain	9.38E+07	93.8				10.6		83.4			
28	crop	water	cropland loss	water gain	6.12E+06	6.1				0.7		82.0			
29	urban	forest	urban loss	forest gain	4.75E+06	4.7	55.8		49.2	9.6	21.3	1.2	27.8	-28.0	-50.1
30	urban	barren	urban loss	barren gain	7.24E+05	0.7	0.9		88.2	1.5	38.1	6.2			
31	urban	grass	urban loss	grass gain	1.76E+07	17.6				35.8		2.0			
32	urban	crop	urban loss	crop gain	2.33E+07	23.3				47.3		10.7			
33	urban	urban	stable urban	stable urban	6.56E+06	6.6		11.8							
34	urban	wetland	urban loss	wetland gain	2.25E+06	2.3				4.6		2.0			
35	urban	water	urban loss	water gain	6.20E+05	0.6				1.3		8.3			
36	wetland	forest	wetland loss	forest gain	7.91E+04	0.1	0.4		0.1	54.4	112.5	0.0	112.8	112.3	25,794.3
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		33.4	0.0	25,827.7	0.0			
38	wetland	grass	wetland loss	grassland gain	2.66E+03	0.0				1.8		0.0			
39	wetland	crop	wetland loss	cropland gain	6.36E+04	0.1				43.7		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	2.90E+05	0.3		66.6							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.52E+06	1.5	26.7		17.6	8.6	7.5	0.4	16.5	-10.2	-38.1
44	water	barren	water loss	barren gain	1.79E+06	1.8	0.4		66.0	10.1	27.9	15.4			
45	water	grass	water loss	grassland gain	6.20E+06	6.2				35.2		0.7			
46	water	crop	water loss	cropland gain	5.18E+06	5.2				29.4		2.4			
47	water	urban	water loss	urban gain	3.12E+05	0.3				1.8		1.5			
48	water	wetland	water loss	wetland gain	2.64E+06	2.6				15.0		2.4			
49	water	water	stable water	stable water	9.07E+06	9.1		34.0							
	Total					6,291.9									

Appendix 2.2.4.15.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Imereti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.95E+09	3,949.9	4,176.0	94.6	226.1		374.8		4,324.7	148.7	3.6
2	forest	barren	forest loss	barren gain	1.36E+05	0.1	66.4		5.4	0.1	9.0	15.4			
3	forest	grass	forest loss	grassland gain	1.56E+08	155.5				68.8		26.4			
4	forest	crop	forest loss	cropland gain	5.79E+07	57.9				25.6		29.1			
5	forest	urban	forest loss	urban gain	4.10E+05	0.4				0.2		6.2			
6	forest	wetland	forest loss	wetland gain	1.16E+07	11.6				5.1		19.2			
7	forest	water	forest loss	water gain	6.88E+05	0.7				0.3		8.2			
8	barren	forest	barren loss	forest gain	1.17E+06	1.2	11.6		11.4	10.3	0.9	0.3	1.1	-10.5	-90.5
9	barren	barren	stable barren	stable barren	2.24E+05	0.2	0.2	1.9	98.1		7.6				
10	barren	grass	barren loss	grassland gain	5.66E+06	5.7				49.8		1.0			
11	barren	crop	barren loss	cropland gain	1.27E+06	1.3				11.2		0.6			
12	barren	urban	barren loss	urban gain	4.34E+05	0.4				3.8		6.6			
13	barren	wetland	barren loss	wetland gain	8.53E+05	0.9				7.5		1.4			
14	barren	water	barren loss	water gain	1.99E+06	2.0				17.5		23.6			
15	grass	forest	grassland loss	forest gain	2.25E+08	225.1	1,001.2		322.1	69.9	589.8	60.1	1,269.0	267.8	26.7
16	grass	barren	grassland loss	barren gain	4.27E+05	0.4	15.9		32.2	0.1	58.9	48.4			
17	grass	grass	stable grassland	stable grass	6.79E+08	679.2		67.8							
18	grass	crop	grassland loss	cropland gain	8.19E+07	81.9				25.4		41.2			
19	grass	urban	grassland loss	urban gain	3.08E+06	3.1				1.0		46.9			
20	grass	wetland	grassland loss	wetland gain	8.95E+06	9.0				2.8		14.9			
21	grass	water	grassland loss	water gain	2.63E+06	2.6				0.8		31.2			
22	crop	forest	cropland loss	forest gain	1.21E+08	121.1	946.6		559.4	21.6	198.6	32.3	585.7	-360.9	-38.1
23	crop	barren	cropland loss	barren gain	1.21E+05	0.1	15.0		59.1	0.0	21.0	13.7			
24	crop	grass	cropland loss	grassland gain	3.99E+08	399.0				71.3		67.6			
25	crop	crop	stable cropland	stable cropland	3.87E+08	387.2		40.9							
26	crop	urban	cropland loss	urban gain	1.98E+06	2.0				0.4		30.1			
27	crop	wetland	cropland loss	wetland gain	3.53E+07	35.3				6.3		58.7			
28	crop	water	cropland loss	water gain	1.93E+06	1.9				0.3		22.9			
29	urban	forest	urban loss	forest gain	1.36E+06	1.4	27.8		22.7	6.0	6.6	0.4	11.7	-16.1	-57.8
30	urban	barren	urban loss	barren gain	1.45E+05	0.1	0.4		81.4	0.6	23.6	16.5			
31	urban	grass	urban loss	grass gain	1.28E+07	12.8				56.5		2.2			
32	urban	crop	urban loss	crop gain	6.79E+06	6.8				30.0		3.4			
33	urban	urban	stable urban	stable urban	5.17E+06	5.2		18.6							
34	urban	wetland	urban loss	wetland gain	1.54E+06	1.5				6.8		2.6			
35	urban	water	urban loss	water gain	1.07E+04	0.0				0.0		0.1			
36	wetland	forest	wetland loss	forest gain	2.55E+07	25.5	112.8		91.7	27.8	60.2	6.8	81.2	-31.5	-28.0
37	wetland	barren	wetland loss	barren gain	4.66E+04	0.0	1.8		81.4	0.1	53.4	5.3			
38	wetland	grass	wetland loss	grassland gain	1.52E+07	15.2				16.6		2.6			
39	wetland	crop	wetland loss	cropland gain	4.92E+07	49.2				53.6		24.8			
40	wetland	urban	wetland loss	urban gain	5.73E+05	0.6				0.6		8.7			
41	wetland	wetland	stable wetland	stable wetland	2.10E+07	21.0		18.6							
42	wetland	water	wetland loss	water gain	1.18E+06	1.2				1.3		14.0			
43	water	forest	water loss	forest gain	5.17E+05	0.5	16.5		5.9	8.8	8.4	0.1	19.1	2.6	15.5
44	water	barren	water loss	barren gain	6.00E+03	0.0	0.3		35.6	0.1	51.0	0.7			
45	water	grass	water loss	grassland gain	1.72E+06	1.7				29.3		0.3			
46	water	crop	water loss	cropland gain	1.58E+06	1.6				26.9		0.8			
47	water	urban	water loss	urban gain	9.28E+04	0.1				1.6		1.4			
48	water	wetland	water loss	wetland gain	1.96E+06	2.0				33.3		3.3			
49	water	water	stable water	stable water	1.07E+07	10.7		64.4							
	Total					6,292.6									

Appendix 2.2.4.15.3. 50-year changes (1965-2015) in land cover and change percentages within Imereti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.87E+09	3,865.7	4,320.6	89.5	455.0		459.0		4,324.7	4.1	0.1
2	forest	barren	forest loss	barren gain	3.36E+05	0.3	68.7		10.5	0.1	10.6	30.4			
3	forest	grass	forest loss	grassland gain	3.86E+08	385.6				84.7		34.0			
4	forest	crop	forest loss	cropland gain	5.87E+07	58.7				12.9		63.7			
5	forest	urban	forest loss	urban gain	4.36E+05	0.4				0.1		5.6			
6	forest	wetland	forest loss	wetland gain	8.86E+06	8.9				1.9		10.9			
7	forest	water	forest loss	water gain	1.04E+06	1.0				0.2		10.9			
8	barren	forest	barren loss	forest gain	2.08E+06	2.1	2.5		2.5	82.9	1.1	0.5	1.1	-1.4	-55.8
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	0.0	100.0		44.2				
10	barren	grass	barren loss	grassland gain	4.20E+05	0.4				16.8		0.0			
11	barren	crop	barren loss	cropland gain	7.98E+03	0.0				0.3		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.21E+08	121.2	271.5		135.4	89.5	1,133.0	26.4	1,269.0	997.6	367.5
16	grass	barren	grassland loss	barren gain	1.04E+05	0.1	4.3		49.9	0.1	417.3	9.4			
17	grass	grass	stable grassland	stable grass	1.36E+08	136.1		50.1							
18	grass	crop	grassland loss	cropland gain	1.12E+07	11.2				8.3		12.1			
19	grass	urban	grassland loss	urban gain	1.97E+05	0.2				0.1		2.5			
20	grass	wetland	grassland loss	wetland gain	1.89E+06	1.9				1.4		2.3			
21	grass	water	grassland loss	water gain	7.87E+05	0.8				0.6		8.2			
22	crop	forest	cropland loss	forest gain	3.28E+08	328.2	1,613.8		1,120.3	29.3	92.2	71.5	585.7	-1,028.1	-63.7
23	crop	barren	cropland loss	barren gain	4.94E+05	0.5	25.6		69.4	0.0	5.7	44.7			
24	crop	grass	cropland loss	grassland gain	7.12E+08	711.8				63.5		62.8			
25	crop	crop	stable cropland	stable cropland	4.94E+08	493.5		30.6							
26	crop	urban	cropland loss	urban gain	6.89E+06	6.9				0.6		88.5			
27	crop	wetland	cropland loss	wetland gain	6.57E+07	65.7				5.9		81.1			
28	crop	water	cropland loss	water gain	7.26E+06	7.3				0.6		75.9			
29	urban	forest	urban loss	forest gain	5.47E+06	5.5	56.9		52.9	10.3	7.8	1.2	11.7	-45.1	-79.4
30	urban	barren	urban loss	barren gain	1.38E+05	0.1	0.9		93.1	0.3	13.7	12.5			
31	urban	grass	urban loss	grass gain	2.74E+07	27.4				51.7		2.4			
32	urban	crop	urban loss	crop gain	1.76E+07	17.6				33.3		19.1			
33	urban	urban	stable urban	stable urban	3.95E+06	4.0		6.9							
34	urban	wetland	urban loss	wetland gain	1.88E+06	1.9				3.6		2.3			
35	urban	water	urban loss	water gain	4.69E+05	0.5				0.9		4.9			
36	wetland	forest	wetland loss	forest gain	6.50E+04	0.1	0.4		0.2	32.8	81.0	0.0	81.2	80.8	18,643.6
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		45.7	0.0	18,689.3	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				0.0		0.0			
39	wetland	crop	wetland loss	cropland gain	1.33E+05	0.1				67.2		0.1			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	2.35E+05	0.2		54.3							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	2.01E+06	2.0	26.9		17.4	11.6	9.6	0.4	19.1	-7.8	-29.0
44	water	barren	water loss	barren gain	3.33E+04	0.0	0.4		64.6	0.2	35.5	3.0			
45	water	grass	water loss	grassland gain	7.82E+06	7.8				45.1		0.7			
46	water	crop	water loss	cropland gain	4.57E+06	4.6				26.3		5.0			
47	water	urban	water loss	urban gain	2.63E+05	0.3				1.5		3.4			
48	water	wetland	water loss	wetland gain	2.66E+06	2.7				15.3		3.3			
49	water	water	stable water	stable water	9.53E+06	9.5		35.4							
	Total					6,292.6									

Appendix 2.2.4.16.1. Soviet era changes (1965-'87) in land cover and change percentages within Samtskhe-Javakheti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.34E+09	1,343.6	1,675.7	80.2	332.1		299.5		1,643.2	-32.5	-1.9
2	forest	barren	forest loss	barren gain	1.31E+06	1.3	31.7		19.8	0.4	17.9	4.9			
3	forest	grass	forest loss	grassland gain	1.91E+08	190.5				57.4		50.9			
4	forest	crop	forest loss	cropland gain	1.26E+08	125.5				37.8		15.4			
5	forest	urban	forest loss	urban gain	3.82E+06	3.8				1.2		38.5			
6	forest	wetland	forest loss	wetland gain	1.08E+07	10.8				3.2		19.3			
7	forest	water	forest loss	water gain	1.11E+05	0.1				0.0		2.0			
8	barren	forest	barren loss	forest gain	1.05E+06	1.0	7.6		6.2	16.9	27.0	0.3	28.4	20.8	271.9
9	barren	barren	stable barren	stable barren	1.44E+06	1.4	0.1	18.9	81.1		353.0				
10	barren	grass	barren loss	grassland gain	4.23E+06	4.2				68.2		1.1			
11	barren	crop	barren loss	cropland gain	9.04E+05	0.9				14.6		0.1			
12	barren	urban	barren loss	urban gain	2.02E+03	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	1.88E+04	0.0				0.3		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.64E+08	264.5	2,523.9		965.0	27.4	374.5	88.3	1,933.3	-590.6	-23.4
16	grass	barren	grassland loss	barren gain	2.46E+07	24.6	47.7		38.2	2.6	14.8	91.3			
17	grass	grass	stable grassland	stable grass	1.56E+09	1,558.9		61.8							
18	grass	crop	grassland loss	cropland gain	6.57E+08	657.0				68.1		80.4			
19	grass	urban	grassland loss	urban gain	4.04E+06	4.0				0.4		40.7			
20	grass	wetland	grassland loss	wetland gain	1.17E+07	11.7				1.2		21.0			
21	grass	water	grassland loss	water gain	3.13E+06	3.1				0.3		55.5			
22	crop	forest	cropland loss	forest gain	3.14E+07	31.4	956.1		229.6	13.7	816.7	10.5	1,543.2	587.1	61.4
23	crop	barren	cropland loss	barren gain	9.65E+05	1.0	18.1		24.0	0.4	85.4	3.6			
24	crop	grass	cropland loss	grassland gain	1.73E+08	172.9				75.3		46.2			
25	crop	crop	stable cropland	stable cropland	7.27E+08	726.5		76.0							
26	crop	urban	cropland loss	urban gain	2.06E+06	2.1				0.9		20.7			
27	crop	wetland	cropland loss	wetland gain	1.99E+07	19.9				8.7		35.7			
28	crop	water	cropland loss	water gain	2.38E+06	2.4				1.0		42.1			
29	urban	forest	urban loss	forest gain	1.31E+06	1.3	12.4		11.3	11.5	9.9	0.4	11.0	-1.4	-11.4
30	urban	barren	urban loss	barren gain	6.79E+04	0.1	0.2		91.4	0.6	80.0	0.3			
31	urban	grass	urban loss	grass gain	5.34E+06	5.3				47.1		1.4			
32	urban	crop	urban loss	crop gain	4.34E+06	4.3				38.2		0.5			
33	urban	urban	stable urban	stable urban	1.07E+06	1.1		8.6							
34	urban	wetland	urban loss	wetland gain	2.72E+05	0.3				2.4		0.5			
35	urban	water	urban loss	water gain	2.22E+04	0.0				0.2		0.4			
36	wetland	forest	wetland loss	forest gain	6.68E+04	0.1	0.3		0.3	20.1	55.8	0.0	55.8	55.4	16,302.1
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		97.6	0.0	16,399.8	0.0			
38	wetland	grass	wetland loss	grassland gain	1.48E+04	0.0				4.5		0.0			
39	wetland	crop	wetland loss	cropland gain	2.46E+05	0.2				74.2		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	8.10E+03	0.0		2.4							
42	wetland	water	wetland loss	water gain	4.05E+03	0.0				1.2		0.1			
43	water	forest	water loss	forest gain	1.23E+06	1.2	115.2		44.5	2.8	5.6	0.4	76.3	-38.8	-33.7
44	water	barren	water loss	barren gain	1.41E+04	0.0	2.2		38.6	0.0	4.9	0.1			
45	water	grass	water loss	grassland gain	1.46E+06	1.5				3.3		0.4			
46	water	crop	water loss	cropland gain	2.87E+07	28.7				64.5		3.5			
47	water	urban	water loss	urban gain	3.38E+03	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.31E+07	13.1				29.4		23.5			
49	water	water	stable water	stable water	7.07E+07	70.7		61.4							
	Total					5,291.3									

Appendix 2.2.4.16.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Samtskhe-Javakheti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.56E+09	1,557.4	1,642.8	94.8	85.3		175.1		1,732.6	89.8	5.5
2	forest	barren	forest loss	barren gain	1.22E+05	0.1	31.1		5.2	0.1	10.7	4.2			
3	forest	grass	forest loss	grassland gain	4.72E+07	47.2				55.3		7.3			
4	forest	crop	forest loss	cropland gain	2.79E+07	27.9				32.7		17.6			
5	forest	urban	forest loss	urban gain	1.13E+05	0.1				0.1		5.6			
6	forest	wetland	forest loss	wetland gain	9.96E+06	10.0				11.7		14.0			
7	forest	water	forest loss	water gain	6.04E+04	0.1				0.1		1.0			
8	barren	forest	barren loss	forest gain	7.42E+05	0.7	28.3		14.5	5.1	2.9	0.4	16.7	-11.6	-41.0
9	barren	barren	stable barren	stable barren	1.38E+07	13.8	0.5	48.8	51.2		10.2				
10	barren	grass	barren loss	grassland gain	1.25E+07	12.5				86.5		1.9			
11	barren	crop	barren loss	cropland gain	5.12E+05	0.5				3.5		0.3			
12	barren	urban	barren loss	urban gain	1.39E+05	0.1				1.0		7.0			
13	barren	wetland	barren loss	wetland gain	4.83E+05	0.5				3.3		0.7			
14	barren	water	barren loss	water gain	7.54E+04	0.1				0.5		1.3			
15	grass	forest	grassland loss	forest gain	7.39E+07	73.9	1,931.8		196.3	37.6	643.1	42.2	2,378.5	446.7	23.1
16	grass	barren	grassland loss	barren gain	1.89E+06	1.9	36.5		10.2	1.0	33.3	65.6			
17	grass	grass	stable grassland	stable grass	1.74E+09	1,735.4		89.8							
18	grass	crop	grassland loss	cropland gain	1.14E+08	113.8				58.0		71.8			
19	grass	urban	grassland loss	urban gain	1.25E+06	1.3				0.6		62.7			
20	grass	wetland	grassland loss	wetland gain	5.16E+06	5.2				2.6		7.3			
21	grass	water	grassland loss	water gain	3.36E+05	0.3				0.2		5.6			
22	crop	forest	cropland loss	forest gain	8.70E+07	87.0	1,542.2		712.8	12.2	158.5	49.7	987.9	-554.3	-35.9
23	crop	barren	cropland loss	barren gain	5.21E+05	0.5	29.2		46.2	0.1	10.3	18.0			
24	crop	grass	cropland loss	grassland gain	5.73E+08	573.0				80.4		89.1			
25	crop	crop	stable cropland	stable cropland	8.29E+08	829.4		53.8							
26	crop	urban	cropland loss	urban gain	4.78E+05	0.5				0.1		23.9			
27	crop	wetland	cropland loss	wetland gain	5.12E+07	51.2				7.2		72.1			
28	crop	water	cropland loss	water gain	6.17E+05	0.6				0.1		10.3			
29	urban	forest	urban loss	forest gain	8.59E+05	0.9	11.0		9.2	9.3	2.0	0.5	3.8	-7.2	-65.7
30	urban	barren	urban loss	barren gain	3.04E+05	0.3	0.2		83.9	3.3	18.2	10.5			
31	urban	grass	urban loss	grass gain	5.98E+06	6.0				64.8		0.9			
32	urban	crop	urban loss	crop gain	1.68E+06	1.7				18.3		1.1			
33	urban	urban	stable urban	stable urban	1.77E+06	1.8		16.1							
34	urban	wetland	urban loss	wetland gain	4.02E+05	0.4				4.4		0.6			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.19E+07	11.9	55.7		35.5	33.7	71.0	6.8	91.2	35.5	63.8
37	wetland	barren	wetland loss	barren gain	3.22E+04	0.0	1.1		63.7	0.1	127.5	1.1			
38	wetland	grass	wetland loss	grassland gain	4.31E+06	4.3				12.1		0.7			
39	wetland	crop	wetland loss	cropland gain	1.43E+07	14.3				40.2		9.0			
40	wetland	urban	wetland loss	urban gain	1.61E+04	0.0				0.0		0.8			
41	wetland	wetland	stable wetland	stable wetland	2.02E+07	20.2		36.3							
42	wetland	water	wetland loss	water gain	4.92E+06	4.9				13.9		81.9			
43	water	forest	water loss	forest gain	6.80E+05	0.7	75.1		5.0	13.6	6.0	0.4	76.1	1.0	1.3
44	water	barren	water loss	barren gain	1.41E+04	0.0	1.4		6.7	0.3	8.0	0.5			
45	water	grass	water loss	grassland gain	1.18E+05	0.1				2.4		0.0			
46	water	crop	water loss	cropland gain	4.16E+05	0.4				8.3		0.3			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	3.77E+06	3.8				75.4		5.3			
49	water	water	stable water	stable water	7.01E+07	70.1		93.3							
	Total					5,286.8									

Appendix 2.2.4.16.3. 50-year changes (1965-2015) in land cover and change percentages within Samtskhe-Javakheti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.37E+09	1,374.2	1,674.5	82.1	300.3		358.4		1,732.6	58.1	3.5
2	forest	barren	forest loss	barren gain	4.59E+05	0.5	31.7		17.9	0.2	21.4	2.9			
3	forest	grass	forest loss	grassland gain	2.29E+08	228.8				76.2		43.4			
4	forest	crop	forest loss	cropland gain	5.76E+07	57.6				19.2		14.6			
5	forest	urban	forest loss	urban gain	1.06E+06	1.1				0.4		34.1			
6	forest	wetland	forest loss	wetland gain	1.22E+07	12.2				4.0		13.3			
7	forest	water	forest loss	water gain	1.94E+05	0.2				0.1		3.5			
8	barren	forest	barren loss	forest gain	1.51E+06	1.5	8.0		7.1	21.2	15.8	0.4	16.7	8.7	108.6
9	barren	barren	stable barren	stable barren	8.87E+05	0.9	0.2	11.1	88.9		197.5				
10	barren	grass	barren loss	grassland gain	5.43E+06	5.4				76.5		1.0			
11	barren	crop	barren loss	cropland gain	1.21E+05	0.1				1.7		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	4.36E+04	0.0				0.6		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	3.26E+08	326.3	2,522.0		671.1	48.6	527.6	91.0	2,378.5	-143.5	-5.7
16	grass	barren	grassland loss	barren gain	1.48E+07	14.8	47.7		26.6	2.2	20.9	93.7			
17	grass	grass	stable grassland	stable grass	1.85E+09	1,850.9		73.4							
18	grass	crop	grassland loss	cropland gain	3.10E+08	310.2				46.2		78.7			
19	grass	urban	grassland loss	urban gain	1.04E+06	1.0				0.2		33.3			
20	grass	wetland	grassland loss	wetland gain	1.59E+07	15.9				2.4		17.4			
21	grass	water	grassland loss	water gain	2.98E+06	3.0				0.4		53.8			
22	crop	forest	cropland loss	forest gain	2.79E+07	27.9	955.7		361.9	7.7	394.2	7.8	987.9	32.2	3.4
23	crop	barren	cropland loss	barren gain	4.55E+05	0.5	18.1		37.9	0.1	41.2	2.9			
24	crop	grass	cropland loss	grassland gain	2.81E+08	280.9				77.6		53.2			
25	crop	crop	stable cropland	stable cropland	5.94E+08	593.8		62.1							
26	crop	urban	cropland loss	urban gain	1.02E+06	1.0				0.3		32.6			
27	crop	wetland	cropland loss	wetland gain	4.93E+07	49.3				13.6		54.1			
28	crop	water	cropland loss	water gain	2.34E+06	2.3				0.6		42.2			
29	urban	forest	urban loss	forest gain	1.60E+06	1.6	12.5		11.9	13.5	3.1	0.4	3.8	-8.7	-69.9
30	urban	barren	urban loss	barren gain	8.40E+04	0.1	0.2		94.8	0.7	24.9	0.5			
31	urban	grass	urban loss	grass gain	7.26E+06	7.3				61.2		1.4			
32	urban	crop	urban loss	crop gain	2.47E+06	2.5				20.8		0.6			
33	urban	urban	stable urban	stable urban	6.53E+05	0.7		5.2							
34	urban	wetland	urban loss	wetland gain	4.15E+05	0.4				3.5		0.5			
35	urban	water	urban loss	water gain	3.29E+04	0.0				0.3		0.6			
36	wetland	forest	wetland loss	forest gain	5.73E+04	0.1	0.3		0.2	27.4	91.1	0.0	91.2	90.9	27,000.3
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		62.1	0.0	27,062.5	0.0			
38	wetland	grass	wetland loss	grassland gain	3.78E+04	0.0				18.1		0.0			
39	wetland	crop	wetland loss	cropland gain	1.14E+05	0.1				54.5		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	1.28E+05	0.1		37.9							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.08E+06	1.1	113.8		43.2	2.5	5.5	0.3	76.1	-37.7	-33.1
44	water	barren	water loss	barren gain	0.00E+00	0.0	2.2		38.0	0.0	4.9	0.0			
45	water	grass	water loss	grassland gain	5.17E+06	5.2				12.0		1.0			
46	water	crop	water loss	cropland gain	2.37E+07	23.7				54.7		6.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.33E+07	13.3				30.8		14.6			
49	water	water	stable water	stable water	7.06E+07	70.6		62.0							
						5,286.8									

Appendix 2.2.4.17.1. Soviet era changes (1965-'87) in land cover and change percentages within Shida Kartli, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.88E+09	1,876.2	2,399.0	78.2	522.8		344.4		2,220.6	-178.4	-7.4
2	forest	barren	forest loss	barren gain	2.33E+06	2.3	46.6		21.8	0.4	14.4	4.8			
3	forest	grass	forest loss	grassland gain	4.26E+08	426.4				81.6		45.3			
4	forest	crop	forest loss	cropland gain	8.55E+07	85.5				16.4		38.4			
5	forest	urban	forest loss	urban gain	3.17E+06	3.2				0.6		13.3			
6	forest	wetland	forest loss	wetland gain	5.34E+06	5.3				1.0		11.8			
7	forest	water	forest loss	water gain	4.98E+04	0.0				0.0		2.8			
8	barren	forest	barren loss	forest gain	6.42E+05	0.6	7.5		5.5	11.6	48.9	0.2	50.9	43.3	577.6
9	barren	barren	stable barren	stable barren	1.96E+06	2.0	0.1	26.1	73.9		651.5				
10	barren	grass	barren loss	grassland gain	4.72E+06	4.7				85.1		0.5			
11	barren	crop	barren loss	cropland gain	1.86E+05	0.2				3.3		0.1			
12	barren	urban	barren loss	urban gain	1.33E+03	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.03E+08	202.8	1,112.3		356.8	56.8	941.2	58.9	1,696.7	584.4	52.5
16	grass	barren	grassland loss	barren gain	3.53E+07	35.3	21.6		32.1	9.9	84.6	72.2			
17	grass	grass	stable grassland	stable grass	7.55E+08	755.5		67.9							
18	grass	crop	grassland loss	cropland gain	1.15E+08	114.9				32.2		51.6			
19	grass	urban	grassland loss	urban gain	2.42E+06	2.4				0.7		10.1			
20	grass	wetland	grassland loss	wetland gain	1.17E+06	1.2				0.3		2.6			
21	grass	water	grassland loss	water gain	2.19E+05	0.2				0.1		12.2			
22	crop	forest	cropland loss	forest gain	1.30E+08	130.0	1,563.8		679.3	19.1	222.6	37.8	1,107.1	-456.7	-29.2
23	crop	barren	cropland loss	barren gain	8.53E+06	8.5	30.4		43.4	1.3	14.2	17.4			
24	crop	grass	cropland loss	grassland gain	4.87E+08	487.2				71.7		51.8			
25	crop	crop	stable cropland	stable cropland	8.84E+08	884.5		56.6							
26	crop	urban	cropland loss	urban gain	1.80E+07	18.0				2.7		75.4			
27	crop	wetland	cropland loss	wetland gain	3.40E+07	34.0				5.0		75.1			
28	crop	water	cropland loss	water gain	1.51E+06	1.5				0.2		84.2			
29	urban	forest	urban loss	forest gain	1.06E+07	10.6	56.2		50.4	21.0	23.9	3.1	29.8	-26.4	-47.0
30	urban	barren	urban loss	barren gain	1.31E+06	1.3	1.1		89.5	2.6	42.6	2.7			
31	urban	grass	urban loss	grass gain	1.53E+07	15.3				30.4		1.6			
32	urban	crop	urban loss	crop gain	1.87E+07	18.7				37.0		8.4			
33	urban	urban	stable urban	stable urban	5.88E+06	5.9		10.5							
34	urban	wetland	urban loss	wetland gain	4.50E+06	4.5				8.9		9.9			
35	urban	water	urban loss	water gain	1.47E+04	0.0				0.0		0.8			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	45.2	0.0	45.2	45.2	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	3.90E+05	0.4	13.4		13.3	2.9	1.8	0.1	1.9	-11.5	-85.6
44	water	barren	water loss	barren gain	1.41E+06	1.4	0.3		99.0	10.6	13.4	2.9			
45	water	grass	water loss	grassland gain	7.52E+06	7.5				56.7		0.8			
46	water	crop	water loss	cropland gain	3.39E+06	3.4				25.6		1.5			
47	water	urban	water loss	urban gain	3.01E+05	0.3				2.3		1.3			
48	water	wetland	water loss	wetland gain	2.51E+05	0.3				1.9		0.6			
49	water	water	stable water	stable water	1.34E+05	0.1		1.0							
	Total					5,152.2									

Appendix 2.2.4.17.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Shida Kartli, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.11E+09	2,106.4	2,221.6	94.8	115.2		464.8		2,571.2	349.6	15.7
2	forest	barren	forest loss	barren gain	1.30E+06	1.3	43.1		5.2	1.1	20.9	22.4			
3	forest	grass	forest loss	grassland gain	5.71E+07	57.1				49.6		12.1			
4	forest	crop	forest loss	cropland gain	5.33E+07	53.3				46.3		20.3			
5	forest	urban	forest loss	urban gain	6.62E+04	0.1				0.1		0.9			
6	forest	wetland	forest loss	wetland gain	3.18E+06	3.2				2.8		12.7			
7	forest	water	forest loss	water gain	2.19E+05	0.2				0.2		2.7			
8	barren	forest	barren loss	forest gain	1.38E+06	1.4	50.9		41.2	3.3	5.8	0.3	15.5	-35.4	-69.6
9	barren	barren	stable barren	stable barren	9.65E+06	9.6	1.0	19.0	81.0		11.4				
10	barren	grass	barren loss	grassland gain	3.70E+07	37.0				89.8		7.9			
11	barren	crop	barren loss	cropland gain	1.02E+06	1.0				2.5		0.4			
12	barren	urban	barren loss	urban gain	3.47E+05	0.3				0.8		4.9			
13	barren	wetland	barren loss	wetland gain	2.65E+05	0.3				0.6		1.1			
14	barren	water	barren loss	water gain	1.19E+06	1.2				2.9		14.7			
15	grass	forest	grassland loss	forest gain	3.72E+08	371.8	1,696.2		562.3	66.1	471.5	80.0	1,605.5	-90.7	-5.3
16	grass	barren	grassland loss	barren gain	3.46E+06	3.5	32.9		33.1	0.6	27.8	59.6			
17	grass	grass	stable grassland	stable grass	1.13E+09	1,133.9		66.9							
18	grass	crop	grassland loss	cropland gain	1.72E+08	171.7				30.5		65.3			
19	grass	urban	grassland loss	urban gain	5.13E+06	5.1				0.9		72.9			
20	grass	wetland	grassland loss	wetland gain	6.29E+06	6.3				1.1		25.1			
21	grass	water	grassland loss	water gain	3.97E+06	4.0				0.7		49.0			
22	crop	forest	cropland loss	forest gain	8.31E+07	83.1	1,107.1		460.5	18.0	262.8	17.9	909.4	-197.7	-17.9
23	crop	barren	cropland loss	barren gain	8.95E+05	0.9	21.5		41.6	0.2	23.7	15.4			
24	crop	grass	cropland loss	grassland gain	3.58E+08	358.3				77.8		76.0			
25	crop	crop	stable cropland	stable cropland	6.47E+08	646.6		58.4							
26	crop	urban	cropland loss	urban gain	1.40E+06	1.4				0.3		20.0			
27	crop	wetland	cropland loss	wetland gain	1.44E+07	14.4				3.1		57.5			
28	crop	water	cropland loss	water gain	2.37E+06	2.4				0.5		29.2			
29	urban	forest	urban loss	forest gain	7.31E+05	0.7	29.8		24.0	3.0	7.0	0.2	12.9	-16.9	-56.8
30	urban	barren	urban loss	barren gain	8.54E+04	0.1	0.6		80.4	0.4	23.6	1.5			
31	urban	grass	urban loss	grass gain	1.35E+07	13.5				56.2		2.9			
32	urban	crop	urban loss	crop gain	9.16E+06	9.2				38.2		3.5			
33	urban	urban	stable urban	stable urban	5.84E+06	5.8		19.6							
34	urban	wetland	urban loss	wetland gain	5.04E+05	0.5				2.1		2.0			
35	urban	water	urban loss	water gain	1.80E+04	0.0				0.1		0.2			
36	wetland	forest	wetland loss	forest gain	7.69E+06	7.7	45.2		40.6	18.9	25.0	1.7	29.7	-15.6	-34.4
37	wetland	barren	wetland loss	barren gain	2.47E+04	0.0	0.9		89.7	0.1	55.3	0.4			
38	wetland	grass	wetland loss	grassland gain	5.00E+06	5.0				12.3		1.1			
39	wetland	crop	wetland loss	cropland gain	2.75E+07	27.5				67.6		10.4			
40	wetland	urban	wetland loss	urban gain	8.62E+04	0.1				0.2		1.2			
41	wetland	wetland	stable wetland	stable wetland	4.65E+06	4.6		10.3							
42	wetland	water	wetland loss	water gain	3.36E+05	0.3				0.8		4.1			
43	water	forest	water loss	forest gain	1.56E+05	0.2	1.9		1.4	11.4	8.1	0.0	8.7	6.7	349.6
44	water	barren	water loss	barren gain	4.32E+04	0.0	0.0		71.5	3.1	421.0	0.7			
45	water	grass	water loss	grassland gain	5.90E+05	0.6				42.9		0.1			
46	water	crop	water loss	cropland gain	1.92E+05	0.2				13.9		0.1			
47	water	urban	water loss	urban gain	2.68E+03	0.0				0.2		0.0			
48	water	wetland	water loss	wetland gain	3.92E+05	0.4				28.5		1.6			
49	water	water	stable water	stable water	5.49E+05	0.5		28.5							
	Total					5,152.7									

Appendix 2.2.4.17.3. 50-year changes (1965-2015) in land cover and change percentages within Shida Kartli, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.09E+09	2,090.2	2,395.9	87.2	305.7		481.0		2,571.2	175.3	7.3
2	forest	barren	forest loss	barren gain	4.94E+05	0.5	46.5		12.8	0.2	20.1	3.3			
3	forest	grass	forest loss	grassland gain	2.61E+08	261.3				85.5		29.1			
4	forest	crop	forest loss	cropland gain	3.95E+07	39.5				12.9		31.0			
5	forest	urban	forest loss	urban gain	2.25E+05	0.2				0.1		2.8			
6	forest	wetland	forest loss	wetland gain	3.91E+06	3.9				1.3		13.2			
7	forest	water	forest loss	water gain	3.04E+05	0.3				0.1		3.8			
8	barren	forest	barren loss	forest gain	7.90E+05	0.8	7.6		7.2	10.9	15.1	0.2	15.5	7.9	104.0
9	barren	barren	stable barren	stable barren	3.55E+05	0.4	0.1	4.7	95.3		199.3				
10	barren	grass	barren loss	grassland gain	6.16E+06	6.2				85.3		0.7			
11	barren	crop	barren loss	cropland gain	2.42E+05	0.2				3.4		0.2			
12	barren	urban	barren loss	urban gain	2.68E+03	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	2.54E+04	0.0				0.4		0.1			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	3.31E+08	331.3	1,116.9		410.6	80.7	899.2	68.9	1,605.5	488.6	43.7
16	grass	barren	grassland loss	barren gain	1.31E+07	13.1	21.7		36.8	3.2	80.5	86.9			
17	grass	grass	stable grassland	stable grass	7.06E+08	706.3		63.2							
18	grass	crop	grassland loss	cropland gain	6.30E+07	63.0				15.3		49.5			
19	grass	urban	grassland loss	urban gain	2.58E+05	0.3				0.1		3.3			
20	grass	wetland	grassland loss	wetland gain	2.40E+06	2.4				0.6		8.1			
21	grass	water	grassland loss	water gain	5.32E+05	0.5				0.1		6.6			
22	crop	forest	cropland loss	forest gain	1.41E+08	140.5	1,562.3		780.1	18.0	127.3	29.2	909.4	-652.9	-41.8
23	crop	barren	cropland loss	barren gain	1.12E+06	1.1	30.3		49.9	0.1	8.1	7.4			
24	crop	grass	cropland loss	grassland gain	6.03E+08	602.7				77.3		67.0			
25	crop	crop	stable cropland	stable cropland	7.82E+08	782.2		50.1							
26	crop	urban	cropland loss	urban gain	6.94E+06	6.9				0.9		87.9			
27	crop	wetland	cropland loss	wetland gain	2.18E+07	21.8				2.8		73.5			
28	crop	water	cropland loss	water gain	6.99E+06	7.0				0.9		87.1			
29	urban	forest	urban loss	forest gain	7.71E+06	7.7	56.7		51.7	14.9	7.9	1.6	12.9	-43.8	-77.3
30	urban	barren	urban loss	barren gain	1.96E+05	0.2	1.1		91.2	0.4	13.9	1.3			
31	urban	grass	urban loss	grass gain	2.01E+07	20.1				38.9		2.2			
32	urban	crop	urban loss	crop gain	2.23E+07	22.3				43.0		17.5			
33	urban	urban	stable urban	stable urban	4.97E+06	5.0		8.8							
34	urban	wetland	urban loss	wetland gain	1.22E+06	1.2				2.4		4.1			
35	urban	water	urban loss	water gain	1.98E+05	0.2				0.4		2.5			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	29.7	0.0	29.7	29.7	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	6.54E+05	0.7	13.4		12.7	5.1	8.0	0.1	8.7	-4.7	-35.2
44	water	barren	water loss	barren gain	1.72E+05	0.2	0.3		95.3	1.4	60.0	1.1			
45	water	grass	water loss	grassland gain	8.88E+06	8.9				69.8		1.0			
46	water	crop	water loss	cropland gain	2.24E+06	2.2				17.6		1.8			
47	water	urban	water loss	urban gain	4.74E+05	0.5				3.7		6.0			
48	water	wetland	water loss	wetland gain	3.07E+05	0.3				2.4		1.0			
49	water	water	stable water	stable water	6.32E+05	0.6		4.7							
	Total					5,152.7									

Appendix 2.2.4.18.1. Soviet era changes (1965-'87) in land cover and change percentages within Mtskheta-Mtianeti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.20E+09	2,204.4	2,647.3	83.3	442.9		487.4		2,691.9	44.6	1.7
2	forest	barren	forest loss	barren gain	7.88E+06	7.9	46.7		16.7	1.8	18.4	3.8			
3	forest	grass	forest loss	grassland gain	3.83E+08	383.3				86.6		64.6			
4	forest	crop	forest loss	cropland gain	4.67E+07	46.7				10.5		28.7			
5	forest	urban	forest loss	urban gain	1.43E+05	0.1				0.0		4.5			
6	forest	wetland	forest loss	wetland gain	2.83E+06	2.8				0.6		17.7			
7	forest	water	forest loss	water gain	2.06E+06	2.1				0.5		17.3			
8	barren	forest	barren loss	forest gain	5.53E+05	0.6	16.2		4.0	13.9	207.0	0.1	219.3	203.1	1,251.4
9	barren	barren	stable barren	stable barren	1.23E+07	12.3	0.3	75.6	24.4		1,275.9				
10	barren	grass	barren loss	grassland gain	2.68E+06	2.7				67.6		0.5			
11	barren	crop	barren loss	cropland gain	3.11E+05	0.3				7.8		0.2			
12	barren	urban	barren loss	urban gain	2.81E+04	0.0				0.7		0.9			
13	barren	wetland	barren loss	wetland gain	8.03E+04	0.1				2.0		0.5			
14	barren	water	barren loss	water gain	3.11E+05	0.3				7.8		2.6			
15	grass	forest	grassland loss	forest gain	4.41E+08	440.8	2,376.7		737.4	59.8	593.4	90.4	2,232.8	-144.0	-6.1
16	grass	barren	grassland loss	barren gain	1.84E+08	183.7	41.9		31.0	24.9	25.0	88.7			
17	grass	grass	stable grassland	stable grass	1.64E+09	1,639.4		69.0							
18	grass	crop	grassland loss	cropland gain	1.08E+08	108.2				14.7		66.6			
19	grass	urban	grassland loss	urban gain	6.06E+05	0.6				0.1		19.2			
20	grass	wetland	grassland loss	wetland gain	1.45E+06	1.5				0.2		9.1			
21	grass	water	grassland loss	water gain	2.54E+06	2.5				0.3		21.3			
22	crop	forest	cropland loss	forest gain	4.38E+07	43.8	600.8		273.1	16.0	162.5	9.0	490.2	-110.6	-18.4
23	crop	barren	cropland loss	barren gain	1.33E+07	13.3	10.6		45.5	4.9	27.0	6.4			
24	crop	grass	cropland loss	grassland gain	1.96E+08	196.2				71.9		33.1			
25	crop	crop	stable cropland	stable cropland	3.28E+08	327.7		54.5							
26	crop	urban	cropland loss	urban gain	2.28E+06	2.3				0.8		72.5			
27	crop	wetland	cropland loss	wetland gain	1.06E+07	10.6				3.9		66.2			
28	crop	water	cropland loss	water gain	6.98E+06	7.0				2.6		58.6			
29	urban	forest	urban loss	forest gain	1.89E+06	1.9	17.5		16.9	11.2	3.2	0.4	3.8	-13.8	-78.5
30	urban	barren	urban loss	barren gain	1.29E+06	1.3	0.3		96.5	7.6	18.0	0.6			
31	urban	grass	urban loss	grass gain	7.45E+06	7.4				44.1		1.3			
32	urban	crop	urban loss	crop gain	5.79E+06	5.8				34.3		3.6			
33	urban	urban	stable urban	stable urban	6.09E+05	0.6		3.5							
34	urban	wetland	urban loss	wetland gain	4.79E+05	0.5				2.8		3.0			
35	urban	water	urban loss	water gain	1.47E+04	0.0				0.1		0.1			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	15.9	0.0	15.9	15.9	64,894.0
37	wetland	barren	wetland loss	barren gain	1.72E+04	0.0	0.0		100.0	70.3	64,994.0	0.0			
38	wetland	grass	wetland loss	grassland gain	5.30E+03	0.0				21.6		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				0.0		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	1.99E+03	0.0				8.1		0.0			
43	water	forest	water loss	forest gain	3.79E+05	0.4	11.8		7.1	5.3	11.9	0.1	16.5	4.8	40.4
44	water	barren	water loss	barren gain	8.97E+05	0.9	0.2		60.6	12.6	100.9	0.4			
45	water	grass	water loss	grassland gain	3.74E+06	3.7				52.3		0.6			
46	water	crop	water loss	cropland gain	1.49E+06	1.5				20.9		0.9			
47	water	urban	water loss	urban gain	8.98E+04	0.1				1.3		2.9			
48	water	wetland	water loss	wetland gain	5.48E+05	0.5				7.7		3.4			
49	water	water	stable water	stable water	4.65E+06	4.6		39.4							
	Total					5,670.4									

Appendix 2.2.4.18.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Mtskheta-Mtianeti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.55E+09	2,547.9	2,692.4	94.6	144.5		419.2		2,967.2	274.8	10.2
2	forest	barren	forest loss	barren gain	1.28E+07	12.8	47.5		5.4	8.9	15.6	25.9			
3	forest	grass	forest loss	grassland gain	1.14E+08	114.0				78.9		26.4			
4	forest	crop	forest loss	cropland gain	1.48E+07	14.8				10.3		18.7			
5	forest	urban	forest loss	urban gain	1.11E+05	0.1				0.1		1.7			
6	forest	wetland	forest loss	wetland gain	2.25E+06	2.3				1.6		12.1			
7	forest	water	forest loss	water gain	4.37E+05	0.4				0.3		6.1			
8	barren	forest	barren loss	forest gain	6.39E+06	6.4	218.8		96.8	6.6	49.4	1.5	171.5	-47.3	-21.6
9	barren	barren	stable barren	stable barren	1.22E+08	122.1	3.9	55.8	44.2		22.6				
10	barren	grass	barren loss	grassland gain	8.31E+07	83.1				85.8		19.2			
11	barren	crop	barren loss	cropland gain	2.89E+06	2.9				3.0		3.6			
12	barren	urban	barren loss	urban gain	1.09E+06	1.1				1.1		16.9			
13	barren	wetland	barren loss	wetland gain	1.66E+06	1.7				1.7		8.9			
14	barren	water	barren loss	water gain	1.69E+06	1.7				1.7		23.7			
15	grass	forest	grassland loss	forest gain	3.51E+08	350.7	2,231.4		445.8	78.7	432.4	83.7	2,218.1	-13.4	-0.6
16	grass	barren	grassland loss	barren gain	2.78E+07	27.8	39.4		20.0	6.2	19.4	56.3			
17	grass	grass	stable grassland	stable grass	1.79E+09	1,785.6		80.0							
18	grass	crop	grassland loss	cropland gain	5.62E+07	56.2				12.6		70.7			
19	grass	urban	grassland loss	urban gain	3.61E+06	3.6				0.8		56.1			
20	grass	wetland	grassland loss	wetland gain	5.81E+06	5.8				1.3		31.3			
21	grass	water	grassland loss	water gain	1.68E+06	1.7				0.4		23.6			
22	crop	forest	cropland loss	forest gain	5.65E+07	56.5	490.2		306.0	18.5	79.5	13.5	263.7	-226.5	-46.2
23	crop	barren	cropland loss	barren gain	7.37E+06	7.4	8.6		62.4	2.4	16.2	14.9			
24	crop	grass	cropland loss	grassland gain	2.31E+08	230.8				75.4		53.4			
25	crop	crop	stable cropland	stable cropland	1.84E+08	184.2		37.6							
26	crop	urban	cropland loss	urban gain	1.51E+06	1.5				0.5		23.4			
27	crop	wetland	cropland loss	wetland gain	7.75E+06	7.7				2.5		41.7			
28	crop	water	cropland loss	water gain	2.03E+06	2.0				0.7		28.5			
29	urban	forest	urban loss	forest gain	2.32E+05	0.2	3.8		3.1	7.5	6.4	0.1	7.1	3.3	89.0
30	urban	barren	urban loss	barren gain	1.14E+05	0.1	0.1		82.5	3.7	171.5	0.2			
31	urban	grass	urban loss	grass gain	1.69E+06	1.7				54.5		0.4			
32	urban	crop	urban loss	crop gain	4.18E+05	0.4				13.5		0.5			
33	urban	urban	stable urban	stable urban	6.57E+05	0.7		17.5							
34	urban	wetland	urban loss	wetland gain	6.12E+05	0.6				19.7		3.3			
35	urban	water	urban loss	water gain	3.47E+04	0.0				1.1		0.5			
36	wetland	forest	wetland loss	forest gain	3.18E+06	3.2	15.9		12.4	25.6	18.6	0.8	22.1	6.2	38.6
37	wetland	barren	wetland loss	barren gain	2.05E+05	0.2	0.3		78.0	1.7	116.6	0.4			
38	wetland	grass	wetland loss	grassland gain	2.65E+06	2.7				21.3		0.6			
39	wetland	crop	wetland loss	cropland gain	5.03E+06	5.0				40.4		6.3			
40	wetland	urban	wetland loss	urban gain	1.16E+05	0.1				0.9		1.8			
41	wetland	wetland	stable wetland	stable wetland	3.51E+06	3.5		22.0							
42	wetland	water	wetland loss	water gain	1.25E+06	1.3				10.1		17.6			
43	water	forest	water loss	forest gain	2.22E+06	2.2	16.6		4.2	53.3	7.1	0.5	19.6	2.9	17.7
44	water	barren	water loss	barren gain	1.09E+06	1.1	0.3		25.1	26.1	42.9	2.2			
45	water	grass	water loss	grassland gain	2.31E+05	0.2				5.5		0.1			
46	water	crop	water loss	cropland gain	1.25E+05	0.1				3.0		0.2			
47	water	urban	water loss	urban gain	3.33E+03	0.0				0.1		0.1			
48	water	wetland	water loss	wetland gain	5.02E+05	0.5				12.0		2.7			
49	water	water	stable water	stable water	1.24E+07	12.4		74.9							
	Total					5,669.2									

Appendix 2.2.4.18.3. 50-year changes (1965-2015) in land cover and change percentages within Mtskheta-Mtianeti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.39E+09	2,386.2	2,645.5	90.2	259.3		581.0		2,967.2	321.7	12.2
2	forest	barren	forest loss	barren gain	6.12E+06	6.1	46.7		9.8	2.4	22.0	3.8			
3	forest	grass	forest loss	grassland gain	2.32E+08	232.2				89.5		41.7			
4	forest	crop	forest loss	cropland gain	1.55E+07	15.5				6.0		24.2			
5	forest	urban	forest loss	urban gain	1.53E+05	0.2				0.1		2.6			
6	forest	wetland	forest loss	wetland gain	3.35E+06	3.4				1.3		15.2			
7	forest	water	forest loss	water gain	1.99E+06	2.0				0.8		13.6			
8	barren	forest	barren loss	forest gain	3.97E+05	0.4	16.3		4.3	9.2	159.6	0.1	171.5	155.3	955.4
9	barren	barren	stable barren	stable barren	1.19E+07	11.9	0.3	73.3	26.7		982.1				
10	barren	grass	barren loss	grassland gain	3.64E+06	3.6				83.8		0.7			
11	barren	crop	barren loss	cropland gain	9.94E+04	0.1				2.3		0.2			
12	barren	urban	barren loss	urban gain	6.02E+04	0.1				1.4		1.0			
13	barren	wetland	barren loss	wetland gain	1.40E+05	0.1				3.2		0.6			
14	barren	water	barren loss	water gain	4.01E+03	0.0				0.1		0.0			
15	grass	forest	grassland loss	forest gain	5.18E+08	517.5	2,377.4		716.4	72.2	557.1	89.1	2,218.1	-159.3	-6.7
16	grass	barren	grassland loss	barren gain	1.50E+08	149.8	41.9		30.1	20.9	23.4	93.9			
17	grass	grass	stable grassland	stable grass	1.66E+09	1,661.0		69.9							
18	grass	crop	grassland loss	cropland gain	4.31E+07	43.1				6.0		67.3			
19	grass	urban	grassland loss	urban gain	1.08E+06	1.1				0.2		18.2			
20	grass	wetland	grassland loss	wetland gain	3.19E+06	3.2				0.4		14.5			
21	grass	water	grassland loss	water gain	1.65E+06	1.6				0.2		11.2			
22	crop	forest	cropland loss	forest gain	6.08E+07	60.8	600.5		400.9	15.2	64.1	10.5	263.7	-336.9	-56.1
23	crop	barren	cropland loss	barren gain	3.04E+06	3.0	10.6		66.8	0.8	10.7	1.9			
24	crop	grass	cropland loss	grassland gain	3.07E+08	307.4				76.7		55.2			
25	crop	crop	stable cropland	stable cropland	2.00E+08	199.6		33.2							
26	crop	urban	cropland loss	urban gain	4.33E+06	4.3				1.1		73.1			
27	crop	wetland	cropland loss	wetland gain	1.44E+07	14.4				3.6		65.0			
28	crop	water	cropland loss	water gain	1.10E+07	11.0				2.7		75.0			
29	urban	forest	urban loss	forest gain	1.44E+06	1.4	17.7		16.5	8.7	5.9	0.2	7.1	-10.6	-59.8
30	urban	barren	urban loss	barren gain	3.50E+05	0.4	0.3		93.3	2.1	33.5	0.2			
31	urban	grass	urban loss	grass gain	9.67E+06	9.7				58.7		1.7			
32	urban	crop	urban loss	crop gain	4.54E+06	4.5				27.6		7.1			
33	urban	urban	stable urban	stable urban	1.19E+06	1.2		6.7							
34	urban	wetland	urban loss	wetland gain	4.47E+05	0.4				2.7		2.0			
35	urban	water	urban loss	water gain	3.21E+04	0.0				0.2		0.2			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	22.1	0.0	22.1	22.1	72,347.5
37	wetland	barren	wetland loss	barren gain	2.78E+04	0.0	0.0		100.0	91.3	72,447.5	0.0			
38	wetland	grass	wetland loss	grassland gain	2.65E+03	0.0				8.7		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				0.0		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	7.65E+05	0.8	11.8		6.9	11.1	14.6	0.1	19.6	7.7	65.7
44	water	barren	water loss	barren gain	2.64E+05	0.3	0.2		58.4	3.8	124.1	0.2			
45	water	grass	water loss	grassland gain	4.13E+06	4.1				59.9		0.7			
46	water	crop	water loss	cropland gain	8.40E+05	0.8				12.2		1.3			
47	water	urban	water loss	urban gain	2.99E+05	0.3				4.3		5.0			
48	water	wetland	water loss	wetland gain	6.01E+05	0.6				8.7		2.7			
49	water	water	stable water	stable water	4.91E+06	4.9		41.6							
	Total					5,669.2									

Appendix 2.2.4.19.1. Soviet era changes (1965-'87) in land cover and change percentages within Kvemo Kartli, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.34E+09	1,337.1	1,873.2	71.4	536.1		239.3		1,576.4	-296.8	-15.8
2	forest	barren	forest loss	barren gain	5.68E+06	5.7	29.6		28.6	1.1	12.8	7.4			
3	forest	grass	forest loss	grassland gain	3.73E+08	373.1				69.6		36.5			
4	forest	crop	forest loss	cropland gain	1.49E+08	148.9				27.8		23.4			
5	forest	urban	forest loss	urban gain	4.31E+04	0.0				0.0		0.8			
6	forest	wetland	forest loss	wetland gain	8.22E+06	8.2				1.5		11.5			
7	forest	water	forest loss	water gain	2.31E+05	0.2				0.0		3.2			
8	barren	forest	barren loss	forest gain	8.72E+03	0.0	2.6		2.2	0.4	76.3	0.0	76.6	74.1	2,897.1
9	barren	barren	stable barren	stable barren	3.13E+05	0.3	0.0	12.2	87.8		2,984.8				
10	barren	grass	barren loss	grassland gain	2.11E+06	2.1				94.2		0.2			
11	barren	crop	barren loss	cropland gain	1.21E+05	0.1				5.4		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	5.76E+02	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	9.35E+07	93.5	2,149.7		588.4	15.9	1,023.5	39.1	2,584.8	435.1	20.2
16	grass	barren	grassland loss	barren gain	6.48E+07	64.8	34.0		27.4	11.0	47.6	84.9			
17	grass	grass	stable grassland	stable grass	1.56E+09	1,561.3		72.6							
18	grass	crop	grassland loss	cropland gain	4.20E+08	419.8				71.3		65.9			
19	grass	urban	grassland loss	urban gain	5.91E+05	0.6				0.1		11.3			
20	grass	wetland	grassland loss	wetland gain	9.20E+06	9.2				1.6		12.9			
21	grass	water	grassland loss	water gain	5.41E+05	0.5				0.1		7.4			
22	crop	forest	cropland loss	forest gain	1.39E+08	139.0	2,133.3		791.7	17.6	637.0	58.1	1,978.6	-154.7	-7.3
23	crop	barren	cropland loss	barren gain	3.87E+06	3.9	33.7		37.1	0.5	29.9	5.1			
24	crop	grass	cropland loss	grassland gain	5.93E+08	593.2				74.9		58.0			
25	crop	crop	stable cropland	stable cropland	1.34E+09	1,341.6		62.9							
26	crop	urban	cropland loss	urban gain	3.96E+06	4.0				0.5		75.4			
27	crop	wetland	cropland loss	wetland gain	4.51E+07	45.1				5.7		63.4			
28	crop	water	cropland loss	water gain	6.44E+06	6.4				0.8		88.6			
29	urban	forest	urban loss	forest gain	5.85E+06	5.8	110.0		108.0	5.4	5.2	2.4	7.3	-102.7	-93.4
30	urban	barren	urban loss	barren gain	1.53E+06	1.5	1.7		98.1	1.4	4.8	2.0			
31	urban	grass	urban loss	grass gain	4.01E+07	40.1				37.2		3.9			
32	urban	crop	urban loss	crop gain	5.75E+07	57.5				53.3		9.0			
33	urban	urban	stable urban	stable urban	2.05E+06	2.1		1.9							
34	urban	wetland	urban loss	wetland gain	2.89E+06	2.9				2.7		4.1			
35	urban	water	urban loss	water gain	5.74E+04	0.1				0.1		0.8			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	71.2	0.0	71.2	71.2	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	9.43E+05	0.9	56.4		33.4	2.8	7.3	0.4	30.3	-26.1	-46.3
44	water	barren	water loss	barren gain	4.71E+05	0.5	0.9		59.2	1.4	12.9	0.6			
45	water	grass	water loss	grassland gain	1.50E+07	15.0				44.8		1.5			
46	water	crop	water loss	cropland gain	1.06E+07	10.6				31.8		1.7			
47	water	urban	water loss	urban gain	6.57E+05	0.7				2.0		12.5			
48	water	wetland	water loss	wetland gain	5.77E+06	5.8				17.3		8.1			
49	water	water	stable water	stable water	2.30E+07	23.0		40.8							
	Total					6,325.2									

Appendix 2.2.4.19.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Kvemo Kartli, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.39E+09	1,388.4	1,576.4	88.1	187.9		13.9		1,402.4	-174.0	-11.0
2	forest	barren	forest loss	barren gain	3.43E+05	0.3	24.9		11.9	0.2	0.9	0.2			
3	forest	grass	forest loss	grassland gain	1.05E+08	104.5				55.6		60.4			
4	forest	crop	forest loss	cropland gain	7.74E+07	77.4				41.2		3.4			
5	forest	urban	forest loss	urban gain	1.20E+05	0.1				0.1		0.0			
6	forest	wetland	forest loss	wetland gain	5.13E+06	5.1				2.7		18.0			
7	forest	water	forest loss	water gain	3.95E+05	0.4				0.2		0.9			
8	barren	forest	barren loss	forest gain	3.94E+05	0.4	76.4		57.8	0.7	200.2	2.8	218.8	142.4	186.4
9	barren	barren	stable barren	stable barren	1.86E+07	18.6	1.2	24.4	75.6		262.1				
10	barren	grass	barren loss	grassland gain	5.52E+07	55.2				95.6		31.9			
11	barren	crop	barren loss	cropland gain	1.25E+06	1.3				2.2		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	7.07E+05	0.7				1.2		2.5			
14	barren	water	barren loss	water gain	1.58E+05	0.2				0.3		0.4			
15	grass	forest	grassland loss	forest gain	1.68E+05	0.2	2,581.3		2,578.2	0.0	173.0	1.2	176.1	-2,405.1	-93.2
16	grass	barren	grassland loss	barren gain	1.34E+08	133.5	40.8		99.9	5.2	6.7	66.7			
17	grass	grass	stable grassland	stable grass	3.11E+06	3.1		0.1							
18	grass	crop	grassland loss	cropland gain	2.15E+09	2,154.5				83.6		94.8			
19	grass	urban	grassland loss	urban gain	2.73E+08	273.0				10.6		20.4			
20	grass	wetland	grassland loss	wetland gain	9.86E+06	9.9				0.4		34.5			
21	grass	water	grassland loss	water gain	7.05E+06	7.1				0.3		15.7			
22	crop	forest	cropland loss	forest gain	3.35E+06	3.4	1,980.7		1,175.8	0.3	2,271.8	24.1	3,076.7	1,096.0	55.3
23	crop	barren	cropland loss	barren gain	6.62E+07	66.2	31.3		59.4	5.6	114.7	33.1			
24	crop	grass	cropland loss	grassland gain	2.56E+05	0.3				0.0		0.1			
25	crop	crop	stable cropland	stable cropland	8.05E+08	804.9		40.6							
26	crop	urban	cropland loss	urban gain	1.07E+09	1,065.6				90.6		79.6			
27	crop	wetland	cropland loss	wetland gain	4.90E+06	4.9				0.4		17.2			
28	crop	water	cropland loss	water gain	3.56E+07	35.6				3.0		79.0			
29	urban	forest	urban loss	forest gain	1.20E+06	1.2	8.5		7.9	15.3	1,338.9	8.7	1,339.6	1,331.1	15,648.5
30	urban	barren	urban loss	barren gain	5.99E+04	0.1	0.1		92.3	0.8	15,740.8	0.0			
31	urban	grass	urban loss	grass gain	1.48E+04	0.0				0.2		0.0			
32	urban	crop	urban loss	crop gain	4.45E+06	4.4				56.6		0.2			
33	urban	urban	stable urban	stable urban	6.55E+05	0.7		7.7							
34	urban	wetland	urban loss	wetland gain	2.02E+06	2.0				25.7		7.1			
35	urban	water	urban loss	water gain	1.10E+05	0.1				1.4		0.2			
36	wetland	forest	wetland loss	forest gain	8.30E+06	8.3	71.2		53.4	15.5	28.6	59.7	46.4	-24.9	-34.9
37	wetland	barren	wetland loss	barren gain	5.40E+04	0.1	1.1		75.0	0.1	40.1	0.0			
38	wetland	grass	wetland loss	grassland gain	1.26E+07	12.6				23.5		7.3			
39	wetland	crop	wetland loss	cropland gain	3.06E+07	30.6				57.2		1.3			
40	wetland	urban	wetland loss	urban gain	1.95E+05	0.2				0.4		0.0			
41	wetland	wetland	stable wetland	stable wetland	1.78E+07	17.8		25.0							
42	wetland	water	wetland loss	water gain	1.75E+06	1.7				3.3		3.9			
43	water	forest	water loss	forest gain	4.92E+05	0.5	30.3		10.5	4.7	45.0	3.5	64.9	34.6	114.1
44	water	barren	water loss	barren gain	1.01E+04	0.0	0.5		34.6	0.1	148.7	0.0			
45	water	grass	water loss	grassland gain	3.95E+05	0.4				3.8		0.2			
46	water	crop	water loss	cropland gain	3.63E+06	3.6				34.7		0.2			
47	water	urban	water loss	urban gain	2.02E+03	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	5.94E+06	5.9				56.7		20.8			
49	water	water	stable water	stable water	1.98E+07	19.8		65.4							
	Total					6,324.7									

Appendix 2.2.4.19.3. 50-year changes (1965-2015) in land cover and change percentages within Kvemo Kartli, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.40E+09	1,402.1	1,873.0	74.9	470.9		195.3		1,597.4	-275.6	-14.7
2	forest	barren	forest loss	barren gain	1.23E+06	1.2	29.6		25.1	0.3	10.4	5.5			
3	forest	grass	forest loss	grassland gain	3.81E+08	380.6				80.8		27.1			
4	forest	crop	forest loss	cropland gain	8.29E+07	82.9				17.6		19.9			
5	forest	urban	forest loss	urban gain	1.12E+05	0.1				0.0		1.2			
6	forest	wetland	forest loss	wetland gain	5.29E+06	5.3				1.1		7.4			
7	forest	water	forest loss	water gain	6.82E+05	0.7				0.1		8.1			
8	barren	forest	barren loss	forest gain	1.45E+04	0.0	2.6		2.4	0.6	22.2	0.0	22.4	19.8	751.6
9	barren	barren	stable barren	stable barren	2.05E+05	0.2	0.0	7.8	92.2		843.8				
10	barren	grass	barren loss	grassland gain	2.33E+06	2.3				96.0		0.2			
11	barren	crop	barren loss	cropland gain	5.76E+04	0.1				2.4		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	1.90E+04	0.0				0.8		0.0			
14	barren	water	barren loss	water gain	6.04E+03	0.0				0.2		0.1			
15	grass	forest	grassland loss	forest gain	1.09E+08	109.3	2,149.9		415.9	26.3	1,402.6	56.0	3,136.6	986.7	45.9
16	grass	barren	grassland loss	barren gain	2.05E+07	20.5	34.0		19.3	4.9	65.2	92.6			
17	grass	grass	stable grassland	stable grass	1.73E+09	1,734.0		80.7							
18	grass	crop	grassland loss	cropland gain	2.77E+08	276.8				66.6		66.3			
19	grass	urban	grassland loss	urban gain	1.49E+06	1.5				0.4		15.9			
20	grass	wetland	grassland loss	wetland gain	6.94E+06	6.9				1.7		9.7			
21	grass	water	grassland loss	water gain	7.42E+05	0.7				0.2		8.8			
22	crop	forest	cropland loss	forest gain	7.74E+07	77.4	2,132.3		1,097.9	7.1	417.6	39.7	1,452.1	-680.3	-31.9
23	crop	barren	cropland loss	barren gain	3.27E+05	0.3	33.7		51.5	0.0	19.6	1.5			
24	crop	grass	cropland loss	grassland gain	9.59E+08	958.9				87.3		68.4			
25	crop	crop	stable cropland	stable cropland	1.03E+09	1,034.4		48.5							
26	crop	urban	cropland loss	urban gain	6.97E+06	7.0				0.6		74.5			
27	crop	wetland	cropland loss	wetland gain	4.77E+07	47.7				4.3		66.4			
28	crop	water	cropland loss	water gain	6.65E+06	6.7				0.6		79.0			
29	urban	forest	urban loss	forest gain	6.57E+06	6.6	110.5		102.0	6.4	9.4	3.4	17.8	-92.7	-83.9
30	urban	barren	urban loss	barren gain	7.54E+04	0.1	1.7		92.4	0.1	8.5	0.3			
31	urban	grass	urban loss	grass gain	4.57E+07	45.7				44.7		3.3			
32	urban	crop	urban loss	crop gain	4.58E+07	45.8				44.9		11.0			
33	urban	urban	stable urban	stable urban	8.45E+06	8.4		7.6							
34	urban	wetland	urban loss	wetland gain	3.61E+06	3.6				3.5		5.0			
35	urban	water	urban loss	water gain	3.36E+05	0.3				0.3		4.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	71.8	0.0	71.8	71.8	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	1.90E+06	1.9	56.4		38.1	5.0	8.4	1.0	26.7	-29.7	-52.7
44	water	barren	water loss	barren gain	1.89E+04	0.0	0.9		67.6	0.0	14.9	0.1			
45	water	grass	water loss	grassland gain	1.51E+07	15.1				39.6		1.1			
46	water	crop	water loss	cropland gain	1.21E+07	12.1				31.6		2.9			
47	water	urban	water loss	urban gain	7.86E+05	0.8				2.1		8.4			
48	water	wetland	water loss	wetland gain	8.26E+06	8.3				21.7		11.5			
49	water	water	stable water	stable water	1.83E+07	18.3		32.4							
	Total					6,324.7									

Appendix 2.2.4.20.1. Soviet era changes (1965-'87) in land cover and change percentages within Tbilisi, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.86E+07	18.6	33.2	56.2	14.5		14.5		33.1	-0.1	-0.2
2	forest	barren	forest loss	barren gain	3.16E+05	0.3	14.8		43.8	2.2	43.6	2.7			
3	forest	grass	forest loss	grassland gain	6.22E+06	6.2				42.8		9.9			
4	forest	crop	forest loss	cropland gain	5.42E+06	5.4				37.3		24.9			
5	forest	urban	forest loss	urban gain	2.59E+05	0.3				1.8		4.3			
6	forest	wetland	forest loss	wetland gain	2.32E+06	2.3				15.9		23.2			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	11.8	0.0	11.8	11.8	219,300.4
9	barren	barren	stable barren	stable barren	2.68E+03	0.0	0.0	50.0	50.0		219,350.4				
10	barren	grass	barren loss	grassland gain	2.68E+03	0.0				100.0		0.0			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				0.0		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	5.60E+06	5.6	58.4		22.4	25.0	62.7	38.7	98.7	40.4	69.1
16	grass	barren	grassland loss	barren gain	2.62E+06	2.6	26.0		38.3	11.7	107.5	22.2			
17	grass	grass	stable grassland	stable grass	3.60E+07	36.0		61.7							
18	grass	crop	grassland loss	cropland gain	1.04E+07	10.4				46.5		47.9			
19	grass	urban	grassland loss	urban gain	2.54E+06	2.5				11.4		42.2			
20	grass	wetland	grassland loss	wetland gain	1.15E+06	1.2				5.1		11.5			
21	grass	water	grassland loss	water gain	6.10E+04	0.1				0.3		7.9			
22	crop	forest	cropland loss	forest gain	3.06E+06	3.1	66.1		47.6	6.4	21.8	21.1	40.2	-25.9	-39.2
23	crop	barren	cropland loss	barren gain	2.20E+06	2.2	29.4		72.1	4.6	32.9	18.7			
24	crop	grass	cropland loss	grassland gain	3.61E+07	36.1				75.7		57.5			
25	crop	crop	stable cropland	stable cropland	1.85E+07	18.5		27.9							
26	crop	urban	cropland loss	urban gain	2.29E+06	2.3				4.8		38.1			
27	crop	wetland	cropland loss	wetland gain	3.42E+06	3.4				7.2		34.2			
28	crop	water	cropland loss	water gain	6.02E+05	0.6				1.3		78.1			
29	urban	forest	urban loss	forest gain	5.23E+06	5.2	51.5		35.2	14.9	6.0	36.2	22.3	-29.1	-56.6
30	urban	barren	urban loss	barren gain	6.05E+06	6.0	22.9		68.3	17.2	11.7	51.4			
31	urban	grass	urban loss	grass gain	1.70E+07	17.0				48.4		27.1			
32	urban	crop	urban loss	crop gain	4.48E+06	4.5				12.7		20.6			
33	urban	urban	stable urban	stable urban	1.63E+07	16.3		31.7							
34	urban	wetland	urban loss	wetland gain	2.28E+06	2.3				6.5		22.8			
35	urban	water	urban loss	water gain	1.08E+05	0.1				0.3		14.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	10.0	0.0	10.0	10.0	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	5.78E+05	0.6	15.7		7.8	7.4	0.8	4.0	8.7	-7.0	-44.6
44	water	barren	water loss	barren gain	5.95E+05	0.6	7.0		49.5	7.6	4.9	5.1			
45	water	grass	water loss	grassland gain	3.43E+06	3.4				44.0		5.5			
46	water	crop	water loss	cropland gain	1.44E+06	1.4				18.4		6.6			
47	water	urban	water loss	urban gain	9.28E+05	0.9				11.9		15.4			
48	water	wetland	water loss	wetland gain	8.26E+05	0.8				10.6		8.3			
49	water	water	stable water	stable water	7.95E+06	7.9		50.5							
	Total					224.9									

Appendix 2.2.4.20.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Tbilisi, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.36E+07	23.6	33.1	71.4	9.5		16.0		39.6	6.6	19.8
2	forest	barren	forest loss	barren gain	3.03E+05	0.3	14.7		28.6	3.2	48.4	7.3			
3	forest	grass	forest loss	grassland gain	3.54E+06	3.5				37.4		9.0			
4	forest	crop	forest loss	cropland gain	3.25E+06	3.2				34.3		20.6			
5	forest	urban	forest loss	urban gain	1.21E+06	1.2				12.8		7.3			
6	forest	wetland	forest loss	wetland gain	1.12E+06	1.1				11.8		17.4			
7	forest	water	forest loss	water gain	4.70E+04	0.0				0.5		2.4			
8	barren	forest	barren loss	forest gain	3.31E+05	0.3	11.8		10.5	3.2	4.1	2.1	5.4	-6.4	-54.2
9	barren	barren	stable barren	stable barren	1.27E+06	1.3	5.2	10.8	89.2		35.0				
10	barren	grass	barren loss	grassland gain	6.13E+06	6.1				58.3		15.5			
11	barren	crop	barren loss	cropland gain	2.66E+05	0.3				2.5		1.7			
12	barren	urban	barren loss	urban gain	2.70E+06	2.7				25.7		16.1			
13	barren	wetland	barren loss	wetland gain	4.44E+05	0.4				4.2		6.9			
14	barren	water	barren loss	water gain	6.42E+05	0.6				6.1		32.3			
15	grass	forest	grassland loss	forest gain	5.97E+06	6.0	98.7		30.7	19.4	39.5	37.2	107.6	8.8	8.9
16	grass	barren	grassland loss	barren gain	1.88E+06	1.9	43.9		31.1	6.1	40.0	45.6			
17	grass	grass	stable grassland	stable grass	6.80E+07	68.0		68.9							
18	grass	crop	grassland loss	cropland gain	1.01E+07	10.1				32.9		64.1			
19	grass	urban	grassland loss	urban gain	1.02E+07	10.2				33.3		61.1			
20	grass	wetland	grassland loss	wetland gain	2.00E+06	2.0				6.5		31.1			
21	grass	water	grassland loss	water gain	5.42E+05	0.5				1.8		27.2			
22	crop	forest	cropland loss	forest gain	4.93E+06	4.9	40.2		29.4	16.7	15.8	30.7	26.5	-13.7	-34.0
23	crop	barren	cropland loss	barren gain	3.93E+05	0.4	17.9		73.2	1.3	39.2	9.5			
24	crop	grass	cropland loss	grassland gain	2.03E+07	20.3				68.9		51.3			
25	crop	crop	stable cropland	stable cropland	1.08E+07	10.8		26.8							
26	crop	urban	cropland loss	urban gain	2.03E+06	2.0				6.9		12.1			
27	crop	wetland	cropland loss	wetland gain	1.53E+06	1.5				5.2		23.8			
28	crop	water	cropland loss	water gain	2.90E+05	0.3				1.0		14.6			
29	urban	forest	urban loss	forest gain	1.05E+06	1.0	22.3		12.2	8.6	16.7	6.5	26.9	4.6	20.4
30	urban	barren	urban loss	barren gain	1.46E+06	1.5	9.9		54.5	12.0	74.9	35.4			
31	urban	grass	urban loss	grass gain	8.03E+06	8.0				65.9		20.3			
32	urban	crop	urban loss	crop gain	6.08E+05	0.6				5.0		3.9			
33	urban	urban	stable urban	stable urban	1.02E+07	10.2		45.5							
34	urban	wetland	urban loss	wetland gain	1.02E+06	1.0				8.4		15.9			
35	urban	water	urban loss	water gain	6.04E+03	0.0				0.0		0.3			
36	wetland	forest	wetland loss	forest gain	3.75E+06	3.7	10.0		7.9	47.5	6.4	23.4	8.5	-1.5	-14.7
37	wetland	barren	wetland loss	barren gain	8.46E+04	0.1	4.4		79.0	1.1	64.3	2.0			
38	wetland	grass	wetland loss	grassland gain	1.49E+06	1.5				18.9		3.8			
39	wetland	crop	wetland loss	cropland gain	1.53E+06	1.5				19.4		9.7			
40	wetland	urban	wetland loss	urban gain	5.69E+05	0.6				7.2		3.4			
41	wetland	wetland	stable wetland	stable wetland	2.10E+06	2.1		21.0							
42	wetland	water	wetland loss	water gain	4.62E+05	0.5				5.9		23.2			
43	water	forest	water loss	forest gain	4.03E+03	0.0	8.7		0.4	1.1	2.0	0.0	10.3	1.6	18.4
44	water	barren	water loss	barren gain	1.34E+03	0.0	3.9		4.4	0.4	22.8	0.0			
45	water	grass	water loss	grassland gain	6.35E+04	0.1				16.6		0.2			
46	water	crop	water loss	cropland gain	3.49E+03	0.0				0.9		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	3.11E+05	0.3				81.1		4.8			
49	water	water	stable water	stable water	8.34E+06	8.3		95.6							
	Total					224.9									

Appendix 2.2.4.20.3. 50-year changes (1965-2015) in land cover and change percentages within Tbilisi, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.13E+07	21.3	33.1	64.5	11.8		18.3		39.6	6.6	19.9
2	forest	barren	forest loss	barren gain	1.26E+05	0.1	14.7		35.5	1.1	55.4	2.3			
3	forest	grass	forest loss	grassland gain	4.88E+06	4.9				41.5		6.7			
4	forest	crop	forest loss	cropland gain	5.53E+06	5.5				47.1		32.5			
5	forest	urban	forest loss	urban gain	6.16E+05	0.6				5.2		6.2			
6	forest	wetland	forest loss	wetland gain	5.92E+05	0.6				5.0		7.0			
7	forest	water	forest loss	water gain	4.70E+03	0.0				0.0		0.3			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	5.4	0.0	5.4	5.4	100,361.6
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	0.0	100.0		100,461.6				
10	barren	grass	barren loss	grassland gain	3.36E+03	0.0				62.5		0.0			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				0.0		0.0			
12	barren	urban	barren loss	urban gain	2.01E+03	0.0				37.5		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	9.07E+06	9.1	58.4		23.3	38.9	72.5	49.5	107.6	49.2	84.2
16	grass	barren	grassland loss	barren gain	9.08E+05	0.9	26.0		40.0	3.9	124.2	16.8			
17	grass	grass	stable grassland	stable grass	3.50E+07	35.0		60.0							
18	grass	crop	grassland loss	cropland gain	7.89E+06	7.9				33.8		46.4			
19	grass	urban	grassland loss	urban gain	3.40E+06	3.4				14.6		34.3			
20	grass	wetland	grassland loss	wetland gain	1.73E+06	1.7				7.4		20.3			
21	grass	water	grassland loss	water gain	3.47E+05	0.3				1.5		23.7			
22	crop	forest	cropland loss	forest gain	4.65E+06	4.6	66.2		56.6	8.2	17.0	25.4	26.5	-39.6	-59.9
23	crop	barren	cropland loss	barren gain	1.08E+06	1.1	29.4		85.6	1.9	25.7	20.0			
24	crop	grass	cropland loss	grassland gain	4.26E+07	42.6				75.1		58.7			
25	crop	crop	stable cropland	stable cropland	9.52E+06	9.5		14.4							
26	crop	urban	cropland loss	urban gain	4.49E+06	4.5				7.9		45.4			
27	crop	wetland	cropland loss	wetland gain	3.07E+06	3.1				5.4		36.0			
28	crop	water	cropland loss	water gain	7.96E+05	0.8				1.4		54.3			
29	urban	forest	urban loss	forest gain	4.05E+06	4.1	51.5		34.5	11.7	9.9	22.1	26.9	-24.7	-47.8
30	urban	barren	urban loss	barren gain	3.03E+06	3.0	22.9		67.0	8.8	19.2	56.2			
31	urban	grass	urban loss	grass gain	2.15E+07	21.5				62.4		29.7			
32	urban	crop	urban loss	crop gain	3.11E+06	3.1				9.0		18.3			
33	urban	urban	stable urban	stable urban	1.70E+07	17.0		33.0							
34	urban	wetland	urban loss	wetland gain	2.49E+06	2.5				7.2		29.2			
35	urban	water	urban loss	water gain	3.18E+05	0.3				0.9		21.7			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	8.5	0.0	8.5	8.5	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	5.61E+05	0.6	15.7		6.9	8.2	1.5	3.1	10.3	-5.4	-34.3
44	water	barren	water loss	barren gain	2.51E+05	0.3	7.0		43.6	3.7	9.3	4.6			
45	water	grass	water loss	grassland gain	3.53E+06	3.5				51.5		4.9			
46	water	crop	water loss	cropland gain	4.86E+05	0.5				7.1		2.9			
47	water	urban	water loss	urban gain	1.39E+06	1.4				20.2		14.0			
48	water	wetland	water loss	wetland gain	6.43E+05	0.6				9.4		7.5			
49	water	water	stable water	stable water	8.86E+06	8.9		56.4							
	Total					224.9									

Appendix 2.2.4.21.1. Soviet era changes (1965-'87) in land cover and change percentages within Kakheti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.74E+09	2,735.6	3,301.3	82.9	565.6		436.8		3,172.5	-128.8	-3.9
2	forest	barren	forest loss	barren gain	1.20E+07	12.0	31.7		17.1	2.1	13.2	14.7			
3	forest	grass	forest loss	grassland gain	4.09E+08	408.5				72.2		35.5			
4	forest	crop	forest loss	cropland gain	1.30E+08	130.0				23.0		17.7			
5	forest	urban	forest loss	urban gain	7.87E+05	0.8				0.1		18.5			
6	forest	wetland	forest loss	wetland gain	1.40E+07	14.0				2.5		16.3			
7	forest	water	forest loss	water gain	3.81E+05	0.4				0.1		7.6			
8	barren	forest	barren loss	forest gain	1.60E+07	16.0	216.4		125.2	12.8	81.6	3.7	172.8	-43.6	-20.1
9	barren	barren	stable barren	stable barren	9.12E+07	91.2	2.1	42.1	57.9		37.7				
10	barren	grass	barren loss	grassland gain	9.93E+07	99.3				79.3		8.6			
11	barren	crop	barren loss	cropland gain	8.47E+06	8.5				6.8		1.2			
12	barren	urban	barren loss	urban gain	1.69E+04	0.0				0.0		0.4			
13	barren	wetland	barren loss	wetland gain	2.25E+05	0.2				0.2		0.3			
14	barren	water	barren loss	water gain	1.20E+06	1.2				1.0		23.8			
15	grass	forest	grassland loss	forest gain	2.04E+08	204.4	3,388.7		800.6	25.5	1,150.8	46.8	3,738.9	350.2	10.3
16	grass	barren	grassland loss	barren gain	5.66E+07	56.6	32.6		23.6	7.1	34.0	69.4			
17	grass	grass	stable grassland	stable grass	2.59E+09	2,588.1		76.4							
18	grass	crop	grassland loss	cropland gain	5.32E+08	532.4				66.5		72.7			
19	grass	urban	grassland loss	urban gain	1.19E+06	1.2				0.1		27.8			
20	grass	wetland	grassland loss	wetland gain	5.41E+06	5.4				0.7		6.3			
21	grass	water	grassland loss	water gain	5.71E+05	0.6				0.1		11.4			
22	crop	forest	cropland loss	forest gain	2.08E+08	207.9	3,285.7		799.1	26.0	732.3	47.6	3,218.9	-66.8	-2.0
23	crop	barren	cropland loss	barren gain	1.10E+07	11.0	31.6		24.3	1.4	22.3	13.4			
24	crop	grass	cropland loss	grassland gain	5.13E+08	513.0				64.2		44.6			
25	crop	crop	stable cropland	stable cropland	2.49E+09	2,486.6		75.7							
26	crop	urban	cropland loss	urban gain	2.16E+06	2.2				0.3		50.8			
27	crop	wetland	cropland loss	wetland gain	6.22E+07	62.2				7.8		72.7			
28	crop	water	cropland loss	water gain	2.87E+06	2.9				0.4		57.2			
29	urban	forest	urban loss	forest gain	6.80E+06	6.8	168.4		167.3	4.1	4.3	1.6	5.4	-163.0	-96.8
30	urban	barren	urban loss	barren gain	1.43E+06	1.4	1.6		99.3	0.9	2.5	1.8			
31	urban	grass	urban loss	grass gain	1.07E+08	107.3				64.1		9.3			
32	urban	crop	urban loss	crop gain	4.93E+07	49.3				29.5		6.7			
33	urban	urban	stable urban	stable urban	1.12E+06	1.1		0.7							
34	urban	wetland	urban loss	wetland gain	2.45E+06	2.4				1.5		2.9			
35	urban	water	urban loss	water gain	6.69E+03	0.0				0.0		0.1			
36	wetland	forest	wetland loss	forest gain	6.64E+02	0.0	3.2		3.2	0.0	85.6	0.0	85.6	82.3	2,554.5
37	wetland	barren	wetland loss	barren gain	4.00E+03	0.0	0.0		100.0	0.1	2,654.5	0.0			
38	wetland	grass	wetland loss	grassland gain	1.81E+06	1.8				56.0		0.2			
39	wetland	crop	wetland loss	cropland gain	1.41E+06	1.4				43.8		0.2			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.78E+06	1.8	36.0		35.4	5.0	5.0	0.4	5.5	-30.4	-84.6
44	water	barren	water loss	barren gain	5.97E+05	0.6	0.3		98.6	1.7	14.0	0.7			
45	water	grass	water loss	grassland gain	2.09E+07	20.9				59.1		1.8			
46	water	crop	water loss	cropland gain	1.07E+07	10.7				30.2		1.5			
47	water	urban	water loss	urban gain	1.07E+05	0.1				0.3		2.5			
48	water	wetland	water loss	wetland gain	1.32E+06	1.3				3.7		1.5			
49	water	water	stable water	stable water	5.16E+05	0.5		1.4							
	Total					10,399.5									

Appendix 2.2.4.21.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Kakheti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.04E+09	3,036.5	3,172.2	95.7	135.8		323.6		3,360.1	187.9	5.9
2	forest	barren	forest loss	barren gain	6.43E+06	6.4	30.5		4.3	4.7	10.2	10.7			
3	forest	grass	forest loss	grassland gain	7.69E+07	76.9				56.7		7.7			
4	forest	crop	forest loss	cropland gain	4.15E+07	41.5				30.6		10.0			
5	forest	urban	forest loss	urban gain	3.22E+05	0.3				0.2		2.1			
6	forest	wetland	forest loss	wetland gain	8.72E+06	8.7				6.4		12.8			
7	forest	water	forest loss	water gain	1.86E+06	1.9				1.4		5.8			
8	barren	forest	barren loss	forest gain	3.48E+06	3.5	170.2		58.0	6.0	60.1	1.1	172.3	2.0	1.2
9	barren	barren	stable barren	stable barren	1.12E+08	112.2	1.6	65.9	34.1		35.3				
10	barren	grass	barren loss	grassland gain	4.59E+07	45.9				79.1		4.6			
11	barren	crop	barren loss	cropland gain	1.62E+06	1.6				2.8		0.4			
12	barren	urban	barren loss	urban gain	4.06E+05	0.4				0.7		2.7			
13	barren	wetland	barren loss	wetland gain	1.36E+06	1.4				2.3		2.0			
14	barren	water	barren loss	water gain	5.27E+06	5.3				9.1		16.3			
15	grass	forest	grassland loss	forest gain	1.81E+08	180.9	3,735.3		601.4	30.1	1,002.0	55.9	4,135.8	400.5	10.7
16	grass	barren	grassland loss	barren gain	4.41E+07	44.1	35.9		16.1	7.3	26.8	73.4			
17	grass	grass	stable grassland	stable grass	3.13E+09	3,133.8		83.9							
18	grass	crop	grassland loss	cropland gain	3.43E+08	342.7				57.0		82.2			
19	grass	urban	grassland loss	urban gain	1.02E+07	10.2				1.7		68.3			
20	grass	wetland	grassland loss	wetland gain	1.31E+07	13.1				2.2		19.2			
21	grass	water	grassland loss	water gain	1.05E+07	10.5				1.7		32.4			
22	crop	forest	cropland loss	forest gain	1.10E+08	109.6	3,218.6		1,044.6	10.5	416.8	33.9	2,590.8	-627.8	-19.5
23	crop	barren	cropland loss	barren gain	8.31E+06	8.3	31.0		32.5	0.8	12.9	13.8			
24	crop	grass	cropland loss	grassland gain	8.69E+08	869.0				83.2		86.7			
25	crop	crop	stable cropland	stable cropland	2.17E+09	2,174.0		67.5							
26	crop	urban	cropland loss	urban gain	3.87E+06	3.9				0.4		25.8			
27	crop	wetland	cropland loss	wetland gain	4.37E+07	43.7				4.2		64.4			
28	crop	water	cropland loss	water gain	1.00E+07	10.0				1.0		31.1			
29	urban	forest	urban loss	forest gain	1.73E+05	0.2	5.4		4.3	4.0	15.0	0.1	16.0	10.7	198.3
30	urban	barren	urban loss	barren gain	6.83E+04	0.1	0.1		80.2	1.6	278.5	0.1			
31	urban	grass	urban loss	grass gain	3.03E+06	3.0				70.3		0.3			
32	urban	crop	urban loss	crop gain	9.37E+05	0.9				21.8		0.2			
33	urban	urban	stable urban	stable urban	1.07E+06	1.1		19.8							
34	urban	wetland	urban loss	wetland gain	8.65E+04	0.1				2.0		0.1			
35	urban	water	urban loss	water gain	1.34E+04	0.0				0.3		0.0			
36	wetland	forest	wetland loss	forest gain	2.90E+07	29.0	85.5		70.3	41.3	67.9	9.0	83.1	-2.4	-2.8
37	wetland	barren	wetland loss	barren gain	2.45E+05	0.2	0.8		82.2	0.3	79.4	0.4			
38	wetland	grass	wetland loss	grassland gain	6.74E+06	6.7				9.6		0.7			
39	wetland	crop	wetland loss	cropland gain	2.95E+07	29.5				42.0		7.1			
40	wetland	urban	wetland loss	urban gain	1.49E+05	0.1				0.2		1.0			
41	wetland	wetland	stable wetland	stable wetland	1.52E+07	15.2		17.8							
42	wetland	water	wetland loss	water gain	4.61E+06	4.6				6.6		14.3			
43	water	forest	water loss	forest gain	4.42E+05	0.4	5.5		3.1	14.0	32.2	0.1	34.6	29.1	528.1
44	water	barren	water loss	barren gain	9.54E+05	1.0	0.1		57.1	30.3	585.2	1.6			
45	water	grass	water loss	grassland gain	3.46E+05	0.3				11.0		0.0			
46	water	crop	water loss	cropland gain	4.75E+05	0.5				15.1		0.1			
47	water	urban	water loss	urban gain	5.36E+03	0.0				0.2		0.0			
48	water	wetland	water loss	wetland gain	9.25E+05	0.9				29.4		1.4			
49	water	water	stable water	stable water	2.36E+06	2.4		42.9							
	Total					10,392.8									

Appendix 2.2.4.21.3. 50-year changes (1965-2015) in land cover and change percentages within Kakheti, Georgia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.81E+09	2,806.1	3,299.9	85.0	493.9		554.1		3,360.1	60.2	1.8
2	forest	barren	forest loss	barren gain	1.26E+07	12.6	31.8		15.0	2.5	16.8	18.6			
3	forest	grass	forest loss	grassland gain	3.92E+08	391.8				79.3		26.6			
4	forest	crop	forest loss	cropland gain	7.41E+07	74.1				15.0		14.5			
5	forest	urban	forest loss	urban gain	2.47E+06	2.5				0.5		21.6			
6	forest	wetland	forest loss	wetland gain	8.88E+06	8.9				1.8		10.7			
7	forest	water	forest loss	water gain	4.03E+06	4.0				0.8		12.3			
8	barren	forest	barren loss	forest gain	1.38E+07	13.8	211.4		106.6	13.0	67.6	2.5	172.3	-39.1	-18.5
9	barren	barren	stable barren	stable barren	1.05E+08	104.7	2.0	49.6	50.4		32.0				
10	barren	grass	barren loss	grassland gain	9.09E+07	90.9				85.3		6.2			
11	barren	crop	barren loss	cropland gain	1.16E+06	1.2				1.1		0.2			
12	barren	urban	barren loss	urban gain	3.86E+05	0.4				0.4		3.4			
13	barren	wetland	barren loss	wetland gain	3.12E+05	0.3				0.3		0.4			
14	barren	water	barren loss	water gain	1.33E+03	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.57E+08	257.5	3,387.4		727.2	35.4	1,475.5	46.5	4,135.8	748.4	22.1
16	grass	barren	grassland loss	barren gain	5.14E+07	51.4	32.6		21.5	7.1	43.6	76.1			
17	grass	grass	stable grassland	stable grass	2.66E+09	2,660.3		78.5							
18	grass	crop	grassland loss	cropland gain	3.99E+08	398.7				54.8		77.8			
19	grass	urban	grassland loss	urban gain	2.45E+06	2.5				0.3		21.5			
20	grass	wetland	grassland loss	wetland gain	1.17E+07	11.7				1.6		14.0			
21	grass	water	grassland loss	water gain	5.44E+06	5.4				0.7		16.6			
22	crop	forest	cropland loss	forest gain	2.65E+08	265.3	3,285.3		1,207.0	22.0	512.4	47.9	2,590.8	-694.6	-21.1
23	crop	barren	cropland loss	barren gain	1.66E+06	1.7	31.6		36.7	0.1	15.6	2.5			
24	crop	grass	cropland loss	grassland gain	8.54E+08	854.3				70.8		57.9			
25	crop	crop	stable cropland	stable cropland	2.08E+09	2,078.4		63.3							
26	crop	urban	cropland loss	urban gain	5.83E+06	5.8				0.5		51.0			
27	crop	wetland	cropland loss	wetland gain	5.69E+07	56.9				4.7		68.4			
28	crop	water	cropland loss	water gain	2.29E+07	22.9				1.9		70.0			
29	urban	forest	urban loss	forest gain	1.44E+07	14.4	169.4		164.8	8.7	11.4	2.6	16.0	-153.4	-90.5
30	urban	barren	urban loss	barren gain	1.72E+06	1.7	1.6		97.3	1.0	6.7	2.5			
31	urban	grass	urban loss	grass gain	1.17E+08	117.2				71.1		7.9			
32	urban	crop	urban loss	crop gain	2.77E+07	27.7				16.8		5.4			
33	urban	urban	stable urban	stable urban	4.60E+06	4.6		2.7							
34	urban	wetland	urban loss	wetland gain	3.45E+06	3.5				2.1		4.2			
35	urban	water	urban loss	water gain	3.48E+05	0.3				0.2		1.1			
36	wetland	forest	wetland loss	forest gain	6.64E+02	0.0	3.2		3.2	0.0	83.1	0.0	83.1	79.9	2,480.2
37	wetland	barren	wetland loss	barren gain	6.66E+03	0.0	0.0		100.0	0.2	2,580.2	0.0			
38	wetland	grass	wetland loss	grassland gain	2.35E+06	2.3				72.8		0.2			
39	wetland	crop	wetland loss	cropland gain	8.69E+05	0.9				27.0		0.2			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	6.72E+02	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	3.02E+06	3.0	36.0		34.2	8.8	32.8	0.5	34.6	-1.4	-4.0
44	water	barren	water loss	barren gain	1.72E+05	0.2	0.3		94.9	0.5	90.9	0.3			
45	water	grass	water loss	grassland gain	1.89E+07	18.9				55.2		1.3			
46	water	crop	water loss	cropland gain	9.89E+06	9.9				28.9		1.9			
47	water	urban	water loss	urban gain	2.91E+05	0.3				0.9		2.6			
48	water	wetland	water loss	wetland gain	1.93E+06	1.9				5.7		2.3			
49	water	water	stable water	stable water	1.85E+06	1.8		5.1							
	Total					10,392.8									

Appendix 2.2.4.22.1. Soviet era changes (1965-'87) in land cover and change percentages within Shirak, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	6.38E+05	0.6	23.9	2.7	23.3		8.1		8.7	-15.2	-63.6
2	forest	barren	forest loss	barren gain	3.46E+04	0.0	1.0		97.3	0.1	33.7	0.2			
3	forest	grass	forest loss	grassland gain	1.48E+07	14.8				63.8		5.2			
4	forest	crop	forest loss	cropland gain	8.30E+06	8.3				35.7		2.0			
5	forest	urban	forest loss	urban gain	4.69E+04	0.0				0.2		1.1			
6	forest	wetland	forest loss	wetland gain	5.29E+04	0.1				0.2		0.4			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	5.6		2.6	0.0	17.9	0.0	21.0	15.4	274.8
9	barren	barren	stable barren	stable barren	3.05E+06	3.0	0.2	54.4	45.6		320.4				
10	barren	grass	barren loss	grassland gain	2.48E+06	2.5				97.4		0.9			
11	barren	crop	barren loss	cropland gain	6.70E+04	0.1				2.6		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	4.79E+06	4.8	1,314.2		434.8	1.1	285.3	59.4	1,164.7	-149.5	-11.4
16	grass	barren	grassland loss	barren gain	1.75E+07	17.5	52.5		33.1	4.0	21.7	97.5			
17	grass	grass	stable grassland	stable grass	8.79E+08	879.4		66.9							
18	grass	crop	grassland loss	cropland gain	4.10E+08	409.8				94.2		96.9			
19	grass	urban	grassland loss	urban gain	7.93E+05	0.8				0.2		18.5			
20	grass	wetland	grassland loss	wetland gain	1.22E+06	1.2				0.3		10.1			
21	grass	water	grassland loss	water gain	7.71E+05	0.8				0.2		9.1			
22	crop	forest	cropland loss	forest gain	3.18E+06	3.2	1,120.6		281.6	1.1	423.0	39.5	1,262.0	141.4	12.6
23	crop	barren	cropland loss	barren gain	3.51E+05	0.4	44.8		25.1	0.1	37.7	2.0			
24	crop	grass	cropland loss	grassland gain	2.57E+08	256.7				91.2		90.0			
25	crop	crop	stable cropland	stable cropland	8.39E+08	839.0		74.9							
26	crop	urban	cropland loss	urban gain	3.43E+06	3.4				1.2		80.0			
27	crop	wetland	cropland loss	wetland gain	1.02E+07	10.2				3.6		83.9			
28	crop	water	cropland loss	water gain	7.69E+06	7.7				2.7		90.5			
29	urban	forest	urban loss	forest gain	8.10E+04	0.1	19.8		13.3	0.6	4.3	1.0	10.8	-9.0	-45.3
30	urban	barren	urban loss	barren gain	2.31E+04	0.0	0.8		66.9	0.2	21.6	0.1			
31	urban	grass	urban loss	grass gain	1.07E+07	10.7				80.5		3.7			
32	urban	crop	urban loss	crop gain	2.40E+06	2.4				18.1		0.6			
33	urban	urban	stable urban	stable urban	6.56E+06	6.6		33.1							
34	urban	wetland	urban loss	wetland gain	4.90E+04	0.0				0.4		0.4			
35	urban	water	urban loss	water gain	3.27E+04	0.0				0.2		0.4			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	12.1	0.0	12.1	12.1	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	6.11E+03	0.0	18.4		3.7	0.2	8.5	0.1	23.1	4.7	25.8
44	water	barren	water loss	barren gain	4.00E+04	0.0	0.7		20.4	1.1	46.2	0.2			
45	water	grass	water loss	grassland gain	5.72E+05	0.6				15.3		0.2			
46	water	crop	water loss	cropland gain	2.47E+06	2.5				66.0		0.6			
47	water	urban	water loss	urban gain	1.84E+04	0.0				0.5		0.4			
48	water	wetland	water loss	wetland gain	6.35E+05	0.6				17.0		5.2			
49	water	water	stable water	stable water	1.46E+07	14.6		79.6							
	Total					2,502.5									

Appendix 2.2.4.22.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Shirak, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.10E+06	3.1	8.5	36.7	5.4		20.1		23.2	14.7	174.1
2	forest	barren	forest loss	barren gain	2.45E+04	0.0	0.3		63.3	0.5	237.4	1.0			
3	forest	grass	forest loss	grassland gain	2.43E+06	2.4				45.5		0.6			
4	forest	crop	forest loss	cropland gain	2.81E+06	2.8				52.6		2.3			
5	forest	urban	forest loss	urban gain	1.02E+04	0.0				0.2		0.4			
6	forest	wetland	forest loss	wetland gain	6.41E+04	0.1				1.2		0.9			
7	forest	water	forest loss	water gain	4.75E+03	0.0				0.1		0.2			
8	barren	forest	barren loss	forest gain	1.97E+04	0.0	20.8		11.9	0.2	2.6	0.1	11.5	-9.3	-44.8
9	barren	barren	stable barren	stable barren	8.90E+06	8.9	0.8	42.8	57.2		12.4				
10	barren	grass	barren loss	grassland gain	1.17E+07	11.7				98.2		2.8			
11	barren	crop	barren loss	cropland gain	7.14E+04	0.1				0.6		0.1			
12	barren	urban	barren loss	urban gain	1.77E+04	0.0				0.1		0.6			
13	barren	wetland	barren loss	wetland gain	1.98E+04	0.0				0.2		0.3			
14	barren	water	barren loss	water gain	8.20E+04	0.1				0.7		3.1			
15	grass	forest	grassland loss	forest gain	7.96E+06	8.0	1,161.8		128.7	6.2	422.3	39.7	1,455.4	293.6	25.3
16	grass	barren	grassland loss	barren gain	1.57E+06	1.6	46.5		11.1	1.2	36.3	60.9			
17	grass	grass	stable grassland	stable grass	1.03E+09	1,033.2		88.9							
18	grass	crop	grassland loss	cropland gain	1.16E+08	115.7				89.9		94.4			
19	grass	urban	grassland loss	urban gain	2.14E+06	2.1				1.7		77.0			
20	grass	wetland	grassland loss	wetland gain	9.74E+05	1.0				0.8		13.2			
21	grass	water	grassland loss	water gain	3.52E+05	0.4				0.3		13.3			
22	crop	forest	cropland loss	forest gain	1.16E+07	11.6	1,259.4		417.7	2.8	122.5	58.0	964.2	-295.2	-23.4
23	crop	barren	cropland loss	barren gain	5.89E+05	0.6	50.5		33.2	0.1	9.7	22.9			
24	crop	grass	cropland loss	grassland gain	4.00E+08	400.0				95.8		94.7			
25	crop	crop	stable cropland	stable cropland	8.42E+08	841.8		66.8							
26	crop	urban	cropland loss	urban gain	6.06E+05	0.6				0.1		21.8			
27	crop	wetland	cropland loss	wetland gain	4.35E+06	4.4				1.0		58.9			
28	crop	water	cropland loss	water gain	4.92E+05	0.5				0.1		18.6			
29	urban	forest	urban loss	forest gain	1.70E+04	0.0	10.8		7.7	0.2	2.8	0.1	6.0	-4.9	-45.0
30	urban	barren	urban loss	barren gain	2.85E+05	0.3	0.4		70.6	3.7	25.6	11.1			
31	urban	grass	urban loss	grass gain	6.85E+06	6.9				89.5		1.6			
32	urban	crop	urban loss	crop gain	4.91E+05	0.5				6.4		0.4			
33	urban	urban	stable urban	stable urban	3.19E+06	3.2		29.4							
34	urban	wetland	urban loss	wetland gain	1.43E+04	0.0				0.2		0.2			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	3.28E+05	0.3	11.8		6.1	5.4	7.4	1.6	13.1	1.3	11.0
37	wetland	barren	wetland loss	barren gain	3.12E+04	0.0	0.5		51.6	0.5	62.6	1.2			
38	wetland	grass	wetland loss	grassland gain	9.34E+05	0.9				15.4		0.2			
39	wetland	crop	wetland loss	cropland gain	3.07E+06	3.1				50.4		2.5			
40	wetland	urban	wetland loss	urban gain	6.13E+03	0.0				0.1		0.2			
41	wetland	wetland	stable wetland	stable wetland	5.71E+06	5.7		48.4							
42	wetland	water	wetland loss	water gain	1.72E+06	1.7				28.2		64.8			
43	water	forest	water loss	forest gain	9.97E+04	0.1	22.8		2.9	3.4	2.6	0.5	22.6	-0.2	-1.1
44	water	barren	water loss	barren gain	7.54E+04	0.1	0.9		12.7	2.6	11.6	2.9			
45	water	grass	water loss	grassland gain	3.95E+05	0.4				13.7		0.1			
46	water	crop	water loss	cropland gain	3.64E+05	0.4				12.6		0.3			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.96E+06	2.0				67.7		26.5			
49	water	water	stable water	stable water	1.99E+07	19.9		87.3							
	Total					2,495.9									

Appendix 2.2.4.22.3. 50-year changes (1965-2015) in land cover and change percentages within Shirak, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.12E+06	2.1	23.9	8.9	21.8		21.5		23.6	-0.3	-1.2
2	forest	barren	forest loss	barren gain	8.13E+03	0.0	1.0		91.1	0.0	90.0	0.1			
3	forest	grass	forest loss	grassland gain	1.59E+07	15.9				72.8		4.0			
4	forest	crop	forest loss	cropland gain	5.84E+06	5.8				26.8		2.5			
5	forest	urban	forest loss	urban gain	8.70E+02	0.0				0.0		0.0			
6	forest	wetland	forest loss	wetland gain	8.76E+04	0.1				0.4		0.6			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	5.6		3.4	0.0	9.4	0.0	11.6	6.0	107.5
9	barren	barren	stable barren	stable barren	2.18E+06	2.2	0.2	38.9	61.1		168.6				
10	barren	grass	barren loss	grassland gain	3.41E+06	3.4				99.7		0.9			
11	barren	crop	barren loss	cropland gain	1.09E+04	0.0				0.3		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.74E+07	17.4	1,314.2		254.5	6.9	398.8	81.0	1,458.6	144.4	11.0
16	grass	barren	grassland loss	barren gain	7.82E+06	7.8	52.5		19.4	3.1	30.3	82.9			
17	grass	grass	stable grassland	stable grass	1.06E+09	1,059.7		80.6							
18	grass	crop	grassland loss	cropland gain	2.27E+08	227.1				89.2		96.0			
19	grass	urban	grassland loss	urban gain	3.43E+05	0.3				0.1		18.6			
20	grass	wetland	grassland loss	wetland gain	1.02E+06	1.0				0.4		7.6			
21	grass	water	grassland loss	water gain	7.65E+05	0.8				0.3		9.9			
22	crop	forest	cropland loss	forest gain	4.00E+06	4.0	1,120.6		390.5	1.0	236.4	18.6	966.5	-154.1	-13.8
23	crop	barren	cropland loss	barren gain	8.08E+05	0.8	44.8		34.9	0.2	21.1	8.6			
24	crop	grass	cropland loss	grassland gain	3.65E+08	365.3				93.5		91.6			
25	crop	crop	stable cropland	stable cropland	7.30E+08	730.1		65.1							
26	crop	urban	cropland loss	urban gain	1.47E+06	1.5				0.4		79.8			
27	crop	wetland	cropland loss	wetland gain	1.20E+07	12.0				3.1		88.7			
28	crop	water	cropland loss	water gain	6.96E+06	7.0				1.8		89.8			
29	urban	forest	urban loss	forest gain	7.42E+04	0.1	19.8		15.7	0.5	1.8	0.3	6.0	-13.9	-69.9
30	urban	barren	urban loss	barren gain	7.83E+05	0.8	0.8		79.2	5.0	9.3	8.3			
31	urban	grass	urban loss	grass gain	1.30E+07	13.0				83.0		3.3			
32	urban	crop	urban loss	crop gain	1.74E+06	1.7				11.1		0.7			
33	urban	urban	stable urban	stable urban	4.12E+06	4.1		20.8							
34	urban	wetland	urban loss	wetland gain	4.50E+04	0.0				0.3		0.3			
35	urban	water	urban loss	water gain	2.32E+04	0.0				0.1		0.3			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	13.5	0.0	13.5	13.5	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	1.08E+04	0.0	18.4		3.4	0.3	7.8	0.1	22.7	4.4	23.7
44	water	barren	water loss	barren gain	1.90E+04	0.0	0.7		18.5	0.6	42.2	0.2			
45	water	grass	water loss	grassland gain	1.20E+06	1.2				35.4		0.3			
46	water	crop	water loss	cropland gain	1.76E+06	1.8				51.8		0.7			
47	water	urban	water loss	urban gain	2.86E+04	0.0				0.8		1.5			
48	water	wetland	water loss	wetland gain	3.75E+05	0.4				11.1		2.8			
49	water	water	stable water	stable water	1.50E+07	15.0		81.5							
	Total					2,502.5									

Appendix 2.2.4.23.1. Soviet era changes (1965-'87) in land cover and change percentages within Aragatsotn, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.72E+07	17.2	37.1	46.2	20.0		30.3		47.5	10.4	27.9
2	forest	barren	forest loss	barren gain	8.90E+05	0.9	1.4		53.8	4.5	81.7	0.7			
3	forest	grass	forest loss	grassland gain	1.35E+07	13.5				67.8		3.2			
4	forest	crop	forest loss	cropland gain	5.20E+06	5.2				26.1		1.8			
5	forest	urban	forest loss	urban gain	2.74E+05	0.3				1.4		7.5			
6	forest	wetland	forest loss	wetland gain	5.71E+04	0.1				0.3		1.8			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	2.12E+04	0.0	20.1		6.3	0.3	122.0	0.1	135.8	115.7	575.3
9	barren	barren	stable barren	stable barren	1.38E+07	13.8	0.8	68.7	31.3		606.6				
10	barren	grass	barren loss	grassland gain	6.19E+06	6.2				98.4		1.4			
11	barren	crop	barren loss	cropland gain	7.31E+04	0.1				1.2		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	3.41E+03	0.0				0.1		0.1			
14	barren	water	barren loss	water gain	2.74E+03	0.0				0.0		0.2			
15	grass	forest	grassland loss	forest gain	1.95E+07	19.5	1,747.9		418.8	4.6	429.6	64.2	1,758.8	10.8	0.6
16	grass	barren	grassland loss	barren gain	1.19E+08	118.9	65.6		24.0	28.4	24.6	97.5			
17	grass	grass	stable grassland	stable grass	1.33E+09	1,329.1		76.0							
18	grass	crop	grassland loss	cropland gain	2.77E+08	276.7				66.1		95.4			
19	grass	urban	grassland loss	urban gain	1.42E+06	1.4				0.3		39.0			
20	grass	wetland	grassland loss	wetland gain	1.48E+06	1.5				0.4		47.1			
21	grass	water	grassland loss	water gain	7.62E+05	0.8				0.2		69.2			
22	crop	forest	cropland loss	forest gain	7.75E+06	7.7	838.5		416.1	1.9	290.0	25.5	712.4	-126.1	-15.0
23	crop	barren	cropland loss	barren gain	2.10E+06	2.1	31.5		49.6	0.5	34.6	1.7			
24	crop	grass	cropland loss	grassland gain	4.02E+08	402.4				96.7		93.7			
25	crop	crop	stable cropland	stable cropland	4.22E+08	422.4		50.4							
26	crop	urban	cropland loss	urban gain	1.95E+06	2.0				0.5		53.4			
27	crop	wetland	cropland loss	wetland gain	1.52E+06	1.5				0.4		48.2			
28	crop	water	cropland loss	water gain	3.36E+05	0.3				0.1		30.5			
29	urban	forest	urban loss	forest gain	3.07E+06	3.1	16.4		15.8	19.4	3.7	10.1	4.2	-12.2	-74.4
30	urban	barren	urban loss	barren gain	1.98E+04	0.0	0.6		96.7	0.1	22.3	0.0			
31	urban	grass	urban loss	grass gain	7.08E+06	7.1				44.7		1.6			
32	urban	crop	urban loss	crop gain	5.60E+06	5.6				35.4		1.9			
33	urban	urban	stable urban	stable urban	5.48E+05	0.5		3.3							
34	urban	wetland	urban loss	wetland gain	6.48E+04	0.1				0.4		2.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	3.2	0.0	3.2	3.2	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	2.12E+04	0.0	2.9		2.9	0.7	1.1	0.1	1.2	-1.8	-60.3
44	water	barren	water loss	barren gain	1.98E+04	0.0	0.1		97.9	0.7	37.6	0.0			
45	water	grass	water loss	grassland gain	4.17E+05	0.4				14.5		0.1			
46	water	crop	water loss	cropland gain	2.38E+06	2.4				83.1		0.8			
47	water	urban	water loss	urban gain	2.74E+03	0.0				0.1		0.1			
48	water	wetland	water loss	wetland gain	2.25E+04	0.0				0.8		0.7			
49	water	water	stable water	stable water	6.15E+04	0.1		2.1							
	Total					2,663.0									

Appendix 2.2.4.23.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Aragatsotn, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.47E+07	34.7	47.5	73.1	12.8		30.3		64.9	17.5	36.9
2	forest	barren	forest loss	barren gain	1.12E+05	0.1	1.8		26.9	0.9	63.7	2.6			
3	forest	grass	forest loss	grassland gain	9.25E+06	9.3				72.5		2.4			
4	forest	crop	forest loss	cropland gain	3.30E+06	3.3				25.9		4.4			
5	forest	urban	forest loss	urban gain	6.86E+03	0.0				0.1		1.0			
6	forest	wetland	forest loss	wetland gain	9.11E+04	0.1				0.7		1.7			
7	forest	water	forest loss	water gain	2.05E+03	0.0				0.0		0.7			
8	barren	forest	barren loss	forest gain	1.00E+05	0.1	135.7		75.6	0.1	4.4	0.3	64.4	-71.3	-52.5
9	barren	barren	stable barren	stable barren	6.01E+07	60.1	5.1	44.3	55.7		3.2				
10	barren	grass	barren loss	grassland gain	7.46E+07	74.6				98.6		19.0			
11	barren	crop	barren loss	cropland gain	6.04E+05	0.6				0.8		0.8			
12	barren	urban	barren loss	urban gain	3.42E+03	0.0				0.0		0.5			
13	barren	wetland	barren loss	wetland gain	3.43E+05	0.3				0.5		6.3			
14	barren	water	barren loss	water gain	3.15E+04	0.0				0.0		10.8			
15	grass	forest	grassland loss	forest gain	1.69E+07	16.9	1,757.8		92.4	18.3	392.7	55.8	2,058.1	300.3	17.1
16	grass	barren	grassland loss	barren gain	3.70E+06	3.7	66.0		5.3	4.0	22.3	84.9			
17	grass	grass	stable grassland	stable grass	1.67E+09	1,665.4		94.7							
18	grass	crop	grassland loss	cropland gain	6.94E+07	69.4				75.1		92.8			
19	grass	urban	grassland loss	urban gain	5.32E+05	0.5				0.6		79.7			
20	grass	wetland	grassland loss	wetland gain	1.87E+06	1.9				2.0		34.4			
21	grass	water	grassland loss	water gain	6.57E+04	0.1				0.1		22.6			
22	crop	forest	cropland loss	forest gain	1.30E+07	13.0	712.3		320.7	4.0	74.8	42.9	466.4	-245.9	-34.5
23	crop	barren	cropland loss	barren gain	4.30E+05	0.4	26.8		45.0	0.1	10.5	9.9			
24	crop	grass	cropland loss	grassland gain	3.05E+08	304.6				95.0		77.6			
25	crop	crop	stable cropland	stable cropland	3.92E+08	391.6		55.0							
26	crop	urban	cropland loss	urban gain	1.24E+05	0.1				0.0		18.6			
27	crop	wetland	cropland loss	wetland gain	2.50E+06	2.5				0.8		46.1			
28	crop	water	cropland loss	water gain	1.08E+05	0.1				0.0		37.2			
29	urban	forest	urban loss	forest gain	3.08E+04	0.0	4.2		3.8	0.8	0.7	0.1	1.1	-3.1	-73.7
30	urban	barren	urban loss	barren gain	6.22E+04	0.1	0.2		89.6	1.7	15.9	1.4			
31	urban	grass	urban loss	grass gain	3.20E+06	3.2				85.1		0.8			
32	urban	crop	urban loss	crop gain	4.55E+05	0.5				12.1		0.6			
33	urban	urban	stable urban	stable urban	4.38E+05	0.4		10.4							
34	urban	wetland	urban loss	wetland gain	1.30E+04	0.0				0.3		0.2			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.68E+05	0.2	3.1		2.2	7.5	5.4	0.6	6.3	3.2	101.5
37	wetland	barren	wetland loss	barren gain	3.41E+03	0.0	0.1		70.9	0.2	172.4	0.1			
38	wetland	grass	wetland loss	grassland gain	1.03E+06	1.0				46.1		0.3			
39	wetland	crop	wetland loss	cropland gain	9.46E+05	0.9				42.4		1.3			
40	wetland	urban	wetland loss	urban gain	1.37E+03	0.0				0.1		0.2			
41	wetland	wetland	stable wetland	stable wetland	9.18E+05	0.9		29.1							
42	wetland	water	wetland loss	water gain	8.33E+04	0.1				3.7		28.7			
43	water	forest	water loss	forest gain	8.20E+04	0.1	1.2		1.0	8.6	0.3	0.3	0.5	-0.7	-56.6
44	water	barren	water loss	barren gain	5.33E+04	0.1	0.0		81.5	5.6	24.9	1.2			
45	water	grass	water loss	grassland gain	9.51E+04	0.1				10.0		0.0			
46	water	crop	water loss	cropland gain	1.13E+05	0.1				11.9		0.2			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	6.07E+05	0.6				63.9		11.2			
49	water	water	stable water	stable water	2.15E+05	0.2		18.5							
	Total					2,661.8									

Appendix 2.2.4.23.3. 50-year changes (1965-2015) in land cover and change percentages within Aragatsotn, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.02E+07	20.2	37.1	54.3	16.9		44.9		65.0	27.9	75.2
2	forest	barren	forest loss	barren gain	8.09E+05	0.8	1.4		45.7	4.8	120.9	1.6			
3	forest	grass	forest loss	grassland gain	1.40E+07	14.0				82.6		2.6			
4	forest	crop	forest loss	cropland gain	2.01E+06	2.0				11.9		1.4			
5	forest	urban	forest loss	urban gain	8.57E+04	0.1				0.5		8.6			
6	forest	wetland	forest loss	wetland gain	3.57E+04	0.0				0.2		0.6			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	2.73E+03	0.0	20.1		7.6	0.0	51.9	0.0	64.5	44.4	220.6
9	barren	barren	stable barren	stable barren	1.25E+07	12.5	0.8	62.2	37.8		258.3				
10	barren	grass	barren loss	grassland gain	7.59E+06	7.6				99.9		1.4			
11	barren	crop	barren loss	cropland gain	4.78E+03	0.0				0.1		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	3.40E+07	34.0	1,747.9		222.8	15.3	533.9	75.8	2,059.0	311.1	17.8
16	grass	barren	grassland loss	barren gain	5.07E+07	50.7	65.6		12.7	22.8	30.5	97.6			
17	grass	grass	stable grassland	stable grass	1.53E+09	1,525.1		87.3							
18	grass	crop	grassland loss	cropland gain	1.35E+08	135.0				60.6		94.3			
19	grass	urban	grassland loss	urban gain	4.56E+05	0.5				0.2		46.0			
20	grass	wetland	grassland loss	wetland gain	2.40E+06	2.4				1.1		37.8			
21	grass	water	grassland loss	water gain	2.06E+05	0.2				0.1		42.7			
22	crop	forest	cropland loss	forest gain	8.32E+06	8.3	838.5		515.2	1.6	143.2	18.5	466.5	-372.0	-44.4
23	crop	barren	cropland loss	barren gain	3.37E+05	0.3	31.5		61.4	0.1	17.1	0.6			
24	crop	grass	cropland loss	grassland gain	5.02E+08	502.0				97.4		94.0			
25	crop	crop	stable cropland	stable cropland	3.23E+08	323.3		38.6							
26	crop	urban	cropland loss	urban gain	4.50E+05	0.4				0.1		45.3			
27	crop	wetland	cropland loss	wetland gain	3.84E+06	3.8				0.7		60.4			
28	crop	water	cropland loss	water gain	2.77E+05	0.3				0.1		57.3			
29	urban	forest	urban loss	forest gain	2.50E+06	2.5	16.4		16.3	15.4	1.0	5.6	1.1	-15.3	-93.3
30	urban	barren	urban loss	barren gain	5.40E+04	0.1	0.6		99.3	0.3	6.1	0.1			
31	urban	grass	urban loss	grass gain	9.87E+06	9.9				60.7		1.8			
32	urban	crop	urban loss	crop gain	3.77E+06	3.8				23.2		2.6			
33	urban	urban	stable urban	stable urban	1.14E+05	0.1		0.7							
34	urban	wetland	urban loss	wetland gain	7.26E+04	0.1				0.4		1.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	6.4	0.0	6.4	6.4	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	5.34E+04	0.1	2.9		2.9	1.8	0.5	0.1	0.5	-2.4	-82.8
44	water	barren	water loss	barren gain	3.07E+04	0.0	0.1		99.3	1.1	16.5	0.1			
45	water	grass	water loss	grassland gain	4.50E+05	0.5				15.5		0.1			
46	water	crop	water loss	cropland gain	2.36E+06	2.4				81.3		1.7			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	8.91E+03	0.0				0.3		0.1			
49	water	water	stable water	stable water	2.19E+04	0.0		0.7							
	Total					2,663.0									

Appendix 2.2.4.24.1. Soviet era changes (1965-'87) in land cover and change percentages within Armavir, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.00E+05	0.2	2.5	8.1	2.3		17.9		18.1	15.7	633.9
2	forest	barren	forest loss	barren gain	0.00E+00	0.0	0.2		91.9	0.0	725.8	0.0			
3	forest	grass	forest loss	grassland gain	6.17E+03	0.0				0.3		0.0			
4	forest	crop	forest loss	cropland gain	1.71E+06	1.7				75.2		2.4			
5	forest	urban	forest loss	urban gain	5.23E+05	0.5				23.0		5.1			
6	forest	wetland	forest loss	wetland gain	2.81E+04	0.0				1.2		0.2			
7	forest	water	forest loss	water gain	5.47E+03	0.0				0.2		0.2			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	7.7	0.0	7.7	7.7	21,010.4
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	0.0	100.0		21,110.4				
10	barren	grass	barren loss	grassland gain	3.37E+04	0.0				92.5		0.0			
11	barren	crop	barren loss	cropland gain	2.75E+03	0.0				7.5		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.41E+06	1.4	443.0		48.4	2.9	442.6	7.8	837.3	394.2	89.0
16	grass	barren	grassland loss	barren gain	3.36E+06	3.4	35.0		10.9	6.9	99.9	43.7			
17	grass	grass	stable grassland	stable grass	3.95E+08	394.7		89.1							
18	grass	crop	grassland loss	cropland gain	3.81E+07	38.1				78.7		52.5			
19	grass	urban	grassland loss	urban gain	1.84E+06	1.8				3.8		18.1			
20	grass	wetland	grassland loss	wetland gain	2.55E+06	2.6				5.3		17.3			
21	grass	water	grassland loss	water gain	1.16E+06	1.2				2.4		48.0			
22	crop	forest	cropland loss	forest gain	1.38E+07	13.8	728.0		432.4	3.2	72.5	76.8	368.0	-360.0	-49.4
23	crop	barren	cropland loss	barren gain	4.09E+06	4.1	57.6		59.4	0.9	10.0	53.2			
24	crop	grass	cropland loss	grassland gain	3.96E+08	396.3				91.7		89.5			
25	crop	crop	stable cropland	stable cropland	2.96E+08	295.6		40.6							
26	crop	urban	cropland loss	urban gain	7.48E+06	7.5				1.7		73.7			
27	crop	wetland	cropland loss	wetland gain	9.65E+06	9.6				2.2		65.3			
28	crop	water	cropland loss	water gain	1.12E+06	1.1				0.3		46.4			
29	urban	forest	urban loss	forest gain	2.20E+06	2.2	75.2		69.6	3.2	10.2	12.3	15.7	-59.5	-79.1
30	urban	barren	urban loss	barren gain	1.63E+05	0.2	6.0		92.6	0.2	13.5	2.1			
31	urban	grass	urban loss	grass gain	3.99E+07	39.9				57.4		9.0			
32	urban	crop	urban loss	crop gain	2.56E+07	25.6				36.7		35.3			
33	urban	urban	stable urban	stable urban	5.59E+06	5.6		7.4							
34	urban	wetland	urban loss	wetland gain	1.63E+06	1.6				2.3		11.0			
35	urban	water	urban loss	water gain	1.29E+05	0.1				0.2		5.4			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	14.8	0.0	14.8	14.8	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	5.57E+05	0.6	15.5		15.3	3.7	2.4	3.1	2.7	-12.8	-82.8
44	water	barren	water loss	barren gain	7.40E+04	0.1	1.2		98.4	0.5	15.6	1.0			
45	water	grass	water loss	grassland gain	6.32E+06	6.3				41.4		1.4			
46	water	crop	water loss	cropland gain	7.09E+06	7.1				46.5		9.8			
47	water	urban	water loss	urban gain	3.10E+05	0.3				2.0		3.1			
48	water	wetland	water loss	wetland gain	9.14E+05	0.9				6.0		6.2			
49	water	water	stable water	stable water	2.56E+05	0.3		1.6							
	Total					1,264.3									

Appendix 2.2.4.24.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Armavir, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.79E+06	1.8	18.0	9.9	16.2		6.6		8.4	-9.6	-53.4
2	forest	barren	forest loss	barren gain	1.37E+03	0.0	1.4		90.1	0.0	36.7	0.2			
3	forest	grass	forest loss	grassland gain	8.69E+06	8.7				53.5		4.7			
4	forest	crop	forest loss	cropland gain	7.14E+06	7.1				44.0		8.8			
5	forest	urban	forest loss	urban gain	1.31E+04	0.0				0.1		0.2			
6	forest	wetland	forest loss	wetland gain	3.91E+05	0.4				2.4		3.3			
7	forest	water	forest loss	water gain	2.75E+03	0.0				0.0		0.6			
8	barren	forest	barren loss	forest gain	7.57E+03	0.0	7.6		7.5	0.1	0.9	0.1	0.9	-6.7	-87.9
9	barren	barren	stable barren	stable barren	3.90E+04	0.0	0.6	0.5	99.5		11.6				
10	barren	grass	barren loss	grassland gain	7.35E+06	7.4				97.5		3.9			
11	barren	crop	barren loss	cropland gain	1.01E+05	0.1				1.3		0.1			
12	barren	urban	barren loss	urban gain	6.46E+04	0.1				0.9		1.0			
13	barren	wetland	barren loss	wetland gain	1.68E+04	0.0				0.2		0.1			
14	barren	water	barren loss	water gain	1.22E+03	0.0				0.0		0.3			
15	grass	forest	grassland loss	forest gain	2.68E+06	2.7	835.0		82.2	3.3	186.5	40.5	939.3	104.3	12.5
16	grass	barren	grassland loss	barren gain	7.45E+05	0.7	66.4		9.8	0.9	22.3	84.8			
17	grass	grass	stable grassland	stable grass	7.53E+08	752.8		90.2							
18	grass	crop	grassland loss	cropland gain	6.87E+07	68.7				83.6		84.7			
19	grass	urban	grassland loss	urban gain	5.64E+06	5.6				6.9		87.9			
20	grass	wetland	grassland loss	wetland gain	4.30E+06	4.3				5.2		36.5			
21	grass	water	grassland loss	water gain	1.21E+05	0.1				0.1		27.9			
22	crop	forest	cropland loss	forest gain	2.50E+06	2.5	364.9		164.1	1.5	81.0	37.8	281.9	-83.0	-22.7
23	crop	barren	cropland loss	barren gain	8.59E+04	0.1	29.0		45.0	0.1	22.2	9.8			
24	crop	grass	cropland loss	grassland gain	1.55E+08	154.6				94.2		82.9			
25	crop	crop	stable cropland	stable cropland	2.01E+08	200.9		55.0							
26	crop	urban	cropland loss	urban gain	6.97E+05	0.7				0.4		10.9			
27	crop	wetland	cropland loss	wetland gain	6.14E+06	6.1				3.7		52.2			
28	crop	water	cropland loss	water gain	7.70E+04	0.1				0.0		17.8			
29	urban	forest	urban loss	forest gain	4.13E+03	0.0	15.2		12.2	0.0	6.4	0.1	9.5	-5.8	-37.8
30	urban	barren	urban loss	barren gain	3.16E+04	0.0	1.2		80.0	0.3	42.2	3.6			
31	urban	grass	urban loss	grass gain	1.14E+07	11.4				93.4		6.1			
32	urban	crop	urban loss	crop gain	5.54E+05	0.6				4.6		0.7			
33	urban	urban	stable urban	stable urban	3.04E+06	3.0		20.0							
34	urban	wetland	urban loss	wetland gain	2.06E+05	0.2				1.7		1.8			
35	urban	water	urban loss	water gain	3.44E+03	0.0				0.0		0.8			
36	wetland	forest	wetland loss	forest gain	1.33E+06	1.3	14.7		9.0	14.8	11.8	20.2	17.4	2.8	18.9
37	wetland	barren	wetland loss	barren gain	1.24E+04	0.0	1.2		61.3	0.1	80.2	1.4			
38	wetland	grass	wetland loss	grassland gain	3.71E+06	3.7				41.2		2.0			
39	wetland	crop	wetland loss	cropland gain	3.71E+06	3.7				41.3		4.6			
40	wetland	urban	wetland loss	urban gain	6.87E+02	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	5.68E+06	5.7		38.7							
42	wetland	water	wetland loss	water gain	2.28E+05	0.2				2.5		52.6			
43	water	forest	water loss	forest gain	8.94E+04	0.1	2.7		2.5	3.6	0.4	1.4	0.6	-2.0	-75.6
44	water	barren	water loss	barren gain	2.06E+03	0.0	0.2		91.9	0.1	16.2	0.2			
45	water	grass	water loss	grassland gain	7.71E+05	0.8				31.5		0.4			
46	water	crop	water loss	cropland gain	8.69E+05	0.9				35.4		1.1			
47	water	urban	water loss	urban gain	1.35E+03	0.0				0.1		0.0			
48	water	wetland	water loss	wetland gain	7.19E+05	0.7				29.3		6.1			
49	water	water	stable water	stable water	2.17E+05	0.2		8.1							
	Total					1,258.1									

Appendix 2.2.4.24.3. 50-year changes (1965-2015) in land cover and change percentages within Armavir, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	7.84E+05	0.8	2.5	31.7	1.7		7.9		8.7	6.3	253.2
2	forest	barren	forest loss	barren gain	0.00E+00	0.0	0.2		68.3	0.0	321.5	0.0			
3	forest	grass	forest loss	grassland gain	1.06E+06	1.1				62.7		0.2			
4	forest	crop	forest loss	cropland gain	5.81E+05	0.6				34.5		1.0			
5	forest	urban	forest loss	urban gain	1.76E+04	0.0				1.0		0.3			
6	forest	wetland	forest loss	wetland gain	2.42E+04	0.0				1.4		0.1			
7	forest	water	forest loss	water gain	4.81E+03	0.0				0.3		0.8			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	0.9	0.0	0.9	0.9	2,486.6
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	0.0	100.0		2,586.6				
10	barren	grass	barren loss	grassland gain	2.82E+04	0.0				77.4		0.0			
11	barren	crop	barren loss	cropland gain	8.24E+03	0.0				22.6		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.56E+06	1.6	443.0		40.1	3.9	540.5	19.6	943.4	500.4	112.9
16	grass	barren	grassland loss	barren gain	5.15E+05	0.5	35.0		9.1	1.3	122.0	54.6			
17	grass	grass	stable grassland	stable grass	4.03E+08	402.9		90.9							
18	grass	crop	grassland loss	cropland gain	3.43E+07	34.3				85.4		58.1			
19	grass	urban	grassland loss	urban gain	9.61E+05	1.0				2.4		18.7			
20	grass	wetland	grassland loss	wetland gain	2.59E+06	2.6				6.5		14.4			
21	grass	water	grassland loss	water gain	2.23E+05	0.2				0.6		37.6			
22	crop	forest	cropland loss	forest gain	5.44E+06	5.4	728.0		503.9	1.1	58.9	68.5	283.0	-445.0	-61.1
23	crop	barren	cropland loss	barren gain	3.56E+05	0.4	57.6		69.2	0.1	8.1	37.8			
24	crop	grass	cropland loss	grassland gain	4.81E+08	481.3				95.5		89.0			
25	crop	crop	stable cropland	stable cropland	2.24E+08	224.0		30.8							
26	crop	urban	cropland loss	urban gain	3.92E+06	3.9				0.8		76.0			
27	crop	wetland	cropland loss	wetland gain	1.27E+07	12.7				2.5		70.5			
28	crop	water	cropland loss	water gain	2.49E+05	0.2				0.0		41.9			
29	urban	forest	urban loss	forest gain	6.59E+05	0.7	75.2		70.9	0.9	5.2	8.3	9.5	-65.7	-87.4
30	urban	barren	urban loss	barren gain	5.84E+04	0.1	6.0		94.2	0.1	6.8	6.2			
31	urban	grass	urban loss	grass gain	4.97E+07	49.7				70.1		9.2			
32	urban	crop	urban loss	crop gain	1.84E+07	18.4				25.9		31.2			
33	urban	urban	stable urban	stable urban	4.36E+06	4.4		5.8							
34	urban	wetland	urban loss	wetland gain	2.00E+06	2.0				2.8		11.1			
35	urban	water	urban loss	water gain	1.16E+05	0.1				0.2		19.6			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	18.0	0.0	18.0	18.0	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	2.83E+05	0.3	15.5		15.4	1.8	0.6	3.6	0.7	-14.8	-95.5
44	water	barren	water loss	barren gain	1.31E+04	0.0	1.2		99.3	0.1	3.8	1.4			
45	water	grass	water loss	grassland gain	8.47E+06	8.5				55.0		1.6			
46	water	crop	water loss	cropland gain	5.71E+06	5.7				37.0		9.7			
47	water	urban	water loss	urban gain	2.56E+05	0.3				1.7		5.0			
48	water	wetland	water loss	wetland gain	6.81E+05	0.7				4.4		3.8			
49	water	water	stable water	stable water	1.06E+05	0.1		0.7							
	Total					1,264.3									

Appendix 2.2.4.25.1. Soviet era changes (1965-'87) in land cover and change percentages within Lori, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	8.37E+08	837.4	1,390.9	60.2	553.6		77.1		914.5	-476.4	-34.3
2	forest	barren	forest loss	barren gain	5.74E+06	5.7	37.4		39.8	1.0	5.5	0.4			
3	forest	grass	forest loss	grassland gain	4.71E+08	470.6				85.0		56.4			
4	forest	crop	forest loss	cropland gain	7.41E+07	74.1				13.4		94.7			
5	forest	urban	forest loss	urban gain	7.36E+05	0.7				0.1		6.5			
6	forest	wetland	forest loss	wetland gain	2.37E+06	2.4				0.4		2.2			
7	forest	water	forest loss	water gain	1.49E+04	0.0				0.0		0.1			
8	barren	forest	barren loss	forest gain	4.36E+04	0.0	108.6		107.8	0.0	1,489.0	0.1	1,489.8	1,381.1	1,271.3
9	barren	barren	stable barren	stable barren	8.13E+05	0.8	2.9	0.7	99.3		1,370.6				
10	barren	grass	barren loss	grassland gain	1.23E+06	1.2				1.1		0.1			
11	barren	crop	barren loss	cropland gain	3.52E+04	0.0				0.0		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	1.07E+08	106.5				98.8		97.7			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	7.23E+07	72.3	1,698.0		1,433.9	5.0	834.1	93.7	1,098.1	-599.9	-35.3
16	grass	barren	grassland loss	barren gain	1.34E+09	1,339.9	45.7		84.4	93.4	49.1	90.0			
17	grass	grass	stable grassland	stable grass	2.64E+08	264.1		15.6							
18	grass	crop	grassland loss	cropland gain	1.93E+06	1.9				0.1		2.5			
19	grass	urban	grassland loss	urban gain	2.40E+06	2.4				0.2		21.3			
20	grass	wetland	grassland loss	wetland gain	5.15E+04	0.1				0.0		0.0			
21	grass	water	grassland loss	water gain	1.74E+07	17.4				1.2		98.3			
22	crop	forest	cropland loss	forest gain	2.30E+06	2.3	510.2		509.7	0.5	78.3	3.0	78.8	-431.4	-84.6
23	crop	barren	cropland loss	barren gain	1.43E+08	143.2	13.7		99.9	28.1	15.3	9.6			
24	crop	grass	cropland loss	grassland gain	3.56E+08	355.6				69.8		42.6			
25	crop	crop	stable cropland	stable cropland	5.28E+05	0.5		0.1							
26	crop	urban	cropland loss	urban gain	8.13E+06	8.1				1.6		72.1			
27	crop	wetland	cropland loss	wetland gain	8.00E+04	0.1				0.0		0.1			
28	crop	water	cropland loss	water gain	2.88E+05	0.3				0.1		1.6			
29	urban	forest	urban loss	forest gain	2.52E+06	2.5	10.2		9.9	25.4	11.3	3.3	11.5	1.3	13.1
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.3		97.4	0.0	110.5	0.0			
31	urban	grass	urban loss	grass gain	5.76E+06	5.8				57.9		0.7			
32	urban	crop	urban loss	crop gain	1.61E+06	1.6				16.2		2.1			
33	urban	urban	stable urban	stable urban	2.67E+05	0.3		2.6							
34	urban	wetland	urban loss	wetland gain	5.37E+04	0.1				0.5		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.63E+04	0.0	1.5		1.5	1.1	109.1	0.0	109.1	107.5	7,047.8
37	wetland	barren	wetland loss	barren gain	5.31E+04	0.1	0.0		100.0	3.5	7,147.8	0.0			
38	wetland	grass	wetland loss	grassland gain	8.50E+05	0.8				55.7		0.1			
39	wetland	crop	wetland loss	cropland gain	5.95E+05	0.6				39.0		0.8			
40	wetland	urban	wetland loss	urban gain	1.22E+04	0.0				0.8		0.1			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	17.7	0.0	17.7	17.7	NA
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
45	water	grass	water loss	grassland gain	0.00E+00	0.0				NA		0.0			
46	water	crop	water loss	cropland gain	0.00E+00	0.0				NA		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				NA		0.0			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				NA		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		NA							
	Total					3,719.5									

Appendix 2.2.4.25.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Lori, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	8.73E+08	872.8	961.5	90.8	88.7		169.0		1,041.8	80.3	8.3
2	forest	barren	forest loss	barren gain	4.44E+05	0.4	25.9		9.2	0.5	17.6	6.8			
3	forest	grass	forest loss	grassland gain	7.21E+07	72.1				81.3		13.6			
4	forest	crop	forest loss	cropland gain	1.54E+07	15.4				17.4		18.9			
5	forest	urban	forest loss	urban gain	4.28E+04	0.0				0.0		0.9			
6	forest	wetland	forest loss	wetland gain	6.75E+05	0.7				0.8		7.8			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	6.66E+05	0.7	83.7		62.6	1.1	6.5	0.4	27.6	-56.0	-67.0
9	barren	barren	stable barren	stable barren	2.11E+07	21.1	2.2	25.2	74.8		7.8				
10	barren	grass	barren loss	grassland gain	5.95E+07	59.5				95.1		11.2			
11	barren	crop	barren loss	cropland gain	9.44E+05	0.9				1.5		1.2			
12	barren	urban	barren loss	urban gain	1.33E+06	1.3				2.1		28.8			
13	barren	wetland	barren loss	wetland gain	8.01E+04	0.1				0.1		0.9			
14	barren	water	barren loss	water gain	1.15E+04	0.0				0.0		6.4			
15	grass	forest	grassland loss	forest gain	1.33E+08	132.7	1,961.4		203.1	65.4	529.9	78.6	2,288.3	326.9	16.7
16	grass	barren	grassland loss	barren gain	5.02E+06	5.0	52.7		10.4	2.5	27.0	76.6			
17	grass	grass	stable grassland	stable grass	1.76E+09	1,758.4		89.6							
18	grass	crop	grassland loss	cropland gain	6.04E+07	60.4				29.8		74.1			
19	grass	urban	grassland loss	urban gain	2.87E+06	2.9				1.4		61.8			
20	grass	wetland	grassland loss	wetland gain	1.97E+06	2.0				1.0		22.7			
21	grass	water	grassland loss	water gain	2.10E+04	0.0				0.0		11.6			
22	crop	forest	cropland loss	forest gain	3.35E+07	33.5	696.0		433.8	7.7	81.6	19.8	343.8	-352.3	-50.6
23	crop	barren	cropland loss	barren gain	1.03E+06	1.0	18.7		62.3	0.2	11.7	15.7			
24	crop	grass	cropland loss	grassland gain	3.93E+08	393.1				90.6		74.2			
25	crop	crop	stable cropland	stable cropland	2.62E+08	262.2		37.7							
26	crop	urban	cropland loss	urban gain	3.88E+05	0.4				0.1		8.4			
27	crop	wetland	cropland loss	wetland gain	5.85E+06	5.8				1.3		67.4			
28	crop	water	cropland loss	water gain	2.17E+04	0.0				0.0		12.0			
29	urban	forest	urban loss	forest gain	7.66E+04	0.1	3.5		3.0	2.6	4.6	0.0	5.1	1.7	48.0
30	urban	barren	urban loss	barren gain	4.96E+04	0.0	0.1		85.4	1.7	133.4	0.8			
31	urban	grass	urban loss	grass gain	2.42E+06	2.4				81.5		0.5			
32	urban	crop	urban loss	crop gain	4.10E+05	0.4				13.8		0.5			
33	urban	urban	stable urban	stable urban	5.08E+05	0.5		14.6							
34	urban	wetland	urban loss	wetland gain	1.36E+04	0.0				0.5		0.2			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	2.02E+06	2.0	12.9		9.3	21.8	8.7	1.2	12.4	-0.6	-4.5
37	wetland	barren	wetland loss	barren gain	6.80E+03	0.0	0.3		71.6	0.1	67.0	0.1			
38	wetland	grass	wetland loss	grassland gain	2.78E+06	2.8				30.0		0.5			
39	wetland	crop	wetland loss	cropland gain	4.33E+06	4.3				46.8		5.3			
40	wetland	urban	wetland loss	urban gain	5.43E+03	0.0				0.1		0.1			
41	wetland	wetland	stable wetland	stable wetland	3.68E+06	3.7		28.4							
42	wetland	water	wetland loss	water gain	1.26E+05	0.1				1.4		70.0			
43	water	forest	water loss	forest gain	6.79E+02	0.0	0.2		0.2	0.5	0.2	0.0	0.2	0.0	18.3
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		92.5	0.0	110.8	0.0			
45	water	grass	water loss	grassland gain	2.31E+04	0.0				15.3		0.0			
46	water	crop	water loss	cropland gain	3.46E+04	0.0				23.0		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	9.22E+04	0.1				61.2		1.1			
49	water	water	stable water	stable water	1.22E+04	0.0		7.5							
	Total					3,719.2									

Appendix 2.2.4.25.3. 50-year changes (1965-2015) in land cover and change percentages within Lori, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.03E+08	903.0	1,390.9	64.9	488.0		138.8		1,041.8	-349.1	-25.1
2	forest	barren	forest loss	barren gain	8.51E+05	0.9	37.4		35.1	0.2	10.0	3.2			
3	forest	grass	forest loss	grassland gain	4.62E+08	461.9				94.7		61.5			
4	forest	crop	forest loss	cropland gain	2.29E+07	22.9				4.7		19.7			
5	forest	urban	forest loss	urban gain	7.39E+05	0.7				0.2		19.3			
6	forest	wetland	forest loss	wetland gain	1.57E+06	1.6				0.3		12.7			
7	forest	water	forest loss	water gain	5.49E+04	0.1				0.0		28.5			
8	barren	forest	barren loss	forest gain	4.56E+04	0.0	2.1		1.4	3.2	27.0	0.0	27.6	25.5	1,200.3
9	barren	barren	stable barren	stable barren	6.83E+05	0.7	0.1	32.1	67.9		1,268.1				
10	barren	grass	barren loss	grassland gain	1.40E+06	1.4				96.8		0.2			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				0.0		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.32E+08	132.2	1,787.2		249.3	53.0	750.7	95.2	2,288.6	501.4	28.1
16	grass	barren	grassland loss	barren gain	2.30E+07	23.0	48.0		14.0	9.2	42.0	85.4			
17	grass	grass	stable grassland	stable grass	1.54E+09	1,537.8		86.0							
18	grass	crop	grassland loss	cropland gain	9.10E+07	91.0				36.5		78.2			
19	grass	urban	grassland loss	urban gain	1.41E+06	1.4				0.6		37.0			
20	grass	wetland	grassland loss	wetland gain	1.69E+06	1.7				0.7		13.7			
21	grass	water	grassland loss	water gain	3.99E+04	0.0				0.0		20.8			
22	crop	forest	cropland loss	forest gain	6.30E+06	6.3	527.3		299.8	2.1	116.4	4.5	343.8	-183.5	-34.8
23	crop	barren	cropland loss	barren gain	1.67E+06	1.7	14.2		56.9	0.6	22.1	6.2			
24	crop	grass	cropland loss	grassland gain	2.81E+08	281.2				93.8		37.5			
25	crop	crop	stable cropland	stable cropland	2.27E+08	227.4		43.1							
26	crop	urban	cropland loss	urban gain	1.57E+06	1.6				0.5		41.1			
27	crop	wetland	cropland loss	wetland gain	8.99E+06	9.0				3.0		72.8			
28	crop	water	cropland loss	water gain	9.76E+04	0.1				0.0		50.7			
29	urban	forest	urban loss	forest gain	3.29E+05	0.3	10.5		9.2	3.6	3.8	0.2	5.1	-5.4	-51.0
30	urban	barren	urban loss	barren gain	1.18E+06	1.2	0.3		87.4	12.9	36.4	4.4			
31	urban	grass	urban loss	grass gain	5.57E+06	5.6				60.6		0.7			
32	urban	crop	urban loss	crop gain	1.99E+06	2.0				21.7		1.7			
33	urban	urban	stable urban	stable urban	1.32E+06	1.3		12.6							
34	urban	wetland	urban loss	wetland gain	1.09E+05	0.1				1.2		0.9			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	12.4	0.0	12.4	12.4	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	0.00E+00	0.0	1.5		1.5	0.0	0.2	0.0	0.2	-1.3	-87.3
44	water	barren	water loss	barren gain	2.36E+05	0.2	0.0		100.0	15.6	12.7	0.9			
45	water	grass	water loss	grassland gain	6.75E+05	0.7				44.7		0.1			
46	water	crop	water loss	cropland gain	5.00E+05	0.5				33.1		0.4			
47	water	urban	water loss	urban gain	9.93E+04	0.1				6.6		2.6			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				0.0		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					3,719.5									

Appendix 2.2.4.26.1. Soviet era changes (1965-'87) in land cover and change percentages within Kotayk, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.16E+07	91.6	134.3	68.2	42.7		51.3		142.9	8.6	6.4
2	forest	barren	forest loss	barren gain	1.23E+04	0.0	7.1		31.8	0.0	38.2	0.2			
3	forest	grass	forest loss	grassland gain	3.88E+07	38.8				91.0		11.1			
4	forest	crop	forest loss	cropland gain	3.70E+06	3.7				8.7		2.1			
5	forest	urban	forest loss	urban gain	1.37E+04	0.0				0.0		0.6			
6	forest	wetland	forest loss	wetland gain	1.16E+05	0.1				0.3		6.6			
7	forest	water	forest loss	water gain	1.02E+04	0.0				0.0		2.6			
8	barren	forest	barren loss	forest gain	1.37E+03	0.0	8.2		7.3	0.0	8.1	0.0	9.0	0.8	9.9
9	barren	barren	stable barren	stable barren	9.02E+05	0.9	0.4	11.0	89.0		98.9				
10	barren	grass	barren loss	grassland gain	7.05E+06	7.1				96.3		2.0			
11	barren	crop	barren loss	cropland gain	2.70E+05	0.3				3.7		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	4.56E+07	45.6	1,284.2		230.4	19.8	351.0	88.9	1,404.8	120.6	9.4
16	grass	barren	grassland loss	barren gain	8.08E+06	8.1	68.2		17.9	3.5	27.3	99.4			
17	grass	grass	stable grassland	stable grass	1.05E+09	1,053.8		82.1							
18	grass	crop	grassland loss	cropland gain	1.75E+08	175.1				76.0		97.0			
19	grass	urban	grassland loss	urban gain	9.31E+05	0.9				0.4		43.3			
20	grass	wetland	grassland loss	wetland gain	5.40E+05	0.5				0.2		30.6			
21	grass	water	grassland loss	water gain	3.77E+04	0.0				0.0		9.6			
22	crop	forest	cropland loss	forest gain	5.19E+06	5.2	447.7		307.0	1.7	180.5	10.1	321.2	-126.5	-28.3
23	crop	barren	cropland loss	barren gain	3.90E+04	0.0	23.8		68.6	0.0	40.3	0.5			
24	crop	grass	cropland loss	grassland gain	2.99E+08	299.1				97.4		85.2			
25	crop	crop	stable cropland	stable cropland	1.41E+08	140.8		31.4							
26	crop	urban	cropland loss	urban gain	1.21E+06	1.2				0.4		56.1			
27	crop	wetland	cropland loss	wetland gain	1.07E+06	1.1				0.3		60.6			
28	crop	water	cropland loss	water gain	3.44E+05	0.3				0.1		87.8			
29	urban	forest	urban loss	forest gain	4.82E+05	0.5	7.9		7.6	6.3	2.2	0.9	2.4	-5.5	-69.3
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.4		96.4	0.0	27.1	0.0			
31	urban	grass	urban loss	grass gain	5.80E+06	5.8				75.8		1.7			
32	urban	crop	urban loss	crop gain	1.33E+06	1.3				17.4		0.7			
33	urban	urban	stable urban	stable urban	2.88E+05	0.3		3.6							
34	urban	wetland	urban loss	wetland gain	3.70E+04	0.0				0.5		2.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	1.8	0.0	1.8	1.8	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	4.80E+03	0.0	0.2		0.2	2.5	0.4	0.0	0.4	0.2	104.5
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		98.2	0.0	202.7	0.0			
45	water	grass	water loss	grassland gain	1.65E+05	0.2				87.0		0.0			
46	water	crop	water loss	cropland gain	1.78E+04	0.0				9.4		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	2.06E+03	0.0				1.1		0.1			
49	water	water	stable water	stable water	3.43E+03	0.0		1.8							
	Total					1,882.6									

Appendix 2.2.4.26.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Kotayk, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.30E+08	129.6	142.9	90.7	13.3		44.3		173.9	31.0	21.7
2	forest	barren	forest loss	barren gain	3.42E+04	0.0	7.6		9.3	0.3	31.0	1.7			
3	forest	grass	forest loss	grassland gain	9.60E+06	9.6				72.3		7.3			
4	forest	crop	forest loss	cropland gain	3.46E+06	3.5				26.1		1.6			
5	forest	urban	forest loss	urban gain	1.17E+04	0.0				0.1		0.5			
6	forest	wetland	forest loss	wetland gain	1.61E+05	0.2				1.2		7.2			
7	forest	water	forest loss	water gain	1.58E+04	0.0				0.1		7.2			
8	barren	forest	barren loss	forest gain	4.12E+03	0.0	9.0		6.9	0.1	2.0	0.0	4.1	-4.9	-54.8
9	barren	barren	stable barren	stable barren	2.11E+06	2.1	0.5	23.4	76.6		21.8				
10	barren	grass	barren loss	grassland gain	6.87E+06	6.9				99.5		5.3			
11	barren	crop	barren loss	cropland gain	2.94E+04	0.0				0.4		0.0			
12	barren	urban	barren loss	urban gain	4.12E+03	0.0				0.1		0.2			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	3.74E+07	37.4	1,404.8		258.7	14.5	130.7	84.6	1,276.8	-128.0	-9.1
16	grass	barren	grassland loss	barren gain	1.64E+06	1.6	74.6		18.4	0.6	9.3	83.1			
17	grass	grass	stable grassland	stable grass	1.15E+09	1,146.1		81.6							
18	grass	crop	grassland loss	cropland gain	2.16E+08	216.4				83.6		98.1			
19	grass	urban	grassland loss	urban gain	2.35E+06	2.3				0.9		95.1			
20	grass	wetland	grassland loss	wetland gain	8.74E+05	0.9				0.3		39.3			
21	grass	water	grassland loss	water gain	7.86E+04	0.1				0.0		36.0			
22	crop	forest	cropland loss	forest gain	6.55E+06	6.5	321.2		120.4	5.4	220.5	14.8	421.3	100.1	31.2
23	crop	barren	cropland loss	barren gain	2.78E+05	0.3	17.1		37.5	0.2	68.7	14.1			
24	crop	grass	cropland loss	grassland gain	1.12E+08	112.3				93.3		85.9			
25	crop	crop	stable cropland	stable cropland	2.01E+08	200.8		62.5							
26	crop	urban	cropland loss	urban gain	1.05E+05	0.1				0.1		4.2			
27	crop	wetland	cropland loss	wetland gain	1.07E+06	1.1				0.9		47.9			
28	crop	water	cropland loss	water gain	8.27E+04	0.1				0.1		37.8			
29	urban	forest	urban loss	forest gain	8.92E+03	0.0	2.4		2.1	0.4	2.5	0.0	2.9	0.4	17.1
30	urban	barren	urban loss	barren gain	1.22E+04	0.0	0.1		84.1	0.6	101.3	0.6			
31	urban	grass	urban loss	grass gain	1.77E+06	1.8				86.0		1.4			
32	urban	crop	urban loss	crop gain	2.52E+05	0.3				12.3		0.1			
33	urban	urban	stable urban	stable urban	3.87E+05	0.4		15.9							
34	urban	wetland	urban loss	wetland gain	1.37E+04	0.0				0.7		0.6			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.77E+05	0.2	1.8		0.8	21.7	2.2	0.4	3.2	1.4	79.7
37	wetland	barren	wetland loss	barren gain	6.86E+02	0.0	0.1		46.2	0.1	125.9	0.0			
38	wetland	grass	wetland loss	grassland gain	1.65E+05	0.2				20.2		0.1			
39	wetland	crop	wetland loss	cropland gain	4.32E+05	0.4				52.9		0.2			
40	wetland	urban	wetland loss	urban gain	6.86E+02	0.0				0.1		0.0			
41	wetland	wetland	stable wetland	stable wetland	9.50E+05	0.9		53.8							
42	wetland	water	wetland loss	water gain	4.15E+04	0.0				5.1		19.0			
43	water	forest	water loss	forest gain	9.97E+04	0.1	0.4		0.2	43.4	0.2	0.2	0.4	0.0	-2.8
44	water	barren	water loss	barren gain	7.55E+03	0.0	0.0		57.9	3.3	55.1	0.4			
45	water	grass	water loss	grassland gain	2.06E+03	0.0				0.9		0.0			
46	water	crop	water loss	cropland gain	1.10E+04	0.0				4.8		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.09E+05	0.1				47.6		4.9			
49	water	water	stable water	stable water	1.67E+05	0.2		42.1							
	Total					1,882.5									

Appendix 2.2.4.26.3. 50-year changes (1965-2015) in land cover and change percentages within Kotayk, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.01E+08	101.2	134.3	75.3	33.1		72.7		173.9	39.6	29.5
2	forest	barren	forest loss	barren gain	4.62E+04	0.0	7.1		24.7	0.1	54.1	1.5			
3	forest	grass	forest loss	grassland gain	2.63E+07	26.3				79.3		9.1			
4	forest	crop	forest loss	cropland gain	6.59E+06	6.6				19.9		2.9			
5	forest	urban	forest loss	urban gain	4.67E+04	0.0				0.1		1.7			
6	forest	wetland	forest loss	wetland gain	1.80E+05	0.2				0.5		5.7			
7	forest	water	forest loss	water gain	6.14E+03	0.0				0.0		1.6			
8	barren	forest	barren loss	forest gain	5.45E+03	0.0	8.2		7.3	0.1	3.1	0.0	4.1	-4.1	-50.4
9	barren	barren	stable barren	stable barren	9.67E+05	1.0	0.4	11.8	88.2		37.9				
10	barren	grass	barren loss	grassland gain	6.81E+06	6.8				93.9		2.4			
11	barren	crop	barren loss	cropland gain	4.37E+05	0.4				6.0		0.2			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	2.06E+03	0.0				0.0		0.1			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	6.88E+07	68.8	1,284.2		294.4	23.4	287.1	94.6	1,276.8	-7.4	-0.6
16	grass	barren	grassland loss	barren gain	2.84E+06	2.8	68.2		22.9	1.0	22.4	91.3			
17	grass	grass	stable grassland	stable grass	9.90E+08	989.7		77.1							
18	grass	crop	grassland loss	cropland gain	2.21E+08	220.6				74.9		95.9			
19	grass	urban	grassland loss	urban gain	1.01E+06	1.0				0.3		37.4			
20	grass	wetland	grassland loss	wetland gain	1.04E+06	1.0				0.4		32.7			
21	grass	water	grassland loss	water gain	1.65E+05	0.2				0.1		42.8			
22	crop	forest	cropland loss	forest gain	3.43E+06	3.4	447.7		256.4	1.3	230.1	4.7	421.4	-26.4	-5.9
23	crop	barren	cropland loss	barren gain	2.22E+05	0.2	23.8		57.3	0.1	51.4	7.1			
24	crop	grass	cropland loss	grassland gain	2.49E+08	249.0				97.1		86.7			
25	crop	crop	stable cropland	stable cropland	1.91E+08	191.3		42.7							
26	crop	urban	cropland loss	urban gain	1.64E+06	1.6				0.6		60.9			
27	crop	wetland	cropland loss	wetland gain	1.89E+06	1.9				0.7		59.6			
28	crop	water	cropland loss	water gain	2.14E+05	0.2				0.1		55.6			
29	urban	forest	urban loss	forest gain	4.72E+05	0.5	7.9		7.8	6.1	2.7	0.6	2.9	-5.1	-64.0
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.4		98.0	0.0	34.0	0.0			
31	urban	grass	urban loss	grass gain	4.86E+06	4.9				62.5		1.7			
32	urban	crop	urban loss	crop gain	2.38E+06	2.4				30.6		1.0			
33	urban	urban	stable urban	stable urban	1.58E+05	0.2		2.0							
34	urban	wetland	urban loss	wetland gain	6.16E+04	0.1				0.8		1.9			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	3.2	0.0	3.2	3.2	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	2.06E+04	0.0	0.2		0.2	10.6	0.4	0.0	0.4	0.2	99.1
44	water	barren	water loss	barren gain	2.06E+03	0.0	0.0		100.0	1.1	199.1	0.1			
45	water	grass	water loss	grassland gain	1.18E+05	0.1				61.0		0.0			
46	water	crop	water loss	cropland gain	5.28E+04	0.1				27.3		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				0.0		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					1,882.6									

Appendix 2.2.4.27.1. Soviet era changes (1965-'87) in land cover and change percentages within Yerevan, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.89E+06	2.9	6.8	42.4	3.9		8.9		11.8	5.0	72.9
2	forest	barren	forest loss	barren gain	8.93E+03	0.0	2.9		57.6	0.2	130.6	1.5			
3	forest	grass	forest loss	grassland gain	2.91E+06	2.9				73.9		3.5			
4	forest	crop	forest loss	cropland gain	3.78E+05	0.4				9.6		6.0			
5	forest	urban	forest loss	urban gain	5.89E+05	0.6				15.0		6.1			
6	forest	wetland	forest loss	wetland gain	5.01E+04	0.1				1.3		6.1			
7	forest	water	forest loss	water gain	2.06E+03	0.0				0.1		0.7			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	0.1		0.1	0.0	0.6	0.0	0.6	0.5	855.8
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	0.0	100.0		955.8				
10	barren	grass	barren loss	grassland gain	5.08E+04	0.1				84.1		0.1			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				0.0		0.0			
12	barren	urban	barren loss	urban gain	9.61E+03	0.0				15.9		0.1			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	4.29E+06	4.3	100.8		12.9	33.3	82.2	48.2	170.1	69.3	68.8
16	grass	barren	grassland loss	barren gain	9.55E+04	0.1	43.2		12.8	0.7	81.6	16.5			
17	grass	grass	stable grassland	stable grass	8.79E+07	87.9		87.2							
18	grass	crop	grassland loss	cropland gain	2.70E+06	2.7				20.9		43.1			
19	grass	urban	grassland loss	urban gain	5.70E+06	5.7				44.2		59.1			
20	grass	wetland	grassland loss	wetland gain	1.12E+05	0.1				0.9		13.5			
21	grass	water	grassland loss	water gain	4.12E+03	0.0				0.0		1.4			
22	crop	forest	cropland loss	forest gain	2.12E+06	2.1	62.6		53.5	4.0	6.3	23.7	15.4	-47.2	-75.5
23	crop	barren	cropland loss	barren gain	2.57E+05	0.3	26.8		85.5	0.5	10.0	44.6			
24	crop	grass	cropland loss	grassland gain	4.72E+07	47.2				88.3		57.4			
25	crop	crop	stable cropland	stable cropland	9.09E+06	9.1		14.5							
26	crop	urban	cropland loss	urban gain	3.34E+06	3.3				6.2		34.6			
27	crop	wetland	cropland loss	wetland gain	3.99E+05	0.4				0.7		48.3			
28	crop	water	cropland loss	water gain	1.65E+05	0.2				0.3		57.1			
29	urban	forest	urban loss	forest gain	2.50E+06	2.5	62.8		38.2	6.6	9.6	28.1	34.3	-28.5	-45.4
30	urban	barren	urban loss	barren gain	2.12E+05	0.2	26.9		60.7	0.6	15.4	36.7			
31	urban	grass	urban loss	grass gain	3.20E+07	32.0				83.8		38.9			
32	urban	crop	urban loss	crop gain	3.09E+06	3.1				8.1		49.4			
33	urban	urban	stable urban	stable urban	2.47E+07	24.7		39.3							
34	urban	wetland	urban loss	wetland gain	2.61E+05	0.3				0.7		31.6			
35	urban	water	urban loss	water gain	1.17E+05	0.1				0.3		40.7			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.8	0.0	0.8	0.8	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	3.44E+03	0.0	0.2		0.2	1.5	0.3	0.0	0.3	0.1	26.1
44	water	barren	water loss	barren gain	3.43E+03	0.0	0.1		98.8	1.5	124.9	0.6			
45	water	grass	water loss	grassland gain	1.21E+05	0.1				53.1		0.1			
46	water	crop	water loss	cropland gain	9.20E+04	0.1				40.3		1.5			
47	water	urban	water loss	urban gain	4.12E+03	0.0				1.8		0.0			
48	water	wetland	water loss	wetland gain	4.12E+03	0.0				1.8		0.5			
49	water	water	stable water	stable water	2.75E+03	0.0		1.2							
	Total					233.3									

Appendix 2.2.4.27.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Yerevan, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.86E+06	2.9	11.8	24.2	8.9		3.0		5.9	-5.9	-50.4
2	forest	barren	forest loss	barren gain	1.03E+04	0.0	5.1		75.8	0.1	25.4	1.1			
3	forest	grass	forest loss	grassland gain	5.35E+06	5.4				59.8		15.0			
4	forest	crop	forest loss	cropland gain	3.21E+06	3.2				35.9		25.6			
5	forest	urban	forest loss	urban gain	1.64E+05	0.2				1.8		1.2			
6	forest	wetland	forest loss	wetland gain	2.12E+05	0.2				2.4		21.5			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	6.87E+03	0.0	0.6		0.6	1.2	0.9	0.2	0.9	0.3	59.4
9	barren	barren	stable barren	stable barren	1.31E+04	0.0	0.2	2.3	97.7		157.1				
10	barren	grass	barren loss	grassland gain	4.77E+05	0.5				84.4		1.3			
11	barren	crop	barren loss	cropland gain	9.62E+03	0.0				1.7		0.1			
12	barren	urban	barren loss	urban gain	6.80E+04	0.1				12.0		0.5			
13	barren	wetland	barren loss	wetland gain	3.44E+03	0.0				0.6		0.3			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.27E+06	2.3	170.1		24.5	9.2	35.6	75.6	181.1	11.0	6.5
16	grass	barren	grassland loss	barren gain	6.36E+05	0.6	72.9		14.4	2.6	20.9	70.1			
17	grass	grass	stable grassland	stable grass	1.46E+08	145.6		85.6							
18	grass	crop	grassland loss	cropland gain	8.70E+06	8.7				35.5		69.4			
19	grass	urban	grassland loss	urban gain	1.25E+07	12.5				51.2		93.7			
20	grass	wetland	grassland loss	wetland gain	3.77E+05	0.4				1.5		38.3			
21	grass	water	grassland loss	water gain	0.00E+00	0.0				0.0		0.0			
22	crop	forest	cropland loss	forest gain	4.29E+05	0.4	15.4		10.5	4.1	12.5	14.3	17.4	2.1	13.4
23	crop	barren	cropland loss	barren gain	8.24E+03	0.0	6.6		68.2	0.1	81.6	0.9			
24	crop	grass	cropland loss	grassland gain	9.25E+06	9.2				88.3		26.0			
25	crop	crop	stable cropland	stable cropland	4.88E+06	4.9		31.8							
26	crop	urban	cropland loss	urban gain	5.87E+05	0.6				5.6		4.4			
27	crop	wetland	cropland loss	wetland gain	2.03E+05	0.2				1.9		20.6			
28	crop	water	cropland loss	water gain	0.00E+00	0.0				0.0		0.0			
29	urban	forest	urban loss	forest gain	2.08E+05	0.2	34.3		21.4	1.0	13.4	6.9	26.3	-8.0	-23.3
30	urban	barren	urban loss	barren gain	2.52E+05	0.3	14.7		62.3	1.2	39.0	27.7			
31	urban	grass	urban loss	grass gain	2.03E+07	20.3				94.9		57.1			
32	urban	crop	urban loss	crop gain	5.04E+05	0.5				2.4		4.0			
33	urban	urban	stable urban	stable urban	1.29E+07	12.9		37.7							
34	urban	wetland	urban loss	wetland gain	1.30E+05	0.1				0.6		13.2			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	8.93E+04	0.1	0.8		0.5	19.0	1.0	3.0	1.3	0.5	62.5
37	wetland	barren	wetland loss	barren gain	1.37E+03	0.0	0.4		56.8	0.3	119.3	0.2			
38	wetland	grass	wetland loss	grassland gain	1.94E+05	0.2				41.3		0.5			
39	wetland	crop	wetland loss	cropland gain	9.95E+04	0.1				21.2		0.8			
40	wetland	urban	wetland loss	urban gain	2.34E+04	0.0				5.0		0.2			
41	wetland	wetland	stable wetland	stable wetland	3.57E+05	0.4		43.2							
42	wetland	water	wetland loss	water gain	6.18E+04	0.1				13.2		100.0			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.3		0.1	0.0	0.1	0.0	0.3	0.0	-0.9
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.1		22.2	0.0	21.2	0.0			
45	water	grass	water loss	grassland gain	1.37E+03	0.0				2.1		0.0			
46	water	crop	water loss	cropland gain	2.75E+03	0.0				4.3		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	6.05E+04	0.1				93.6		6.1			
49	water	water	stable water	stable water	2.27E+05	0.2		77.8							
	Total					233.3									

Appendix 2.2.4.27.3. 50-year changes (1965-2015) in land cover and change percentages within Yerevan, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.18E+06	1.2	6.8	17.3	5.6		4.7		5.9	-1.0	-14.2
2	forest	barren	forest loss	barren gain	2.06E+03	0.0	2.9		82.7	0.0	68.6	0.2			
3	forest	grass	forest loss	grassland gain	3.96E+06	4.0				70.2		4.2			
4	forest	crop	forest loss	cropland gain	1.23E+06	1.2				21.7		12.8			
5	forest	urban	forest loss	urban gain	3.80E+05	0.4				6.7		4.3			
6	forest	wetland	forest loss	wetland gain	7.76E+04	0.1				1.4		5.8			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	0.1		0.1	0.0	0.9	0.0	0.9	0.9	1,423.3
9	barren	barren	stable barren	stable barren	6.87E+02	0.0	0.0	1.1	98.9		1,522.2				
10	barren	grass	barren loss	grassland gain	5.43E+04	0.1				90.8		0.1			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				0.0		0.0			
12	barren	urban	barren loss	urban gain	5.49E+03	0.0				9.2		0.1			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.75E+06	2.8	100.8		13.8	20.0	94.2	58.8	181.1	80.4	79.7
16	grass	barren	grassland loss	barren gain	2.45E+05	0.2	43.2		13.7	1.8	93.4	26.6			
17	grass	grass	stable grassland	stable grass	8.70E+07	87.0		86.3							
18	grass	crop	grassland loss	cropland gain	5.11E+06	5.1				37.0		53.4			
19	grass	urban	grassland loss	urban gain	5.40E+06	5.4				39.1		60.4			
20	grass	wetland	grassland loss	wetland gain	2.90E+05	0.3				2.1		21.6			
21	grass	water	grassland loss	water gain	0.00E+00	0.0				0.0		0.0			
22	crop	forest	cropland loss	forest gain	1.03E+06	1.0	62.6		54.7	1.9	9.6	21.9	17.4	-45.2	-72.2
23	crop	barren	cropland loss	barren gain	2.62E+05	0.3	26.8		87.5	0.5	15.3	28.5			
24	crop	grass	cropland loss	grassland gain	4.96E+07	49.6				90.7		52.7			
25	crop	crop	stable cropland	stable cropland	7.84E+06	7.8		12.5							
26	crop	urban	cropland loss	urban gain	3.15E+06	3.1				5.8		35.2			
27	crop	wetland	cropland loss	wetland gain	5.03E+05	0.5				0.9		37.4			
28	crop	water	cropland loss	water gain	1.69E+05	0.2				0.3		58.9			
29	urban	forest	urban loss	forest gain	9.01E+05	0.9	62.8		45.4	2.0	8.9	19.3	26.3	-36.5	-58.1
30	urban	barren	urban loss	barren gain	4.11E+05	0.4	26.9		72.3	0.9	14.2	44.6			
31	urban	grass	urban loss	grass gain	4.04E+07	40.4				88.8		42.9			
32	urban	crop	urban loss	crop gain	3.17E+06	3.2				7.0		33.1			
33	urban	urban	stable urban	stable urban	1.74E+07	17.4		27.7							
34	urban	wetland	urban loss	wetland gain	4.66E+05	0.5				1.0		34.7			
35	urban	water	urban loss	water gain	1.18E+05	0.1				0.3		41.1			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	1.3	0.0	1.3	1.3	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.2		0.2	0.0	0.3	0.0	0.3	0.1	24.9
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.1		99.4	0.0	124.3	0.0			
45	water	grass	water loss	grassland gain	1.63E+05	0.2				71.0		0.2			
46	water	crop	water loss	cropland gain	5.97E+04	0.1				26.0		0.6			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	6.87E+03	0.0				3.0		0.5			
49	water	water	stable water	stable water	1.37E+03	0.0		0.6							
	Total					233.3									

Appendix 2.2.4.28.1. Soviet era changes (1965-'87) in land cover and change percentages within Ararat, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.95E+07	19.5	135.4	14.4	115.9		20.7		40.2	-95.2	-70.3
2	forest	barren	forest loss	barren gain	9.86E+04	0.1	7.6		85.6	0.1	15.3	1.7			
3	forest	grass	forest loss	grassland gain	1.02E+08	101.9				87.9		20.7			
4	forest	crop	forest loss	cropland gain	1.36E+07	13.6				11.7		15.7			
5	forest	urban	forest loss	urban gain	9.64E+03	0.0				0.0		0.4			
6	forest	wetland	forest loss	wetland gain	3.05E+05	0.3				0.3		5.3			
7	forest	water	forest loss	water gain	8.94E+03	0.0				0.0		0.2			
8	barren	forest	barren loss	forest gain	8.94E+03	0.0	6.8		5.9	0.2	6.0	0.0	6.8	0.1	1.0
9	barren	barren	stable barren	stable barren	8.85E+05	0.9	0.4	13.1	86.9		87.9				
10	barren	grass	barren loss	grassland gain	5.63E+06	5.6				95.6		1.1			
11	barren	crop	barren loss	cropland gain	2.53E+05	0.3				4.3		0.3			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.46E+07	14.6	1,146.6		89.5	16.3	492.5	70.4	1,549.6	403.0	35.1
16	grass	barren	grassland loss	barren gain	5.68E+06	5.7	64.0		7.8	6.3	43.0	95.3			
17	grass	grass	stable grassland	stable grass	1.06E+09	1,057.1		92.2							
18	grass	crop	grassland loss	cropland gain	6.70E+07	67.0				74.8		77.6			
19	grass	urban	grassland loss	urban gain	3.33E+05	0.3				0.4		12.3			
20	grass	wetland	grassland loss	wetland gain	1.12E+06	1.1				1.2		19.4			
21	grass	water	grassland loss	water gain	8.44E+05	0.8				0.9		23.3			
22	crop	forest	cropland loss	forest gain	5.59E+06	5.6	460.0		364.6	1.5	86.4	27.0	181.7	-278.3	-60.5
23	crop	barren	cropland loss	barren gain	1.75E+05	0.2	25.7		79.3	0.0	18.8	2.9			
24	crop	grass	cropland loss	grassland gain	3.50E+08	350.2				96.0		71.1			
25	crop	crop	stable cropland	stable cropland	9.54E+07	95.4		20.7							
26	crop	urban	cropland loss	urban gain	2.31E+06	2.3				0.6		85.3			
27	crop	wetland	cropland loss	wetland gain	3.95E+06	3.9				1.1		68.6			
28	crop	water	cropland loss	water gain	2.40E+06	2.4				0.7		66.2			
29	urban	forest	urban loss	forest gain	4.92E+05	0.5	39.6		38.5	1.3	2.7	2.4	3.8	-35.8	-90.4
30	urban	barren	urban loss	barren gain	4.14E+03	0.0	2.2		97.3	0.0	6.8	0.1			
31	urban	grass	urban loss	grass gain	3.23E+07	32.3				83.9		6.6			
32	urban	crop	urban loss	crop gain	4.95E+06	4.9				12.8		5.7			
33	urban	urban	stable urban	stable urban	1.08E+06	1.1		2.7							
34	urban	wetland	urban loss	wetland gain	3.79E+05	0.4				1.0		6.6			
35	urban	water	urban loss	water gain	3.74E+05	0.4				1.0		10.3			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	5.8	0.0	5.8	5.8	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	4.61E+04	0.0	3.2		3.2	1.5	3.6	0.2	3.6	0.5	14.9
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.2		100.0	0.0	114.9	0.0			
45	water	grass	water loss	grassland gain	2.49E+06	2.5				78.9		0.5			
46	water	crop	water loss	cropland gain	5.61E+05	0.6				17.8		0.6			
47	water	urban	water loss	urban gain	5.57E+04	0.1				1.8		2.1			
48	water	wetland	water loss	wetland gain	3.44E+03	0.0				0.1		0.1			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					1,791.5									

Appendix 2.2.4.28.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Ararat, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.07E+07	30.7	39.8	77.1	9.1		26.2		56.9	17.1	42.9
2	forest	barren	forest loss	barren gain	6.68E+04	0.1	2.2		22.9	0.7	65.8	3.4			
3	forest	grass	forest loss	grassland gain	5.21E+06	5.2				57.1		5.3			
4	forest	crop	forest loss	cropland gain	3.61E+06	3.6				39.5		1.7			
5	forest	urban	forest loss	urban gain	8.27E+03	0.0				0.1		0.2			
6	forest	wetland	forest loss	wetland gain	2.35E+05	0.2				2.6		2.3			
7	forest	water	forest loss	water gain	6.20E+03	0.0				0.1		0.5			
8	barren	forest	barren loss	forest gain	2.48E+04	0.0	6.8		5.0	0.5	2.0	0.1	3.9	-3.0	-43.5
9	barren	barren	stable barren	stable barren	1.86E+06	1.9	0.4	27.3	72.7		29.2				
10	barren	grass	barren loss	grassland gain	4.57E+06	4.6				92.3		4.6			
11	barren	crop	barren loss	cropland gain	3.22E+05	0.3				6.5		0.2			
12	barren	urban	barren loss	urban gain	2.06E+03	0.0				0.0		0.1			
13	barren	wetland	barren loss	wetland gain	2.07E+03	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	3.23E+04	0.0				0.7		2.8			
15	grass	forest	grassland loss	forest gain	1.80E+07	18.0	1,542.0		234.8	7.7	98.7	68.6	1,406.0	-136.0	-8.8
16	grass	barren	grassland loss	barren gain	1.65E+06	1.7	86.6		15.2	0.7	6.4	83.1			
17	grass	grass	stable grassland	stable grass	1.31E+09	1,307.3		84.8							
18	grass	crop	grassland loss	cropland gain	2.05E+08	205.3				87.5		96.7			
19	grass	urban	grassland loss	urban gain	3.08E+06	3.1				1.3		86.2			
20	grass	wetland	grassland loss	wetland gain	6.28E+06	6.3				2.7		60.4			
21	grass	water	grassland loss	water gain	4.40E+05	0.4				0.2		38.1			
22	crop	forest	cropland loss	forest gain	7.83E+06	7.8	179.0		95.6	8.2	212.3	29.9	295.7	116.7	65.2
23	crop	barren	cropland loss	barren gain	2.16E+05	0.2	10.1		53.4	0.2	118.6	10.9			
24	crop	grass	cropland loss	grassland gain	8.34E+07	83.4				87.2		84.4			
25	crop	crop	stable cropland	stable cropland	8.34E+07	83.4		46.6							
26	crop	urban	cropland loss	urban gain	4.84E+05	0.5				0.5		13.5			
27	crop	wetland	cropland loss	wetland gain	3.57E+06	3.6				3.7		34.3			
28	crop	water	cropland loss	water gain	1.42E+05	0.1				0.1		12.3			
29	urban	forest	urban loss	forest gain	7.56E+03	0.0	3.8		3.2	0.2	3.6	0.0	4.1	0.3	8.6
30	urban	barren	urban loss	barren gain	2.41E+04	0.0	0.2		85.7	0.7	94.3	1.2			
31	urban	grass	urban loss	grass gain	3.00E+06	3.0				92.5		3.0			
32	urban	crop	urban loss	crop gain	1.92E+05	0.2				5.9		0.1			
33	urban	urban	stable urban	stable urban	5.42E+05	0.5		14.3							
34	urban	wetland	urban loss	wetland gain	1.99E+04	0.0				0.6		0.2			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	3.59E+05	0.4	5.6		4.2	8.5	10.4	1.4	11.8	6.2	110.4
37	wetland	barren	wetland loss	barren gain	1.31E+04	0.0	0.3		75.8	0.3	186.2	0.7			
38	wetland	grass	wetland loss	grassland gain	1.61E+06	1.6				38.1		1.6			
39	wetland	crop	wetland loss	cropland gain	1.71E+06	1.7				40.4		0.8			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	1.35E+06	1.4		24.2							
42	wetland	water	wetland loss	water gain	5.35E+05	0.5				12.6		46.3			
43	water	forest	water loss	forest gain	4.82E+03	0.0	3.6		2.4	0.2	1.2	0.0	2.4	-1.3	-34.8
44	water	barren	water loss	barren gain	1.58E+04	0.0	0.2		66.6	0.7	31.8	0.8			
45	water	grass	water loss	grassland gain	9.72E+05	1.0				40.2		1.0			
46	water	crop	water loss	cropland gain	1.14E+06	1.1				47.0		0.5			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	2.90E+05	0.3				12.0		2.8			
49	water	water	stable water	stable water	1.21E+06	1.2		33.4							
	Total					1,780.7									

Appendix 2.2.4.28.3. 50-year changes (1965-2015) in land cover and change percentages within Ararat, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.01E+07	30.1	135.4	22.2	105.3		26.9		57.0	-78.4	-57.9
2	forest	barren	forest loss	barren gain	1.27E+05	0.1	7.6		77.8	0.1	19.9	4.2			
3	forest	grass	forest loss	grassland gain	8.14E+07	81.4				77.3		21.1			
4	forest	crop	forest loss	cropland gain	2.32E+07	23.2				22.0		18.5			
5	forest	urban	forest loss	urban gain	2.86E+05	0.3				0.3		9.1			
6	forest	wetland	forest loss	wetland gain	2.30E+05	0.2				0.2		1.9			
7	forest	water	forest loss	water gain	6.19E+03	0.0				0.0		0.2			
8	barren	forest	barren loss	forest gain	1.51E+04	0.0	6.8		5.9	0.3	3.0	0.1	3.9	-2.9	-43.0
9	barren	barren	stable barren	stable barren	8.72E+05	0.9	0.4	12.9	87.1		44.2				
10	barren	grass	barren loss	grassland gain	5.64E+06	5.6				95.4		1.5			
11	barren	crop	barren loss	cropland gain	2.58E+05	0.3				4.4		0.2			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.22E+07	22.2	1,146.6		120.9	18.4	385.2	82.6	1,410.9	264.3	23.1
16	grass	barren	grassland loss	barren gain	2.66E+06	2.7	64.0		10.5	2.2	33.6	88.9			
17	grass	grass	stable grassland	stable grass	1.03E+09	1,025.7		89.5							
18	grass	crop	grassland loss	cropland gain	9.37E+07	93.7				77.5		74.6			
19	grass	urban	grassland loss	urban gain	4.21E+05	0.4				0.3		13.4			
20	grass	wetland	grassland loss	wetland gain	1.16E+06	1.2				1.0		9.4			
21	grass	water	grassland loss	water gain	6.56E+05	0.7				0.5		26.2			
22	crop	forest	cropland loss	forest gain	3.77E+06	3.8	460.0		284.9	1.3	125.7	14.0	300.8	-159.2	-34.6
23	crop	barren	cropland loss	barren gain	1.97E+05	0.2	25.7		61.9	0.1	27.3	6.6			
24	crop	grass	cropland loss	grassland gain	2.67E+08	266.8				93.7		69.3			
25	crop	crop	stable cropland	stable cropland	1.75E+08	175.1		38.1							
26	crop	urban	cropland loss	urban gain	2.40E+06	2.4				0.8		76.3			
27	crop	wetland	cropland loss	wetland gain	1.02E+07	10.2				3.6		82.6			
28	crop	water	cropland loss	water gain	1.51E+06	1.5				0.5		60.2			
29	urban	forest	urban loss	forest gain	8.49E+05	0.8	39.6		38.6	2.2	3.1	3.2	4.1	-35.5	-89.6
30	urban	barren	urban loss	barren gain	6.87E+03	0.0	2.2		97.5	0.0	7.9	0.2			
31	urban	grass	urban loss	grass gain	2.90E+07	29.0				75.0		7.5			
32	urban	crop	urban loss	crop gain	7.77E+06	7.8				20.1		6.2			
33	urban	urban	stable urban	stable urban	9.73E+05	1.0		2.5							
34	urban	wetland	urban loss	wetland gain	6.85E+05	0.7				1.8		5.6			
35	urban	water	urban loss	water gain	3.32E+05	0.3				0.9		13.3			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	12.3	0.0	12.3	12.3	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	3.65E+04	0.0	3.2		3.2	1.2	2.5	0.1	2.5	-0.7	-20.9
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.2		100.0	0.0	79.1	0.0			
45	water	grass	water loss	grassland gain	2.30E+06	2.3				72.9		0.6			
46	water	crop	water loss	cropland gain	7.14E+05	0.7				22.6		0.6			
47	water	urban	water loss	urban gain	3.86E+04	0.0				1.2		1.2			
48	water	wetland	water loss	wetland gain	6.82E+04	0.1				2.2		0.6			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					1,791.5									

Appendix 2.2.4.29.1. Soviet era changes (1965-'87) in land cover and change percentages within Tavush, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.23E+09	1,229.9	1,477.7	83.2	247.7		142.7		1,372.7	-105.0	-7.1
2	forest	barren	forest loss	barren gain	3.61E+04	0.0	54.5		16.8	0.0	9.7	1.2			
3	forest	grass	forest loss	grassland gain	2.07E+08	206.8				83.5		87.8			
4	forest	crop	forest loss	cropland gain	4.04E+07	40.4				16.3		14.2			
5	forest	urban	forest loss	urban gain	5.72E+04	0.1				0.0		20.3			
6	forest	wetland	forest loss	wetland gain	4.75E+05	0.5				0.2		19.8			
7	forest	water	forest loss	water gain	6.11E+03	0.0				0.0		0.4			
8	barren	forest	barren loss	forest gain	5.45E+03	0.0	0.1		0.1	4.2	3.0	0.0	3.0	2.9	2,204.3
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	0.0	100.0		2,304.3				
10	barren	grass	barren loss	grassland gain	1.11E+05	0.1				85.3		0.0			
11	barren	crop	barren loss	cropland gain	1.36E+04	0.0				10.5		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.29E+08	128.6	1,137.6		373.9	34.4	235.5	90.1	999.1	-138.5	-12.2
16	grass	barren	grassland loss	barren gain	5.56E+04	0.1	41.9		32.9	0.0	20.7	1.9			
17	grass	grass	stable grassland	stable grass	7.64E+08	763.6		67.1							
18	grass	crop	grassland loss	cropland gain	2.44E+08	243.6				65.1		85.8			
19	grass	urban	grassland loss	urban gain	2.11E+05	0.2				0.1		75.1			
20	grass	wetland	grassland loss	wetland gain	1.11E+06	1.1				0.3		46.3			
21	grass	water	grassland loss	water gain	4.29E+05	0.4				0.1		28.0			
22	crop	forest	cropland loss	forest gain	1.30E+07	13.0	91.0		41.5	31.4	284.0	9.1	333.4	242.5	266.6
23	crop	barren	cropland loss	barren gain	0.00E+00	0.0	3.4		45.6	0.0	312.2	0.0			
24	crop	grass	cropland loss	grassland gain	2.66E+07	26.6				64.0		11.3			
25	crop	crop	stable cropland	stable cropland	4.95E+07	49.5		54.4							
26	crop	urban	cropland loss	urban gain	1.08E+04	0.0				0.0		3.9			
27	crop	wetland	cropland loss	wetland gain	8.07E+05	0.8				1.9		33.6			
28	crop	water	cropland loss	water gain	1.09E+06	1.1				2.6		71.1			
29	urban	forest	urban loss	forest gain	4.55E+05	0.5	5.1		5.1	8.9	0.3	0.3	0.3	-4.8	-94.3
30	urban	barren	urban loss	barren gain	2.90E+06	2.9	0.2		99.8	57.0	5.5	96.9			
31	urban	grass	urban loss	grass gain	1.71E+06	1.7				33.6		0.7			
32	urban	crop	urban loss	crop gain	8.17E+03	0.0				0.2		0.0			
33	urban	urban	stable urban	stable urban	1.09E+04	0.0		0.2							
34	urban	wetland	urban loss	wetland gain	7.46E+03	0.0				0.1		0.3			
35	urban	water	urban loss	water gain	6.79E+03	0.0				0.1		0.4			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	2.4	0.0	2.4	2.4	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	6.87E+05	0.7	1.0		1.0	69.9	1.5	0.5	1.5	0.5	55.8
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	155.8	0.0			
45	water	grass	water loss	grassland gain	2.92E+05	0.3				29.7		0.1			
46	water	crop	water loss	cropland gain	2.04E+03	0.0				0.2		0.0			
47	water	urban	water loss	urban gain	2.04E+03	0.0				0.2		0.7			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				0.0		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					2,712.4									

Appendix 2.2.4.29.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Tavush, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.28E+09	1,281.5	1,372.0	93.4	90.4		94.6		1,376.2	4.2	0.3
2	forest	barren	forest loss	barren gain	7.96E+03	0.0	50.6		6.6	0.0	6.9	8.1			
3	forest	grass	forest loss	grassland gain	6.01E+07	60.1				66.4		30.0			
4	forest	crop	forest loss	cropland gain	3.01E+07	30.1				33.3		20.5			
5	forest	urban	forest loss	urban gain	9.49E+03	0.0				0.0		0.9			
6	forest	wetland	forest loss	wetland gain	1.75E+05	0.2				0.2		4.7			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	3.27E+04	0.0	0.1		0.1	34.6	0.1	0.0	0.1	0.0	4.4
9	barren	barren	stable barren	stable barren	5.44E+03	0.0	0.0	5.4	94.6		98.9				
10	barren	grass	barren loss	grassland gain	3.53E+04	0.0				37.4		0.0			
11	barren	crop	barren loss	cropland gain	4.08E+03	0.0				4.3		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	1.76E+04	0.0				18.7		0.5			
14	barren	water	barren loss	water gain	4.75E+03	0.0				5.0		1.7			
15	grass	forest	grassland loss	forest gain	7.09E+07	70.9	1,000.6		189.5	37.4	200.5	75.0	1,011.7	11.1	1.1
16	grass	barren	grassland loss	barren gain	7.34E+04	0.1	36.9		18.9	0.0	20.0	74.3			
17	grass	grass	stable grassland	stable grass	8.11E+08	811.1		81.1							
18	grass	crop	grassland loss	cropland gain	1.16E+08	116.2				61.4		79.0			
19	grass	urban	grassland loss	urban gain	9.05E+05	0.9				0.5		87.0			
20	grass	wetland	grassland loss	wetland gain	1.24E+06	1.2				0.7		33.4			
21	grass	water	grassland loss	water gain	5.56E+04	0.1				0.0		20.1			
22	crop	forest	cropland loss	forest gain	2.33E+07	23.3	335.4		164.9	14.1	147.2	24.6	317.8	-17.7	-5.3
23	crop	barren	cropland loss	barren gain	1.61E+04	0.0	12.4		49.1	0.0	43.9	16.3			
24	crop	grass	cropland loss	grassland gain	1.40E+08	139.9				84.9		69.8			
25	crop	crop	stable cropland	stable cropland	1.71E+08	170.6		50.9							
26	crop	urban	cropland loss	urban gain	1.22E+05	0.1				0.1		11.7			
27	crop	wetland	cropland loss	wetland gain	1.38E+06	1.4				0.8		37.1			
28	crop	water	cropland loss	water gain	1.39E+05	0.1				0.1		50.2			
29	urban	forest	urban loss	forest gain	2.45E+04	0.0	0.3		0.2	10.1	1.0	0.0	1.1	0.8	275.9
30	urban	barren	urban loss	barren gain	1.36E+03	0.0	0.0		83.6	0.6	359.5	1.4			
31	urban	grass	urban loss	grass gain	1.78E+05	0.2				73.6		0.1			
32	urban	crop	urban loss	crop gain	3.53E+04	0.0				14.6		0.0			
33	urban	urban	stable urban	stable urban	4.75E+04	0.0		16.4							
34	urban	wetland	urban loss	wetland gain	2.72E+03	0.0				1.1		0.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	3.57E+05	0.4	2.4		1.5	24.4	3.7	0.4	4.7	2.3	94.1
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.1		60.8	0.0	154.9	0.0			
38	wetland	grass	wetland loss	grassland gain	2.97E+05	0.3				20.4		0.1			
39	wetland	crop	wetland loss	cropland gain	7.26E+05	0.7				49.7		0.5			
40	wetland	urban	wetland loss	urban gain	3.39E+03	0.0				0.2		0.3			
41	wetland	wetland	stable wetland	stable wetland	9.44E+05	0.9		39.2							
42	wetland	water	wetland loss	water gain	7.73E+04	0.1				5.3		27.9			
43	water	forest	water loss	forest gain	2.72E+03	0.0	1.5		0.9	0.3	0.3	0.0	0.9	-0.7	-43.1
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.1		61.1	0.0	18.1	0.0			
45	water	grass	water loss	grassland gain	3.73E+03	0.0				0.4		0.0			
46	water	crop	water loss	cropland gain	2.71E+04	0.0				2.9		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	9.04E+05	0.9				96.4		24.3			
49	water	water	stable water	stable water	5.96E+05	0.6		38.9							
	Total					2,712.3									

Appendix 2.2.4.29.3. 50-year changes (1965-2015) in land cover and change percentages within Tavush, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.25E+09	1,246.3	1,477.7	84.3	231.4		129.9		1,376.2	-101.5	-6.9
2	forest	barren	forest loss	barren gain	3.06E+04	0.0	54.5		15.7	0.0	8.8	29.5			
3	forest	grass	forest loss	grassland gain	2.07E+08	207.5				89.7		84.4			
4	forest	crop	forest loss	cropland gain	2.32E+07	23.2				10.0		8.7			
5	forest	urban	forest loss	urban gain	1.53E+05	0.2				0.1		18.0			
6	forest	wetland	forest loss	wetland gain	4.77E+05	0.5				0.2		10.2			
7	forest	water	forest loss	water gain	7.47E+03	0.0				0.0		0.9			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	0.1		0.1	0.0	0.1	0.0	0.1	0.0	-20.0
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	0.0	100.0		80.0				
10	barren	grass	barren loss	grassland gain	1.23E+05	0.1				94.8		0.1			
11	barren	crop	barren loss	cropland gain	6.78E+03	0.0				5.2		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.25E+08	125.4	1,137.6		371.7	33.7	245.9	96.6	1,011.7	-125.8	-11.1
16	grass	barren	grassland loss	barren gain	6.84E+04	0.1	41.9		32.7	0.0	21.6	65.9			
17	grass	grass	stable grassland	stable grass	7.66E+08	765.9		67.3							
18	grass	crop	grassland loss	cropland gain	2.43E+08	243.4				65.5		90.8			
19	grass	urban	grassland loss	urban gain	5.92E+05	0.6				0.2		69.6			
20	grass	wetland	grassland loss	wetland gain	1.93E+06	1.9				0.5		41.3			
21	grass	water	grassland loss	water gain	3.20E+05	0.3				0.1		36.6			
22	crop	forest	cropland loss	forest gain	3.88E+06	3.9	91.0		41.3	9.4	268.1	3.0	317.8	226.8	249.3
23	crop	barren	cropland loss	barren gain	0.00E+00	0.0	3.4		45.4	0.0	294.7	0.0			
24	crop	grass	cropland loss	grassland gain	3.46E+07	34.6				83.8		14.1			
25	crop	crop	stable cropland	stable cropland	4.96E+07	49.6		54.6							
26	crop	urban	cropland loss	urban gain	1.04E+05	0.1				0.3		12.2			
27	crop	wetland	cropland loss	wetland gain	2.16E+06	2.2				5.2		46.3			
28	crop	water	cropland loss	water gain	5.39E+05	0.5				1.3		61.7			
29	urban	forest	urban loss	forest gain	5.23E+05	0.5	5.1		4.9	10.8	0.9	0.4	1.1	-4.0	-78.6
30	urban	barren	urban loss	barren gain	4.76E+03	0.0	0.2		95.3	0.1	16.7	4.6			
31	urban	grass	urban loss	grass gain	3.05E+06	3.1				62.9		1.2			
32	urban	crop	urban loss	crop gain	1.20E+06	1.2				24.7		0.4			
33	urban	urban	stable urban	stable urban	2.38E+05	0.2		4.7							
34	urban	wetland	urban loss	wetland gain	7.06E+04	0.1				1.5		1.5			
35	urban	water	urban loss	water gain	6.78E+03	0.0				0.1		0.8			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	4.7	0.0	4.7	4.7	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	2.38E+04	0.0	1.0		1.0	2.4	0.9	0.0	0.9	-0.1	-11.9
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	88.1	0.0			
45	water	grass	water loss	grassland gain	5.92E+05	0.6				59.8		0.2			
46	water	crop	water loss	cropland gain	3.42E+05	0.3				34.6		0.1			
47	water	urban	water loss	urban gain	1.36E+03	0.0				0.1		0.2			
48	water	wetland	water loss	wetland gain	3.05E+04	0.0				3.1		0.7			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					2,712.4									

Appendix 2.2.4.30.1. Soviet era changes (1965-'87) in land cover and change percentages within Gegharkunik, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	5.74E+07	57.4	81.9	70.1	24.5		64.4		121.8	39.8	48.6
2	forest	barren	forest loss	barren gain	1.19E+04	0.0	1.8		29.9	0.0	78.5	0.1			
3	forest	grass	forest loss	grassland gain	2.17E+07	21.7				88.3		9.2			
4	forest	crop	forest loss	cropland gain	2.75E+06	2.8				11.2		0.5			
5	forest	urban	forest loss	urban gain	2.05E+04	0.0				0.1		0.3			
6	forest	wetland	forest loss	wetland gain	9.77E+04	0.1				0.4		0.2			
7	forest	water	forest loss	water gain	6.85E+02	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	1.79E+04	0.0	23.2		20.9	0.1	12.3	0.0	14.6	-8.6	-37.1
9	barren	barren	stable barren	stable barren	2.30E+06	2.3	0.5	9.9	90.1		53.0				
10	barren	grass	barren loss	grassland gain	2.03E+07	20.3				97.0		8.6			
11	barren	crop	barren loss	cropland gain	6.11E+05	0.6				2.9		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	6.15E+03	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	6.88E+02	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	4.82E+07	48.2	2,538.2		633.9	7.6	235.9	74.9	2,140.1	-398.1	-15.7
16	grass	barren	grassland loss	barren gain	8.40E+06	8.4	55.5		25.0	1.3	9.3	68.4			
17	grass	grass	stable grassland	stable grass	1.90E+09	1,904.2		75.0							
18	grass	crop	grassland loss	cropland gain	5.70E+08	569.8				89.9		98.9			
19	grass	urban	grassland loss	urban gain	2.10E+06	2.1				0.3		35.7			
20	grass	wetland	grassland loss	wetland gain	5.18E+06	5.2				0.8		11.3			
21	grass	water	grassland loss	water gain	2.28E+05	0.2				0.0		15.9			
22	crop	forest	cropland loss	forest gain	1.55E+07	15.5	671.5		239.0	6.5	575.9	24.0	1,008.5	336.9	50.2
23	crop	barren	cropland loss	barren gain	7.34E+05	0.7	14.7		35.6	0.3	85.8	6.0			
24	crop	grass	cropland loss	grassland gain	1.89E+08	189.0				79.1		80.1			
25	crop	crop	stable cropland	stable cropland	4.33E+08	432.6		64.4							
26	crop	urban	cropland loss	urban gain	3.66E+06	3.7				1.5		62.3			
27	crop	wetland	cropland loss	wetland gain	2.89E+07	28.9				12.1		63.3			
28	crop	water	cropland loss	water gain	1.20E+06	1.2				0.5		84.0			
29	urban	forest	urban loss	forest gain	3.23E+05	0.3	6.0		5.6	5.7	5.9	0.5	6.2	0.2	3.9
30	urban	barren	urban loss	barren gain	2.78E+06	2.8	0.1		94.3	49.3	98.2	22.6			
31	urban	grass	urban loss	grass gain	2.45E+06	2.5				43.5		1.0			
32	urban	crop	urban loss	crop gain	7.59E+04	0.1				1.3		0.0			
33	urban	urban	stable urban	stable urban	3.38E+05	0.3		5.7							
34	urban	wetland	urban loss	wetland gain	5.50E+03	0.0				0.1		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	45.6	0.0	45.6	45.6	195,088.7
37	wetland	barren	wetland loss	barren gain	6.88E+02	0.0	0.0		100.0	2.9	195,188.7	0.0			
38	wetland	grass	wetland loss	grassland gain	1.93E+04	0.0				82.3		0.0			
39	wetland	crop	wetland loss	cropland gain	3.44E+03	0.0				14.7		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	3.49E+05	0.3	1,253.4		17.4	2.0	1.4	0.5	1,237.4	-15.9	-1.3
44	water	barren	water loss	barren gain	3.59E+05	0.4	27.4		1.4	2.1	0.1	2.9			
45	water	grass	water loss	grassland gain	2.48E+06	2.5				14.3		1.1			
46	water	crop	water loss	cropland gain	2.64E+06	2.6				15.2		0.5			
47	water	urban	water loss	urban gain	9.23E+04	0.1				0.5		1.6			
48	water	wetland	water loss	wetland gain	1.14E+07	11.4				65.9		25.1			
49	water	water	stable water	stable water	1.24E+09	1,236.0		98.6							
	Total					4,574.2									

Appendix 2.2.4.30.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Gegharkunik, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	7.38E+07	73.8	121.7	60.6	47.9		24.3		98.1	-23.7	-19.4
2	forest	barren	forest loss	barren gain	4.61E+04	0.0	2.7		39.4	0.1	19.9	0.7			
3	forest	grass	forest loss	grassland gain	3.37E+07	33.7				70.4		8.1			
4	forest	crop	forest loss	cropland gain	8.84E+06	8.8				18.4		3.1			
5	forest	urban	forest loss	urban gain	2.26E+04	0.0				0.0		0.9			
6	forest	wetland	forest loss	wetland gain	5.11E+06	5.1				10.7		11.9			
7	forest	water	forest loss	water gain	1.83E+05	0.2				0.4		1.2			
8	barren	forest	barren loss	forest gain	1.07E+05	0.1	11.8		7.6	1.4	6.3	0.4	10.4	-1.4	-11.6
9	barren	barren	stable barren	stable barren	4.12E+06	4.1	0.3	35.0	65.0		53.4				
10	barren	grass	barren loss	grassland gain	6.48E+06	6.5				84.8		1.6			
11	barren	crop	barren loss	cropland gain	4.70E+05	0.5				6.2		0.2			
12	barren	urban	barren loss	urban gain	1.37E+03	0.0				0.0		0.1			
13	barren	wetland	barren loss	wetland gain	4.15E+05	0.4				5.4		1.0			
14	barren	water	barren loss	water gain	1.70E+05	0.2				2.2		1.2			
15	grass	forest	grassland loss	forest gain	1.08E+07	10.8	2,139.5		303.4	3.6	417.3	44.6	2,253.4	113.9	5.3
16	grass	barren	grassland loss	barren gain	5.96E+06	6.0	46.8		14.2	2.0	19.5	94.8			
17	grass	grass	stable grassland	stable grass	1.84E+09	1,836.1		85.8							
18	grass	crop	grassland loss	cropland gain	2.72E+08	272.4				89.8		94.1			
19	grass	urban	grassland loss	urban gain	2.31E+06	2.3				0.8		92.9			
20	grass	wetland	grassland loss	wetland gain	1.00E+07	10.0				3.3		23.2			
21	grass	water	grassland loss	water gain	1.93E+06	1.9				0.6		13.1			
22	crop	forest	cropland loss	forest gain	7.02E+06	7.0	1,010.8		410.3	1.7	289.6	28.9	890.1	-120.7	-11.9
23	crop	barren	cropland loss	barren gain	2.76E+05	0.3	22.1		40.6	0.1	28.7	4.4			
24	crop	grass	cropland loss	grassland gain	3.72E+08	372.1				90.7		89.2			
25	crop	crop	stable cropland	stable cropland	6.00E+08	600.5		59.4							
26	crop	urban	cropland loss	urban gain	1.38E+05	0.1				0.0		5.6			
27	crop	wetland	cropland loss	wetland gain	2.63E+07	26.3				6.4		61.0			
28	crop	water	cropland loss	water gain	4.48E+06	4.5				1.1		30.4			
29	urban	forest	urban loss	forest gain	4.52E+04	0.0	5.9		5.4	0.8	2.5	0.2	3.0	-3.0	-49.9
30	urban	barren	urban loss	barren gain	1.37E+03	0.0	0.1		91.6	0.0	41.7	0.0			
31	urban	grass	urban loss	grass gain	3.44E+06	3.4				63.2		0.8			
32	urban	crop	urban loss	crop gain	1.29E+06	1.3				23.7		0.4			
33	urban	urban	stable urban	stable urban	5.01E+05	0.5		8.4							
34	urban	wetland	urban loss	wetland gain	6.44E+05	0.6				11.8		1.5			
35	urban	water	urban loss	water gain	2.39E+04	0.0				0.4		0.2			
36	wetland	forest	wetland loss	forest gain	6.20E+06	6.2	46.0		22.3	27.9	43.1	25.6	66.8	20.8	45.3
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	1.0		48.4	0.0	93.7	0.0			
38	wetland	grass	wetland loss	grassland gain	1.52E+06	1.5				6.8		0.4			
39	wetland	crop	wetland loss	cropland gain	6.58E+06	6.6				29.6		2.3			
40	wetland	urban	wetland loss	urban gain	1.37E+04	0.0				0.1		0.6			
41	wetland	wetland	stable wetland	stable wetland	2.37E+07	23.7		51.6							
42	wetland	water	wetland loss	water gain	7.94E+06	7.9				35.7		53.9			
43	water	forest	water loss	forest gain	7.09E+04	0.1	1,237.5		0.7	9.7	14.7	0.3	1,251.4	14.0	1.1
44	water	barren	water loss	barren gain	0.00E+00	0.0	27.1		0.1	0.0	1.2	0.0			
45	water	grass	water loss	grassland gain	1.37E+04	0.0				1.9		0.0			
46	water	crop	water loss	cropland gain	2.06E+04	0.0				2.8		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	6.24E+05	0.6				85.6		1.4			
49	water	water	stable water	stable water	1.24E+09	1,236.7		99.9							
	Total					4,573.2									

Appendix 2.2.4.30.3. 50-year changes (1965-2015) in land cover and change percentages within Gegharkunik, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	5.79E+07	57.9	81.9	70.6	24.1		7.8		65.7	-16.2	-19.8
2	forest	barren	forest loss	barren gain	6.81E+02	0.0	1.8		29.4	0.0	9.6	0.0			
3	forest	grass	forest loss	grassland gain	2.20E+07	22.0				91.3		5.3			
4	forest	crop	forest loss	cropland gain	1.82E+06	1.8				7.6		48.7			
5	forest	urban	forest loss	urban gain	5.47E+03	0.0				0.0		0.0			
6	forest	wetland	forest loss	wetland gain	2.57E+05	0.3				1.1		1.6			
7	forest	water	forest loss	water gain	3.42E+03	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	3.43E+03	0.0	47.2		44.5	0.0	2,211.2	0.0	2,214.0	2,166.8	4,594.0
9	barren	barren	stable barren	stable barren	2.72E+06	2.7	1.0	5.8	94.2		4,688.3				
10	barren	grass	barren loss	grassland gain	2.01E+07	20.1				45.2		4.8			
11	barren	crop	barren loss	cropland gain	4.02E+05	0.4				0.9		10.7			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	1.37E+03	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	2.40E+07	24.0				53.9		59.8			
15	grass	forest	grassland loss	forest gain	7.52E+06	7.5	2,529.9		2,015.5	0.4	416.4	95.9	930.8	-1,599.2	-63.2
16	grass	barren	grassland loss	barren gain	1.98E+09	1,982.5	55.3		79.7	98.4	16.5	89.7			
17	grass	grass	stable grassland	stable grass	5.14E+08	514.4		20.3							
18	grass	crop	grassland loss	cropland gain	1.11E+06	1.1				0.1		29.7			
19	grass	urban	grassland loss	urban gain	7.85E+06	7.8				0.4		13.7			
20	grass	wetland	grassland loss	wetland gain	8.92E+05	0.9				0.0		5.6			
21	grass	water	grassland loss	water gain	1.57E+07	15.7				0.8		39.2			
22	crop	forest	cropland loss	forest gain	1.65E+05	0.2	656.2		654.5	0.0	3.7	2.1	5.4	-650.8	-99.2
23	crop	barren	cropland loss	barren gain	2.26E+08	225.9	14.3		99.7	34.5	0.6	10.2			
24	crop	grass	cropland loss	grassland gain	3.72E+08	371.9				56.8		89.3			
25	crop	crop	stable cropland	stable cropland	1.70E+06	1.7		0.3							
26	crop	urban	cropland loss	urban gain	4.96E+07	49.6				7.6		86.3			
27	crop	wetland	cropland loss	wetland gain	6.61E+06	6.6				1.0		41.3			
28	crop	water	cropland loss	water gain	3.93E+05	0.4				0.1		1.0			
29	urban	forest	urban loss	forest gain	9.60E+03	0.0	5.6		4.7	0.2	57.5	0.1	58.3	52.7	941.9
30	urban	barren	urban loss	barren gain	2.91E+06	2.9	0.1		84.7	61.3	1,026.6	0.1			
31	urban	grass	urban loss	grass gain	1.65E+06	1.6				34.7		0.4			
32	urban	crop	urban loss	crop gain	1.59E+05	0.2				3.4		4.3			
33	urban	urban	stable urban	stable urban	8.54E+05	0.9		15.3							
34	urban	wetland	urban loss	wetland gain	1.99E+04	0.0				0.4		0.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	16.0	0.0	16.0	16.0	465,579.9
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	465,679.9	0.0			
38	wetland	grass	wetland loss	grassland gain	2.75E+03	0.0				80.0		0.0			
39	wetland	crop	wetland loss	cropland gain	6.87E+02	0.0				20.0		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.44E+05	0.1	1,253.4		9.4	1.5	40.1	1.8	1,284.0	30.7	2.4
44	water	barren	water loss	barren gain	3.43E+03	0.0	27.4		0.8	0.0	3.2	0.0			
45	water	grass	water loss	grassland gain	8.16E+05	0.8				8.6		0.2			
46	water	crop	water loss	cropland gain	2.45E+05	0.2				2.6		6.5			
47	water	urban	water loss	urban gain	4.10E+03	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	8.23E+06	8.2				87.1		51.4			
49	water	water	stable water	stable water	1.24E+09	1,243.9		99.2							
	Total					4,574.2									

Appendix 2.2.4.31.1. Soviet era changes (1965-'87) in land cover and change percentages within Vayots Dzor, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	6.39E+06	6.4	41.2	15.5	34.8		22.6		29.0	-12.1	-29.5
2	forest	barren	forest loss	barren gain	3.35E+05	0.3	4.3		84.5	1.0	55.0	1.9			
3	forest	grass	forest loss	grassland gain	3.29E+07	32.9				94.7		64.6			
4	forest	crop	forest loss	cropland gain	1.47E+06	1.5				4.2		3.2			
5	forest	urban	forest loss	urban gain	1.38E+03	0.0				0.0		11.8			
6	forest	wetland	forest loss	wetland gain	3.73E+04	0.0				0.1		6.2			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	3.45E+03	0.0	13.5		12.2	0.0	17.9	0.0	19.2	5.7	42.4
9	barren	barren	stable barren	stable barren	1.24E+06	1.2	1.4	9.2	90.8		133.1				
10	barren	grass	barren loss	grassland gain	1.18E+07	11.8				96.4		23.1			
11	barren	crop	barren loss	cropland gain	4.34E+05	0.4				3.6		0.9			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.21E+07	22.1	890.0		84.5	26.1	51.0	97.5	856.6	-33.5	-3.8
16	grass	barren	grassland loss	barren gain	1.76E+07	17.6	93.5		9.5	20.8	5.7	98.1			
17	grass	grass	stable grassland	stable grass	8.06E+08	805.6		90.5							
18	grass	crop	grassland loss	cropland gain	4.43E+07	44.3				52.4		95.3			
19	grass	urban	grassland loss	urban gain	1.04E+04	0.0				0.0		88.2			
20	grass	wetland	grassland loss	wetland gain	5.42E+05	0.5				0.6		90.9			
21	grass	water	grassland loss	water gain	2.55E+04	0.0				0.0		90.2			
22	crop	forest	cropland loss	forest gain	2.94E+05	0.3	4.8		4.4	6.7	46.4	1.3	46.9	42.0	867.1
23	crop	barren	cropland loss	barren gain	0.00E+00	0.0	0.5		91.0	0.0	958.2	0.0			
24	crop	grass	cropland loss	grassland gain	4.10E+06	4.1				92.9		8.0			
25	crop	crop	stable cropland	stable cropland	4.35E+05	0.4		9.0							
26	crop	urban	cropland loss	urban gain	0.00E+00	0.0				0.0		0.0			
27	crop	wetland	cropland loss	wetland gain	1.66E+04	0.0				0.4		2.8			
28	crop	water	cropland loss	water gain	2.76E+03	0.0				0.1		9.8			
29	urban	forest	urban loss	forest gain	2.78E+05	0.3	2.7		2.7	10.1	0.0	1.2	0.0	-2.7	-99.6
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.3		100.0	0.0	0.4	0.0			
31	urban	grass	urban loss	grass gain	2.19E+06	2.2				80.0		4.3			
32	urban	crop	urban loss	crop gain	2.69E+05	0.3				9.8		0.6			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	6.91E+02	0.0				0.0		0.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.6	0.0	0.6	0.6	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.0	0.0	0.0	0.0	NA
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
45	water	grass	water loss	grassland gain	0.00E+00	0.0				NA		0.0			
46	water	crop	water loss	cropland gain	0.00E+00	0.0				NA		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				NA		0.0			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				NA		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		NA							
	Total					952.2									

Appendix 2.2.4.31.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Vayots Dzor, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.23E+07	22.3	29.0	77.1	6.6		20.5		42.9	13.9	47.9
2	forest	barren	forest loss	barren gain	2.07E+03	0.0	3.0		22.9	0.0	70.8	0.1			
3	forest	grass	forest loss	grassland gain	3.66E+06	3.7				55.1		9.7			
4	forest	crop	forest loss	cropland gain	2.93E+06	2.9				44.2		3.9			
5	forest	urban	forest loss	urban gain	1.24E+04	0.0				0.2		5.6			
6	forest	wetland	forest loss	wetland gain	3.52E+04	0.0				0.5		12.4			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	9.45E+04	0.1	19.1		14.2	0.7	1.5	0.5	6.4	-12.7	-66.6
9	barren	barren	stable barren	stable barren	4.87E+06	4.9	2.0	25.6	74.4		7.8				
10	barren	grass	barren loss	grassland gain	1.36E+07	13.6				95.7		36.1			
11	barren	crop	barren loss	cropland gain	5.10E+05	0.5				3.6		0.7			
12	barren	urban	barren loss	urban gain	6.89E+02	0.0				0.0		0.3			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.78E+07	17.8	855.4		90.9	19.6	37.7	86.6	802.2	-53.2	-6.2
16	grass	barren	grassland loss	barren gain	1.44E+06	1.4	90.0		10.6	1.6	4.4	96.9			
17	grass	grass	stable grassland	stable grass	7.65E+08	764.5		89.4							
18	grass	crop	grassland loss	cropland gain	7.14E+07	71.4				78.5		95.3			
19	grass	urban	grassland loss	urban gain	2.00E+05	0.2				0.2		89.5			
20	grass	wetland	grassland loss	wetland gain	1.15E+05	0.1				0.1		40.5			
21	grass	water	grassland loss	water gain	2.76E+03	0.0				0.0		6.5			
22	crop	forest	cropland loss	forest gain	2.63E+06	2.6	46.8		22.8	11.5	74.9	12.8	98.9	52.1	111.2
23	crop	barren	cropland loss	barren gain	4.35E+04	0.0	4.9		48.7	0.2	159.9	2.9			
24	crop	grass	cropland loss	grassland gain	2.00E+07	20.0				87.6		53.0			
25	crop	crop	stable cropland	stable cropland	2.40E+07	24.0		51.3							
26	crop	urban	cropland loss	urban gain	1.04E+04	0.0				0.0		4.6			
27	crop	wetland	cropland loss	wetland gain	1.32E+05	0.1				0.6		46.6			
28	crop	water	cropland loss	water gain	4.83E+03	0.0				0.0		11.3			
29	urban	forest	urban loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	0.2	0.0	0.2	0.2	1,806.5
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	1,906.5	0.0			
31	urban	grass	urban loss	grass gain	1.17E+04	0.0				100.0		0.0			
32	urban	crop	urban loss	crop gain	0.00E+00	0.0				0.0		0.0			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	0.00E+00	0.0				0.0		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	2.83E+04	0.0	0.6		0.6	5.0	0.3	0.1	0.3	-0.3	-47.1
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.1		94.6	0.0	47.4	0.0			
38	wetland	grass	wetland loss	grassland gain	4.30E+05	0.4				76.2		1.1			
39	wetland	crop	wetland loss	cropland gain	7.11E+04	0.1				12.6		0.1			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	3.25E+04	0.0		5.4							
42	wetland	water	wetland loss	water gain	3.52E+04	0.0				6.2		82.3			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	0.0	0.0	0.1	0.0	107.4
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		43.9	0.0	151.3	0.0			
45	water	grass	water loss	grassland gain	5.52E+03	0.0				44.4		0.0			
46	water	crop	water loss	cropland gain	5.52E+03	0.0				44.4		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.38E+03	0.0				11.1		0.5			
49	water	water	stable water	stable water	1.59E+04	0.0		56.1							
	Total					951.0									

Appendix 2.2.4.31.3. 50-year changes (1965-2015) in land cover and change percentages within Vayots Dzor, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	8.90E+06	8.9	41.2	21.6	32.3		34.0		42.9	1.7	4.2
2	forest	barren	forest loss	barren gain	1.17E+04	0.0	4.3		78.4	0.0	82.6	0.2			
3	forest	grass	forest loss	grassland gain	2.23E+07	22.3				69.0		55.4			
4	forest	crop	forest loss	cropland gain	9.97E+06	10.0				30.9		10.2			
5	forest	urban	forest loss	urban gain	6.91E+03	0.0				0.0		5.3			
6	forest	wetland	forest loss	wetland gain	2.21E+04	0.0				0.1		7.0			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	1.38E+04	0.0	13.5		12.7	0.1	5.7	0.0	6.4	-7.0	-52.2
9	barren	barren	stable barren	stable barren	7.62E+05	0.8	1.4	5.7	94.3		42.1				
10	barren	grass	barren loss	grassland gain	1.24E+07	12.4				97.6		30.8			
11	barren	crop	barren loss	cropland gain	2.91E+05	0.3				2.3		0.3			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	3.35E+07	33.5	890.0		126.9	26.4	40.2	98.7	803.3	-86.7	-9.7
16	grass	barren	grassland loss	barren gain	5.62E+06	5.6	93.5		14.3	4.4	4.5	99.1			
17	grass	grass	stable grassland	stable grass	7.63E+08	763.1		85.7							
18	grass	crop	grassland loss	cropland gain	8.74E+07	87.4				68.9		89.2			
19	grass	urban	grassland loss	urban gain	7.81E+04	0.1				0.1		60.4			
20	grass	wetland	grassland loss	wetland gain	2.10E+05	0.2				0.2		66.5			
21	grass	water	grassland loss	water gain	4.56E+04	0.0				0.0		77.6			
22	crop	forest	cropland loss	forest gain	1.37E+05	0.1	4.8		3.8	3.6	98.0	0.4	99.0	94.2	1,943.3
23	crop	barren	cropland loss	barren gain	5.53E+03	0.0	0.5		79.3	0.1	2,022.6	0.1			
24	crop	grass	cropland loss	grassland gain	3.59E+06	3.6				93.4		8.9			
25	crop	crop	stable cropland	stable cropland	1.00E+06	1.0		20.7							
26	crop	urban	cropland loss	urban gain	4.42E+04	0.0				1.2		34.2			
27	crop	wetland	cropland loss	wetland gain	5.39E+04	0.1				1.4		17.1			
28	crop	water	cropland loss	water gain	1.31E+04	0.0				0.3		22.4			
29	urban	forest	urban loss	forest gain	2.98E+05	0.3	2.7		2.6	11.3	0.1	0.9	0.2	-2.5	-91.8
30	urban	barren	urban loss	barren gain	3.18E+04	0.0	0.3		96.5	1.2	4.7	0.6			
31	urban	grass	urban loss	grass gain	1.94E+06	1.9				73.2		4.8			
32	urban	crop	urban loss	crop gain	3.50E+05	0.3				13.2		0.4			
33	urban	urban	stable urban	stable urban	9.47E+04	0.1		3.5							
34	urban	wetland	urban loss	wetland gain	2.97E+04	0.0				1.1		9.4			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.3	0.0	0.3	0.3	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.1	0.0	0.1	0.1	NA
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
45	water	grass	water loss	grassland gain	0.00E+00	0.0				NA		0.0			
46	water	crop	water loss	cropland gain	0.00E+00	0.0				NA		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				NA		0.0			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				NA		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		NA							
	Total					952.2									

Appendix 2.2.4.32.1. Soviet era changes (1965-'87) in land cover and change percentages within Syunik, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.78E+08	278.3	686.5	40.5	408.2		95.8		374.2	-312.4	-45.5
2	forest	barren	forest loss	barren gain	3.09E+06	3.1	32.7		59.5	0.8	14.0	17.1			
3	forest	grass	forest loss	grassland gain	3.17E+08	317.3				77.7		75.7			
4	forest	crop	forest loss	cropland gain	8.55E+07	85.5				21.0		37.8			
5	forest	urban	forest loss	urban gain	3.26E+05	0.3				0.1		51.5			
6	forest	wetland	forest loss	wetland gain	1.74E+06	1.7				0.4		60.8			
7	forest	water	forest loss	water gain	1.97E+05	0.2				0.0		18.1			
8	barren	forest	barren loss	forest gain	5.12E+05	0.5	99.9		86.1	0.6	18.1	0.5	31.9	-68.0	-68.1
9	barren	barren	stable barren	stable barren	1.38E+07	13.8	4.8	13.8	86.2		18.1				
10	barren	grass	barren loss	grassland gain	8.06E+07	80.6				93.6		19.2			
11	barren	crop	barren loss	cropland gain	4.76E+06	4.8				5.5		2.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	4.53E+04	0.0				0.1		1.6			
14	barren	water	barren loss	water gain	1.52E+05	0.2				0.2		13.9			
15	grass	forest	grassland loss	forest gain	9.49E+07	94.9	1,253.0		247.0	38.4	419.2	99.0	1,425.1	172.1	13.7
16	grass	barren	grassland loss	barren gain	1.47E+07	14.7	59.7		19.7	6.0	33.5	81.5			
17	grass	grass	stable grassland	stable grass	1.01E+09	1,006.0		80.3							
18	grass	crop	grassland loss	cropland gain	1.36E+08	135.5				54.9		59.8			
19	grass	urban	grassland loss	urban gain	3.08E+05	0.3				0.1		48.5			
20	grass	wetland	grassland loss	wetland gain	9.04E+05	0.9				0.4		31.5			
21	grass	water	grassland loss	water gain	6.89E+05	0.7				0.3		63.3			
22	crop	forest	cropland loss	forest gain	3.73E+05	0.4	55.5		20.3	1.8	226.5	0.4	261.7	206.2	371.5
23	crop	barren	cropland loss	barren gain	4.88E+04	0.0	2.6		36.6	0.2	408.1	0.3			
24	crop	grass	cropland loss	grassland gain	1.97E+07	19.7				97.1		4.7			
25	crop	crop	stable cropland	stable cropland	3.52E+07	35.2		63.4							
26	crop	urban	cropland loss	urban gain	0.00E+00	0.0				0.0		0.0			
27	crop	wetland	cropland loss	wetland gain	1.16E+05	0.1				0.6		4.1			
28	crop	water	cropland loss	water gain	4.59E+04	0.0				0.2		4.2			
29	urban	forest	urban loss	forest gain	4.10E+04	0.0	2.3		2.3	1.8	0.6	0.0	0.7	-1.6	-71.2
30	urban	barren	urban loss	barren gain	2.08E+05	0.2	0.1		98.8	9.2	27.6	1.2			
31	urban	grass	urban loss	grass gain	1.41E+06	1.4				61.9		0.3			
32	urban	crop	urban loss	crop gain	6.02E+05	0.6				26.5		0.3			
33	urban	urban	stable urban	stable urban	2.78E+04	0.0		1.2							
34	urban	wetland	urban loss	wetland gain	6.94E+03	0.0				0.3		0.2			
35	urban	water	urban loss	water gain	5.57E+03	0.0				0.2		0.5			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	2.9	0.0	2.9	2.9	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	8.53E+03	0.0	0.3		0.3	3.0	1.1	0.0	1.1	0.8	266.5
44	water	barren	water loss	barren gain	8.36E+02	0.0	0.0		94.3	0.3	360.8	0.0			
45	water	grass	water loss	grassland gain	1.29E+05	0.1				45.2		0.0			
46	water	crop	water loss	cropland gain	9.45E+04	0.1				33.2		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	5.19E+04	0.1				18.3		1.8			
49	water	water	stable water	stable water	1.73E+04	0.0		5.7							
	Total					2,097.5									

Appendix 2.2.4.32.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Syunik, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.52E+08	351.5	373.5	94.1	22.0		124.7		476.3	102.7	27.5
2	forest	barren	forest loss	barren gain	2.25E+05	0.2	17.9		5.9	1.0	33.4	4.9			
3	forest	grass	forest loss	grassland gain	1.29E+07	12.9				58.5		11.1			
4	forest	crop	forest loss	cropland gain	8.76E+06	8.8				39.8		5.0			
5	forest	urban	forest loss	urban gain	5.57E+03	0.0				0.0		0.5			
6	forest	wetland	forest loss	wetland gain	1.13E+05	0.1				0.5		10.5			
7	forest	water	forest loss	water gain	3.34E+04	0.0				0.2		2.6			
8	barren	forest	barren loss	forest gain	3.98E+05	0.4	31.6		20.9	1.9	4.6	0.3	15.3	-16.3	-51.5
9	barren	barren	stable barren	stable barren	1.07E+07	10.7	1.5	33.9	66.1		14.6				
10	barren	grass	barren loss	grassland gain	1.85E+07	18.5				88.5		16.0			
11	barren	crop	barren loss	cropland gain	1.80E+06	1.8				8.6		1.0			
12	barren	urban	barren loss	urban gain	1.11E+05	0.1				0.5		9.0			
13	barren	wetland	barren loss	wetland gain	7.44E+04	0.1				0.4		6.9			
14	barren	water	barren loss	water gain	1.88E+04	0.0				0.1		1.5			
15	grass	forest	grassland loss	forest gain	9.45E+07	94.5	1,419.7		262.6	36.0	115.9	75.7	1,272.9	-146.7	-10.3
16	grass	barren	grassland loss	barren gain	3.41E+06	3.4	67.9		18.5	1.3	8.2	73.8			
17	grass	grass	stable grassland	stable grass	1.16E+09	1,157.1		81.5							
18	grass	crop	grassland loss	cropland gain	1.63E+08	162.8				62.0		93.6			
19	grass	urban	grassland loss	urban gain	9.95E+05	1.0				0.4		81.1			
20	grass	wetland	grassland loss	wetland gain	4.13E+05	0.4				0.2		38.2			
21	grass	water	grassland loss	water gain	4.96E+05	0.5				0.2		38.8			
22	crop	forest	cropland loss	forest gain	2.87E+07	28.7	261.5		113.9	25.2	174.0	23.0	321.6	60.1	23.0
23	crop	barren	cropland loss	barren gain	9.13E+05	0.9	12.5		43.5	0.8	66.5	19.8			
24	crop	grass	cropland loss	grassland gain	8.34E+07	83.4				73.2		71.9			
25	crop	crop	stable cropland	stable cropland	1.48E+08	147.6		56.5							
26	crop	urban	cropland loss	urban gain	1.15E+05	0.1				0.1		9.3			
27	crop	wetland	cropland loss	wetland gain	2.80E+05	0.3				0.2		25.9			
28	crop	water	cropland loss	water gain	4.79E+05	0.5				0.4		37.4			
29	urban	forest	urban loss	forest gain	1.81E+04	0.0	0.7		0.5	3.3	1.2	0.0	1.3	0.7	102.5
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		83.0	0.0	185.5	0.0			
31	urban	grass	urban loss	grass gain	4.10E+05	0.4				74.7		0.4			
32	urban	crop	urban loss	crop gain	1.17E+05	0.1				21.4		0.1			
33	urban	urban	stable urban	stable urban	1.12E+05	0.1		17.0							
34	urban	wetland	urban loss	wetland gain	3.48E+03	0.0				0.6		0.3			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.10E+06	1.1	2.9		2.4	45.2	1.1	0.9	1.5	-1.4	-47.7
37	wetland	barren	wetland loss	barren gain	9.06E+03	0.0	0.1		85.4	0.4	37.7	0.2			
38	wetland	grass	wetland loss	grassland gain	6.46E+05	0.6				26.4		0.6			
39	wetland	crop	wetland loss	cropland gain	4.32E+05	0.4				17.7		0.2			
40	wetland	urban	wetland loss	urban gain	6.96E+02	0.0				0.0		0.1			
41	wetland	wetland	stable wetland	stable wetland	4.17E+05	0.4		14.6							
42	wetland	water	wetland loss	water gain	2.52E+05	0.3				10.3		19.7			
43	water	forest	water loss	forest gain	4.60E+04	0.0	1.1		0.4	11.7	1.3	0.0	2.0	0.9	79.8
44	water	barren	water loss	barren gain	6.38E+04	0.1	0.1		35.4	16.2	115.3	1.4			
45	water	grass	water loss	grassland gain	7.17E+04	0.1				18.2		0.1			
46	water	crop	water loss	cropland gain	1.60E+04	0.0				4.1		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.96E+05	0.2				49.8		18.1			
49	water	water	stable water	stable water	7.17E+05	0.7		64.6							
	Total					2,090.9									

Appendix 2.2.4.32.3. 50-year changes (1965-2015) in land cover and change percentages within Syunik, Armenia.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.47E+08	346.8	686.5	50.5	339.7		130.2		477.0	-209.5	-30.5
2	forest	barren	forest loss	barren gain	6.36E+05	0.6	32.7		49.5	0.2	19.0	22.1			
3	forest	grass	forest loss	grassland gain	2.64E+08	263.5				77.6		72.9			
4	forest	crop	forest loss	cropland gain	7.36E+07	73.6				21.7		26.3			
5	forest	urban	forest loss	urban gain	5.15E+05	0.5				0.2		45.5			
6	forest	wetland	forest loss	wetland gain	4.59E+05	0.5				0.1		30.4			
7	forest	water	forest loss	water gain	9.33E+05	0.9				0.3		48.6			
8	barren	forest	barren loss	forest gain	5.25E+05	0.5	99.9		87.1	0.6	2.9	0.4	15.7	-84.2	-84.3
9	barren	barren	stable barren	stable barren	1.28E+07	12.8	4.8	12.8	87.2		2.9				
10	barren	grass	barren loss	grassland gain	8.41E+07	84.1				96.6		23.3			
11	barren	crop	barren loss	cropland gain	2.35E+06	2.3				2.7		0.8			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	2.80E+03	0.0				0.0		0.2			
14	barren	water	barren loss	water gain	1.05E+05	0.1				0.1		5.4			
15	grass	forest	grassland loss	forest gain	1.29E+08	129.2	1,253.0		336.6	38.4	361.6	99.2	1,278.0	25.0	2.0
16	grass	barren	grassland loss	barren gain	2.03E+06	2.0	59.7		26.9	0.6	28.9	70.6			
17	grass	grass	stable grassland	stable grass	9.16E+08	916.4		73.1							
18	grass	crop	grassland loss	cropland gain	2.03E+08	203.1				60.4		72.6			
19	grass	urban	grassland loss	urban gain	6.00E+05	0.6				0.2		53.0			
20	grass	wetland	grassland loss	wetland gain	9.61E+05	1.0				0.3		63.8			
21	grass	water	grassland loss	water gain	6.86E+05	0.7				0.2		35.7			
22	crop	forest	cropland loss	forest gain	3.57E+05	0.4	55.5		13.2	2.7	279.7	0.3	322.0	266.5	480.2
23	crop	barren	cropland loss	barren gain	6.68E+04	0.1	2.6		23.8	0.5	504.0	2.3			
24	crop	grass	cropland loss	grassland gain	1.27E+07	12.7				96.0		3.5			
25	crop	crop	stable cropland	stable cropland	4.23E+07	42.3		76.2							
26	crop	urban	cropland loss	urban gain	1.67E+04	0.0				0.1		1.5			
27	crop	wetland	cropland loss	wetland gain	1.60E+04	0.0				0.1		1.1			
28	crop	water	cropland loss	water gain	7.70E+04	0.1				0.6		4.0			
29	urban	forest	urban loss	forest gain	9.31E+04	0.1	2.3		2.1	4.5	1.1	0.1	1.3	-1.0	-41.6
30	urban	barren	urban loss	barren gain	1.44E+05	0.1	0.1		90.8	6.9	49.3	5.0			
31	urban	grass	urban loss	grass gain	1.21E+06	1.2				57.8		0.3			
32	urban	crop	urban loss	crop gain	5.02E+05	0.5				24.1		0.2			
33	urban	urban	stable urban	stable urban	2.11E+05	0.2		9.2							
34	urban	wetland	urban loss	wetland gain	1.95E+04	0.0				0.9		1.3			
35	urban	water	urban loss	water gain	1.21E+05	0.1				5.8		6.3			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	1.5	0.0	1.5	1.5	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	2.51E+04	0.0	0.3		0.2	10.8	1.9	0.0	2.0	1.7	559.3
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		77.1	0.0	636.4	0.0			
45	water	grass	water loss	grassland gain	7.74E+04	0.1				33.3		0.0			
46	water	crop	water loss	cropland gain	8.14E+04	0.1				35.0		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	4.87E+04	0.0				21.0		3.2			
49	water	water	stable water	stable water	6.93E+04	0.1		22.9							
	Total					2,097.5									

Appendix 2.2.4.33.1. Soviet era changes (1965-'87) in land cover and change percentages within Ganja-Gazakh, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.98E+08	998.4	2,278.8	43.8	1,280.4		247.1		1,245.5	-1,033.3	-45.3
2	forest	barren	forest loss	barren gain	5.04E+06	5.0	19.5		56.2	0.4	10.8	11.0			
3	forest	grass	forest loss	grassland gain	9.32E+08	931.8				72.8		48.6			
4	forest	crop	forest loss	cropland gain	3.01E+08	300.9				23.5		19.7			
5	forest	urban	forest loss	urban gain	3.41E+05	0.3				0.0		8.8			
6	forest	wetland	forest loss	wetland gain	9.30E+06	9.3				0.7		14.4			
7	forest	water	forest loss	water gain	3.31E+07	33.1				2.6		30.4			
8	barren	forest	barren loss	forest gain	7.69E+05	0.8	79.7		54.6	1.4	45.8	0.3	70.8	-8.9	-11.1
9	barren	barren	stable barren	stable barren	2.50E+07	25.0	0.7	31.4	68.6		57.5				
10	barren	grass	barren loss	grassland gain	5.28E+07	52.8				96.6		2.8			
11	barren	crop	barren loss	cropland gain	1.03E+06	1.0				1.9		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	4.46E+04	0.0				0.1		0.1			
14	barren	water	barren loss	water gain	1.60E+04	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.04E+08	203.9	6,832.9		1,403.6	14.5	1,917.6	82.5	7,346.9	513.9	7.5
16	grass	barren	grassland loss	barren gain	3.67E+07	36.7	58.4		20.5	2.6	28.1	80.1			
17	grass	grass	stable grassland	stable grass	5.43E+09	5,429.3		79.5							
18	grass	crop	grassland loss	cropland gain	1.11E+09	1,109.6				79.1		72.6			
19	grass	urban	grassland loss	urban gain	1.65E+06	1.6				0.1		42.6			
20	grass	wetland	grassland loss	wetland gain	1.49E+07	14.9				1.1		23.2			
21	grass	water	grassland loss	water gain	3.68E+07	36.8				2.6		33.8			
22	crop	forest	cropland loss	forest gain	2.69E+07	26.9	2,101.8		890.6	3.0	1,528.1	10.9	2,739.3	637.5	30.3
23	crop	barren	cropland loss	barren gain	2.96E+06	3.0	18.0		42.4	0.3	72.7	6.5			
24	crop	grass	cropland loss	grassland gain	8.00E+08	799.9				89.8		41.7			
25	crop	crop	stable cropland	stable cropland	1.21E+09	1,211.2		57.6							
26	crop	urban	cropland loss	urban gain	1.63E+06	1.6				0.2		42.3			
27	crop	wetland	cropland loss	wetland gain	2.42E+07	24.2				2.7		37.6			
28	crop	water	cropland loss	water gain	3.50E+07	35.0				3.9		32.2			
29	urban	forest	urban loss	forest gain	1.25E+07	12.5	210.9		208.7	6.0	3.9	5.1	6.1	-204.8	-97.1
30	urban	barren	urban loss	barren gain	6.29E+05	0.6	1.8		98.9	0.3	1.8	1.4			
31	urban	grass	urban loss	grass gain	9.89E+07	98.9				47.4		5.2			
32	urban	crop	urban loss	crop gain	8.63E+07	86.3				41.3		5.6			
33	urban	urban	stable urban	stable urban	2.23E+06	2.2		1.1							
34	urban	wetland	urban loss	wetland gain	6.50E+06	6.5				3.1		10.1			
35	urban	water	urban loss	water gain	3.91E+06	3.9				1.9		3.6			
36	wetland	forest	wetland loss	forest gain	1.37E+03	0.0	0.0		0.0	6.9	64.4	0.0	64.4	64.4	324,882.9
37	wetland	barren	wetland loss	barren gain	6.85E+02	0.0	0.0		100.0	3.5	324,982.9	0.0			
38	wetland	grass	wetland loss	grassland gain	1.71E+04	0.0				86.2		0.0			
39	wetland	crop	wetland loss	cropland gain	6.85E+02	0.0				3.5		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	3.01E+06	3.0	201.4		77.6	3.9	108.8	1.2	232.6	31.2	15.5
44	water	barren	water loss	barren gain	4.62E+05	0.5	1.7		38.5	0.6	54.0	1.0			
45	water	grass	water loss	grassland gain	3.42E+07	34.2				44.1		1.8			
46	water	crop	water loss	cropland gain	3.03E+07	30.3				39.0		2.0			
47	water	urban	water loss	urban gain	2.43E+05	0.2				0.3		6.3			
48	water	wetland	water loss	wetland gain	9.44E+06	9.4				12.2		14.7			
49	water	water	stable water	stable water	1.24E+08	123.8		61.5							
	Total					11,705.6									

Appendix 2.2.4.33.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Ganja-Gazakh, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.35E+08	935.3	1,245.4	75.1	310.0		140.5		1,075.9	-169.5	-13.6
2	forest	barren	forest loss	barren gain	2.29E+05	0.2	10.6		24.9	0.1	11.3	0.5			
3	forest	grass	forest loss	grassland gain	2.10E+08	210.4				67.9		15.9			
4	forest	crop	forest loss	cropland gain	9.49E+07	94.9				30.6		10.8			
5	forest	urban	forest loss	urban gain	5.03E+04	0.1				0.0		0.2			
6	forest	wetland	forest loss	wetland gain	3.43E+06	3.4				1.1		5.9			
7	forest	water	forest loss	water gain	1.07E+06	1.1				0.3		2.6			
8	barren	forest	barren loss	forest gain	3.32E+05	0.3	70.1		40.2	0.8	45.7	0.2	75.6	5.5	7.9
9	barren	barren	stable barren	stable barren	2.99E+07	29.9	0.6	42.7	57.3		65.2				
10	barren	grass	barren loss	grassland gain	3.75E+07	37.5				93.5		2.8			
11	barren	crop	barren loss	cropland gain	1.52E+06	1.5				3.8		0.2			
12	barren	urban	barren loss	urban gain	1.18E+05	0.1				0.3		0.4			
13	barren	wetland	barren loss	wetland gain	1.57E+05	0.2				0.4		0.3			
14	barren	water	barren loss	water gain	5.04E+05	0.5				1.3		1.2			
15	grass	forest	grassland loss	forest gain	8.34E+07	83.4	7,345.7		908.5	9.2	1,319.4	59.3	7,756.6	410.9	5.6
16	grass	barren	grassland loss	barren gain	4.32E+07	43.2	62.8		12.4	4.8	18.0	94.5			
17	grass	grass	stable grassland	stable grass	6.44E+09	6,437.1		87.6							
18	grass	crop	grassland loss	cropland gain	7.31E+08	731.2				80.5		83.5			
19	grass	urban	grassland loss	urban gain	2.23E+07	22.3				2.5		71.2			
20	grass	wetland	grassland loss	wetland gain	1.39E+07	13.9				1.5		23.8			
21	grass	water	grassland loss	water gain	1.46E+07	14.6				1.6		36.1			
22	crop	forest	cropland loss	forest gain	5.02E+07	50.2	2,739.2		1,152.0	4.4	875.7	35.7	2,462.9	-276.3	-10.1
23	crop	barren	cropland loss	barren gain	1.90E+06	1.9	23.4		42.1	0.2	32.0	4.2			
24	crop	grass	cropland loss	grassland gain	1.04E+09	1,043.7				90.6		79.1			
25	crop	crop	stable cropland	stable cropland	1.59E+09	1,587.2		57.9							
26	crop	urban	cropland loss	urban gain	8.68E+06	8.7				0.8		27.7			
27	crop	wetland	cropland loss	wetland gain	3.28E+07	32.8				2.8		56.1			
28	crop	water	cropland loss	water gain	1.47E+07	14.7				1.3		36.5			
29	urban	forest	urban loss	forest gain	1.91E+04	0.0	6.1		3.8	0.5	31.3	0.0	33.6	27.6	452.8
30	urban	barren	urban loss	barren gain	2.59E+04	0.0	0.1		61.9	0.7	514.7	0.1			
31	urban	grass	urban loss	grass gain	3.12E+06	3.1				82.8		0.2			
32	urban	crop	urban loss	crop gain	4.20E+05	0.4				11.2		0.0			
33	urban	urban	stable urban	stable urban	2.32E+06	2.3		38.1							
34	urban	wetland	urban loss	wetland gain	1.40E+05	0.1				3.7		0.2			
35	urban	water	urban loss	water gain	4.14E+04	0.0				1.1		0.1			
36	wetland	forest	wetland loss	forest gain	6.22E+06	6.2	64.4		47.4	13.1	58.4	4.4	75.4	11.0	17.1
37	wetland	barren	wetland loss	barren gain	2.34E+05	0.2	0.6		73.7	0.5	90.8	0.5			
38	wetland	grass	wetland loss	grassland gain	1.22E+07	12.2				25.8		0.9			
39	wetland	crop	wetland loss	cropland gain	1.92E+07	19.2				40.5		2.2			
40	wetland	urban	wetland loss	urban gain	6.53E+04	0.1				0.1		0.2			
41	wetland	wetland	stable wetland	stable wetland	1.69E+07	16.9		26.3							
42	wetland	water	wetland loss	water gain	9.47E+06	9.5				20.0		23.4			
43	water	forest	water loss	forest gain	3.97E+05	0.4	232.5		49.6	0.8	40.4	0.3	223.3	-9.2	-4.0
44	water	barren	water loss	barren gain	1.41E+05	0.1	2.0		21.3	0.3	17.4	0.3			
45	water	grass	water loss	grassland gain	1.24E+07	12.4				25.1		0.9			
46	water	crop	water loss	cropland gain	2.85E+07	28.5				57.4		3.3			
47	water	urban	water loss	urban gain	9.71E+04	0.1				0.2		0.3			
48	water	wetland	water loss	wetland gain	8.03E+06	8.0				16.2		13.7			
49	water	water	stable water	stable water	1.83E+08	182.9		78.7							
	Total					11,703.3									

Appendix 2.2.4.33.3. 50-year changes (1965-2015) in land cover and change percentages within Ganja-Gazakh, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.01E+08	900.7	2,278.8	39.5	1,378.1		175.2		1,075.9	-1,202.9	-52.8
2	forest	barren	forest loss	barren gain	3.20E+06	3.2	19.5		60.5	0.2	7.7	6.2			
3	forest	grass	forest loss	grassland gain	1.01E+09	1,012.8				73.5		48.2			
4	forest	crop	forest loss	cropland gain	3.22E+08	322.0				23.4		23.7			
5	forest	urban	forest loss	urban gain	1.53E+06	1.5				0.1		7.9			
6	forest	wetland	forest loss	wetland gain	7.60E+06	7.6				0.6		10.1			
7	forest	water	forest loss	water gain	3.10E+07	31.0				2.2		30.3			
8	barren	forest	barren loss	forest gain	4.38E+05	0.4	79.7		54.6	0.8	51.3	0.2	76.4	-3.3	-4.2
9	barren	barren	stable barren	stable barren	2.51E+07	25.1	0.7	31.4	68.6		64.4				
10	barren	grass	barren loss	grassland gain	5.35E+07	53.5				98.0		2.6			
11	barren	crop	barren loss	cropland gain	6.31E+05	0.6				1.2		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	5.49E+03	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.29E+08	128.8	6,832.9		1,174.8	11.0	2,099.6	73.5	7,757.8	924.8	13.5
16	grass	barren	grassland loss	barren gain	4.48E+07	44.8	58.4		17.2	3.8	30.7	87.2			
17	grass	grass	stable grassland	stable grass	5.66E+09	5,658.2		82.8							
18	grass	crop	grassland loss	cropland gain	9.47E+08	947.2				80.6		69.8			
19	grass	urban	grassland loss	urban gain	9.84E+06	9.8				0.8		50.9			
20	grass	wetland	grassland loss	wetland gain	1.73E+07	17.3				1.5		23.0			
21	grass	water	grassland loss	water gain	2.69E+07	26.9				2.3		26.3			
22	crop	forest	cropland loss	forest gain	2.70E+07	27.0	2,101.8		995.6	2.7	1,356.9	15.4	2,463.1	361.3	17.2
23	crop	barren	cropland loss	barren gain	2.16E+06	2.2	18.0		47.4	0.2	64.6	4.2			
24	crop	grass	cropland loss	grassland gain	8.86E+08	886.3				89.0		42.2			
25	crop	crop	stable cropland	stable cropland	1.11E+09	1,106.2		52.6							
26	crop	urban	cropland loss	urban gain	6.78E+06	6.8				0.7		35.0			
27	crop	wetland	cropland loss	wetland gain	3.39E+07	33.9				3.4		45.0			
28	crop	water	cropland loss	water gain	3.94E+07	39.4				4.0		38.5			
29	urban	forest	urban loss	forest gain	1.53E+07	15.3	210.9		196.6	7.8	19.3	8.8	33.6	-177.3	-84.1
30	urban	barren	urban loss	barren gain	1.09E+06	1.1	1.8		93.2	0.6	9.2	2.1			
31	urban	grass	urban loss	grass gain	1.10E+08	110.3				56.1		5.3			
32	urban	crop	urban loss	crop gain	5.76E+07	57.6				29.3		4.2			
33	urban	urban	stable urban	stable urban	1.43E+07	14.3		6.8							
34	urban	wetland	urban loss	wetland gain	7.30E+06	7.3				3.7		9.7			
35	urban	water	urban loss	water gain	4.96E+06	5.0				2.5		4.8			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	75.4	0.0	75.4	75.4	380,458.3
37	wetland	barren	wetland loss	barren gain	6.85E+02	0.0	0.0		100.0	3.5	380,558.3	0.0			
38	wetland	grass	wetland loss	grassland gain	1.91E+04	0.0				96.5		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				0.0		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	3.66E+06	3.7	201.4		80.4	4.5	102.3	2.1	223.4	22.0	10.9
44	water	barren	water loss	barren gain	9.77E+04	0.1	1.7		39.9	0.1	50.8	0.2			
45	water	grass	water loss	grassland gain	3.67E+07	36.7				45.7		1.7			
46	water	crop	water loss	cropland gain	2.95E+07	29.5				36.7		2.2			
47	water	urban	water loss	urban gain	1.20E+06	1.2				1.5		6.2			
48	water	wetland	water loss	wetland gain	9.25E+06	9.3				11.5		12.3			
49	water	water	stable water	stable water	1.21E+08	121.1		60.1							
	Total					11,705.6									

Appendix 2.2.4.34.1. Soviet era changes (1965-'87) in land cover and change percentages within Kalbajar-Lachin, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.21E+08	920.6	2,073.6	44.4	1,153.0		114.6		1,035.3	-1,038.4	-50.1
2	forest	barren	forest loss	barren gain	1.21E+07	12.1	47.3		55.6	1.1	5.5	25.8			
3	forest	grass	forest loss	grassland gain	8.41E+08	841.4				73.0		91.0			
4	forest	crop	forest loss	cropland gain	2.92E+08	292.2				25.3		51.7			
5	forest	urban	forest loss	urban gain	2.01E+06	2.0				0.2		57.7			
6	forest	wetland	forest loss	wetland gain	4.74E+06	4.7				0.4		58.1			
7	forest	water	forest loss	water gain	5.42E+05	0.5				0.0		26.3			
8	barren	forest	barren loss	forest gain	1.34E+05	0.1	49.6		35.7	0.4	47.2	0.1	61.0	11.5	23.1
9	barren	barren	stable barren	stable barren	1.39E+07	13.9	1.1	28.0	72.0		95.2				
10	barren	grass	barren loss	grassland gain	3.49E+07	34.9				97.7		3.8			
11	barren	crop	barren loss	cropland gain	6.06E+05	0.6				1.7		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	4.68E+04	0.0				0.1		0.6			
14	barren	water	barren loss	water gain	3.79E+04	0.0				0.1		1.8			
15	grass	forest	grassland loss	forest gain	1.11E+08	110.8	2,139.1		415.7	26.6	925.0	96.6	2,648.4	509.3	23.8
16	grass	barren	grassland loss	barren gain	3.37E+07	33.7	48.7		19.4	8.1	43.2	71.5			
17	grass	grass	stable grassland	stable grass	1.72E+09	1,723.4		80.6							
18	grass	crop	grassland loss	cropland gain	2.66E+08	265.9				64.0		47.1			
19	grass	urban	grassland loss	urban gain	1.47E+06	1.5				0.4		42.2			
20	grass	wetland	grassland loss	wetland gain	2.50E+06	2.5				0.6		30.7			
21	grass	water	grassland loss	water gain	1.41E+06	1.4				0.3		68.4			
22	crop	forest	cropland loss	forest gain	3.28E+06	3.3	107.6		45.8	7.2	564.9	2.9	626.6	519.0	482.5
23	crop	barren	cropland loss	barren gain	6.89E+05	0.7	2.5		42.6	1.5	525.1	1.5			
24	crop	grass	cropland loss	grassland gain	4.12E+07	41.2				89.8		4.4			
25	crop	crop	stable cropland	stable cropland	6.17E+07	61.7		57.4							
26	crop	urban	cropland loss	urban gain	3.44E+03	0.0				0.0		0.1			
27	crop	wetland	cropland loss	wetland gain	6.40E+05	0.6				1.4		7.9			
28	crop	water	cropland loss	water gain	6.95E+04	0.1				0.2		3.4			
29	urban	forest	urban loss	forest gain	3.82E+05	0.4	10.4		10.4	3.7	3.5	0.3	3.5	-6.9	-66.3
30	urban	barren	urban loss	barren gain	3.99E+05	0.4	0.2		100.0	3.9	33.7	0.8			
31	urban	grass	urban loss	grass gain	5.92E+06	5.9				57.1		0.6			
32	urban	crop	urban loss	crop gain	3.64E+06	3.6				35.2		0.6			
33	urban	urban	stable urban	stable urban	3.44E+03	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	9.75E+03	0.0				0.1		0.1			
35	urban	water	urban loss	water gain	3.42E+03	0.0				0.0		0.2			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	8.2	0.0	8.2	8.2	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	7.98E+04	0.1	8.1		4.8	1.7	2.1	0.1	5.3	-2.8	-34.1
44	water	barren	water loss	barren gain	2.25E+05	0.2	0.2		59.6	4.7	25.5	0.5			
45	water	grass	water loss	grassland gain	1.67E+06	1.7				34.7		0.2			
46	water	crop	water loss	cropland gain	2.62E+06	2.6				54.5		0.5			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	2.13E+05	0.2				4.4		2.6			
49	water	water	stable water	stable water	3.26E+06	3.3		40.4							
	Total					4,388.3									

Appendix 2.2.4.34.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Kalbajar-Lachin, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.62E+08	961.5	1,035.2	92.9	73.7		267.2		1,228.8	193.6	18.7
2	forest	barren	forest loss	barren gain	6.18E+03	0.0	23.6		7.1	0.0	25.8	0.2			
3	forest	grass	forest loss	grassland gain	4.43E+07	44.3				60.2		14.4			
4	forest	crop	forest loss	cropland gain	2.77E+07	27.7				37.7		8.9			
5	forest	urban	forest loss	urban gain	5.93E+04	0.1				0.1		9.7			
6	forest	wetland	forest loss	wetland gain	1.37E+06	1.4				1.9		4.5			
7	forest	water	forest loss	water gain	1.37E+05	0.1				0.2		4.0			
8	barren	forest	barren loss	forest gain	1.33E+06	1.3	60.5		51.0	2.6	3.3	0.5	12.7	-47.8	-79.0
9	barren	barren	stable barren	stable barren	9.46E+06	9.5	1.4	15.6	84.4		5.4				
10	barren	grass	barren loss	grassland gain	4.69E+07	46.9				92.0		15.3			
11	barren	crop	barren loss	cropland gain	2.14E+06	2.1				4.2		0.7			
12	barren	urban	barren loss	urban gain	2.21E+04	0.0				0.0		3.6			
13	barren	wetland	barren loss	wetland gain	3.55E+05	0.4				0.7		1.2			
14	barren	water	barren loss	water gain	2.61E+05	0.3				0.5		7.7			
15	grass	forest	grassland loss	forest gain	1.57E+08	156.7	2,646.7		448.9	34.9	306.9	58.7	2,504.7	-142.0	-5.4
16	grass	barren	grassland loss	barren gain	2.94E+06	2.9	60.3		17.0	0.7	11.6	90.4			
17	grass	grass	stable grassland	stable grass	2.20E+09	2,197.8		83.0							
18	grass	crop	grassland loss	cropland gain	2.79E+08	279.0				62.2		89.6			
19	grass	urban	grassland loss	urban gain	4.46E+05	0.4				0.1		72.8			
20	grass	wetland	grassland loss	wetland gain	8.87E+06	8.9				2.0		29.1			
21	grass	water	grassland loss	water gain	8.74E+05	0.9				0.2		25.7			
22	crop	forest	cropland loss	forest gain	1.05E+08	104.5	626.4		338.7	30.9	311.3	39.1	599.0	-27.4	-4.4
23	crop	barren	cropland loss	barren gain	2.16E+05	0.2	14.3		54.1	0.1	49.7	6.6			
24	crop	grass	cropland loss	grassland gain	2.12E+08	212.4				62.7		69.2			
25	crop	crop	stable cropland	stable cropland	2.88E+08	287.7		45.9							
26	crop	urban	cropland loss	urban gain	6.34E+04	0.1				0.0		10.3			
27	crop	wetland	cropland loss	wetland gain	1.97E+07	19.7				5.8		64.5			
28	crop	water	cropland loss	water gain	1.81E+06	1.8				0.5		53.4			
29	urban	forest	urban loss	forest gain	3.39E+05	0.3	3.5		3.3	10.3	0.6	0.1	0.8	-2.7	-76.8
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.1		94.4	0.0	17.6	0.0			
31	urban	grass	urban loss	grass gain	2.26E+06	2.3				68.7		0.7			
32	urban	crop	urban loss	crop gain	6.87E+05	0.7				20.9		0.2			
33	urban	urban	stable urban	stable urban	1.96E+05	0.2		5.6							
34	urban	wetland	urban loss	wetland gain	3.47E+03	0.0				0.1		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	3.80E+06	3.8	8.2		6.6	57.2	30.5	1.4	32.0	23.8	292.1
37	wetland	barren	wetland loss	barren gain	1.79E+04	0.0	0.2		81.4	0.3	373.4	0.6			
38	wetland	grass	wetland loss	grassland gain	8.40E+05	0.8				12.7		0.3			
39	wetland	crop	wetland loss	cropland gain	1.65E+06	1.7				24.9		0.5			
40	wetland	urban	wetland loss	urban gain	2.22E+04	0.0				0.3		3.6			
41	wetland	wetland	stable wetland	stable wetland	1.52E+06	1.5		18.6							
42	wetland	water	wetland loss	water gain	3.11E+05	0.3				4.7		9.2			
43	water	forest	water loss	forest gain	4.68E+05	0.5	5.3		0.9	53.8	3.4	0.2	7.9	2.5	47.4
44	water	barren	water loss	barren gain	7.09E+04	0.1	0.1		16.3	8.2	63.6	2.2			
45	water	grass	water loss	grassland gain	4.98E+04	0.0				5.7		0.0			
46	water	crop	water loss	cropland gain	6.23E+04	0.1				7.2		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	2.18E+05	0.2				25.1		0.7			
49	water	water	stable water	stable water	4.47E+06	4.5		83.7							
	Total					4,385.8									

Appendix 2.2.4.34.3. 50-year changes (1965-2015) in land cover and change percentages within Kalbajar-Lachin, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.08E+09	1,079.0	2,073.6	52.0	994.7		149.9		1,228.9	-844.8	-40.7
2	forest	barren	forest loss	barren gain	1.56E+05	0.2	47.3		48.0	0.0	7.2	3.6			
3	forest	grass	forest loss	grassland gain	7.51E+08	751.4				75.5		90.2			
4	forest	crop	forest loss	cropland gain	2.35E+08	235.4				23.7		43.3			
5	forest	urban	forest loss	urban gain	5.66E+05	0.6				0.1		70.0			
6	forest	wetland	forest loss	wetland gain	5.71E+06	5.7				0.6		17.8			
7	forest	water	forest loss	water gain	1.47E+06	1.5				0.1		33.7			
8	barren	forest	barren loss	forest gain	1.77E+05	0.2	49.6		41.0	0.4	4.4	0.1	12.9	-36.6	-73.9
9	barren	barren	stable barren	stable barren	8.54E+06	8.5	1.1	17.2	82.8		8.8				
10	barren	grass	barren loss	grassland gain	4.04E+07	40.4				98.6		4.9			
11	barren	crop	barren loss	cropland gain	4.09E+05	0.4				1.0		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	7.59E+03	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.44E+08	143.7	2,139.1		465.2	30.9	832.6	95.9	2,506.5	367.4	17.2
16	grass	barren	grassland loss	barren gain	4.11E+06	4.1	48.7		21.7	0.9	38.9	93.7			
17	grass	grass	stable grassland	stable grass	1.67E+09	1,673.9		78.3							
18	grass	crop	grassland loss	cropland gain	3.04E+08	304.0				65.3		55.9			
19	grass	urban	grassland loss	urban gain	2.43E+05	0.2				0.1		30.0			
20	grass	wetland	grassland loss	wetland gain	1.14E+07	11.4				2.5		35.6			
21	grass	water	grassland loss	water gain	1.73E+06	1.7				0.4		39.8			
22	crop	forest	cropland loss	forest gain	4.76E+06	4.8	107.6		51.9	9.2	543.5	3.2	599.2	491.6	457.0
23	crop	barren	cropland loss	barren gain	6.89E+02	0.0	2.5		48.2	0.0	505.2	0.0			
24	crop	grass	cropland loss	grassland gain	3.52E+07	35.2				67.8		4.2			
25	crop	crop	stable cropland	stable cropland	5.57E+07	55.7		51.8							
26	crop	urban	cropland loss	urban gain	0.00E+00	0.0				0.0		0.0			
27	crop	wetland	cropland loss	wetland gain	1.17E+07	11.7				22.6		36.6			
28	crop	water	cropland loss	water gain	2.08E+05	0.2				0.4		4.8			
29	urban	forest	urban loss	forest gain	7.88E+05	0.8	10.4		10.4	7.6	0.8	0.5	0.8	-9.5	-92.2
30	urban	barren	urban loss	barren gain	2.75E+03	0.0	0.2		100.0	0.0	7.8	0.1			
31	urban	grass	urban loss	grass gain	4.70E+06	4.7				45.4		0.6			
32	urban	crop	urban loss	crop gain	2.73E+06	2.7				26.3		0.5			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	1.20E+06	1.2				11.6		3.7			
35	urban	water	urban loss	water gain	9.44E+05	0.9				9.1		21.7			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	32.0	0.0	32.0	32.0	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	4.91E+05	0.5	8.1		4.5	11.0	4.4	0.3	7.9	-0.1	-1.6
44	water	barren	water loss	barren gain	1.18E+05	0.1	0.2		55.5	2.6	53.9	2.7			
45	water	grass	water loss	grassland gain	9.05E+05	0.9				20.2		0.1			
46	water	crop	water loss	cropland gain	9.94E+05	1.0				22.2		0.2			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	1.98E+06	2.0				44.1		6.2			
49	water	water	stable water	stable water	3.59E+06	3.6		44.5							
	Total					4,388.3									

Appendix 2.2.4.35.1. Soviet era changes (1965-'87) in land cover and change percentages within Nakhchivan, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.81E+06	1.8	79.5	2.3	77.7		5.6		7.4	-72.1	-90.7
2	forest	barren	forest loss	barren gain	1.63E+06	1.6	7.3		97.7	2.1	7.0	6.0			
3	forest	grass	forest loss	grassland gain	6.45E+07	64.5				83.0		68.2			
4	forest	crop	forest loss	cropland gain	1.09E+07	10.9				14.0		27.4			
5	forest	urban	forest loss	urban gain	6.21E+05	0.6				0.8		11.6			
6	forest	wetland	forest loss	wetland gain	8.29E+04	0.1				0.1		26.8			
7	forest	water	forest loss	water gain	9.79E+03	0.0				0.0		8.2			
8	barren	forest	barren loss	forest gain	2.08E+05	0.2	42.8		30.8	0.7	27.3	3.7	39.4	-3.5	-8.1
9	barren	barren	stable barren	stable barren	1.21E+07	12.1	3.9	28.1	71.9		63.8				
10	barren	grass	barren loss	grassland gain	2.71E+07	27.1				88.0		28.7			
11	barren	crop	barren loss	cropland gain	3.38E+06	3.4				11.0		8.5			
12	barren	urban	barren loss	urban gain	2.38E+04	0.0				0.1		0.4			
13	barren	wetland	barren loss	wetland gain	4.88E+03	0.0				0.0		1.6			
14	barren	water	barren loss	water gain	7.37E+04	0.1				0.2		62.0			
15	grass	forest	grassland loss	forest gain	5.32E+06	5.3	964.1		61.3	8.7	94.5	95.3	997.3	33.2	3.4
16	grass	barren	grassland loss	barren gain	2.57E+07	25.7	88.4		6.4	41.9	9.8	94.0			
17	grass	grass	stable grassland	stable grass	9.03E+08	902.8		93.6							
18	grass	crop	grassland loss	cropland gain	2.54E+07	25.4				41.4		64.0			
19	grass	urban	grassland loss	urban gain	4.72E+06	4.7				7.7		88.0			
20	grass	wetland	grassland loss	wetland gain	2.08E+05	0.2				0.3		67.1			
21	grass	water	grassland loss	water gain	1.85E+04	0.0				0.0		15.6			
22	crop	forest	cropland loss	forest gain	1.19E+04	0.0	4.1		2.8	0.4	39.6	0.2	40.9	36.8	900.5
23	crop	barren	cropland loss	barren gain	1.05E+04	0.0	0.4		69.4	0.4	969.9	0.0			
24	crop	grass	cropland loss	grassland gain	2.78E+06	2.8				98.1		2.9			
25	crop	crop	stable cropland	stable cropland	1.25E+06	1.2		30.6							
26	crop	urban	cropland loss	urban gain	0.00E+00	0.0				0.0		0.0			
27	crop	wetland	cropland loss	wetland gain	1.40E+04	0.0				0.5		4.5			
28	crop	water	cropland loss	water gain	1.68E+04	0.0				0.6		14.1			
29	urban	forest	urban loss	forest gain	4.12E+04	0.0	0.2		0.2	17.9	5.4	0.7	5.4	5.1	2,232.2
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	2,332.2	0.0			
31	urban	grass	urban loss	grass gain	1.78E+05	0.2				77.3		0.2			
32	urban	crop	urban loss	crop gain	1.12E+04	0.0				4.8		0.0			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	0.00E+00	0.0				0.0		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.3	0.0	0.3	0.3	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	0.1	0.0	0.1	0.1	1,444.7
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	1,544.7	0.0			
45	water	grass	water loss	grassland gain	2.10E+03	0.0				27.3		0.0			
46	water	crop	water loss	cropland gain	5.59E+03	0.0				72.7		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				0.0		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					1,090.8									

Appendix 2.2.4.35.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Nakhchivan, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.53E+06	3.5	7.4	47.9	3.8		5.4		8.9	1.6	21.1
2	forest	barren	forest loss	barren gain	6.79E+04	0.1	0.7		52.1	1.8	73.2	3.9			
3	forest	grass	forest loss	grassland gain	2.26E+06	2.3				58.9		4.6			
4	forest	crop	forest loss	cropland gain	1.44E+06	1.4				37.6		1.8			
5	forest	urban	forest loss	urban gain	7.69E+03	0.0				0.2		2.3			
6	forest	wetland	forest loss	wetland gain	6.07E+04	0.1				1.6		9.5			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	1.20E+05	0.1	38.9		31.3	0.4	1.8	2.2	9.3	-29.6	-76.0
9	barren	barren	stable barren	stable barren	7.55E+06	7.6	3.6	19.4	80.6		4.5				
10	barren	grass	barren loss	grassland gain	2.81E+07	28.1				89.6		57.8			
11	barren	crop	barren loss	cropland gain	3.14E+06	3.1				10.0		3.9			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	1.26E+04	0.0				0.0		2.0			
14	barren	water	barren loss	water gain	1.70E+02	0.0				0.0		0.2			
15	grass	forest	grassland loss	forest gain	3.90E+06	3.9	991.8		82.7	4.7	48.6	72.4	957.7	-34.1	-3.4
16	grass	barren	grassland loss	barren gain	1.38E+06	1.4	91.4		8.3	1.7	4.9	78.4			
17	grass	grass	stable grassland	stable grass	9.09E+08	909.1		91.7							
18	grass	crop	grassland loss	cropland gain	7.67E+07	76.7				92.8		94.2			
19	grass	urban	grassland loss	urban gain	3.16E+05	0.3				0.4		93.8			
20	grass	wetland	grassland loss	wetland gain	2.68E+05	0.3				0.3		41.8			
21	grass	water	grassland loss	water gain	7.18E+04	0.1				0.1		71.7			
22	crop	forest	cropland loss	forest gain	1.18E+06	1.2	40.8		14.7	8.1	81.5	22.0	107.6	66.8	163.7
23	crop	barren	cropland loss	barren gain	2.73E+05	0.3	3.8		36.1	1.9	199.7	15.5			
24	crop	grass	cropland loss	grassland gain	1.29E+07	12.9				87.8		26.6			
25	crop	crop	stable cropland	stable cropland	2.61E+07	26.1		63.9							
26	crop	urban	cropland loss	urban gain	1.33E+04	0.0				0.1		3.9			
27	crop	wetland	cropland loss	wetland gain	2.93E+05	0.3				2.0		45.7			
28	crop	water	cropland loss	water gain	2.75E+04	0.0				0.2		27.4			
29	urban	forest	urban loss	forest gain	4.61E+04	0.0	5.4		5.4	0.9	0.3	0.9	0.3	-5.0	-93.6
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.5		99.9	0.0	6.3	0.0			
31	urban	grass	urban loss	grass gain	5.27E+06	5.3				98.2		10.8			
32	urban	crop	urban loss	crop gain	5.31E+04	0.1				1.0		0.1			
33	urban	urban	stable urban	stable urban	4.88E+03	0.0		0.1							
34	urban	wetland	urban loss	wetland gain	0.00E+00	0.0				0.0		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	9.27E+04	0.1	0.3		0.3	34.2	0.6	1.7	0.7	0.4	121.5
37	wetland	barren	wetland loss	barren gain	2.79E+03	0.0	0.0		89.2	1.0	210.7	0.2			
38	wetland	grass	wetland loss	grassland gain	6.03E+04	0.1				22.2		0.1			
39	wetland	crop	wetland loss	cropland gain	1.15E+05	0.1				42.4		0.1			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	3.27E+04	0.0		10.8							
42	wetland	water	wetland loss	water gain	6.72E+02	0.0				0.2		0.7			
43	water	forest	water loss	forest gain	4.67E+04	0.0	0.1		0.1	42.2	0.1	0.9	0.1	0.0	-8.9
44	water	barren	water loss	barren gain	3.68E+04	0.0	0.0		93.0	33.2	84.1	2.1			
45	water	grass	water loss	grassland gain	1.67E+04	0.0				15.1		0.0			
46	water	crop	water loss	cropland gain	3.50E+03	0.0				3.2		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	6.99E+03	0.0				6.3		1.1			
49	water	water	stable water	stable water	8.33E+03	0.0		7.0							
	Total					1,084.7									

Appendix 2.2.4.35.3. 50-year changes (1965-2015) in land cover and change percentages within Nakhchivan, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.82E+06	1.8	79.5	2.3	77.7		7.1		8.9	-70.5	-88.8
2	forest	barren	forest loss	barren gain	6.00E+05	0.6	7.3		97.7	0.8	9.0	27.1			
3	forest	grass	forest loss	grassland gain	5.59E+07	55.9				71.9		60.5			
4	forest	crop	forest loss	cropland gain	2.09E+07	20.9				26.9		19.5			
5	forest	urban	forest loss	urban gain	3.84E+04	0.0				0.0		11.2			
6	forest	wetland	forest loss	wetland gain	2.78E+05	0.3				0.4		41.4			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	1.95E+05	0.2	42.8		35.5	0.5	2.2	2.7	9.5	-33.3	-77.7
9	barren	barren	stable barren	stable barren	7.34E+06	7.3	3.9	17.1	82.9		5.2				
10	barren	grass	barren loss	grassland gain	3.30E+07	33.0				92.9		35.8			
11	barren	crop	barren loss	cropland gain	2.29E+06	2.3				6.4		2.1			
12	barren	urban	barren loss	urban gain	1.68E+04	0.0				0.0		4.9			
13	barren	wetland	barren loss	wetland gain	3.49E+03	0.0				0.0		0.5			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	6.89E+06	6.9	964.1		93.0	7.4	92.3	96.8	963.4	-0.7	-0.1
16	grass	barren	grassland loss	barren gain	1.61E+06	1.6	88.4		9.6	1.7	9.6	72.9			
17	grass	grass	stable grassland	stable grass	8.71E+08	871.2		90.4							
18	grass	crop	grassland loss	cropland gain	8.37E+07	83.7				90.1		78.3			
19	grass	urban	grassland loss	urban gain	2.82E+05	0.3				0.3		82.3			
20	grass	wetland	grassland loss	wetland gain	3.64E+05	0.4				0.4		54.2			
21	grass	water	grassland loss	water gain	9.45E+04	0.1				0.1		90.5			
22	crop	forest	cropland loss	forest gain	1.19E+04	0.0	4.1		3.3	0.4	106.9	0.2	107.7	103.7	2,536.0
23	crop	barren	cropland loss	barren gain	0.00E+00	0.0	0.4		80.4	0.0	2,616.4	0.0			
24	crop	grass	cropland loss	grassland gain	3.23E+06	3.2				98.4		3.5			
25	crop	crop	stable cropland	stable cropland	8.02E+05	0.8		19.6							
26	crop	urban	cropland loss	urban gain	5.59E+03	0.0				0.2		1.6			
27	crop	wetland	cropland loss	wetland gain	2.59E+04	0.0				0.8		3.9			
28	crop	water	cropland loss	water gain	9.95E+03	0.0				0.3		9.5			
29	urban	forest	urban loss	forest gain	1.82E+04	0.0	0.2		0.2	7.9	0.3	0.3	0.3	0.1	48.9
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	148.9	0.0			
31	urban	grass	urban loss	grass gain	1.70E+05	0.2				73.9		0.2			
32	urban	crop	urban loss	crop gain	4.19E+04	0.0				18.2		0.0			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	0.00E+00	0.0				0.0		0.0			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.7	0.0	0.7	0.7	NA
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		NA	NA	NA	0.0			
38	wetland	grass	wetland loss	grassland gain	0.00E+00	0.0				NA		0.0			
39	wetland	crop	wetland loss	cropland gain	0.00E+00	0.0				NA		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				NA		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		NA							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				NA		0.0			
43	water	forest	water loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	0.1	0.0	0.1	0.1	1,258.4
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	1,358.4	0.0			
45	water	grass	water loss	grassland gain	3.50E+03	0.0				45.5		0.0			
46	water	crop	water loss	cropland gain	4.19E+03	0.0				54.5		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	0.00E+00	0.0				0.0		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					1,090.8									

Appendix 2.2.4.36.1. Soviet era changes (1965-'87) in land cover and change percentages within Yukhari Karabakh, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	8.72E+08	871.6	2,067.4	42.2	1,195.8		97.3		968.9	-1,098.6	-53.1
2	forest	barren	forest loss	barren gain	9.04E+07	90.4	31.3		57.8	7.6	4.7	23.2			
3	forest	grass	forest loss	grassland gain	7.16E+08	716.2				59.9		61.9			
4	forest	crop	forest loss	cropland gain	3.71E+08	370.8				31.0		30.7			
5	forest	urban	forest loss	urban gain	9.92E+05	1.0				0.1		24.2			
6	forest	wetland	forest loss	wetland gain	1.60E+07	16.0				1.3		55.9			
7	forest	water	forest loss	water gain	1.43E+06	1.4				0.1		35.1			
8	barren	forest	barren loss	forest gain	5.14E+04	0.1	5.0		3.0	1.7	389.4	0.1	391.4	386.4	7,693.5
9	barren	barren	stable barren	stable barren	2.03E+06	2.0	0.1	40.5	59.5		7,753.0				
10	barren	grass	barren loss	grassland gain	2.46E+06	2.5				82.2		0.2			
11	barren	crop	barren loss	cropland gain	4.80E+05	0.5				16.1		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	1.15E+03	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	9.09E+07	90.9	3,491.0		1,168.2	7.8	1,156.8	93.4	3,479.5	-11.5	-0.3
16	grass	barren	grassland loss	barren gain	2.80E+08	280.2	52.9		33.5	24.0	33.1	72.0			
17	grass	grass	stable grassland	stable grass	2.32E+09	2,322.7		66.5							
18	grass	crop	grassland loss	cropland gain	7.90E+08	790.4				67.7		65.4			
19	grass	urban	grassland loss	urban gain	1.45E+06	1.4				0.1		35.3			
20	grass	wetland	grassland loss	wetland gain	4.47E+06	4.5				0.4		15.6			
21	grass	water	grassland loss	water gain	8.84E+05	0.9				0.1		21.7			
22	crop	forest	cropland loss	forest gain	5.23E+06	5.2	925.6		414.4	1.3	1,208.1	5.4	1,719.3	793.7	85.8
23	crop	barren	cropland loss	barren gain	1.52E+07	15.2	14.0		44.8	3.7	130.5	3.9			
24	crop	grass	cropland loss	grassland gain	3.84E+08	384.5				92.8		33.2			
25	crop	crop	stable cropland	stable cropland	5.11E+08	511.2		55.2							
26	crop	urban	cropland loss	urban gain	1.48E+06	1.5				0.4		36.1			
27	crop	wetland	cropland loss	wetland gain	6.70E+06	6.7				1.6		23.4			
28	crop	water	cropland loss	water gain	1.33E+06	1.3				0.3		32.8			
29	urban	forest	urban loss	forest gain	8.53E+05	0.9	72.9		72.5	1.2	4.1	0.9	4.5	-68.4	-93.8
30	urban	barren	urban loss	barren gain	2.88E+06	2.9	1.1		99.5	4.0	5.6	0.7			
31	urban	grass	urban loss	grass gain	3.70E+07	37.0				51.1		3.2			
32	urban	crop	urban loss	crop gain	3.04E+07	30.4				42.0		2.5			
33	urban	urban	stable urban	stable urban	3.91E+05	0.4		0.5							
34	urban	wetland	urban loss	wetland gain	9.11E+05	0.9				1.3		3.2			
35	urban	water	urban loss	water gain	4.19E+05	0.4				0.6		10.3			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	28.6	0.0	28.6	28.6	71,665.7
37	wetland	barren	wetland loss	barren gain	3.43E+03	0.0	0.0		100.0	8.6	71,765.7	0.0			
38	wetland	grass	wetland loss	grassland gain	9.61E+03	0.0				24.1		0.0			
39	wetland	crop	wetland loss	cropland gain	2.68E+04	0.0				67.3		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	2.60E+05	0.3	34.6		34.3	0.8	4.1	0.3	4.3	-30.2	-87.4
44	water	barren	water loss	barren gain	7.28E+05	0.7	0.5		99.2	2.1	11.8	0.2			
45	water	grass	water loss	grassland gain	1.66E+07	16.6				48.3		1.4			
46	water	crop	water loss	cropland gain	1.60E+07	16.0				46.6		1.3			
47	water	urban	water loss	urban gain	1.82E+05	0.2				0.5		4.4			
48	water	wetland	water loss	wetland gain	5.54E+05	0.6				1.6		1.9			
49	water	water	stable water	stable water	2.77E+05	0.3		0.8							
	Total					6,596.5									

Appendix 2.2.4.36.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Yukhari Karabakh, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.18E+08	917.8	968.7	94.7	51.0		250.5		1,168.3	199.6	20.6
2	forest	barren	forest loss	barren gain	3.09E+04	0.0	14.7		5.3	0.1	25.9	0.9			
3	forest	grass	forest loss	grassland gain	2.74E+07	27.4				53.7		2.4			
4	forest	crop	forest loss	cropland gain	2.27E+07	22.7				44.5		3.3			
5	forest	urban	forest loss	urban gain	3.64E+04	0.0				0.1		1.2			
6	forest	wetland	forest loss	wetland gain	7.59E+05	0.8				1.5		2.5			
7	forest	water	forest loss	water gain	6.45E+04	0.1				0.1		1.0			
8	barren	forest	barren loss	forest gain	1.90E+06	1.9	391.1		387.7	0.5	3.3	0.8	6.7	-384.4	-98.3
9	barren	barren	stable barren	stable barren	3.37E+06	3.4	5.9	0.9	99.1		0.8				
10	barren	grass	barren loss	grassland gain	3.66E+08	366.2				94.5		32.6			
11	barren	crop	barren loss	cropland gain	1.82E+07	18.2				4.7		2.6			
12	barren	urban	barren loss	urban gain	8.32E+05	0.8				0.2		27.0			
13	barren	wetland	barren loss	wetland gain	3.01E+05	0.3				0.1		1.0			
14	barren	water	barren loss	water gain	2.30E+05	0.2				0.1		3.6			
15	grass	forest	grassland loss	forest gain	1.17E+08	117.4	3,477.7		774.7	15.2	1,124.4	46.9	3,827.4	349.7	10.1
16	grass	barren	grassland loss	barren gain	2.57E+06	2.6	52.8		22.3	0.3	32.3	77.7			
17	grass	grass	stable grassland	stable grass	2.70E+09	2,702.9		77.7							
18	grass	crop	grassland loss	cropland gain	6.41E+08	641.1				82.8		92.6			
19	grass	urban	grassland loss	urban gain	1.77E+06	1.8				0.2		57.3			
20	grass	wetland	grassland loss	wetland gain	9.45E+06	9.4				1.2		31.6			
21	grass	water	grassland loss	water gain	2.46E+06	2.5				0.3		38.3			
22	crop	forest	cropland loss	forest gain	1.18E+08	117.6	1,717.2		865.9	13.6	692.5	46.9	1,543.8	-173.3	-10.1
23	crop	barren	cropland loss	barren gain	6.74E+05	0.7	26.1		50.4	0.1	40.3	20.4			
24	crop	grass	cropland loss	grassland gain	7.26E+08	725.8				83.8		64.6			
25	crop	crop	stable cropland	stable cropland	8.51E+08	851.3		49.6							
26	crop	urban	cropland loss	urban gain	4.37E+05	0.4				0.1		14.2			
27	crop	wetland	cropland loss	wetland gain	1.79E+07	17.9				2.1		60.1			
28	crop	water	cropland loss	water gain	3.40E+06	3.4				0.4		53.0			
29	urban	forest	urban loss	forest gain	7.60E+04	0.1	4.5		4.3	1.8	3.1	0.0	3.3	-1.2	-27.0
30	urban	barren	urban loss	barren gain	3.11E+04	0.0	0.1		95.7	0.7	68.7	0.9			
31	urban	grass	urban loss	grass gain	2.53E+06	2.5				58.9		0.2			
32	urban	crop	urban loss	crop gain	1.62E+06	1.6				37.7		0.2			
33	urban	urban	stable urban	stable urban	1.91E+05	0.2		4.3							
34	urban	wetland	urban loss	wetland gain	3.88E+04	0.0				0.9		0.1			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.36E+07	13.6	28.0		24.6	55.3	29.9	5.4	33.3	5.3	18.9
37	wetland	barren	wetland loss	barren gain	1.38E+03	0.0	0.4		87.8	0.0	106.6	0.0			
38	wetland	grass	wetland loss	grassland gain	2.13E+06	2.1				8.7		0.2			
39	wetland	crop	wetland loss	cropland gain	8.57E+06	8.6				34.9		1.2			
40	wetland	urban	wetland loss	urban gain	7.64E+03	0.0				0.0		0.2			
41	wetland	wetland	stable wetland	stable wetland	3.42E+06	3.4		12.2							
42	wetland	water	wetland loss	water gain	2.65E+05	0.3				1.1		4.1			
43	water	forest	water loss	forest gain	2.20E+04	0.0	4.1		2.0	1.1	6.4	0.0	8.5	4.4	108.0
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.1		49.7	0.0	157.7	0.0			
45	water	grass	water loss	grassland gain	3.16E+05	0.3				15.6		0.0			
46	water	crop	water loss	cropland gain	3.17E+05	0.3				15.7		0.0			
47	water	urban	water loss	urban gain	4.86E+03	0.0				0.2		0.2			
48	water	wetland	water loss	wetland gain	1.36E+06	1.4				67.4		4.6			
49	water	water	stable water	stable water	2.05E+06	2.0		50.3							
	Total					6,591.2									

Appendix 2.2.4.36.3. 50-year changes (1965-2015) in land cover and change percentages within Yukhari Karabakh, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.05E+09	1,054.5	2,067.4	51.0	1,012.9		114.2		1,168.7	-898.8	-43.5
2	forest	barren	forest loss	barren gain	5.05E+05	0.5	31.3		49.0	0.0	5.5	8.4			
3	forest	grass	forest loss	grassland gain	8.00E+08	800.1				79.0		63.0			
4	forest	crop	forest loss	cropland gain	2.00E+08	199.9				19.7		19.0			
5	forest	urban	forest loss	urban gain	5.53E+05	0.6				0.1		18.7			
6	forest	wetland	forest loss	wetland gain	8.60E+06	8.6				0.8		24.7			
7	forest	water	forest loss	water gain	3.22E+06	3.2				0.3		41.8			
8	barren	forest	barren loss	forest gain	1.16E+05	0.1	5.0		4.4	2.7	6.0	0.1	6.7	1.7	33.0
9	barren	barren	stable barren	stable barren	6.53E+05	0.7	0.1	13.0	87.0		120.0				
10	barren	grass	barren loss	grassland gain	3.80E+06	3.8				87.0		0.3			
11	barren	crop	barren loss	cropland gain	4.52E+05	0.5				10.4		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.08E+08	107.8	3,491.0		932.0	11.6	1,270.6	94.4	3,829.6	338.6	9.7
16	grass	barren	grassland loss	barren gain	4.63E+06	4.6	52.9		26.7	0.5	36.4	76.9			
17	grass	grass	stable grassland	stable grass	2.56E+09	2,559.0		73.3							
18	grass	crop	grassland loss	cropland gain	8.07E+08	806.8				86.6		76.9			
19	grass	urban	grassland loss	urban gain	1.68E+06	1.7				0.2		56.6			
20	grass	wetland	grassland loss	wetland gain	8.36E+06	8.4				0.9		24.0			
21	grass	water	grassland loss	water gain	2.67E+06	2.7				0.3		34.6			
22	crop	forest	cropland loss	forest gain	4.57E+06	4.6	925.6		430.6	1.1	1,049.7	4.0	1,544.7	619.2	66.9
23	crop	barren	cropland loss	barren gain	4.20E+05	0.4	14.0		46.5	0.1	113.4	7.0			
24	crop	grass	cropland loss	grassland gain	4.13E+08	413.0				95.9		32.5			
25	crop	crop	stable cropland	stable cropland	4.95E+08	495.0		53.5							
26	crop	urban	cropland loss	urban gain	5.25E+05	0.5				0.1		17.7			
27	crop	wetland	cropland loss	wetland gain	1.11E+07	11.1				2.6		31.8			
28	crop	water	cropland loss	water gain	9.34E+05	0.9				0.2		12.1			
29	urban	forest	urban loss	forest gain	1.21E+06	1.2	72.9		72.6	1.7	3.0	1.1	3.3	-69.6	-95.5
30	urban	barren	urban loss	barren gain	4.46E+05	0.4	1.1		99.5	0.6	4.1	7.4			
31	urban	grass	urban loss	grass gain	3.69E+07	36.9				50.9		2.9			
32	urban	crop	urban loss	crop gain	3.04E+07	30.4				41.9		2.9			
33	urban	urban	stable urban	stable urban	3.35E+05	0.3		0.5							
34	urban	wetland	urban loss	wetland gain	2.71E+06	2.7				3.7		7.8			
35	urban	water	urban loss	water gain	8.84E+05	0.9				1.2		11.5			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	34.9	0.0	34.9	34.8	87,356.6
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	87,456.6	0.0			
38	wetland	grass	wetland loss	grassland gain	2.20E+04	0.0				55.1		0.0			
39	wetland	crop	wetland loss	cropland gain	1.79E+04	0.0				44.9		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	4.78E+05	0.5	34.6		33.6	1.4	7.7	0.4	8.7	-25.9	-74.9
44	water	barren	water loss	barren gain	2.30E+04	0.0	0.5		97.2	0.1	22.3	0.4			
45	water	grass	water loss	grassland gain	1.67E+07	16.7				49.7		1.3			
46	water	crop	water loss	cropland gain	1.21E+07	12.1				35.9		1.1			
47	water	urban	water loss	urban gain	2.09E+05	0.2				0.6		7.0			
48	water	wetland	water loss	wetland gain	4.12E+06	4.1				12.3		11.8			
49	water	water	stable water	stable water	9.69E+05	1.0		2.8							
	Total					6,596.5									

Appendix 2.2.4.37.1. Soviet era changes (1965-'87) in land cover and change percentages within Sheki-Zagatala, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.77E+09	1,771.1	2,369.8	74.7	598.7		587.5		2,358.6	-11.2	-0.5
2	forest	barren	forest loss	barren gain	2.60E+07	26.0	30.4		25.3	4.3	24.8	4.4			
3	forest	grass	forest loss	grassland gain	2.38E+08	237.9				39.7		37.1			
4	forest	crop	forest loss	cropland gain	2.77E+08	277.1				46.3		31.0			
5	forest	urban	forest loss	urban gain	3.43E+06	3.4				0.6		23.1			
6	forest	wetland	forest loss	wetland gain	5.39E+07	53.9				9.0		29.6			
7	forest	water	forest loss	water gain	4.40E+05	0.4				0.1		6.0			
8	barren	forest	barren loss	forest gain	8.90E+05	0.9	28.2		2.5	35.8	592.4	0.2	618.1	589.9	2,091.4
9	barren	barren	stable barren	stable barren	2.57E+07	25.7	0.4	91.2	8.8		2,100.2				
10	barren	grass	barren loss	grassland gain	1.32E+06	1.3				53.3		0.2			
11	barren	crop	barren loss	cropland gain	1.05E+05	0.1				4.2		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	3.23E+04	0.0				1.3		0.0			
14	barren	water	barren loss	water gain	1.34E+05	0.1				5.4		1.8			
15	grass	forest	grassland loss	forest gain	3.47E+08	347.0	2,857.2		1,508.8	23.0	641.4	59.1	1,989.8	-867.5	-30.4
16	grass	barren	grassland loss	barren gain	5.30E+08	530.0	36.7		52.8	35.1	22.4	89.5			
17	grass	grass	stable grassland	stable grass	1.35E+09	1,348.4		47.2							
18	grass	crop	grassland loss	cropland gain	6.12E+08	612.3				40.6		68.4			
19	grass	urban	grassland loss	urban gain	6.34E+06	6.3				0.4		42.7			
20	grass	wetland	grassland loss	wetland gain	1.17E+07	11.7				0.8		6.4			
21	grass	water	grassland loss	water gain	1.58E+06	1.6				0.1		21.5			
22	crop	forest	cropland loss	forest gain	2.35E+08	234.9	2,492.0		777.1	30.2	895.2	40.0	2,610.2	118.1	4.7
23	crop	barren	cropland loss	barren gain	3.13E+07	31.3	32.0		31.2	4.0	35.9	5.3			
24	crop	grass	cropland loss	grassland gain	3.85E+08	385.5				49.6		60.1			
25	crop	crop	stable cropland	stable cropland	1.71E+09	1,715.0		68.8							
26	crop	urban	cropland loss	urban gain	4.97E+06	5.0				0.6		33.5			
27	crop	wetland	cropland loss	wetland gain	1.15E+08	115.2				14.8		63.2			
28	crop	water	cropland loss	water gain	5.19E+06	5.2				0.7		70.7			
29	urban	forest	urban loss	forest gain	3.23E+06	3.2	24.1		23.2	13.9	14.8	0.6	15.7	-8.4	-34.8
30	urban	barren	urban loss	barren gain	2.89E+06	2.9	0.3		96.3	12.4	61.5	0.5			
31	urban	grass	urban loss	grass gain	1.34E+07	13.4				57.6		2.1			
32	urban	crop	urban loss	crop gain	2.94E+06	2.9				12.7		0.3			
33	urban	urban	stable urban	stable urban	8.90E+05	0.9		3.7							
34	urban	wetland	urban loss	wetland gain	7.92E+05	0.8				3.4		0.4			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	2.48E+04	0.0	0.1		0.1	19.8	182.2	0.0	182.2	182.1	144,927.6
37	wetland	barren	wetland loss	barren gain	4.70E+03	0.0	0.0		100.0	3.7	145,027.6	0.0			
38	wetland	grass	wetland loss	grassland gain	5.71E+04	0.1				45.5		0.0			
39	wetland	crop	wetland loss	cropland gain	3.90E+04	0.0				31.0		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.40E+06	1.4	14.3		10.5	13.4	7.3	0.2	11.2	-3.1	-21.9
44	water	barren	water loss	barren gain	2.29E+06	2.3	0.2		73.3	21.9	51.4	0.4			
45	water	grass	water loss	grassland gain	3.26E+06	3.3				31.1		0.5			
46	water	crop	water loss	cropland gain	2.76E+06	2.8				26.4		0.3			
47	water	urban	water loss	urban gain	1.05E+05	0.1				1.0		0.7			
48	water	wetland	water loss	wetland gain	6.52E+05	0.7				6.2		0.4			
49	water	water	stable water	stable water	3.81E+06	3.8		26.7							
	Total					7,785.8									

Appendix 2.2.4.37.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Sheki-Zagatala, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.97E+09	1,972.7	2,358.5	83.6	385.7		255.0		2,227.7	-130.7	-5.5
2	forest	barren	forest loss	barren gain	1.02E+07	10.2	30.3		16.4	2.6	10.8	18.8			
3	forest	grass	forest loss	grassland gain	2.30E+08	229.9				59.6		16.2			
4	forest	crop	forest loss	cropland gain	1.10E+08	110.2				28.6		26.9			
5	forest	urban	forest loss	urban gain	2.54E+06	2.5				0.7		7.3			
6	forest	wetland	forest loss	wetland gain	3.18E+07	31.8				8.2		44.3			
7	forest	water	forest loss	water gain	1.10E+06	1.1				0.3		5.3			
8	barren	forest	barren loss	forest gain	8.45E+06	8.4	618.1		289.5	2.9	54.4	3.3	383.0	-235.2	-38.0
9	barren	barren	stable barren	stable barren	3.29E+08	328.6	7.9	53.2	46.8		8.8				
10	barren	grass	barren loss	grassland gain	2.58E+08	257.5				88.9		18.2			
11	barren	crop	barren loss	cropland gain	8.27E+06	8.3				2.9		2.0			
12	barren	urban	barren loss	urban gain	5.52E+06	5.5				1.9		15.8			
13	barren	wetland	barren loss	wetland gain	8.71E+05	0.9				0.3		1.2			
14	barren	water	barren loss	water gain	8.91E+06	8.9				3.1		43.0			
15	grass	forest	grassland loss	forest gain	8.42E+07	84.2	1,989.6		349.9	24.1	1,417.8	33.0	3,057.6	1,068.0	53.7
16	grass	barren	grassland loss	barren gain	3.73E+07	37.3	25.6		17.6	10.7	71.3	68.7			
17	grass	grass	stable grassland	stable grass	1.64E+09	1,639.8		82.4							
18	grass	crop	grassland loss	cropland gain	2.05E+08	205.2				58.7		50.2			
19	grass	urban	grassland loss	urban gain	1.44E+07	14.4				4.1		41.4			
20	grass	wetland	grassland loss	wetland gain	4.34E+06	4.3				1.2		6.0			
21	grass	water	grassland loss	water gain	4.33E+06	4.3				1.2		20.9			
22	crop	forest	cropland loss	forest gain	1.17E+08	116.7	2,610.0		1,065.9	10.9	409.0	45.8	1,953.1	-656.9	-25.2
23	crop	barren	cropland loss	barren gain	5.63E+06	5.6	33.5		40.8	0.5	15.7	10.4			
24	crop	grass	cropland loss	grassland gain	8.94E+08	894.1				83.9		63.1			
25	crop	crop	stable cropland	stable cropland	1.54E+09	1,544.1		59.2							
26	crop	urban	cropland loss	urban gain	1.09E+07	10.9				1.0		31.4			
27	crop	wetland	cropland loss	wetland gain	3.41E+07	34.1				3.2		47.4			
28	crop	water	cropland loss	water gain	4.53E+06	4.5				0.4		21.9			
29	urban	forest	urban loss	forest gain	5.12E+05	0.5	15.7		10.7	4.8	34.9	0.2	39.9	24.2	153.7
30	urban	barren	urban loss	barren gain	4.95E+05	0.5	0.2		67.8	4.6	221.5	0.9			
31	urban	grass	urban loss	grass gain	7.30E+06	7.3				68.4		0.5			
32	urban	crop	urban loss	crop gain	1.63E+06	1.6				15.3		0.4			
33	urban	urban	stable urban	stable urban	5.07E+06	5.1		32.2							
34	urban	wetland	urban loss	wetland gain	6.84E+05	0.7				6.4		1.0			
35	urban	water	urban loss	water gain	4.45E+04	0.0				0.4		0.2			
36	wetland	forest	wetland loss	forest gain	4.46E+07	44.6	182.2		160.1	27.9	71.8	17.5	94.0	-88.2	-48.4
37	wetland	barren	wetland loss	barren gain	3.12E+05	0.3	2.3		87.8	0.2	39.4	0.6			
38	wetland	grass	wetland loss	grassland gain	2.84E+07	28.4				17.7		2.0			
39	wetland	crop	wetland loss	cropland gain	8.35E+07	83.5				52.2		20.4			
40	wetland	urban	wetland loss	urban gain	1.44E+06	1.4				0.9		4.1			
41	wetland	wetland	stable wetland	stable wetland	2.21E+07	22.1		12.2							
42	wetland	water	wetland loss	water gain	1.81E+06	1.8				1.1		8.7			
43	water	forest	water loss	forest gain	5.08E+05	0.5	11.1		1.8	28.2	20.7	0.2	30.1	18.9	169.7
44	water	barren	water loss	barren gain	4.08E+05	0.4	0.1		16.2	22.7	185.9	0.8			
45	water	grass	water loss	grassland gain	6.57E+05	0.7				36.5		0.0			
46	water	crop	water loss	cropland gain	1.49E+05	0.1				8.3		0.0			
47	water	urban	water loss	urban gain	2.72E+03	0.0				0.2		0.0			
48	water	wetland	water loss	wetland gain	7.62E+04	0.1				4.2		0.1			
49	water	water	stable water	stable water	9.35E+06	9.3		83.8							
	Total					7,785.3									

Appendix 2.2.4.37.3. 50-year changes (1965-2015) in land cover and change percentages within Sheki-Zagatala, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.65E+09	1,654.0	2,369.8	69.8	715.8		573.8		2,227.8	-142.0	-6.0
2	forest	barren	forest loss	barren gain	1.41E+07	14.1	30.4		30.2	2.0	24.2	3.9			
3	forest	grass	forest loss	grassland gain	4.45E+08	445.2				62.2		33.1			
4	forest	crop	forest loss	cropland gain	2.01E+08	201.3				28.1		30.2			
5	forest	urban	forest loss	urban gain	8.63E+06	8.6				1.2		23.1			
6	forest	wetland	forest loss	wetland gain	4.55E+07	45.5				6.4		48.4			
7	forest	water	forest loss	water gain	1.09E+06	1.1				0.2		4.3			
8	barren	forest	barren loss	forest gain	7.48E+05	0.7	28.2		2.3	33.0	357.1	0.1	383.0	354.8	1,257.8
9	barren	barren	stable barren	stable barren	2.59E+07	25.9	0.4	92.0	8.0		1,265.9				
10	barren	grass	barren loss	grassland gain	1.45E+06	1.5				63.9		0.1			
11	barren	crop	barren loss	cropland gain	6.33E+04	0.1				2.8		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	2.69E+03	0.0				0.1		0.0			
14	barren	water	barren loss	water gain	4.70E+03	0.0				0.2		0.0			
15	grass	forest	grassland loss	forest gain	3.24E+08	323.9	2,857.2		1,145.5	28.3	1,346.0	56.5	3,057.7	200.5	7.0
16	grass	barren	grassland loss	barren gain	3.33E+08	332.6	36.7		40.1	29.0	47.1	93.1			
17	grass	grass	stable grassland	stable grass	1.71E+09	1,711.7		59.9							
18	grass	crop	grassland loss	cropland gain	4.61E+08	460.9				40.2		69.2			
19	grass	urban	grassland loss	urban gain	1.21E+07	12.1				1.1		32.3			
20	grass	wetland	grassland loss	wetland gain	9.03E+06	9.0				0.8		9.6			
21	grass	water	grassland loss	water gain	7.06E+06	7.1				0.6		27.6			
22	crop	forest	cropland loss	forest gain	2.44E+08	244.1	2,492.0		1,204.9	20.3	666.1	42.5	1,953.2	-538.8	-21.6
23	crop	barren	cropland loss	barren gain	7.64E+06	7.6	32.0		48.4	0.6	26.7	2.1			
24	crop	grass	cropland loss	grassland gain	8.81E+08	880.9				73.1		65.4			
25	crop	crop	stable cropland	stable cropland	1.29E+09	1,287.1		51.6							
26	crop	urban	cropland loss	urban gain	1.64E+07	16.4				1.4		43.9			
27	crop	wetland	cropland loss	wetland gain	3.85E+07	38.5				3.2		41.0			
28	crop	water	cropland loss	water gain	1.74E+07	17.4				1.4		68.1			
29	urban	forest	urban loss	forest gain	3.65E+06	3.7	24.1		21.5	17.0	37.3	0.6	39.9	15.8	65.5
30	urban	barren	urban loss	barren gain	1.08E+06	1.1	0.3		89.1	5.0	154.6	0.3			
31	urban	grass	urban loss	grass gain	1.40E+07	14.0				64.9		1.0			
32	urban	crop	urban loss	crop gain	2.25E+06	2.2				10.4		0.3			
33	urban	urban	stable urban	stable urban	2.62E+06	2.6		10.9							
34	urban	wetland	urban loss	wetland gain	5.63E+05	0.6				2.6		0.6			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	2.96E+04	0.0	0.1		0.1	23.5	94.0	0.0	94.0	93.9	74,717.1
37	wetland	barren	wetland loss	barren gain	6.71E+02	0.0	0.0		100.0	0.5	74,817.1	0.0			
38	wetland	grass	wetland loss	grassland gain	2.96E+04	0.0				23.5		0.0			
39	wetland	crop	wetland loss	cropland gain	6.58E+04	0.1				52.4		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	1.41E+06	1.4	14.3		9.8	14.4	25.6	0.2	30.1	15.8	110.5
44	water	barren	water loss	barren gain	1.71E+06	1.7	0.2		68.4	17.5	178.9	0.5			
45	water	grass	water loss	grassland gain	4.48E+06	4.5				45.9		0.3			
46	water	crop	water loss	cropland gain	1.56E+06	1.6				16.0		0.2			
47	water	urban	water loss	urban gain	2.51E+05	0.3				2.6		0.7			
48	water	wetland	water loss	wetland gain	3.54E+05	0.4				3.6		0.4			
49	water	water	stable water	stable water	4.51E+06	4.5		31.6							
	Total					7,785.8									

Appendix 2.2.4.38.1. Soviet era changes (1965-'87) in land cover and change percentages within Aran, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.09E+07	10.9	73.9	14.7	63.0		77.0		87.9	14.0	19.0
2	forest	barren	forest loss	barren gain	2.01E+06	2.0	0.4		85.3	3.2	104.3	0.9			
3	forest	grass	forest loss	grassland gain	2.74E+07	27.4				43.5		0.6			
4	forest	crop	forest loss	cropland gain	2.54E+07	25.4				40.4		1.3			
5	forest	urban	forest loss	urban gain	2.54E+04	0.0				0.0		0.1			
6	forest	wetland	forest loss	wetland gain	7.77E+06	7.8				12.3		2.0			
7	forest	water	forest loss	water gain	3.18E+05	0.3				0.5		0.3			
8	barren	forest	barren loss	forest gain	3.96E+04	0.0	3.1		3.0	1.3	221.5	0.1	221.6	218.4	6,974.6
9	barren	barren	stable barren	stable barren	1.15E+05	0.1	0.0	3.7	96.3		7,070.9				
10	barren	grass	barren loss	grassland gain	1.95E+06	2.0				64.8		0.0			
11	barren	crop	barren loss	cropland gain	9.39E+05	0.9				31.1		0.0			
12	barren	urban	barren loss	urban gain	1.16E+04	0.0				0.4		0.0			
13	barren	wetland	barren loss	wetland gain	7.10E+04	0.1				2.4		0.0			
14	barren	water	barren loss	water gain	6.89E+02	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	3.25E+07	32.5	7,874.0		1,986.8	1.6	4,528.5	42.2	10,415.7	2,541.7	32.3
16	grass	barren	grassland loss	barren gain	1.38E+08	138.4	42.5		25.2	7.0	57.5	62.5			
17	grass	grass	stable grassland	stable grass	5.89E+09	5,887.2		74.8							
18	grass	crop	grassland loss	cropland gain	1.66E+09	1,663.0				83.7		87.3			
19	grass	urban	grassland loss	urban gain	1.71E+07	17.1				0.9		47.0			
20	grass	wetland	grassland loss	wetland gain	1.07E+08	107.1				5.4		28.3			
21	grass	water	grassland loss	water gain	2.86E+07	28.6				1.4		26.5			
22	crop	forest	cropland loss	forest gain	3.90E+07	39.0	9,790.5		4,708.5	0.8	1,905.7	50.6	6,987.8	-2,802.8	-28.6
23	crop	barren	cropland loss	barren gain	7.13E+07	71.3	52.9		48.1	1.5	19.5	32.2			
24	crop	grass	cropland loss	grassland gain	4.27E+09	4,268.5				90.7		94.3			
25	crop	crop	stable cropland	stable cropland	5.08E+09	5,082.1		51.9							
26	crop	urban	cropland loss	urban gain	1.88E+07	18.8				0.4		51.7			
27	crop	wetland	cropland loss	wetland gain	2.46E+08	246.0				5.2		64.9			
28	crop	water	cropland loss	water gain	6.49E+07	64.9				1.4		60.2			
29	urban	forest	urban loss	forest gain	1.17E+06	1.2	189.9		187.9	0.6	36.3	1.5	38.3	-151.6	-79.8
30	urban	barren	urban loss	barren gain	2.29E+06	2.3	1.0		98.9	1.2	19.1	1.0			
31	urban	grass	urban loss	grass gain	1.11E+08	111.2				59.2		2.5			
32	urban	crop	urban loss	crop gain	6.80E+07	68.0				36.2		3.6			
33	urban	urban	stable urban	stable urban	2.02E+06	2.0		1.1							
34	urban	wetland	urban loss	wetland gain	4.83E+06	4.8				2.6		1.3			
35	urban	water	urban loss	water gain	4.27E+05	0.4				0.2		0.4			
36	wetland	forest	wetland loss	forest gain	2.55E+06	2.6	350.1		245.1	1.0	379.1	3.3	484.1	134.0	38.3
37	wetland	barren	wetland loss	barren gain	2.59E+06	2.6	1.9		70.0	1.1	108.3	1.2			
38	wetland	grass	wetland loss	grassland gain	9.97E+07	99.7				40.7		2.2			
39	wetland	crop	wetland loss	cropland gain	1.26E+08	126.3				51.5		6.6			
40	wetland	urban	wetland loss	urban gain	3.52E+05	0.4				0.1		1.0			
41	wetland	wetland	stable wetland	stable wetland	1.05E+08	105.0		30.0							
42	wetland	water	wetland loss	water gain	1.36E+07	13.6				5.6		12.6			
43	water	forest	water loss	forest gain	1.77E+06	1.8	224.6		61.7	2.9	107.9	2.3	270.8	46.2	20.6
44	water	barren	water loss	barren gain	4.80E+06	4.8	1.2		27.5	7.8	48.0	2.2			
45	water	grass	water loss	grassland gain	1.97E+07	19.7				31.9		0.4			
46	water	crop	water loss	cropland gain	2.20E+07	22.0				35.7		1.2			
47	water	urban	water loss	urban gain	7.57E+04	0.1				0.1		0.2			
48	water	wetland	water loss	wetland gain	1.33E+07	13.3				21.6		3.5			
49	water	water	stable water	stable water	1.63E+08	162.9		72.5							
	Total					18,506.1									

Appendix 2.2.4.38.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Aran, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.32E+07	33.2	87.8	37.8	54.6		48.6		81.8	-6.0	-6.8
2	forest	barren	forest loss	barren gain	2.96E+05	0.3	0.5		62.2	0.5	55.4	0.3			
3	forest	grass	forest loss	grassland gain	2.96E+07	29.6				54.3		1.0			
4	forest	crop	forest loss	cropland gain	1.93E+07	19.3				35.3		0.8			
5	forest	urban	forest loss	urban gain	1.35E+05	0.1				0.2		0.2			
6	forest	wetland	forest loss	wetland gain	4.86E+06	4.9				8.9		1.5			
7	forest	water	forest loss	water gain	3.85E+05	0.4				0.7		0.5			
8	barren	forest	barren loss	forest gain	8.69E+05	0.9	221.6		203.4	0.4	94.5	1.8	112.6	-109.0	-49.2
9	barren	barren	stable barren	stable barren	1.81E+07	18.1	1.2	8.2	91.8		42.6				
10	barren	grass	barren loss	grassland gain	1.66E+08	166.3				81.8		5.7			
11	barren	crop	barren loss	cropland gain	2.12E+07	21.2				10.4		0.9			
12	barren	urban	barren loss	urban gain	8.71E+05	0.9				0.4		1.3			
13	barren	wetland	barren loss	wetland gain	2.20E+06	2.2				1.1		0.7			
14	barren	water	barren loss	water gain	1.20E+07	12.0				5.9		15.2			
15	grass	forest	grassland loss	forest gain	1.34E+07	13.4	10,415.3		2,511.4	0.5	2,925.0	27.5	10,828.9	413.6	4.0
16	grass	barren	grassland loss	barren gain	8.56E+07	85.6	56.3		24.1	3.4	28.1	90.6			
17	grass	grass	stable grassland	stable grass	7.90E+09	7,903.9		75.9							
18	grass	crop	grassland loss	cropland gain	2.21E+09	2,214.0				88.2		93.8			
19	grass	urban	grassland loss	urban gain	5.25E+07	52.5				2.1		79.2			
20	grass	wetland	grassland loss	wetland gain	1.14E+08	114.3				4.6		35.6			
21	grass	water	grassland loss	water gain	3.17E+07	31.7				1.3		40.1			
22	crop	forest	cropland loss	forest gain	2.46E+07	24.6	6,986.8		2,821.9	0.9	2,359.1	50.5	6,524.0	-462.8	-6.6
23	crop	barren	cropland loss	barren gain	6.97E+06	7.0	37.8		40.4	0.2	33.8	7.4			
24	crop	grass	cropland loss	grassland gain	2.60E+09	2,599.7				92.1		88.9			
25	crop	crop	stable cropland	stable cropland	4.16E+09	4,164.9		59.6							
26	crop	urban	cropland loss	urban gain	1.20E+07	12.0				0.4		18.1			
27	crop	wetland	cropland loss	wetland gain	1.67E+08	167.5				5.9		52.1			
28	crop	water	cropland loss	water gain	1.13E+07	11.3				0.4		14.2			
29	urban	forest	urban loss	forest gain	9.61E+03	0.0	38.3		33.3	0.0	66.2	0.0	71.2	32.9	85.8
30	urban	barren	urban loss	barren gain	1.04E+05	0.1	0.2		87.1	0.3	172.9	0.1			
31	urban	grass	urban loss	grass gain	2.67E+07	26.7				79.9		0.9			
32	urban	crop	urban loss	crop gain	4.91E+06	4.9				14.7		0.2			
33	urban	urban	stable urban	stable urban	4.96E+06	5.0		12.9							
34	urban	wetland	urban loss	wetland gain	1.44E+06	1.4				4.3		0.4			
35	urban	water	urban loss	water gain	2.27E+05	0.2				0.7		0.3			
36	wetland	forest	wetland loss	forest gain	9.57E+06	9.6	483.6		203.2	4.7	321.2	19.7	601.5	118.0	24.4
37	wetland	barren	wetland loss	barren gain	1.27E+06	1.3	2.6		42.0	0.6	66.4	1.3			
38	wetland	grass	wetland loss	grassland gain	7.53E+07	75.3				37.0		2.6			
39	wetland	crop	wetland loss	cropland gain	9.30E+07	93.0				45.7		3.9			
40	wetland	urban	wetland loss	urban gain	6.52E+05	0.7				0.3		1.0			
41	wetland	wetland	stable wetland	stable wetland	2.80E+08	280.3		58.0							
42	wetland	water	wetland loss	water gain	2.35E+07	23.5				11.6		29.7			
43	water	forest	water loss	forest gain	2.37E+05	0.2	270.3		65.7	0.4	79.1	0.5	283.7	13.4	4.9
44	water	barren	water loss	barren gain	2.05E+05	0.2	1.5		24.3	0.3	29.3	0.2			
45	water	grass	water loss	grassland gain	2.75E+07	27.5				41.8		0.9			
46	water	crop	water loss	cropland gain	6.81E+06	6.8				10.4		0.3			
47	water	urban	water loss	urban gain	1.11E+05	0.1				0.2		0.2			
48	water	wetland	water loss	wetland gain	3.09E+07	30.9				47.0		9.6			
49	water	water	stable water	stable water	2.05E+08	204.6		75.7							
	Total					18,503.7									

Appendix 2.2.4.38.3. 50-year changes (1965-2015) in land cover and change percentages within Aran, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	7.86E+06	7.9	73.9	10.6	66.0		74.0		81.8	8.0	10.8
2	forest	barren	forest loss	barren gain	5.85E+05	0.6	0.4		89.4	0.9	100.2	0.5			
3	forest	grass	forest loss	grassland gain	3.97E+07	39.7				60.2		0.8			
4	forest	crop	forest loss	cropland gain	1.94E+07	19.4				29.4		1.0			
5	forest	urban	forest loss	urban gain	1.40E+05	0.1				0.2		0.2			
6	forest	wetland	forest loss	wetland gain	5.05E+06	5.0				7.6		1.0			
7	forest	water	forest loss	water gain	1.11E+06	1.1				1.7		0.9			
8	barren	forest	barren loss	forest gain	2.07E+03	0.0	3.1		3.1	0.1	112.6	0.0	112.6	109.5	3,495.8
9	barren	barren	stable barren	stable barren	4.84E+04	0.0	0.0	1.5	98.5		3,594.2				
10	barren	grass	barren loss	grassland gain	2.19E+06	2.2				71.0		0.0			
11	barren	crop	barren loss	cropland gain	7.27E+05	0.7				23.6		0.0			
12	barren	urban	barren loss	urban gain	8.80E+04	0.1				2.9		0.1			
13	barren	wetland	barren loss	wetland gain	4.79E+04	0.0				1.6		0.0			
14	barren	water	barren loss	water gain	2.94E+04	0.0				1.0		0.0			
15	grass	forest	grassland loss	forest gain	3.26E+07	32.6	7,874.0		2,060.0	1.6	5,015.2	44.1	10,829.2	2,955.2	37.5
16	grass	barren	grassland loss	barren gain	9.48E+07	94.8	42.5		26.2	4.6	63.7	84.2			
17	grass	grass	stable grassland	stable grass	5.81E+09	5,814.0		73.8							
18	grass	crop	grassland loss	cropland gain	1.71E+09	1,711.5				83.1		89.6			
19	grass	urban	grassland loss	urban gain	2.44E+07	24.4				1.2		37.7			
20	grass	wetland	grassland loss	wetland gain	1.66E+08	166.4				8.1		33.5			
21	grass	water	grassland loss	water gain	3.03E+07	30.3				1.5		24.3			
22	crop	forest	cropland loss	forest gain	3.61E+07	36.1	9,790.5		5,176.9	0.7	1,911.2	48.9	6,524.9	-3,265.6	-33.4
23	crop	barren	cropland loss	barren gain	1.47E+07	14.7	52.9		52.9	0.3	19.5	13.1			
24	crop	grass	cropland loss	grassland gain	4.71E+09	4,709.3				91.0		93.9			
25	crop	crop	stable cropland	stable cropland	4.61E+09	4,613.7		47.1							
26	crop	urban	cropland loss	urban gain	3.89E+07	38.9				0.8		60.2			
27	crop	wetland	cropland loss	wetland gain	3.01E+08	301.5				5.8		60.7			
28	crop	water	cropland loss	water gain	7.64E+07	76.4				1.5		61.4			
29	urban	forest	urban loss	forest gain	1.06E+06	1.1	189.9		183.4	0.6	64.7	1.4	71.2	-118.7	-62.5
30	urban	barren	urban loss	barren gain	1.69E+06	1.7	1.0		96.5	0.9	34.0	1.5			
31	urban	grass	urban loss	grass gain	1.20E+08	119.9				65.4		2.4			
32	urban	crop	urban loss	crop gain	5.53E+07	55.3				30.2		2.9			
33	urban	urban	stable urban	stable urban	6.58E+06	6.6		3.5							
34	urban	wetland	urban loss	wetland gain	4.43E+06	4.4				2.4		0.9			
35	urban	water	urban loss	water gain	9.16E+05	0.9				0.5		0.7			
36	wetland	forest	wetland loss	forest gain	2.85E+06	2.9	350.1		244.5	1.2	496.8	3.9	602.4	252.3	72.1
37	wetland	barren	wetland loss	barren gain	4.41E+05	0.4	1.9		69.8	0.2	141.9	0.4			
38	wetland	grass	wetland loss	grassland gain	1.18E+08	118.0				48.3		2.4			
39	wetland	crop	wetland loss	cropland gain	1.07E+08	106.5				43.6		5.6			
40	wetland	urban	wetland loss	urban gain	9.43E+05	0.9				0.4		1.5			
41	wetland	wetland	stable wetland	stable wetland	1.06E+08	105.6		30.2							
42	wetland	water	wetland loss	water gain	1.58E+07	15.8				6.4		12.7			
43	water	forest	water loss	forest gain	1.33E+06	1.3	224.6		65.0	2.1	124.4	1.8	284.0	59.4	26.4
44	water	barren	water loss	barren gain	3.68E+05	0.4	1.2		29.0	0.6	55.4	0.3			
45	water	grass	water loss	grassland gain	2.60E+07	26.0				40.0		0.5			
46	water	crop	water loss	cropland gain	1.77E+07	17.7				27.3		0.9			
47	water	urban	water loss	urban gain	2.05E+05	0.2				0.3		0.3			
48	water	wetland	water loss	wetland gain	1.94E+07	19.4				29.8		3.9			
49	water	water	stable water	stable water	1.60E+08	159.6		71.0							
	Total					18,506.1									

Appendix 2.2.4.39.1. Soviet era changes (1965-'87) in land cover and change percentages within Guba-Khachmaz, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	9.19E+08	919.1	1,195.4	76.9	276.3		393.4		1,312.5	117.1	9.8
2	forest	barren	forest loss	barren gain	5.44E+06	5.4	18.9		23.1	2.0	32.9	2.0			
3	forest	grass	forest loss	grassland gain	2.08E+08	207.6				75.1		26.3			
4	forest	crop	forest loss	cropland gain	6.21E+07	62.1				22.5		12.1			
5	forest	urban	forest loss	urban gain	5.20E+04	0.1				0.0		1.0			
6	forest	wetland	forest loss	wetland gain	1.15E+06	1.1				0.4		2.1			
7	forest	water	forest loss	water gain	1.82E+04	0.0				0.0		0.3			
8	barren	forest	barren loss	forest gain	1.77E+06	1.8	28.0		5.2	34.2	275.4	0.4	298.2	270.3	966.6
9	barren	barren	stable barren	stable barren	2.28E+07	22.8	0.4	81.5	18.5		985.0				
10	barren	grass	barren loss	grassland gain	2.83E+06	2.8				54.8		0.4			
11	barren	crop	barren loss	cropland gain	3.34E+05	0.3				6.5		0.1			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	3.11E+04	0.0				0.6		0.1			
14	barren	water	barren loss	water gain	2.01E+05	0.2				3.9		3.5			
15	grass	forest	grassland loss	forest gain	2.54E+08	254.4	3,298.2		1,000.7	25.4	790.6	64.7	3,088.2	-210.1	-6.4
16	grass	barren	grassland loss	barren gain	2.59E+08	259.2	52.2		30.3	25.9	24.0	94.1			
17	grass	grass	stable grassland	stable grass	2.30E+09	2,297.5		69.7							
18	grass	crop	grassland loss	cropland gain	4.41E+08	440.8				44.1		86.1			
19	grass	urban	grassland loss	urban gain	4.79E+06	4.8				0.5		88.5			
20	grass	wetland	grassland loss	wetland gain	3.75E+07	37.5				3.7		67.5			
21	grass	water	grassland loss	water gain	3.98E+06	4.0				0.4		68.8			
22	crop	forest	cropland loss	forest gain	1.35E+08	134.6	1,760.5		724.3	18.6	512.1	34.2	1,548.3	-212.2	-12.1
23	crop	barren	cropland loss	barren gain	9.86E+06	9.9	27.9		41.1	1.4	29.1	3.6			
24	crop	grass	cropland loss	grassland gain	5.62E+08	561.9				77.6		71.1			
25	crop	crop	stable cropland	stable cropland	1.04E+09	1,036.3		58.9							
26	crop	urban	cropland loss	urban gain	5.50E+05	0.5				0.1		10.2			
27	crop	wetland	cropland loss	wetland gain	1.64E+07	16.4				2.3		29.6			
28	crop	water	cropland loss	water gain	9.89E+05	1.0				0.1		17.1			
29	urban	forest	urban loss	forest gain	2.26E+06	2.3	21.8		21.6	10.5	5.4	0.6	5.6	-16.2	-74.2
30	urban	barren	urban loss	barren gain	2.63E+05	0.3	0.3		99.0	1.2	24.8	0.1			
31	urban	grass	urban loss	grass gain	1.14E+07	11.4				53.0		1.4			
32	urban	crop	urban loss	crop gain	7.50E+06	7.5				34.8		1.5			
33	urban	urban	stable urban	stable urban	2.14E+05	0.2		1.0							
34	urban	wetland	urban loss	wetland gain	1.06E+05	0.1				0.5		0.2			
35	urban	water	urban loss	water gain	6.09E+03	0.0				0.0		0.1			
36	wetland	forest	wetland loss	forest gain	6.28E+04	0.1	3.6		0.9	6.8	55.5	0.0	58.2	54.6	1,503.0
37	wetland	barren	wetland loss	barren gain	3.38E+03	0.0	0.1		25.3	0.4	1,528.4	0.0			
38	wetland	grass	wetland loss	grassland gain	1.32E+05	0.1				14.4		0.0			
39	wetland	crop	wetland loss	cropland gain	1.30E+05	0.1				14.1		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	2.71E+06	2.7		74.7							
42	wetland	water	wetland loss	water gain	5.92E+05	0.6				64.3		10.2			
43	water	forest	water loss	forest gain	3.23E+05	0.3	9.5		9.3	3.5	5.8	0.1	5.9	-3.6	-37.5
44	water	barren	water loss	barren gain	6.72E+05	0.7	0.2		98.5	7.2	61.0	0.2			
45	water	grass	water loss	grassland gain	6.77E+06	6.8				72.5		0.9			
46	water	crop	water loss	cropland gain	1.21E+06	1.2				12.9		0.2			
47	water	urban	water loss	urban gain	2.16E+04	0.0				0.2		0.4			
48	water	wetland	water loss	wetland gain	3.43E+05	0.3				3.7		0.6			
49	water	water	stable water	stable water	1.42E+05	0.1		1.5							
	Total					6,317.0									

Appendix 2.2.4.39.2 Post-Soviet changes (1987-2015) in land cover and change percentages within Guba-Khachmaz, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	1.07E+09	1,071.1	1,311.1	81.7	239.9		141.8		1,213.0	-98.1	-7.5
2	forest	barren	forest loss	barren gain	5.61E+06	5.6	20.9		18.3	2.3	10.8	7.6			
3	forest	grass	forest loss	grassland gain	1.22E+08	121.6				50.7		16.4			
4	forest	crop	forest loss	cropland gain	8.79E+07	87.9				36.6		18.1			
5	forest	urban	forest loss	urban gain	2.55E+05	0.3				0.1		1.7			
6	forest	wetland	forest loss	wetland gain	2.46E+07	24.6				10.2		31.5			
7	forest	water	forest loss	water gain	8.91E+04	0.1				0.0		4.3			
8	barren	forest	barren loss	forest gain	2.65E+06	2.6	295.6		106.6	2.5	73.7	1.9	262.7	-32.9	-11.1
9	barren	barren	stable barren	stable barren	1.89E+08	189.0	4.7	63.9	36.1		24.9				
10	barren	grass	barren loss	grassland gain	9.81E+07	98.1				92.0		13.2			
11	barren	crop	barren loss	cropland gain	4.34E+06	4.3				4.1		0.9			
12	barren	urban	barren loss	urban gain	9.81E+05	1.0				0.9		6.7			
13	barren	wetland	barren loss	wetland gain	3.37E+05	0.3				0.3		0.4			
14	barren	water	barren loss	water gain	2.51E+05	0.3				0.2		12.0			
15	grass	forest	grassland loss	forest gain	8.99E+07	89.9	3,072.6		562.8	16.0	743.1	63.4	3,252.9	180.3	5.9
16	grass	barren	grassland loss	barren gain	6.47E+07	64.7	49.0		18.3	11.5	24.2	87.7			
17	grass	grass	stable grassland	stable grass	2.51E+09	2,509.8		81.7							
18	grass	crop	grassland loss	cropland gain	3.83E+08	382.8				68.0		79.0			
19	grass	urban	grassland loss	urban gain	1.09E+07	10.9				1.9		74.1			
20	grass	wetland	grassland loss	wetland gain	1.34E+07	13.4				2.4		17.2			
21	grass	water	grassland loss	water gain	1.08E+06	1.1				0.2		51.7			
22	crop	forest	cropland loss	forest gain	4.71E+07	47.1	1,540.6		605.7	7.8	484.4	33.2	1,419.2	-121.3	-7.9
23	crop	barren	cropland loss	barren gain	3.13E+06	3.1	24.5		39.3	0.5	31.4	4.2			
24	crop	grass	cropland loss	grassland gain	5.14E+08	514.4				84.9		69.2			
25	crop	crop	stable cropland	stable cropland	9.35E+08	934.9		60.7							
26	crop	urban	cropland loss	urban gain	2.43E+06	2.4				0.4		16.5			
27	crop	wetland	cropland loss	wetland gain	3.81E+07	38.1				6.3		48.9			
28	crop	water	cropland loss	water gain	4.39E+05	0.4				0.1		20.9			
29	urban	forest	urban loss	forest gain	2.70E+04	0.0	5.4		4.8	0.6	14.7	0.0	15.3	9.9	185.6
30	urban	barren	urban loss	barren gain	2.77E+04	0.0	0.1		89.4	0.6	275.0	0.0			
31	urban	grass	urban loss	grass gain	3.79E+06	3.8				79.1		0.5			
32	urban	crop	urban loss	crop gain	4.55E+05	0.5				9.5		0.1			
33	urban	urban	stable urban	stable urban	5.67E+05	0.6		10.6							
34	urban	wetland	urban loss	wetland gain	4.80E+05	0.5				10.0		0.6			
35	urban	water	urban loss	water gain	1.28E+04	0.0				0.3		0.6			
36	wetland	forest	wetland loss	forest gain	1.87E+06	1.9	47.5		15.8	11.8	78.0	1.3	109.7	62.2	131.0
37	wetland	barren	wetland loss	barren gain	8.75E+04	0.1	0.8		33.3	0.6	164.2	0.1			
38	wetland	grass	wetland loss	grassland gain	4.76E+06	4.8				30.1		0.6			
39	wetland	crop	wetland loss	cropland gain	8.76E+06	8.8				55.5		1.8			
40	wetland	urban	wetland loss	urban gain	9.86E+04	0.1				0.6		0.7			
41	wetland	wetland	stable wetland	stable wetland	3.17E+07	31.7		66.7							
42	wetland	water	wetland loss	water gain	2.22E+05	0.2				1.4		10.6			
43	water	forest	water loss	forest gain	2.39E+05	0.2	2.6		2.2	10.7	2.1	0.2	2.4	-0.1	-5.2
44	water	barren	water loss	barren gain	2.04E+05	0.2	0.0		86.9	9.1	81.7	0.3			
45	water	grass	water loss	grassland gain	5.41E+05	0.5				24.3		0.1			
46	water	crop	water loss	cropland gain	1.68E+05	0.2				7.5		0.0			
47	water	urban	water loss	urban gain	5.44E+04	0.1				2.4		0.4			
48	water	wetland	water loss	wetland gain	1.02E+06	1.0				45.9		1.3			
49	water	water	stable water	stable water	3.36E+05	0.3		13.1							
	Total					6,275.2									

Appendix 2.2.4.29.3. 50-year changes (1965-2015) in land cover and change percentages within Guba-Khachmaz, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	8.76E+08	876.5	1,195.4	73.3	318.9		337.8		1,214.3	18.9	1.6
2	forest	barren	forest loss	barren gain	5.77E+06	5.8	18.9		26.7	1.8	28.3	2.4			
3	forest	grass	forest loss	grassland gain	2.30E+08	230.0				72.1		24.9			
4	forest	crop	forest loss	cropland gain	7.13E+07	71.3				22.4		13.9			
5	forest	urban	forest loss	urban gain	3.43E+05	0.3				0.1		2.2			
6	forest	wetland	forest loss	wetland gain	1.14E+07	11.4				3.6		9.9			
7	forest	water	forest loss	water gain	2.56E+04	0.0				0.0		0.9			
8	barren	forest	barren loss	forest gain	8.78E+05	0.9	28.0		4.0	21.8	239.7	0.3	263.6	235.6	842.6
9	barren	barren	stable barren	stable barren	2.39E+07	23.9	0.4	85.6	14.4		857.1				
10	barren	grass	barren loss	grassland gain	3.02E+06	3.0				74.9		0.3			
11	barren	crop	barren loss	cropland gain	1.33E+05	0.1				3.3		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	2.32E+08	231.5	3,298.2		947.8	24.4	923.4	68.5	3,273.8	-24.4	-0.7
16	grass	barren	grassland loss	barren gain	2.29E+08	229.1	52.2		28.7	24.2	28.0	95.6			
17	grass	grass	stable grassland	stable grass	2.35E+09	2,350.4		71.3							
18	grass	crop	grassland loss	cropland gain	4.34E+08	433.6				45.7		84.5			
19	grass	urban	grassland loss	urban gain	8.32E+06	8.3				0.9		52.8			
20	grass	wetland	grassland loss	wetland gain	4.37E+07	43.7				4.6		37.9			
21	grass	water	grassland loss	water gain	1.57E+06	1.6				0.2		52.8			
22	crop	forest	cropland loss	forest gain	1.04E+08	103.7	1,760.5		846.9	12.2	513.3	30.7	1,427.0	-333.5	-18.9
23	crop	barren	cropland loss	barren gain	3.94E+06	3.9	27.9		48.1	0.5	29.2	1.6			
24	crop	grass	cropland loss	grassland gain	6.72E+08	672.4				79.4		72.8			
25	crop	crop	stable cropland	stable cropland	9.14E+08	913.6		51.9							
26	crop	urban	cropland loss	urban gain	6.56E+06	6.6				0.8		41.6			
27	crop	wetland	cropland loss	wetland gain	5.91E+07	59.1				7.0		51.3			
28	crop	water	cropland loss	water gain	1.15E+06	1.2				0.1		38.8			
29	urban	forest	urban loss	forest gain	1.26E+06	1.3	21.8		20.5	6.1	15.8	0.4	17.0	-4.8	-21.9
30	urban	barren	urban loss	barren gain	1.84E+05	0.2	0.3		94.3	0.9	72.4	0.1			
31	urban	grass	urban loss	grass gain	1.13E+07	11.3				54.8		1.2			
32	urban	crop	urban loss	crop gain	7.30E+06	7.3				35.6		1.4			
33	urban	urban	stable urban	stable urban	1.24E+06	1.2		5.7							
34	urban	wetland	urban loss	wetland gain	5.29E+05	0.5				2.6		0.5			
35	urban	water	urban loss	water gain	1.26E+04	0.0				0.1		0.4			
36	wetland	forest	wetland loss	forest gain	1.19E+05	0.1	3.6		0.5	23.4	115.2	0.0	118.4	114.7	3,157.7
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.1		14.0	0.0	3,171.7	0.0			
38	wetland	grass	wetland loss	grassland gain	1.50E+05	0.2				29.6		0.0			
39	wetland	crop	wetland loss	cropland gain	2.49E+04	0.0				4.9		0.0			
40	wetland	urban	wetland loss	urban gain	1.78E+03	0.0				0.4		0.0			
41	wetland	wetland	stable wetland	stable wetland	3.13E+06	3.1		86.0							
42	wetland	water	wetland loss	water gain	2.11E+05	0.2				41.7		7.1			
43	water	forest	water loss	forest gain	3.31E+05	0.3	9.5		9.4	3.5	3.0	0.1	3.0	-6.5	-68.3
44	water	barren	water loss	barren gain	6.74E+05	0.7	0.2		99.6	7.1	31.3	0.3			
45	water	grass	water loss	grassland gain	6.56E+06	6.6				69.4		0.7			
46	water	crop	water loss	cropland gain	9.20E+05	0.9				9.7		0.2			
47	water	urban	water loss	urban gain	5.44E+05	0.5				5.8		3.5			
48	water	wetland	water loss	wetland gain	4.24E+05	0.4				4.5		0.4			
49	water	water	stable water	stable water	3.38E+04	0.0		0.4							
	Total					6,317.0									

Appendix 2.2.4.40.1. Soviet era changes (1965-'87) in land cover and change percentages within Daghlig Shirvan, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	5.97E+08	597.5	779.6	76.6	182.1		211.4		808.8	29.3	3.8
2	forest	barren	forest loss	barren gain	2.10E+06	2.1	13.6		23.4	1.2	27.1	1.3			
3	forest	grass	forest loss	grassland gain	1.18E+08	118.3				64.9		18.3			
4	forest	crop	forest loss	cropland gain	5.74E+07	57.4				31.5		9.0			
5	forest	urban	forest loss	urban gain	3.61E+05	0.4				0.2		9.5			
6	forest	wetland	forest loss	wetland gain	3.83E+06	3.8				2.1		17.4			
7	forest	water	forest loss	water gain	1.32E+05	0.1				0.1		6.8			
8	barren	forest	barren loss	forest gain	7.09E+04	0.1	7.6		3.5	2.0	163.4	0.0	167.5	159.9	2,098.7
9	barren	barren	stable barren	stable barren	4.09E+06	4.1	0.1	53.6	46.4		2,145.1				
10	barren	grass	barren loss	grassland gain	3.45E+06	3.4				97.5		0.5			
11	barren	crop	barren loss	cropland gain	1.70E+04	0.0				0.5		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.99E+08	199.5	3,887.6		938.5	21.3	647.8	94.4	3,596.9	-290.7	-7.5
16	grass	barren	grassland loss	barren gain	1.58E+08	157.7	67.7		24.1	16.8	16.7	96.5			
17	grass	grass	stable grassland	stable grass	2.95E+09	2,949.0		75.9							
18	grass	crop	grassland loss	cropland gain	5.74E+08	574.2				61.2		90.4			
19	grass	urban	grassland loss	urban gain	2.18E+06	2.2				0.2		57.2			
20	grass	wetland	grassland loss	wetland gain	4.56E+06	4.6				0.5		20.8			
21	grass	water	grassland loss	water gain	4.30E+05	0.4				0.0		22.1			
22	crop	forest	cropland loss	forest gain	1.03E+07	10.3	1,043.5		539.4	1.9	635.5	4.9	1,139.6	96.1	9.2
23	crop	barren	cropland loss	barren gain	2.95E+06	2.9	18.2		51.7	0.5	60.9	1.8			
24	crop	grass	cropland loss	grassland gain	5.11E+08	510.8				94.7		78.8			
25	crop	crop	stable cropland	stable cropland	5.04E+08	504.1		48.3							
26	crop	urban	cropland loss	urban gain	7.26E+05	0.7				0.1		19.0			
27	crop	wetland	cropland loss	wetland gain	1.33E+07	13.3				2.5		60.4			
28	crop	water	cropland loss	water gain	1.38E+06	1.4				0.3		70.9			
29	urban	forest	urban loss	forest gain	9.17E+05	0.9	11.7		11.6	7.9	3.8	0.4	4.0	-7.7	-66.1
30	urban	barren	urban loss	barren gain	1.59E+05	0.2	0.2		98.8	1.4	32.6	0.1			
31	urban	grass	urban loss	grass gain	7.13E+06	7.1				61.7		1.1			
32	urban	crop	urban loss	crop gain	3.22E+06	3.2				27.9		0.5			
33	urban	urban	stable urban	stable urban	1.46E+05	0.1		1.2							
34	urban	wetland	urban loss	wetland gain	1.23E+05	0.1				1.1		0.6			
35	urban	water	urban loss	water gain	3.41E+03	0.0				0.0		0.2			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	22.0	0.0	22.0	22.0	94,357.1
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	94,457.1	0.0			
38	wetland	grass	wetland loss	grassland gain	8.90E+03	0.0				38.2		0.0			
39	wetland	crop	wetland loss	cropland gain	1.44E+04	0.0				61.8		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	6.48E+05	0.6	12.0		10.8	6.0	1.9	0.3	3.1	-8.8	-73.7
44	water	barren	water loss	barren gain	5.55E+05	0.6	0.2		90.0	5.2	16.3	0.3			
45	water	grass	water loss	grassland gain	8.21E+06	8.2				76.3		1.3			
46	water	crop	water loss	cropland gain	6.00E+05	0.6				5.6		0.1			
47	water	urban	water loss	urban gain	5.47E+05	0.5				5.1		14.3			
48	water	wetland	water loss	wetland gain	1.96E+05	0.2				1.8		0.9			
49	water	water	stable water	stable water	1.20E+06	1.2		10.0							
	Total					5,741.9									

Appendix 2.2.4.40.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Daghlig Shirvan, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	6.69E+08	668.5	808.8	82.7	140.3		67.9		736.4	-72.4	-8.9
2	forest	barren	forest loss	barren gain	8.27E+05	0.8	14.1		17.3	0.6	8.4	1.8			
3	forest	grass	forest loss	grassland gain	9.41E+07	94.1				67.1		13.9			
4	forest	crop	forest loss	cropland gain	3.26E+07	32.6				23.2		9.4			
5	forest	urban	forest loss	urban gain	1.29E+05	0.1				0.1		2.3			
6	forest	wetland	forest loss	wetland gain	1.26E+07	12.6				9.0		60.2			
7	forest	water	forest loss	water gain	1.36E+03	0.0				0.0		0.3			
8	barren	forest	barren loss	forest gain	4.28E+05	0.4	167.4		79.7	0.5	46.9	0.6	134.7	-32.7	-19.6
9	barren	barren	stable barren	stable barren	8.77E+07	87.7	2.9	52.4	47.6		28.0				
10	barren	grass	barren loss	grassland gain	7.76E+07	77.6				97.4		11.4			
11	barren	crop	barren loss	cropland gain	1.25E+06	1.2				1.6		0.4			
12	barren	urban	barren loss	urban gain	3.63E+05	0.4				0.5		6.5			
13	barren	wetland	barren loss	wetland gain	5.52E+04	0.1				0.1		0.3			
14	barren	water	barren loss	water gain	1.43E+04	0.0				0.0		3.2			
15	grass	forest	grassland loss	forest gain	4.81E+07	48.1	3,596.8		397.8	12.1	677.7	70.8	3,876.7	279.9	7.8
16	grass	barren	grassland loss	barren gain	4.39E+07	43.9	62.6		11.1	11.0	18.8	93.4			
17	grass	grass	stable grassland	stable grass	3.20E+09	3,199.0		88.9							
18	grass	crop	grassland loss	cropland gain	2.99E+08	298.7				75.1		86.4			
19	grass	urban	grassland loss	urban gain	4.46E+06	4.5				1.1		80.0			
20	grass	wetland	grassland loss	wetland gain	2.49E+06	2.5				0.6		11.9			
21	grass	water	grassland loss	water gain	1.47E+05	0.1				0.0		33.2			
22	crop	forest	cropland loss	forest gain	1.76E+07	17.6	1,139.6		524.0	3.4	345.7	25.8	961.2	-178.4	-15.7
23	crop	barren	cropland loss	barren gain	2.04E+06	2.0	19.8		46.0	0.4	30.3	4.3			
24	crop	grass	cropland loss	grassland gain	4.99E+08	498.5				95.1		73.6			
25	crop	crop	stable cropland	stable cropland	6.16E+08	615.6		54.0							
26	crop	urban	cropland loss	urban gain	6.07E+05	0.6				0.1		10.9			
27	crop	wetland	cropland loss	wetland gain	5.21E+06	5.2				1.0		24.9			
28	crop	water	cropland loss	water gain	8.61E+04	0.1				0.0		19.4			
29	urban	forest	urban loss	forest gain	4.97E+04	0.0	4.0		3.5	1.4	5.6	0.1	6.0	2.1	51.8
30	urban	barren	urban loss	barren gain	1.27E+05	0.1	0.1		88.8	3.6	140.6	0.3			
31	urban	grass	urban loss	grass gain	2.88E+06	2.9				81.9		0.4			
32	urban	crop	urban loss	crop gain	4.19E+05	0.4				11.9		0.1			
33	urban	urban	stable urban	stable urban	4.43E+05	0.4		11.2							
34	urban	wetland	urban loss	wetland gain	4.29E+04	0.0				1.2		0.2			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.79E+06	1.8	22.0		18.7	9.6	21.0	2.6	24.3	2.3	10.4
37	wetland	barren	wetland loss	barren gain	2.04E+04	0.0	0.4		84.9	0.1	95.3	0.0			
38	wetland	grass	wetland loss	grassland gain	4.25E+06	4.3				22.8		0.6			
39	wetland	crop	wetland loss	cropland gain	1.24E+07	12.4				66.4		3.6			
40	wetland	urban	wetland loss	urban gain	1.50E+04	0.0				0.1		0.3			
41	wetland	wetland	stable wetland	stable wetland	3.32E+06	3.3		15.1							
42	wetland	water	wetland loss	water gain	1.95E+05	0.2				1.0		43.9			
43	water	forest	water loss	forest gain	1.23E+04	0.0	3.1		1.2	1.0	0.4	0.0	2.4	-0.8	-24.7
44	water	barren	water loss	barren gain	7.76E+04	0.1	0.1		38.8	6.4	14.1	0.2			
45	water	grass	water loss	grassland gain	3.23E+05	0.3				26.5		0.0			
46	water	crop	water loss	cropland gain	2.70E+05	0.3				22.1		0.1			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	5.37E+05	0.5				44.1		2.6			
49	water	water	stable water	stable water	1.92E+06	1.9		61.2							
	Total					5,741.7									

Appendix 2.2.4.40.3. 50-year changes (1965-2015) in land cover and change percentages within Daghlig Shirvan, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	5.37E+08	536.8	779.6	68.9	242.7		199.6		736.4	-43.1	-5.5
2	forest	barren	forest loss	barren gain	2.01E+06	2.0	13.6		31.1	0.8	25.6	1.5			
3	forest	grass	forest loss	grassland gain	1.70E+08	169.8				69.9		22.1			
4	forest	crop	forest loss	cropland gain	5.68E+07	56.8				23.4		11.0			
5	forest	urban	forest loss	urban gain	3.63E+05	0.4				0.1		6.5			
6	forest	wetland	forest loss	wetland gain	1.37E+07	13.7				5.6		56.3			
7	forest	water	forest loss	water gain	1.60E+05	0.2				0.1		13.5			
8	barren	forest	barren loss	forest gain	7.36E+04	0.1	7.6		3.8	1.9	131.0	0.0	134.8	127.2	1,668.9
9	barren	barren	stable barren	stable barren	3.77E+06	3.8	0.1	49.5	50.5		1,719.3				
10	barren	grass	barren loss	grassland gain	3.76E+06	3.8				97.7		0.5			
11	barren	crop	barren loss	cropland gain	1.43E+04	0.0				0.4		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	1.92E+08	191.8	3,887.6		777.5	24.7	766.7	96.1	3,876.8	-10.8	-0.3
16	grass	barren	grassland loss	barren gain	1.25E+08	124.5	67.7		20.0	16.0	19.7	95.1			
17	grass	grass	stable grassland	stable grass	3.11E+09	3,110.0		80.0							
18	grass	crop	grassland loss	cropland gain	4.54E+08	454.3				58.4		88.3			
19	grass	urban	grassland loss	urban gain	2.83E+06	2.8				0.4		50.8			
20	grass	wetland	grassland loss	wetland gain	3.89E+06	3.9				0.5		16.0			
21	grass	water	grassland loss	water gain	1.97E+05	0.2				0.0		16.6			
22	crop	forest	cropland loss	forest gain	6.63E+06	6.6	1,043.5		596.6	1.1	514.3	3.3	961.2	-82.3	-7.9
23	crop	barren	cropland loss	barren gain	3.22E+06	3.2	18.2		57.2	0.5	49.3	2.5			
24	crop	grass	cropland loss	grassland gain	5.78E+08	577.9				96.9		75.4			
25	crop	crop	stable cropland	stable cropland	4.47E+08	446.9		42.8							
26	crop	urban	cropland loss	urban gain	1.80E+06	1.8				0.3		32.3			
27	crop	wetland	cropland loss	wetland gain	6.18E+06	6.2				1.0		25.5			
28	crop	water	cropland loss	water gain	8.28E+05	0.8				0.1		69.9			
29	urban	forest	urban loss	forest gain	6.26E+05	0.6	11.7		11.2	5.6	5.6	0.3	6.0	-5.7	-48.5
30	urban	barren	urban loss	barren gain	3.27E+05	0.3	0.2		96.2	2.9	47.7	0.2			
31	urban	grass	urban loss	grass gain	7.50E+06	7.5				66.6		1.0			
32	urban	crop	urban loss	crop gain	2.63E+06	2.6				23.4		0.5			
33	urban	urban	stable urban	stable urban	4.46E+05	0.4		3.8							
34	urban	wetland	urban loss	wetland gain	1.72E+05	0.2				1.5		0.7			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	0.00E+00	0.0	0.0		0.0	0.0	24.3	0.0	24.3	24.3	104,226.1
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	104,326.1	0.0			
38	wetland	grass	wetland loss	grassland gain	7.53E+03	0.0				32.4		0.0			
39	wetland	crop	wetland loss	cropland gain	1.57E+04	0.0				67.6		0.0			
40	wetland	urban	wetland loss	urban gain	0.00E+00	0.0				0.0		0.0			
41	wetland	wetland	stable wetland	stable wetland	0.00E+00	0.0		0.0							
42	wetland	water	wetland loss	water gain	0.00E+00	0.0				0.0		0.0			
43	water	forest	water loss	forest gain	5.02E+05	0.5	12.0		10.8	4.7	1.2	0.3	2.4	-9.6	-80.2
44	water	barren	water loss	barren gain	9.13E+05	0.9	0.2		90.1	8.5	9.9	0.7			
45	water	grass	water loss	grassland gain	7.81E+06	7.8				72.5		1.0			
46	water	crop	water loss	cropland gain	6.02E+05	0.6				5.6		0.1			
47	water	urban	water loss	urban gain	5.78E+05	0.6				5.4		10.4			
48	water	wetland	water loss	wetland gain	3.64E+05	0.4				3.4		1.5			
49	water	water	stable water	stable water	1.18E+06	1.2		9.9							
	Total					5,741.9									

Appendix 2.2.4.41.1. Soviet era changes (1965-'87) in land cover and change percentages within Absheron, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	4.73E+07	47.3	64.8	73.0	17.5		48.5		95.7	31.0	47.8
2	forest	barren	forest loss	barren gain	1.03E+06	1.0	1.2		27.0	5.9	74.9	0.7			
3	forest	grass	forest loss	grassland gain	1.34E+07	13.4				76.7		2.3			
4	forest	crop	forest loss	cropland gain	1.57E+06	1.6				9.0		1.9			
5	forest	urban	forest loss	urban gain	1.18E+05	0.1				0.7		0.5			
6	forest	wetland	forest loss	wetland gain	1.14E+06	1.1				6.5		3.0			
7	forest	water	forest loss	water gain	2.04E+05	0.2				1.2		0.7			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	49.1		47.9	0.0	139.9	0.0	141.1	91.9	187.1
9	barren	barren	stable barren	stable barren	1.22E+06	1.2	0.9	2.5	97.5		284.7				
10	barren	grass	barren loss	grassland gain	4.77E+07	47.7				99.6		8.1			
11	barren	crop	barren loss	cropland gain	1.33E+05	0.1				0.3		0.2			
12	barren	urban	barren loss	urban gain	2.82E+04	0.0				0.1		0.1			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	1.03E+04	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	4.74E+07	47.4	4,376.6		262.5	18.0	586.5	97.7	4,700.6	324.0	7.4
16	grass	barren	grassland loss	barren gain	1.02E+08	102.1	84.2		6.0	38.9	13.4	73.0			
17	grass	grass	stable grassland	stable grass	4.11E+09	4,114.1		94.0							
18	grass	crop	grassland loss	cropland gain	7.35E+07	73.5				28.0		88.1			
19	grass	urban	grassland loss	urban gain	1.33E+07	13.3				5.1		53.2			
20	grass	wetland	grassland loss	wetland gain	1.37E+07	13.7				5.2		36.2			
21	grass	water	grassland loss	water gain	1.24E+07	12.4				4.7		41.9			
22	crop	forest	cropland loss	forest gain	5.32E+05	0.5	427.2		404.2	0.1	83.4	1.1	106.4	-320.8	-75.1
23	crop	barren	cropland loss	barren gain	1.07E+07	10.7	8.2		94.6	2.6	19.5	7.6			
24	crop	grass	cropland loss	grassland gain	3.57E+08	357.2				88.4		60.9			
25	crop	crop	stable cropland	stable cropland	2.30E+07	23.0		5.4							
26	crop	urban	cropland loss	urban gain	1.12E+07	11.2				2.8		44.8			
27	crop	wetland	cropland loss	wetland gain	1.00E+07	10.0				2.5		26.6			
28	crop	water	cropland loss	water gain	1.45E+07	14.5				3.6		48.9			
29	urban	forest	urban loss	forest gain	5.22E+05	0.5	252.6		201.7	0.3	25.1	1.1	76.0	-176.6	-69.9
30	urban	barren	urban loss	barren gain	2.51E+07	25.1	4.9		79.9	12.4	9.9	17.9			
31	urban	grass	urban loss	grass gain	1.64E+08	164.0				81.3		28.0			
32	urban	crop	urban loss	crop gain	7.40E+06	7.4				3.7		8.9			
33	urban	urban	stable urban	stable urban	5.09E+07	50.9		20.1							
34	urban	wetland	urban loss	wetland gain	4.15E+06	4.2				2.1		11.0			
35	urban	water	urban loss	water gain	5.87E+05	0.6				0.3		2.0			
36	wetland	forest	wetland loss	forest gain	4.03E+04	0.0	5.7		4.8	0.8	37.8	0.1	38.7	33.0	582.7
37	wetland	barren	wetland loss	barren gain	4.42E+05	0.4	0.1		84.3	9.3	667.0	0.3			
38	wetland	grass	wetland loss	grassland gain	1.98E+06	2.0				41.4		0.3			
39	wetland	crop	wetland loss	cropland gain	2.76E+05	0.3				5.8		0.3			
40	wetland	urban	wetland loss	urban gain	1.19E+05	0.1				2.5		0.5			
41	wetland	wetland	stable wetland	stable wetland	8.92E+05	0.9		15.7							
42	wetland	water	wetland loss	water gain	1.92E+06	1.9				40.2		6.5			
43	water	forest	water loss	forest gain	1.30E+04	0.0	21.8		12.3	0.1	29.7	0.0	39.2	17.4	79.8
44	water	barren	water loss	barren gain	5.36E+05	0.5	0.4		56.2	4.4	136.0	0.4			
45	water	grass	water loss	grassland gain	2.21E+06	2.2				18.0		0.4			
46	water	crop	water loss	cropland gain	5.12E+05	0.5				4.2		0.6			
47	water	urban	water loss	urban gain	2.34E+05	0.2				1.9		0.9			
48	water	wetland	water loss	wetland gain	8.76E+06	8.8				71.4		23.2			
49	water	water	stable water	stable water	9.56E+06	9.6		43.8							
	Total					5,197.7									

Appendix 2.2.4.41.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Absheron, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	4.66E+07	46.6	64.8	72.0	18.1		51.1		97.8	33.0	51.0
2	forest	barren	forest loss	barren gain	8.37E+05	0.8	1.2		28.0	4.6	79.0	0.6			
3	forest	grass	forest loss	grassland gain	1.46E+07	14.6				80.4		2.4			
4	forest	crop	forest loss	cropland gain	1.88E+06	1.9				10.4		3.0			
5	forest	urban	forest loss	urban gain	3.04E+05	0.3				1.7		0.6			
6	forest	wetland	forest loss	wetland gain	3.67E+05	0.4				2.0		1.5			
7	forest	water	forest loss	water gain	1.62E+05	0.2				0.9		0.6			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	49.1		47.7	0.0	150.5	0.0	151.9	102.8	209.3
9	barren	barren	stable barren	stable barren	1.45E+06	1.5	0.9	3.0	97.0		306.3				
10	barren	grass	barren loss	grassland gain	4.74E+07	47.4				99.5		7.8			
11	barren	crop	barren loss	cropland gain	1.53E+05	0.2				0.3		0.2			
12	barren	urban	barren loss	urban gain	7.94E+04	0.1				0.2		0.2			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				0.0		0.0			
14	barren	water	barren loss	water gain	2.39E+04	0.0				0.1		0.1			
15	grass	forest	grassland loss	forest gain	4.90E+07	49.0	4,376.6		276.9	17.7	604.3	95.8	4,704.0	327.4	7.5
16	grass	barren	grassland loss	barren gain	1.18E+08	117.8	84.2		6.3	42.5	13.8	78.3			
17	grass	grass	stable grassland	stable grass	4.10E+09	4,099.7		93.7							
18	grass	crop	grassland loss	cropland gain	5.60E+07	56.0				20.2		90.8			
19	grass	urban	grassland loss	urban gain	3.13E+07	31.3				11.3		60.5			
20	grass	wetland	grassland loss	wetland gain	9.95E+06	10.0				3.6		40.3			
21	grass	water	grassland loss	water gain	1.29E+07	12.9				4.6		48.7			
22	crop	forest	cropland loss	forest gain	1.08E+06	1.1	427.2		419.1	0.3	61.7	2.1	69.8	-357.4	-83.7
23	crop	barren	cropland loss	barren gain	1.29E+07	12.9	8.2		98.1	3.1	14.4	8.6			
24	crop	grass	cropland loss	grassland gain	3.67E+08	367.2				87.6		60.8			
25	crop	crop	stable cropland	stable cropland	8.10E+06	8.1		1.9							
26	crop	urban	cropland loss	urban gain	1.98E+07	19.8				4.7		38.3			
27	crop	wetland	cropland loss	wetland gain	5.73E+06	5.7				1.4		23.2			
28	crop	water	cropland loss	water gain	1.23E+07	12.3				2.9		46.6			
29	urban	forest	urban loss	forest gain	8.93E+05	0.9	252.6		190.5	0.5	51.7	1.7	113.8	-138.8	-54.9
30	urban	barren	urban loss	barren gain	1.76E+07	17.6	4.9		75.4	9.2	20.5	11.7			
31	urban	grass	urban loss	grass gain	1.67E+08	167.3				87.8		27.7			
32	urban	crop	urban loss	crop gain	2.97E+06	3.0				1.6		4.8			
33	urban	urban	stable urban	stable urban	6.21E+07	62.1		24.6							
34	urban	wetland	urban loss	wetland gain	1.63E+06	1.6				0.9		6.6			
35	urban	water	urban loss	water gain	1.31E+05	0.1				0.1		0.5			
36	wetland	forest	wetland loss	forest gain	9.79E+03	0.0	5.7		4.6	0.2	24.7	0.0	25.7	20.1	354.6
37	wetland	barren	wetland loss	barren gain	6.31E+05	0.6	0.1		81.4	13.7	435.9	0.4			
38	wetland	grass	wetland loss	grassland gain	2.77E+06	2.8				60.2		0.5			
39	wetland	crop	wetland loss	cropland gain	1.50E+05	0.2				3.3		0.2			
40	wetland	urban	wetland loss	urban gain	1.32E+05	0.1				2.9		0.3			
41	wetland	wetland	stable wetland	stable wetland	1.06E+06	1.1		18.6							
42	wetland	water	wetland loss	water gain	9.11E+05	0.9				19.8		3.4			
43	water	forest	water loss	forest gain	1.92E+05	0.2	21.8		13.6	1.4	26.4	0.4	34.6	12.8	58.7
44	water	barren	water loss	barren gain	7.08E+05	0.7	0.4		62.3	5.2	121.0	0.5			
45	water	grass	water loss	grassland gain	5.06E+06	5.1				37.3		0.8			
46	water	crop	water loss	cropland gain	5.25E+05	0.5				3.9		0.9			
47	water	urban	water loss	urban gain	9.31E+04	0.1				0.7		0.2			
48	water	wetland	water loss	wetland gain	7.01E+06	7.0				51.6		28.4			
49	water	water	stable water	stable water	8.23E+06	8.2		37.7							
	Total					5,197.7									

Appendix 2.2.4.41.3. 50-year changes (1965-2015) in land cover and change percentages within Absheron, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	8.52E+07	85.2	95.7	89.1	10.5		12.1		97.4	1.7	1.7
2	forest	barren	forest loss	barren gain	2.13E+05	0.2	1.9		10.9	2.0	12.7	0.2			
3	forest	grass	forest loss	grassland gain	5.87E+06	5.9				56.1		2.5			
4	forest	crop	forest loss	cropland gain	4.04E+06	4.0				38.6		7.8			
5	forest	urban	forest loss	urban gain	8.97E+04	0.1				0.9		0.1			
6	forest	wetland	forest loss	wetland gain	2.46E+05	0.2				2.4		1.7			
7	forest	water	forest loss	water gain	0.00E+00	0.0				0.0		0.0			
8	barren	forest	barren loss	forest gain	3.83E+05	0.4	136.6		110.1	0.3	119.2	3.2	145.7	9.1	6.6
9	barren	barren	stable barren	stable barren	2.65E+07	26.5	2.7	19.4	80.6		87.2				
10	barren	grass	barren loss	grassland gain	9.99E+07	99.9				90.7		41.9			
11	barren	crop	barren loss	cropland gain	1.64E+06	1.6				1.5		3.2			
12	barren	urban	barren loss	urban gain	7.53E+06	7.5				6.8		10.1			
13	barren	wetland	barren loss	wetland gain	2.60E+05	0.3				0.2		1.8			
14	barren	water	barren loss	water gain	3.92E+05	0.4				0.4		3.4			
15	grass	forest	grassland loss	forest gain	8.90E+06	8.9	4,648.6		238.5	3.7	238.7	73.3	4,648.9	0.2	0.0
16	grass	barren	grassland loss	barren gain	1.14E+08	114.2	90.6		5.1	47.9	5.1	95.8			
17	grass	grass	stable grassland	stable grass	4.41E+09	4,410.2		94.9							
18	grass	crop	grassland loss	cropland gain	4.29E+07	42.9				18.0		83.2			
19	grass	urban	grassland loss	urban gain	6.24E+07	62.4				26.2		83.5			
20	grass	wetland	grassland loss	wetland gain	5.41E+06	5.4				2.3		36.8			
21	grass	water	grassland loss	water gain	4.65E+06	4.6				1.9		40.4			
22	crop	forest	cropland loss	forest gain	1.51E+06	1.5	101.9		85.3	1.8	51.6	12.5	68.2	-33.7	-33.1
23	crop	barren	cropland loss	barren gain	1.34E+06	1.3	2.0		83.7	1.6	50.6	1.1			
24	crop	grass	cropland loss	grassland gain	7.71E+07	77.1				90.3		32.3			
25	crop	crop	stable cropland	stable cropland	1.66E+07	16.6		16.3							
26	crop	urban	cropland loss	urban gain	3.40E+06	3.4				4.0		4.5			
27	crop	wetland	cropland loss	wetland gain	1.57E+06	1.6				1.8		10.7			
28	crop	water	cropland loss	water gain	4.59E+05	0.5				0.5		4.0			
29	urban	forest	urban loss	forest gain	6.36E+04	0.1	73.2		36.5	0.2	74.7	0.5	111.4	38.3	52.3
30	urban	barren	urban loss	barren gain	1.62E+06	1.6	1.4		49.9	4.4	102.2	1.4			
31	urban	grass	urban loss	grass gain	3.38E+07	33.8				92.7		14.2			
32	urban	crop	urban loss	crop gain	6.79E+05	0.7				1.9		1.3			
33	urban	urban	stable urban	stable urban	3.67E+07	36.7		50.1							
34	urban	wetland	urban loss	wetland gain	2.56E+05	0.3				0.7		1.7			
35	urban	water	urban loss	water gain	5.23E+04	0.1				0.1		0.5			
36	wetland	forest	wetland loss	forest gain	1.17E+06	1.2	35.8		26.1	4.5	14.7	9.6	24.5	-11.3	-31.6
37	wetland	barren	wetland loss	barren gain	1.64E+06	1.6	0.7		72.7	6.3	41.1	1.4			
38	wetland	grass	wetland loss	grassland gain	1.42E+07	14.2				54.7		6.0			
39	wetland	crop	wetland loss	cropland gain	1.84E+06	1.8				7.1		3.6			
40	wetland	urban	wetland loss	urban gain	1.22E+06	1.2				4.7		1.6			
41	wetland	wetland	stable wetland	stable wetland	9.77E+06	9.8		27.3							
42	wetland	water	wetland loss	water gain	5.94E+06	5.9				22.8		51.7			
43	water	forest	water loss	forest gain	1.05E+05	0.1	37.2		15.6	0.7	11.5	0.9	33.1	-4.2	-11.2
44	water	barren	water loss	barren gain	2.01E+05	0.2	0.7		42.0	1.3	30.9	0.2			
45	water	grass	water loss	grassland gain	7.79E+06	7.8				49.8		3.3			
46	water	crop	water loss	cropland gain	4.63E+05	0.5				3.0		0.9			
47	water	urban	water loss	urban gain	1.17E+05	0.1				0.8		0.2			
48	water	wetland	water loss	wetland gain	6.97E+06	7.0				44.6		47.4			
49	water	water	stable water	stable water	2.16E+07	21.6		58.0							
	Total					5,129.1									

Appendix 2.2.4.42.1. Soviet era changes (1965-'87) in land cover and change percentages within Lankaran, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	8.45E+06	8.5	115.9	7.3	107.4		4.0		12.4	-103.4	-89.3
2	forest	barren	forest loss	barren gain	0.00E+00	0.0	10.9		92.7	0.0	3.4	0.0			
3	forest	grass	forest loss	grassland gain	3.45E+07	34.5				32.1		20.4			
4	forest	crop	forest loss	cropland gain	7.19E+07	71.9				66.9		21.4			
5	forest	urban	forest loss	urban gain	8.76E+04	0.1				0.1		6.9			
6	forest	wetland	forest loss	wetland gain	9.37E+05	0.9				0.9		1.1			
7	forest	water	forest loss	water gain	2.16E+04	0.0				0.0		2.8			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.1	0.0	0.1	0.1	NA
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	NA	NA		NA				
10	barren	grass	barren loss	grassland gain	0.00E+00	0.0				NA		0.0			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				NA		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				NA		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				NA		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				NA		0.0			
15	grass	forest	grassland loss	forest gain	2.75E+06	2.7	439.1		279.7	1.0	168.8	68.9	328.2	-110.9	-25.3
16	grass	barren	grassland loss	barren gain	4.17E+04	0.0	41.3		63.7	0.0	38.5	30.3			
17	grass	grass	stable grassland	stable grass	1.59E+08	159.3		36.3							
18	grass	crop	grassland loss	cropland gain	2.55E+08	254.8				91.1		75.8			
19	grass	urban	grassland loss	urban gain	2.39E+05	0.2				0.1		18.7			
20	grass	wetland	grassland loss	wetland gain	2.17E+07	21.7				7.7		25.2			
21	grass	water	grassland loss	water gain	1.82E+05	0.2				0.1		23.9			
22	crop	forest	cropland loss	forest gain	9.80E+05	1.0	471.2		190.3	0.5	336.3	24.5	617.1	146.0	31.0
23	crop	barren	cropland loss	barren gain	9.60E+04	0.1	44.3		40.4	0.1	71.4	69.7			
24	crop	grass	cropland loss	grassland gain	1.25E+08	124.8				65.6		73.9			
25	crop	crop	stable cropland	stable cropland	2.81E+08	280.9		59.6							
26	crop	urban	cropland loss	urban gain	8.90E+05	0.9				0.5		69.9			
27	crop	wetland	cropland loss	wetland gain	6.31E+07	63.1				33.2		73.3			
28	crop	water	cropland loss	water gain	4.64E+05	0.5				0.2		60.8			
29	urban	forest	urban loss	forest gain	6.96E+03	0.0	12.3		12.3	0.1	1.3	0.2	1.3	-11.0	-89.6
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	1.2		100.0	0.0	10.4	0.0			
31	urban	grass	urban loss	grass gain	8.12E+06	8.1				66.2		4.8			
32	urban	crop	urban loss	crop gain	3.74E+06	3.7				30.5		1.1			
33	urban	urban	stable urban	stable urban	0.00E+00	0.0		0.0							
34	urban	wetland	urban loss	wetland gain	3.81E+05	0.4				3.1		0.4			
35	urban	water	urban loss	water gain	1.18E+04	0.0				0.1		1.6			
36	wetland	forest	wetland loss	forest gain	8.21E+04	0.1	25.5		7.4	1.1	86.1	2.1	104.2	78.7	308.7
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	2.4		29.0	0.0	337.7	0.0			
38	wetland	grass	wetland loss	grassland gain	1.43E+06	1.4				19.4		0.8			
39	wetland	crop	wetland loss	cropland gain	5.73E+06	5.7				77.6		1.7			
40	wetland	urban	wetland loss	urban gain	5.63E+04	0.1				0.8		4.4			
41	wetland	wetland	stable wetland	stable wetland	1.81E+07	18.1		71.0							
42	wetland	water	wetland loss	water gain	8.34E+04	0.1				1.1		10.9			
43	water	forest	water loss	forest gain	1.72E+05	0.2	0.3		0.3	58.0	0.8	4.3	0.8	0.5	156.9
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	256.9	0.0			
45	water	grass	water loss	grassland gain	4.94E+04	0.0				16.6		0.0			
46	water	crop	water loss	cropland gain	4.24E+04	0.0				14.3		0.0			
47	water	urban	water loss	urban gain	1.39E+03	0.0				0.5		0.1			
48	water	wetland	water loss	wetland gain	3.13E+04	0.0				10.6		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					1,064.2									

Appendix 2.2.4.42.2. Post-Soviet changes (1987-2015) in land cover and change percentages within Lankaran, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	3.01E+06	3.0	12.4	24.2	9.4		0.4		3.5	-9.0	-72.2
2	forest	barren	forest loss	barren gain	0.00E+00	0.0	1.2		75.8	0.0	3.5	0.0			
3	forest	grass	forest loss	grassland gain	2.79E+03	0.0				0.0		0.0			
4	forest	crop	forest loss	cropland gain	5.58E+06	5.6				59.3		3.6			
5	forest	urban	forest loss	urban gain	3.68E+06	3.7				39.2		67.1			
6	forest	wetland	forest loss	wetland gain	6.27E+03	0.0				0.1		0.1			
7	forest	water	forest loss	water gain	1.37E+05	0.1				1.5		8.8			
8	barren	forest	barren loss	forest gain	1.39E+03	0.0	0.1		0.1	1.0	0.1	0.3	0.1	0.0	7.1
9	barren	barren	stable barren	stable barren	3.48E+03	0.0	0.0	2.5	97.5		104.6				
10	barren	grass	barren loss	grassland gain	9.67E+04	0.1				72.0		0.0			
11	barren	crop	barren loss	cropland gain	3.20E+04	0.0				23.8		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				0.0		0.0			
13	barren	wetland	barren loss	wetland gain	4.17E+03	0.0				3.1		0.1			
14	barren	water	barren loss	water gain	0.00E+00	0.0				0.0		0.0			
15	grass	forest	grassland loss	forest gain	9.47E+04	0.1	326.1		131.3	0.1	210.8	21.5	405.7	79.6	24.4
16	grass	barren	grassland loss	barren gain	1.09E+05	0.1	30.9		40.3	0.1	64.6	75.9			
17	grass	grass	stable grassland	stable grass	1.95E+08	194.8		59.7							
18	grass	crop	grassland loss	cropland gain	1.27E+08	127.4				97.1		83.3			
19	grass	urban	grassland loss	urban gain	1.35E+06	1.4				1.0		24.7			
20	grass	wetland	grassland loss	wetland gain	2.03E+06	2.0				1.5		25.5			
21	grass	water	grassland loss	water gain	2.44E+05	0.2				0.2		15.8			
22	crop	forest	cropland loss	forest gain	1.43E+05	0.1	611.3		210.1	0.1	152.9	32.4	554.2	-57.2	-9.4
23	crop	barren	cropland loss	barren gain	2.43E+04	0.0	57.9		34.4	0.0	25.0	16.9			
24	crop	grass	cropland loss	grassland gain	2.04E+08	203.8				97.0		96.7			
25	crop	crop	stable cropland	stable cropland	4.01E+08	401.3		65.6							
26	crop	urban	cropland loss	urban gain	1.50E+05	0.1				0.1		2.7			
27	crop	wetland	cropland loss	wetland gain	5.82E+06	5.8				2.8		72.9			
28	crop	water	cropland loss	water gain	8.13E+04	0.1				0.0		5.3			
29	urban	forest	urban loss	forest gain	0.00E+00	0.0	1.3		1.2	0.0	5.5	0.0	5.5	4.2	334.3
30	urban	barren	urban loss	barren gain	0.00E+00	0.0	0.1		98.1	0.0	432.4	0.0			
31	urban	grass	urban loss	grass gain	4.74E+05	0.5				38.0		0.2			
32	urban	crop	urban loss	crop gain	7.41E+05	0.7				59.5		0.5			
33	urban	urban	stable urban	stable urban	2.36E+04	0.0		1.9							
34	urban	wetland	urban loss	wetland gain	3.06E+04	0.0				2.5		0.4			
35	urban	water	urban loss	water gain	0.00E+00	0.0				0.0		0.0			
36	wetland	forest	wetland loss	forest gain	1.99E+05	0.2	104.2		26.4	0.8	8.0	45.3	85.7	-18.5	-17.7
37	wetland	barren	wetland loss	barren gain	1.04E+04	0.0	9.9		25.4	0.0	7.7	7.2			
38	wetland	grass	wetland loss	grassland gain	6.21E+06	6.2				23.5		2.9			
39	wetland	crop	wetland loss	cropland gain	1.89E+07	18.9				71.6		12.4			
40	wetland	urban	wetland loss	urban gain	6.26E+03	0.0				0.0		0.1			
41	wetland	wetland	stable wetland	stable wetland	7.78E+07	77.8		74.6							
42	wetland	water	wetland loss	water gain	1.09E+06	1.1				4.1		70.1			
43	water	forest	water loss	forest gain	2.08E+03	0.0	0.8		0.8	0.3	1.5	0.5	1.5	0.8	102.5
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.1		100.0	0.0	202.5	0.0			
45	water	grass	water loss	grassland gain	1.97E+05	0.2				25.8		0.1			
46	water	crop	water loss	cropland gain	1.79E+05	0.2				23.4		0.1			
47	water	urban	water loss	urban gain	2.97E+05	0.3				38.8		5.4			
48	water	wetland	water loss	wetland gain	8.96E+04	0.1				11.7		1.1			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					1,056.2									

Appendix 2.2.4.42.3. 50-year changes (1965-2015) in land cover and change percentages within Lankaran, Azerbaijan.

	From	To	change class	change class	sq m	sq km	Total class	Stable %	Loss	Percent from loss	Gain	Percent from gain	Now	change	% change
1	forest	forest	stable forest	stable forest	2.54E+06	2.5	115.9	2.2	113.3		0.9		3.4	-112.4	-97.0
2	forest	barren	forest loss	barren gain	0.00E+00	0.0	10.9		97.8	0.0	0.8	0.0			
3	forest	grass	forest loss	grassland gain	5.31E+07	53.1				46.9		28.6			
4	forest	crop	forest loss	cropland gain	5.99E+07	59.9				52.8		23.1			
5	forest	urban	forest loss	urban gain	1.74E+04	0.0				0.0		2.3			
6	forest	wetland	forest loss	wetland gain	3.33E+05	0.3				0.3		0.5			
7	forest	water	forest loss	water gain	9.73E+03	0.0				0.0		0.6			
8	barren	forest	barren loss	forest gain	0.00E+00	0.0	0.0		0.0	NA	0.2	0.0	0.2	0.2	NA
9	barren	barren	stable barren	stable barren	0.00E+00	0.0	0.0	NA	NA		NA				
10	barren	grass	barren loss	grassland gain	0.00E+00	0.0				NA		0.0			
11	barren	crop	barren loss	cropland gain	0.00E+00	0.0				NA		0.0			
12	barren	urban	barren loss	urban gain	0.00E+00	0.0				NA		0.0			
13	barren	wetland	barren loss	wetland gain	0.00E+00	0.0				NA		0.0			
14	barren	water	barren loss	water gain	0.00E+00	0.0				NA		0.0			
15	grass	forest	grassland loss	forest gain	5.18E+05	0.5	439.1		209.9	0.2	185.8	57.1	414.9	-24.1	-5.5
16	grass	barren	grassland loss	barren gain	7.02E+04	0.1	41.3		47.8	0.0	42.3	46.1			
17	grass	grass	stable grassland	stable grass	2.29E+08	229.1		52.2							
18	grass	crop	grassland loss	cropland gain	1.90E+08	189.8				90.4		73.2			
19	grass	urban	grassland loss	urban gain	1.15E+05	0.1				0.1		15.2			
20	grass	wetland	grassland loss	wetland gain	1.92E+07	19.2				9.1		27.1			
21	grass	water	grassland loss	water gain	2.52E+05	0.3				0.1		16.8			
22	crop	forest	cropland loss	forest gain	1.91E+05	0.2	471.2		174.0	0.1	259.3	21.1	556.5	85.3	18.1
23	crop	barren	cropland loss	barren gain	4.66E+04	0.0	44.3		36.9	0.0	55.0	30.6			
24	crop	grass	cropland loss	grassland gain	1.21E+08	121.5				69.8		65.4			
25	crop	crop	stable cropland	stable cropland	2.97E+08	297.2		63.1							
26	crop	urban	cropland loss	urban gain	6.24E+05	0.6				0.4		82.2			
27	crop	wetland	cropland loss	wetland gain	5.10E+07	51.0				29.3		72.0			
28	crop	water	cropland loss	water gain	6.93E+05	0.7				0.4		46.2			
29	urban	forest	urban loss	forest gain	2.99E+04	0.0	12.3		11.5	0.3	0.8	3.3	1.5	-10.7	-87.4
30	urban	barren	urban loss	barren gain	3.55E+04	0.0	1.2		93.6	0.3	6.2	23.3			
31	urban	grass	urban loss	grass gain	9.07E+06	9.1				79.0		4.9			
32	urban	crop	urban loss	crop gain	2.12E+06	2.1				18.5		0.8			
33	urban	urban	stable urban	stable urban	7.81E+05	0.8		6.4							
34	urban	wetland	urban loss	wetland gain	2.12E+05	0.2				1.8		0.3			
35	urban	water	urban loss	water gain	6.27E+03	0.0				0.1		0.4			
36	wetland	forest	wetland loss	forest gain	2.57E+04	0.0	25.5		10.2	0.3	70.8	2.8	86.1	60.6	237.7
37	wetland	barren	wetland loss	barren gain	0.00E+00	0.0	2.4		39.8	0.0	277.5	0.0			
38	wetland	grass	wetland loss	grassland gain	2.05E+06	2.1				20.2		1.1			
39	wetland	crop	wetland loss	cropland gain	7.54E+06	7.5				74.2		2.9			
40	wetland	urban	wetland loss	urban gain	2.09E+03	0.0				0.0		0.3			
41	wetland	wetland	stable wetland	stable wetland	1.53E+07	15.3		60.2							
42	wetland	water	wetland loss	water gain	5.38E+05	0.5				5.3		35.9			
43	water	forest	water loss	forest gain	1.43E+05	0.1	0.3		0.3	48.2	1.5	15.8	1.5	1.2	404.7
44	water	barren	water loss	barren gain	0.00E+00	0.0	0.0		100.0	0.0	504.7	0.0			
45	water	grass	water loss	grassland gain	7.59E+04	0.1				25.6		0.0			
46	water	crop	water loss	cropland gain	4.60E+04	0.0				15.5		0.0			
47	water	urban	water loss	urban gain	0.00E+00	0.0				0.0		0.0			
48	water	wetland	water loss	wetland gain	3.20E+04	0.0				10.8		0.0			
49	water	water	stable water	stable water	0.00E+00	0.0		0.0							
	Total					1,064.2									

Chapter 3. The impact of half-a-century of land cover changes on wild ungulates in Azerbaijan.

Abstract

Historical changes in land cover and habitats can influence current distributions of wildlife species that are threatened by habitat loss due to anthropogenic activities. Understanding the historical habitats of wildlife is thus crucial for effective conservation planning and setting conservation priorities. However, the absence of baseline data on historical habitats hinders such efforts. Cold-war spy satellite data (Corona) could potentially provide information on past land cover and potential habitat conditions though. Here, we demonstrate the value of Corona data for long-term habitat assessments. Our goal was to evaluate over 55 years of changes in potential habitats of wild ungulate species in Azerbaijan – goitered gazelle (*Gazella subgutturosa*), East Caucasian tur (*Capra cylindricornis*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), Gmelin's mouflon (*Ovis gmelinii*), chamois (*Rupicapra rupicapra*) and bezoar goat (*Capra aegagrus*). Specifically, we: (a) developed models and maps for relative likelihood of species' presence in 2021; (b) applied the models developed for 2021 to map the relative likelihood of species' presence in 1965; (c) evaluated 55-year changes by comparing historical and current potential habitats; and (d) summarized changes in potential habitat within protected areas versus the year of their establishment to assess if they successfully conserved and restored potential suitable habitat. Our species presence data was collected by standardized monitoring and field surveys by local field biologists, and from collar data (gazelle), as a part of local wildlife conservation programs. We used land cover maps derived from recent (Sentinel-2) and historical (Corona) satellite data, plus TerraClim climate data, global datasets for the duration of frozen ground with and without snow cover, and SRTM elevation data to produce ensemble models for

each species using *biomod2* in R. Our models had on average a True Skill Statistic (TSS) of 79.6% and an Area Under the Curve (AUC) of 95.9%, as well as 90.4% sensitivity and 89.3% specificity. We found that potential habitats of wild ungulates in Azerbaijan decreased, especially in mountainous areas, consistent with forest loss trends. For mountainous species, the overall decrease in potential habitat ranged from 16% to 75% with least changes for bezoar goat and most for East Caucasian tur. In lowlands, the potential habitats of gazelle increased within protected areas but outside they shifted, possibly due to concomitant abandoned and new agricultural fields in the lowlands of Azerbaijan. Strictly protected areas established after the collapse of the Soviet Union were the most successful, with 13 to 214% increase in potential habitats. We had expected that protected areas with a longer history would yield better outcomes, but those established during the Soviet era exhibited more often a decrease in potential habitats (7 to 64% decrease), and rarely an increase. More broadly, we demonstrate here the feasibility of using Corona satellite data in assessing wildlife species' potential habitat changes over 55 years. Our findings highlight the importance of considering historical changes and provide valuable information for conservation planning.

Introduction

Wild species' current distributions are tied to historical changes in land cover and habitats, highlighting species' adapting capability (Hofman-Kamińska et al., 2019). This adaptability faces serious threats though from rapid habitat loss due to overexploitation and the expansion of anthropogenic activities (Pereira et al., 2012). Understanding the historical habitats of wildlife species and their current status, and taking into account the previous landscape changes is essential to accurately determine conservation priorities (Popescu et al., 2020), and to effectively

design and implement long-term conservation programs that integrate the planning of land use, socio-economic development, and conservation (Quintero et al., 2023).

Assessing the extent to which environmental conditions change over time can provide valuable insights into the challenges and opportunities that biodiversity faces (Radeloff et al., 2015). Prior information on the state of nature that could be a target for restoration of habitat for wild species is often lacking, primarily due to the absence of baseline data. However, 1960s ca. 2.5-m resolution Corona spy satellite data could potentially fill this information need by extending the Earth observation timeline by approximately two decades prior to the availability of medium-resolution (30-m) Landsat satellite imagery, and four decades prior to high-resolution (< 5 m) satellite data. By evaluating the magnitude of environmental changes since the Corona era, it may be possible to quantify resulting effects on species' habitats. Accordingly, the declassified Corona satellite data could provide better baselines for conservation planning. In this study, we aim to explore the dynamic relationship between species and their habitats to help identify potential threats and guide effective conservation strategies and management decisions within changing environments.

Human-driven land cover changes and habitat disruption are some of the most important causes of habitat and biodiversity loss across the globe (Daskalova et al., 2020; Jaureguiberry et al., 2022). Changes have been especially rapid since the mid-20th century due to agricultural mechanization (Crossley et al., 2021), the green revolution (Evenson and Gollin, 2003; Shiferaw et al., 2013), and widespread urbanization (Hosner et al., 2018; United Nations, 2019), and the subsequent reduction of habitats for birds, mammals, and other taxa (e.g., Pidgeon et al., 2014). Understanding the effects of these global changes due to human activities on wildlife species habitats can help identify areas where conservation efforts are most needed.

The Caucasus region is a biodiversity hotspot that has suffered considerable losses in its native biodiversity (Myers et al., 2000). Due to its geographical location, the Caucasus, particularly Azerbaijan, holds high importance as a corridor for migratory species (Heiss, 2018, 2013), and plays an important role in supporting the seasonal movements and breeding activities of resident species, especially within transboundary networks (Farhadinia et al., 2015; Guliev et al., 2009; Talibov et al., 2009). However, the Caucasus has undergone major land cover changes that have diminished the habitats of wildlife species and reduced their populations (Mallon et al., 2007; Nakajima, 2023), primarily due to habitat loss and degradation (Etzold, 2005; Wiesmair et al., 2017).

The Caucasus had a millennia-long history of land use that has shaped the current land cover (Belonovskaya et al., 2016). However, land cover changes were especially rapid after World War II due to population increases, and economical demands from other parts of the Soviet Union (Clem, 1980), which results in prioritizing agriculture over wildlife habitats, and giving conservation a secondary role. Policies promoting land use intensification, especially in the 1950s and 1960s increased pressure on local wildlife habitats throughout former Soviet countries (Mazhitova et al., 2021). Especially in the 21st century, there have been efforts aiming to reverse habitat destruction, and restore wildlife habitats (Askerov et al., 2021; Weinberg et al., 2020), but many wildlife species in the Caucasus remain endangered (Red Book, 2023). Given the ongoing trends of widespread land cover change (Buchner et al., 2020; Rizayeva, previous chapter), the loss of habitats may become irreversible. To prevent the loss of habitats and corridors for wild species, both locally and regionally, it is crucial to understand the long-term patterns of these losses, in order to formulate effective conservation and restoration strategies within the Caucasus biodiversity hotspot.

Population decreases of many large ungulate species have led to their disappearance from large portions of their past distributions (Di Marco et al., 2014; Milner-Gulland et al., 2001). Furthermore, climate change can affect wild species' reproductive cycles, accelerate spread of various diseases, increase competition for scarce resources, and alter environmental conditions leading to habitat loss. As such, the effects of climate change can disrupt foraging opportunities by shortening green-up duration, especially for ungulate species surfing the green wave (Aikens et al., 2017; Bischof et al., 2012; Merkle et al., 2016). High reproductive rates in some species facilitates their ability to respond to disturbances and to rebound their populations (Polishchuk, 2002). However, large ungulate species typically require more time to adapt to and reproduce under new conditions, which makes them vulnerable to even minor environmental changes and places their populations at higher risk of extinction (Morris and Doak, 2002).

The Caucasus, a region with rich livestock farming history, is experiencing drastic declines in wild ungulate populations. Populations of East Caucasian tur (*Capra cylindricornis*) dropped in Dagestan, Russia, from 20,000 in the 1970s to 16,000 in the 2010s (Ravkin, 1975, cited in Babaev and Yarovenko, 2021), and in Azerbaijan, from 8,000 in the 1960s (Syroechkovskii and Rogacheva, 1975) to 5,300 in 2006 (Guliev et al., 2009). Reports of early 1970s mouflon (*Ovis gmelinii*) populations range between 350-400 (Airumyan and Gasparyan, 1976; Yavruyan, 1975, cited in Khorozyan et al., 2009) and 1000-1200 (Alekperov et al., 1976, cited in Talibov et al., 2009), but by 2007, only about 200 individuals remained (Khorozyan et al., 2009; Talibov et al., 2009). Bezoar goat (*Capra aegagrus*) numbers remained relatively stable at about 500 individuals in Armenia (Gasparyan, 1974; Khorozyan et al., 2009), 1,000-1,500 in Azerbaijan (Kuliev, 1981; Mammadov and Bayramov, 2019; Talibov et al., 2009), 900 in Türkiye (Diker et al., 2009), and 300 in Georgia (Arabuli, 1989; Kapanadze, 1975), but their numbers are low

(Weinberg et al., 2020), suggesting that they may not be able to recover from past disturbances. The population declines of wild ungulates in the Caucasus are due to many factors including poaching, trophy hunting (Ghoddousi et al., 2019; Sarasa, 2013; Shokri et al., 2021), livestock competition, and habitat degradation (Guliev et al., 2009; Soofi et al., 2019; Talibov et al., 2009). To understand how these factors influence populations, it is important to examine periods of higher population levels, such as those in the mid-20th century. By examining historical conditions, it may be possible to detect the drivers responsible for subsequent population declines.

Our main goal was to evaluate long-term changes in habitat availability of wild ungulate species in Azerbaijan. Our objectives were to: (a) develop models and maps of the relative likelihood of species' presence in 2021; (b) apply the models developed for 2021 to map the relative likelihood of species' presence in 1965; (c) evaluate 55-year changes by comparing historical and current potential habitats; and (d) summarize changes in potential habitat within protected areas versus the year of their establishment to assess if they successfully conserved and restored potential suitable habitat. Given the increase in land use pressures throughout the Caucasus, we expected that wild species habitats in Azerbaijan decreased, both in mountainous areas where forest loss occurred since 1965 (Buchner et al., 2020; Rizayeva, previous chapter), and in lowlands, because of grassland degradation (Lewińska et al., 2021, 2020).

Methods

Study area

Our study area covers approximately 125,000 km^2, most of Azerbaijan and a 25-km buffer, in the Caucasus eco-region (Figure 3.1). Despite Azerbaijan's relatively small area of only 86,000 km^2, it features remarkable geographical and biological diversity. A total of 407 bird, 126 mammal, 123 fish, 64 reptile and 11 amphibian species reside at elevations ranging from -32 m along the Caspian Sea coast to 4,466 m at the Bazar Duzu peak in the Greater Caucasus. The landscapes of Azerbaijan are also stopover sites for numerous migratory species (Heiss, 2016; Yusifov and Ahmadov, 2021). However, along with changes in land cover, the effects of climate change are strong in Azerbaijan (Bassullu and Sanchez-Paus Díaz, 2023) with plant species shifting upward from alpine-subalpine to subnival landscapes (Yusifov, 2022).

Data

Our focal species were goitered gazelle (*Gazelle subgutturosa;* hereafter 'gazelle'), East Caucasian tur (*Capra cylindricornis;* hereafter 'tur'), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), Gmelin's mouflon (Ovis gmelinii; hereafter 'mouflon'), chamois (*Rupicapra rupicapra*) and bezoar goat (*Capra aegagrus*; hereafter 'bezoar'). We chose these ungulate species for our study because all are on the local red list of endangered species (Red Book, 2023), and because they represent all ungulate species in Azerbaijan other than the ubiquotous wild boar and newly reintroduced European bison. Our presence data was collected by standardized monitoring and field surveys by local field biologists, and from collar data (gazelle), as a part of local wildlife conservation programs of the World Wildlife Fund (WWF) (Weinberg, 2013, 2015). Our presence data is for 1998 through 2022. Since our focal year for modeling the relative likelihood of species' presence is 2021, we ensured that the locations of presence points remained stable between the year that they were sampled and 2021. For this purpose, we used the Landsat-derived land cover maps from 1987 to 2015 (Buchner et al., 2020),

plus Sentinel-2-derived land cover maps for 2020 (Zanaga et al., 2021) and 2021 (Zanaga et al., 2022). If location of a point encountered land cover changes between any time points, we used the Google Earth Pro to visually assess those points and determine whether the change corresponded to the year the point was sampled. If a change occurred between when the point was acquired and our focal year 2021, then we removed that point from further analyses.

Our selection of environmental variables (Table 3.1) was based on their availability for both 2021 and 1965, as well as their biological importance for our species, and importance demonstrated by previous studies (Bleyhl et al., 2017; Kuemmerle et al., 2020; Sarukhanova, 2021). Our study area for potential habitat change assessment is limited to where Corona data was available, thus covering about 75% of Azerbaijan. To account for resources located at close proximity outside of political borders, we included all areas within 25 km of Azerbaijan's borders. Thus, we covered about 125,000 km^2 to model relative likelihood of presence for 2021 and 90,000 km^2 for 1965. For 2021, we used the 10-m Sentinel-2-derived maps (Zanaga et al., 2022), 5-year average of 4-km climate data from TerraClimate (averaged for 2018-2022) (Abatzoglou et al., 2018), as well as the 2010-2014 average of 5-km snow data (Zhu et al., 2019) and resampled all of them to 30-m. For 1965, we used land cover maps derived using Corona satellite imagery (2.5-m) (Rizayeva, previous chapter), 4-km climate data from TerraClimate (averaged for 1962-1966) (Abatzoglou et al., 2018) and the 1982-1986 average of 5-km snow data (Zhu et al., 2019), and resampled all of them to 30-m. Our initial tests using the low-resolution datasets (climate and snow) showed their high variability within our study area, which is why we included them. We used 30-m as a unified spatial resolution for our study based on daily movements of our focal species (Askerov et al., 2021; Babaev and Magomedov, 2014; Weinberg, 1984). To account for topographic information, we used the 30-m SRTM data (Farr et

al., 2007) for both 1965 and 2021 to derive elevation, slope, aspect and terrain ruggedness. We calculated Euclidean distance to urban areas and to water bodies for both the 2021 and 1965 land cover maps.

We ensured that the projections, spatial resolutions and extent matched for all predictor variables. To correct for sampling bias by spatial filtering (Dormann et al., 2007; Phillips et al., 2009; Veloz, 2009), we ensured that our presence data points for each species were at least 1 km apart from each other (Table 3.2, Figure 3.2). To summarize stable and changed areas within and outside of protected areas, we downloaded the protected area borders from the World Database on Protected Areas (Figure 3a) (UNEP-WCMC and IUCN, 2023). We also summarized the resulting maps using the global biomes dataset (Figure 3.3b) (Olson et al., 2001).

Modeling species' potential current distributions

To map relative likelihood of presence, we constructed single-species ensemble models for 2021 for each of our species (Figure 3.4). Specifically, we applied an ensemble of a generalized linear model (GLM), boosted regression tree (GBM), classification tree analysis (CTA), multiple adaptive regression splines (MARS), random forest (RF), maximum entropy (MAXNET), and artificial neural network (ANN) models available in *biomod2* package (Thuiller et al., 2009) in R software (R Core Team, 2023). Biomod2 performs well, especially when working with small sample sizes (Luo et al., 2017), such as ours, and can help mitigate uncertainties that arise in single-species modeling (Hao et al., 2019; Thuiller et al., 2016). Since we had only presence data available for all of our species, we used quadrature points (pseudo-absence and background). We selected a common approach for generating quadrature points for all species that is a 'disk' strategy setting the minimum and maximum distance to 2 and 20 km, respectively. Our rationale for selecting these distances was based on the average farthest distances that our species travel

and are comparable to those in other studies of our focal species (Askerov et al., 2021; Babaev and Magomedov, 2014; Weinberg, 1984). Given that each algorithm produces best results with different number of quadrature points (e.g. CTA, GBM, and RF perform better with equal number of presence and pseudo-absence points, while for MARS, 100 pseudo-absences are sufficient, see Barbet-Massin et al., 2012), we conducted numerous tests to select the best common number of quadrature points. Specifically, we set the number of quadrature points equal to presence points, as well as 1,000, 5,000, and 10,000 (or maximum possible, Appendix 3.1), and compared model results. While generating quadrature points, we ensured that no point was located within water bodies or urban areas. To verify that our data is independent (Dormann, et al. 2013), we built correlation plots and matrices for each species and retained only those with Pearson correlation coefficient ≤ 0.7. Our selection of predictor variables used for each species modeling was based on the results of their correlation assessment using each species' data, the variance inflation factor (VIF ≤ 10.0 based on the results of linear models), and stepwise selection of predictor variables.

To measure the predictive accuracy of our models, we calculated the true skill statistic (TSS) (Allouche et al., 2006), and the area under the receiver operating characteristic curve (AUC ROC) (Guisan et al., 2017; Hanley and McNeil, 1982), as well as model sensitivity and specificity. We chose these evaluation metrics because TSS works well for imbalanced datasets, and measures a model's ability to distinguish between presence and absence accounting for omission and commission errors (Allouche et al., 2006; Shabani et al., 2018). AUC identifies the optimal trade-off between true positives (sensitivity) and true negatives (specificity) (Guisan et al., 2017). Sensitivity and specificity are independent of each other and also independent of prevalence (Shabani et al., 2018). We conducted k-fold cross-validation by randomly splitting

the presence/quadrature data into training (80%) and testing (20%) points, and conducted three cross-validation runs. We assessed the predictor variable importance using built-in function within biomod2, which computes the model prediction and calculates the Pearson's correlation between reference and predictions for each predictor variable. The resulting score is subtracted from one, with higher scores indicating less correlation between reference and predictions, meaning a stronger influence of that variable on the model's predictive power. We also produced response plots for each predictor variable based on GLMs. We constructed ensemble models (*EMwmean*), calculating the weighted average relative likelihood of single models, with weights based on their AUC scores. To summarize the changes, we categorized the results to the following four grades based on the relative likelihood of species' presence: 0-0.1 – potential non-habitat; 0.1-0.3 – potential least-suitable habitat; 0.3-0.55 – potential moderately-suitable habitat; and >0.55 – potential highly-suitable habitat. We selected these values based on expert knowledge so that the potential habitats deemed suitable matched used habitat in 2021 well.

Modeling species' potential 1965 distributions and assessing changes

To hindcast the relative likelihood of our species' presence in 1965, we applied the 2021 models for each species to our 1965 variables. Although we had access to some archival data on species populations and habitats from reports of protected areas in the 1950s to '70s, those data were too scarce for a formal validation. Instead, we used them to discuss descriptively how well our findings in 1965 match with the protected area reports.

To evaluate changes from 1965 to 2021, we compared the potential habitat maps for both time points. We grouped species according to their altitudinal preferences into lowland and mountain species. The mountain species primarily inhabit Caucasus-Anatolian-Hyrcanian temperate forests (including Caspian Hyrcanian mixed forests and Caucasus mixed forests) biome, while

the lowland species inhabit Azerbaijan shrub desert and steppe biome (Olson et al., 2001). However, because our study area for change includes less than 50% of Caspian Hyrcanian and Montane steppe, and none of Elburz range forest steppe, we focused mostly on Caucasus mixed forests and Azerbaijan shrub desert and steppe biomes.

Evaluating the success of Protected Areas

To assess how successful protected areas were in preserving species' potential habitats we summarized our resulting maps by the borders of two groups of protected areas: those in IUCN categories I and II, including national parks, and strict nature reserves (gorug or zapovednik), and those in IUCN categories III-VI, including state nature sanctuaries (yasaglig or zakaznik), managed reserves, privately protected areas, and natural monuments (Appendix 3.2, Figure 3.3a). We also categorized them based on the year of their establishment, while accounting for the fact that protected areas took several years to receive their designated status, as follows: those established before 1970, between 1970-'90 (i.e., those established in the late-Soviet era), and after 1990 (i.e., those established after the Soviet Union collapsed) (Appendix 3.2).

Results

Our final dataset was comprised of 919 presence points for all species combined. Based on numerous ensemble model tests, we determined that the maximum number of quadrature points yielded consistently higher mean AUC and TSS scores for the majority of our focal species (Appendix 3.3). Our variable correlation test results showed that there was some correlation between terrain and climate variables (Appendix 3.4, Appendix 3.7). The reason for that correlation might be that the elevation data was employed in deriving the climatic variables

(Hijmans et al., 2005). All other variables had low correlation. Based on our tests using four sets of quadrature data, all species exhibited strong positive correlation between slope and terrain ruggedness index (TRI). Our lowland species showed high negative correlation between precipitation, temperature, snow and elevation (Appendix 3.4, Appendix 3.7). The predictor variables that we employed for our final models included at least one variable from each group of predictor variables (land cover, climate, terrain and proximity variables) (Table 3.3).

Model performance

K-fold cross-validation showed high prediction accuracy of the ensemble models with excellent mean predictive performance (Figure 3.5). Our ensemble models identified that the main driving factors for the relative likelihood of species' presences in Azerbaijan varied among species (Table 3.4). Temperature was the most important predictor variable for gazelle. For mountain species, such as red deer and roe deer, land cover was the most important predictor variable, whereas for species with fewer presence points, such as bezoar, chamois, and mouflon, the most important variables were TRI, distance to urban, and distance to water, respectively.

Based on our response plots (Appendix 3.8), the relative likelihood of presence for bezoar was associated with higher terrain ruggedness, for chamois with larger distance from urban areas, and for gazelle with annual average temperatures between 15.5 and 16.5º C. For mouflon, the relative likelihood of presence was associated with lower precipitation and closer distances to water, and for tur with on average 60-100 frozen days in a year with snow cover. Overall, the relative likelihood of presences for all of our focal species were negatively associated with distance to water and positively associated with distance to urban areas.

Potential habitat change

Since we categorized our maps into four grades based on the relative likelihood of species' presences (see Methods, Modeling species' current distributions), we further report changes in the resulting maps (Appendix 3.10-3.11) as potential habitat changes (Appendix 3.12). For bezoar, potential highly-suitable area increased from 160 km^2 in 1965 to 1,250 km^2 in 2021, but potential moderately- and least-suitable areas decreased by 25% (1,200 km^2) and 17% (12,000 km^2), respectively (Figure 3.6, Appendix 3.5). The expansion of potential highly-suitable areas for bezoar was concentrated in protected areas with 1,250 km^2 more potential habitat in protected areas in 2021 than in 1965. However, potential habitats for bezoar also degraded with 12,150 km^2 more potential non-habitat in 2021 than in 1965 overall. For chamois, all three categories of potential suitable habitat decreased, resulting in a total decrease of 28% (21,350 km^2) less potential habitat. In protected areas, there were losses of potential bezoar habitat too. Although there was some improvement from potentially least-suitable areas to potential moderately and highly-suitable areas (5% increase from 1965 to 2021, 303 km^2), overall potentially suitable areas decreased by 13% (1,100 km^2). Similarly, while we observed an overall increase in potentially highly-suitable habitat area for gazelle (by 450 km^2), the potential habitat improvement was often within the protected areas with 120 km^2 more potentially highly-suitable, 190 km^2 more potentially moderately-suitable and 240 km^2 more potentially least-suitable area in 2021 compared to 1965. The maps for mouflon presented an unusual pattern, with very little potentially highly-suitable habitat and no potential non-habitats within our entire study area. Change occurred mainly between potentially least-suitable and moderately-suitable habitats, with 11,500 km^2 change from potentially least-suitable to moderately-suitable habitat from 1960 to 2021. Of these changes, only about 1,100 km^2 occurred within protected areas. Based on the overall numbers, the potentially suitable habitats for red deer decreased both for the entire study

area and within the protected areas. A total of 12,400 km^2 decreased in potential habitat of red deer from 1965 to 2021, out of which, 1,000 km^2 were in protected areas. Similarly, potential habitat of roe deer degraded by 12,500 km^2 with 2,200 km^2 less potentially highly-suitable and 11,000 km^2 less potentially least-suitable habitat by 2021. However, we also found some increase in potentially moderately-suitable roe deer habitat (40 km^2 in protected areas and 400 km^2 overall), mainly due to degraded potentially highly-suitable habitat. Finally, potential habitat of tur experienced the largest losses with almost 24,000 km^2 less potentially suitable habitat in 2021 than in 1965. However, potentially highly-suitable habitats of tur increased by about 350 km^2, out of which only 50 km^2 were within protected areas. As expected, potential habitats of our mountain species were consistently in the Caucasus mixed forests, while the lowland species' potential habitats (gazelle) were concentrated in Azerbaijan shrub desert and steppe (Figure 3.7).

Although we observed an overall slight increase in potential gazelle habitat, it was often in protected areas, especially higher in strictly protected areas established after 1990, the collapse of the Soviet Union (Figure 3.8). For mountain species, the success of protected areas of IUCN categories III-VI varied by years they were established and by species. In strictly protected areas, the potential habitats increased consistently regardless of the year of their establishment, except for protected areas established between 1970-'90, for potential tur habitats that decreased, and for red deer for which potentially highly-suitable areas increased, but potentially moderately-suitable and least-suitable area decreased. Finally, strictly protected areas established in the post-Soviet era had consistently higher rates of improvement in potential habitats and lower rates of degradation than those established in the Soviet era (Appendix 3.6).

Discussion

Most time series studies aimed to assess habitat changes start after the launch of freely available Landsat data in the 1980s, but by then much habitat had already been lost. This is a great example of a shifting baseline syndrome: limited or missing information on past conditions resulting in a gradual change in the understanding of natural environment (Soga and Gaston, 2018). The Corona Spy satellite images allowed us to extend our analysis of potential habitat conditions in the past back to the 1960s and thus reduce the shifting baseline syndrome. Furthermore, Corona data helped us to evaluate whether the protected areas that were established either during the Soviet or the post-Soviet era were successful in conserving and restoring the species' potential habitats and to compare the effects of concomitant institutional changes on wildlife conservation. We were able to generate highly accurate models (average TSS: 79.6%; average AUC: 95.9%; average sensitivity: 90.4%; average specificity: 89.3%), and to project them back to mid-20th century, and analyze changes over 55 years. We found that potential habitats of ungulates in Azerbaijan consistently decreased for mountain species. However, in strictly protected areas, we observed increases in habitat for all our species, which suggests that well-managed strictly protected areas can be successful. For our lowland species, we found that although there was an increase in potential habitat area, it was largely limited to protected areas, and potential habitats shifted outside of the protected areas, possibly because of abandonment of agricultural fields in some areas paired with agricultural expansion elsewhere from 1965 to 2021 (Rizayeva, previous chapter).

From 1965 to 2021, potential habitats of most of our species decreased within our study area, which we attribute to several reasons. The long-term land cover changes in the Caucasus, influenced by Soviet policies and subsequent institutional changes following the dissolution of

the Soviet Union, had strong effects on the management of forests (Rizayeva, previous chapter). Consequently, loss of forests resulted in potential habitat loss and degradation particularly for red deer and roe deer, which rely on forests. In addition, the decrease in potential habitats of mountain species may be due to high grazing pressure in summer pastures (Guliyev et al., 2009; Zazanashvili and Mallon, 2009) and resulting potential habitat loss (Bleyhl et al., 2019), because some historic summer pastures were inaccessible due to regional conflicts (de Leeuw et al., 2019). In areas where livestock grazing occurs within the potential habitats of our species, it disrupts wildlife's daily activity patterns, leading them to favor isolated forests and appear in meadows primarily during dawn or dusk (Heptner et al., 1961; Heptner and Formozov, 1941; Vereshchagin, 1938). Thus, the institutional shifts and political conflicts had profound adverse impacts on wildlife, and long-term satellite data offered us the opportunity to capture potential habitat changes that were the result of these political events.

However, increasing availability of strictly protected areas improved the potential habitat for all of our species, highlighting the success of the protected areas. The potential habitats of our ungulate species have overall decreased, but protected areas, specifically the strictly protected areas were successful. However, exclusively relying on strictly protected areas cannot address the array of ecosystem challenges. In addition, although we observed the majority of the decrease in potential habitats of red deer and roe deer outside of protected areas, there were also declines within some of the protected areas, which suggests that they lost habitat not only due to forest loss, but rather due to a broader issue of ecosystem-wide degradation. It is important to implement more conservation-friendly land management and crop cultivation practices, especially in close proximity of protected areas, possibly through the expansion of transition and buffer zones. Notably, more than half of the strictly protected areas were established in the post-

Soviet era and they were highly successful. Although we observed improvements in the older protected areas as well, their progress was more gradual. The main reason for the greater magnitude of improvements in potential habitat within recently established protected areas is that the Corona-derived land cover maps provided information for the era before their establishment. Our findings highlight the conservation benefits of all strictly protected areas, including the newer ones, and support the intensification of conservation efforts by expanding existing protected areas and establishing new ones, ultimately contributing to the conservation of species' habitats and populations. Hence, Corona data can provide information for the era before the establishment of many protected areas globally, enabling assessments of their effectiveness in conserving and restoring wildlife habitats and populations.

Our results support other studies conducted in the Caucasus region that reported the decrease in wildlife populations (Zazanashvili and Mallon, 2009), potentially due to competition with livestock, and habitat degradation (Avaliani et al., 2007). Competition with livestock is especially a threat for mountain species (Weinberg et al., 2022). The habitats of bezoar goat have decreased since early 20th century by more than half in the Russian Caucasus, and currently cover areas within the protected areas, which provide refugia that are inaccessible to people (Akhmedov et al., 2009). Environmental factors, such as climate and terrain were often among the most important in predicting the relative likelihood of presence for most of our focal species (Gavashelishvili, 2009), but aspect was not significant, possibly due to species migrations during different seasons, which we did not consider (Gavashelishvili, 2004). Our resulting maps support previous studies indicating that the habitats of tur do not overlap with those of bezoar, potentially due to competition for food resources (Gavashelishvili, 2009). Our findings are also consistent with historical reports of tur habitats from 1953, indicating that their core habitats in Zagatala

reserve were alpine and subalpine meadows, and some forested areas and forest edges (Heptner et al., 1961). In 1961, red deer were reintroduced to Goygol National Park and kept in an enclosure with further successful breeding (Bayramov and Aliyev, 1967), because the majority of red deer habitat in this protected area was already lost prior to the 1960s. Indeed, our 1965 predictions showed that Goygol National Park had only potential least-suitable habitats for red deer back then. In 2021, our maps present larger areas of potential highly- and moderately-suitable habitats, supporting the thriving red deer population in the park (Guliyev, 2014). Similarly, our 1965 map for potential bezoar goat habitat align with the historical reports of their preferences, favoring rocky slopes within Goygol National Park (Bayramov and Aliyev, 1967). Reports from 1957 indicate tur populations in the valleys of Jurmut and Samur rivers (Popkov, 1957), consistent with our 1965 maps of potential habitats for tur. Finally, our 1965 maps for chamois also align with areas of their historical preference, such as near forests, grasslands, steep rocky slopes (Popkova, 1961). Although the gazelle reintroductions in Georgia between 1989-1990 and 2009-2012 were unsuccessful, subsequent efforts were made, and they are now thriving in open and undisturbed lowlands (Mallon et al., 2012). In Azerbaijan, mouflon are currently only found in Nakhchivan (Talibov et al., 2009), while a larger population exists in western Iran (Shackleton, 1997), but our results reveal the potential for them to thrive across larger areas.

While habitat degradation due to intensive human activities has historically been the predominant reason for the declines of our species' populations (Coppes et al., 2017; Scholten et al., 2018), they also encounter other threats. The main threats causing species' population losses include hunting and trade (Guliev et al., 2009), which intensified after the collapse of the Soviet Union due to the lack of enforcement (Bleyhl et al., 2021; Mallon and Jiang, 2009). The decrease

in wild mammal populations of the Caucasus occurred largely in the 1950s (Ryabov, 1957) and many populations were at low levels by 1965, also possibly due to the harsh 1949-1950 winter (Gavrin and Donaurov, 1954). Often human-induced, but occasionally also lightning-caused fires in the forests of Azerbaijan have ocurred also in the past century (Vinogradov and Chernavskaya, 1966), but by 2019-2020, they have become a major threat affecting forests, grasslands, and croplands (Bassullu and Sanchez-Paus Díaz, 2023), and causing habitat loss for local ungulate species. Given that our focal species commonly inhabit rocky slopes of the mountains, erosion is and has been another threat both now and in the 1960s as well (Jabbarov, 1971). Although pressure from domesticated sheep in alpine meadows causes more pressure for populations of our mountain species (Guliyev et al., 2009), our species also constitute some part of the carnivore species diet, such as striped hyaena (*Hyaena hyaena*), jackal (*Canis aureus*), and brown bear (*Ursus arctos*), as well as grey wolf (*canis lupus*), Eurasian lynx (*lynx lynx*), and Caucasian leopard (*Panthera pardus ciscaucasica*) (Gavashelishvili, 2004; Kotov, 1958; Nasimovich, 1940). For example, despite having optimal conditions for growth, the tur population in the Zagatala State Nature Reserve remained stable from 1944 to 1958 due to carnivores (Mehdiyev and Efendiyev, 1959). The Caucasian leopard was historically been the main carnivore predating our mountain species in the Greater Caucasus, but now numbers of leopards are low (Askerov et al., 2019). The rapid decline in habitats of wild ungulates is also threatening for their predators though because they are losing their prey (Breitenmoser, 2010), which in its turn is leading to conflicts with domestic animals and increased human-wildlife conflict (Babrgir et al., 2017).

Our findings for ungulates and their potential habitats in Azerbaijan are consistent with trends in other countries that experienced the socioeconomic shocks associated with the collapse of the

Soviet Union (Bragina et al., 2015). Immediately after the collapse, Russia's moose populations declined rapidly (Razenkova et al., 2020). In European Russia, the habitats within protected areas remained stable or increased (Sieber et al., 2015), similar to what we found. Additionally, our results align with the post-Soviet deforestation trends in European Russia, indicating that strictly protected areas were successful, and are more successful than other types of protected areas (Wendland et al., 2015). Furthermore, in the North Caspian lowlands of southern Russia, abandonment of croplands due to the Soviet Union collapse led to an improvement in habitat (Hölzel et al., 2002). Meanwhile, in the post-Soviet EU member states, habitat degradation outside of protected areas was higher immediately after the collapse, but this trend decreased by the early 2000s (Biró et al., 2018; Mihók et al., 2017). Hence, the impact of the socioeconomic shocks depends on both prior processes and the events following the shock, and as we present here, Corona data can provide information for the pre-shock era.

The historical Corona spy satellite imagery has not been commonly applied for wildlife studies. However, it has been used to successfully detect burrows of a marmot species in Kazakhstan (Munteanu et al., 2020) and nests of red ants in Romania (Klimetzek et al., 2021). More broadly, the availability of historical high-resolution satellite imagery holds great potential for wildlife management and science (Munteanu et al., in press). It can strongly contribute to our understanding of historical land cover patterns and facilitate the evaluation of the long-term impacts resulting from land use decisions.

While based on well-performing models, and agreeing with expert opinions from local field biologists and scientists, it is important to acknowledge a few limitations of our study. One potential limitation is related to the use of climatic variables, which were significant predictors for models of most species. The coarse spatial resolution of our original climate data, about 4

km, may have led to both over- and under-estimation of potential habitat area. Additionally, the historical climate data is extrapolated from a limited number of weather stations. For example, during the Soviet era, only two weather stations were present in Azerbaijan and a limited number in the wider Caucasus (Zandler et al., 2020). Furthermore, other environmental factors, such as cropland age, availability of salt licks, proximity to shepherd camps, NDVI and length of growing season are important factors influencing habitat choices of our ungulate species (Bleyhl et al., 2019, 2017; Kuemmerle et al., 2020; Sarukhanova et al., in preparation), but we were unable to include them as predictor variables because these datasets were not available for 1965. Finally, the scarcity of our red-listed species in Azerbaijan resulted in limited presence data, which may have negatively affected our results, particularly for bezoar, chamois, and mouflon. Nevertheless, our results are highly promising and consistent with on the ground observations.

Our change analyses enabled us to identify and evaluate potential historical and current habitat for seven ungulate species in Azerbaijan. Our results showed that there is a considerable decrease in potential habitats throughout. Based on our findings, the protected areas in the region that have grown considerably in the 21st century (Zazanashvili et al., 2012) are successful. However, areas surrounding them are experiencing large shifts or losses in potential habitats of wild species due to land use, urging for better policy and management decisions.

The conservation of ungulate populations in Azerbaijan and the broader Caucasus eco-region holds considerable direct and indirect implications for overall conservation efforts (Kuemmerle et al., 2020). Conducting potential habitat change analyses over 55 years can provide valuable insights to inform land use management for core habitats and areas that are important for the connectivity network. Moreover, our findings can help raise awareness among local communities, which requires addressing social factors, such as enhancing the compensation of

park rangers (Farhadinia et al., 2023) and generating employment opportunities that minimize the impact on natural resources (e.g., SeaWeb, 2005). Furthermore, it is crucial to raise awareness among tourists who utilize the natural resources of the Caucasus region (Gokhelashvili et al., 2002). Our findings have practical implications for management decisions, including prioritizing conservation efforts, the establishment of new protected areas, and the management of existing ones. Despite the early establishment of the first protected area in Azerbaijan under Soviet rule in 1929 (Gyzyl-Aghaj reserve), it took nearly three decades for a second protected area to be established (Turian-chay reserve in 1958). Nonetheless, the current trajectory of countries in the Caucasus eco-region offers hope for improved conservation.

Evaluating the effects of land cover changes on wild species habitats is important for conservation, maintaining ecosystem stability, protecting human well-being, and promoting long-term sustainability. Wildlife species play important roles in ecosystems and can be indicators of environmental health (Gregory and van Strien, 2010; Lacher Jr et al., 2019; Ramirez et al., 2018). Presence, abundance, and distribution of wildlife species reflect the condition of ecosystems, but changes in land cover can diminish their habitats, leading to the loss of biodiversity (Jaureguiberry et al., 2022). Furthermore, the habitats of wildlife species provide numerous ecosystem services that directly or indirectly benefit human well-being (Harrison et al., 2014; Tscharntke et al., 2005). Our study shows how long-term land cover changes have affected wildlife species' potential habitats, and helps advance scientific understanding and develop targeted conservation strategies. Furthermore, our results provide valuable insights for decision-making and policy changes at both local and regional levels. It is essential to recognize that local changes, particularly in areas such as the Caucasus eco-region, can have substantial influence on large-scale processes in the long-term. Therefore, uncovering the baselines and

understanding potential habitat changes is important to identify the areas important for conservation, to prioritize effective conservation and management strategies, such as habitat restoration and conservation, mitigating risks associated with climate change, and preserving biodiversity.

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Tables and Figures

Table 3.1: List of all predictor variables employed in our analyses, including their short names, data sources, spatial resolution, and measurement unit

Group	Predictor variable long name	Short name	Source	Resolution	Unit
Land cover	Land cover 2021	Land cover	ESA WorldCover, Zanaga et al., 2022	10 m	LC type
	Land cover 1965		Rizayeva, previous chapter	2.5 m	LC type
Climate	Average 5-year temperature (2018-2022 vs 1962-1966)	Temperature	TerraClimate, Abatzoglou et al., 2018	4 km	°C
	Average 5-year precipitation (2018-2022 vs 1962-1966)	Precipitation	TerraClimate, Abatzoglou et al., 2018	4 km	mm
	Average 5-year days of frozen ground with snow cover (2010-2014 vs 1982-1986)	DSC	Global Subnivium Data, Zhu et al., 2019	5 km	days
	Average 5-year days of frozen ground without snow cover (2010-2014 vs 1982-1986)	DFWOS	Global Subnivium Data, Zhu et al., 2019	5 km	days

Terrain	Elevation	Elevation	derived from SRTM, Farr et al., 2007	30 m	m
	Slope	Slope	derived from SRTM, Farr et al., 2007	30 m	°
	Aspect	Aspect	derived from SRTM, Farr et al., 2007	30 m	°
	Terrain Ruggedness Index	TRI	derived from SRTM, Farr et al., 2007	30 m	m
Proximity	Distance to urban (2021 vs 1965)	Distance to urban	calculated from land cover maps above	10 m	km
	Distance to water (2021 vs 1965)	Distance to water	calculated from land cover maps above	10 m	km

Table 3.2: Description of species presence data: years the data were acquired, original number of presence points, and number of presence points located at least 1 km apart from each other and used in final models

	Acquisition years	Original number	Number after 1 km filtering
bezoar	2016-2021	221	52
chamois	1998-2021	129	44
gazelle	2012-2022	4,878	323
mouflon	2016-2021	63	53
red deer	2003-2021	200	137
roe deer	1998-2021	128	125
tur	1998-2020	4,771	185
Total		10,607	923

Table 3.3: List of variables employed in final models to map relative likelihood of presence for each species, based on test results reported in Appendix 3.3, 3.4, and 3.7. The predictor variables correspond to those in Table 3.1

		bezoar	chamois	gazelle	mouflon	red deer	roe deer	tur
Land Cover	Land cover 2021 vs 1965	✓	✓	✓	✓	✓	✓	✓
Climate	Average 5-year temperature (2018-2022 vs 1962-1966)	✗	✗	✓	✗	✗	✗	✗
	Average 5-year precipitation (2018-2022 vs 1962-1966)	✗	✓	✗	✓	✗	✗	✓
	Average 5-year dsc (2010-2014 vs 1982-1986)	✓	✗	✗	✗	✓	✓	✓
	Average 5-year dfwos (2010-2014 vs 1982-1986)	✗	✗	✓	✗	✗	✓	✗
Terrain	Aspect	✗	✗	✓	✗	✓	✓	✓
	Terrain Ruggedness Index	✓	✓	✓	✓	✓	✓	✓
Proximity	Distance to urban	✓	✓	✓	✓	✓	✓	✓
	Distance to water	✓	✗	✓	✓	✓	✓	✓
Total number of predictor variables		5	4	7	5	6	7	7

Table 3.4: Variable importance estimates in final ensemble models for each species, calculated using built-in function within biomod2. The function computes the model prediction and calculates the Pearson's correlation between reference and predictions for each predictor variable. The resulting score is subtracted from one, with higher scores indicating less correlation between reference and predictions, meaning a stronger influence of that variable on the model's predictive power. In bold, is the most important variable for the corresponding species. The values represent relative importance of variables, collectively summing up to 100% for each species

		bezoar	chamois	gazelle	mouflon	red deer	roe deer	tur
Land cover	Land cover map	20.5	20.7	3.4	1.3	**42.9**	**77.9**	0.5
Climate	Temperature	–	–	**52.1**	–	–	–	–
	Precipitation	–	20.6	–	24.6	–	–	35.0
	DFWOS	–	–	23.8	–	–	0.3	–
	DSC	19.3	–	–	–	39.2	16.8	**42.8**
Terrain	Aspect	–	–	0.2	–	0.8	0.3	1.1
	TRI	**52.1**	11.8	7.3	7.7	0.2	0.4	3.9
Proximity	Distance to urban	3.1	**46.8**	11.8	**34.6**	14.2	3.4	13.8
	Distance to water	4.9	–	1.4	31.7	2.7	0.9	2.8

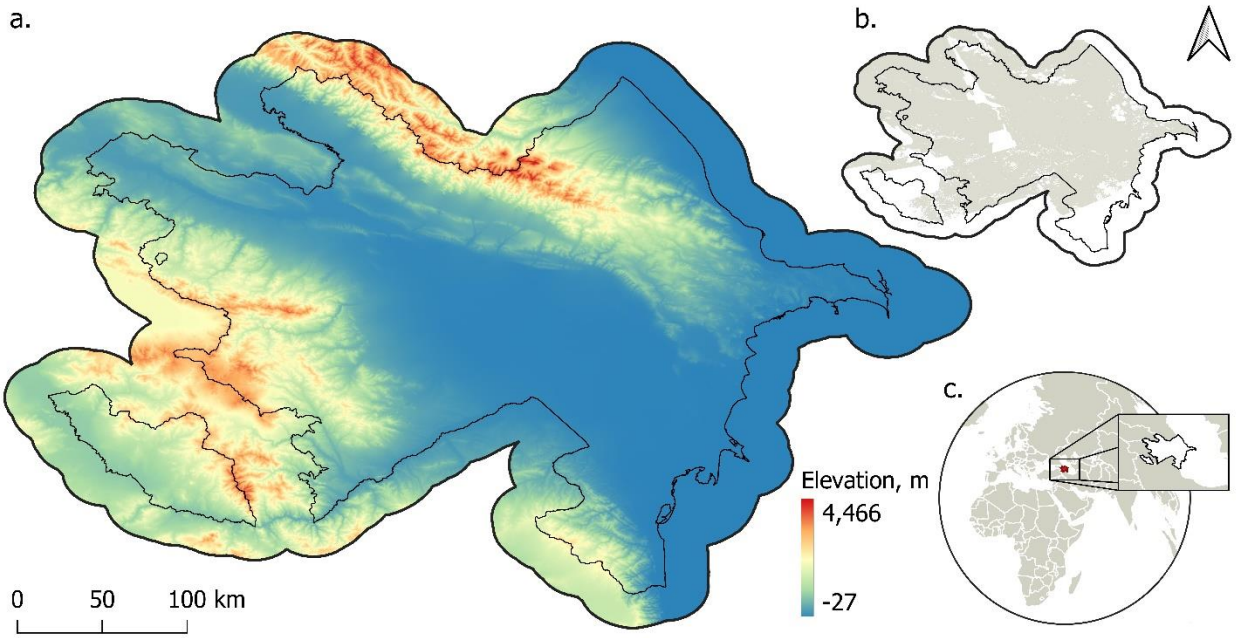


Figure 3.1: Study area encompassing Azerbaijan and a 25-km buffer around its borders. a. Elevation map within the study area; b. Outline of the study area used for potential habitat change analyses, based on the availability of Corona satellite data; c. Location of the study area on a world map

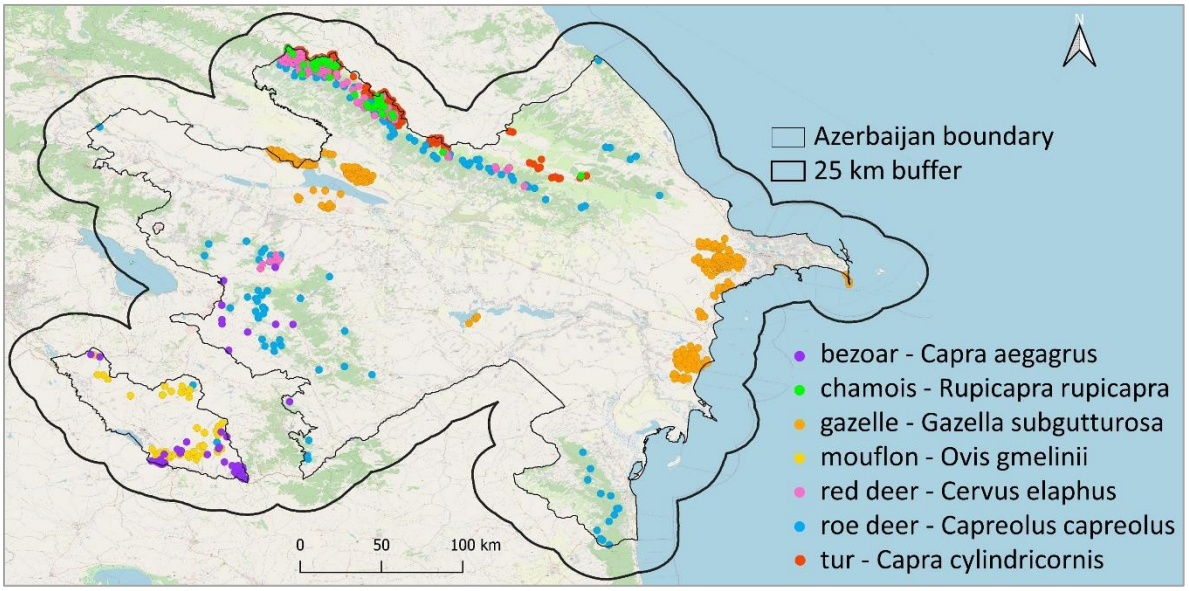
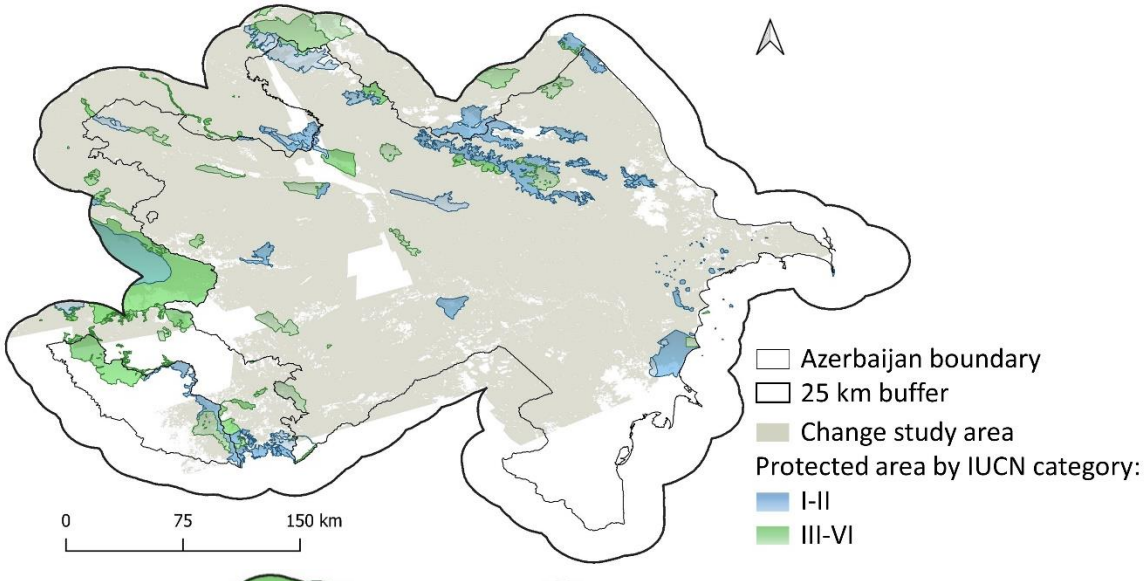


Figure 3.2: Final set of presence points for each species used for modeling, corresponding to the numbers in Table 3.2. The points for each species are located at a minimum distance of 1 km from each other

a.



b.

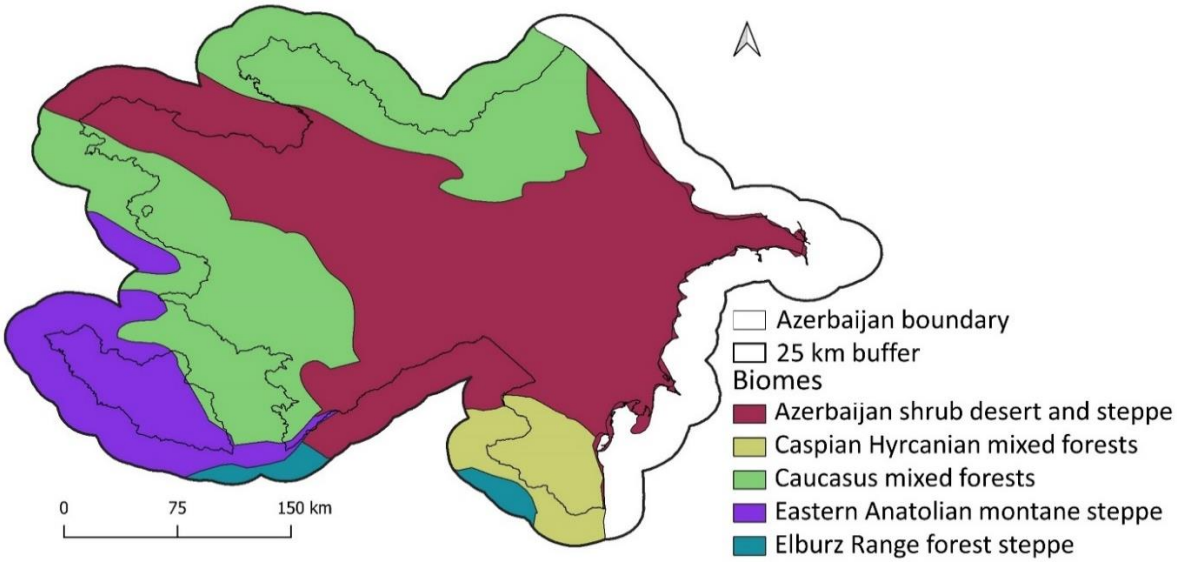


Figure 3.3: a. Map of protected areas overlaying the study area for potential habitat change assessment. The protected areas are separated by IUCN management status: in green – categories I-II; in blue – categories III-VI; b. Global biomes (Olson et al., 2001) within our study area. The protected areas correspond to those in Appendix 3.2

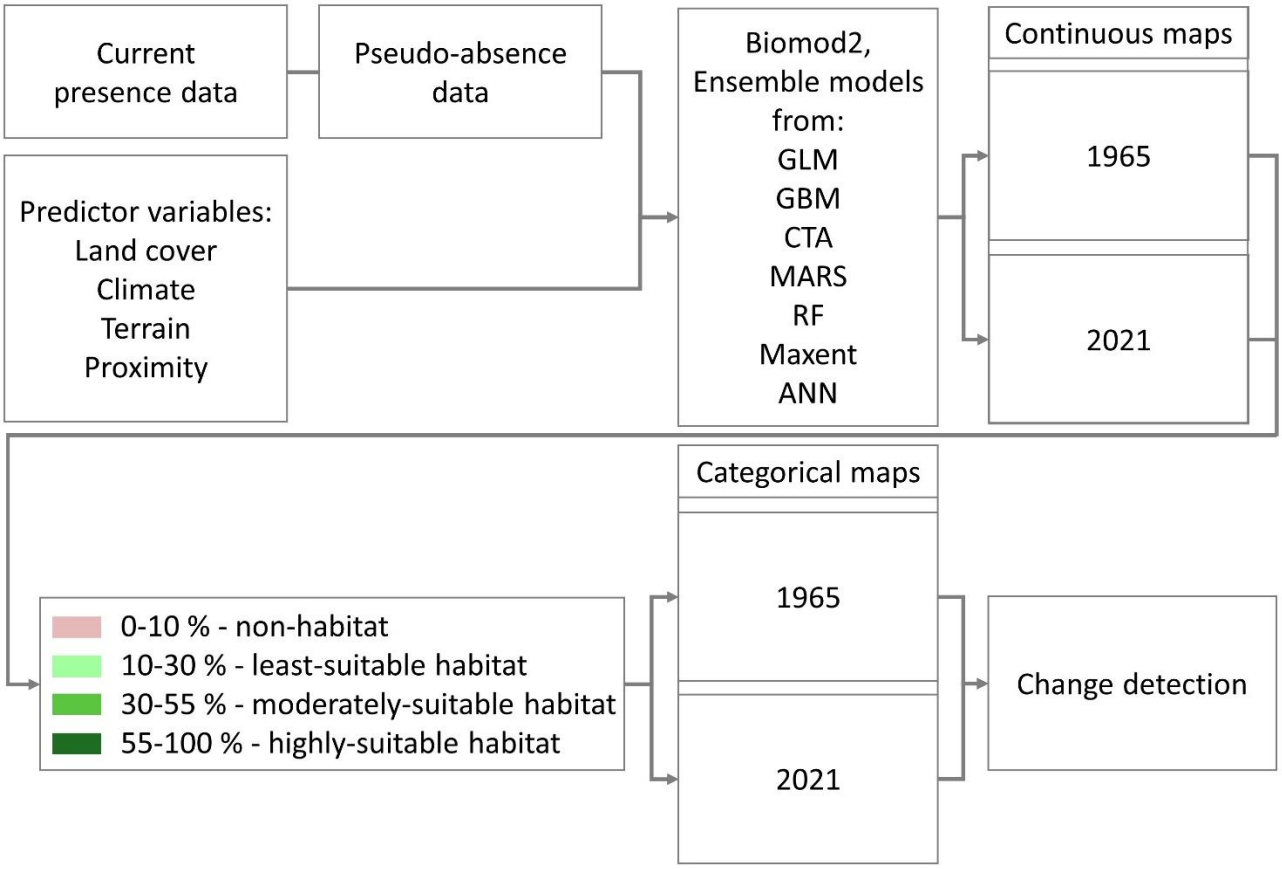


Figure 3.4: Flowchart depicting our modeling and change mapping using R package biomod2 and further post-processing in QGIS v3.28.11

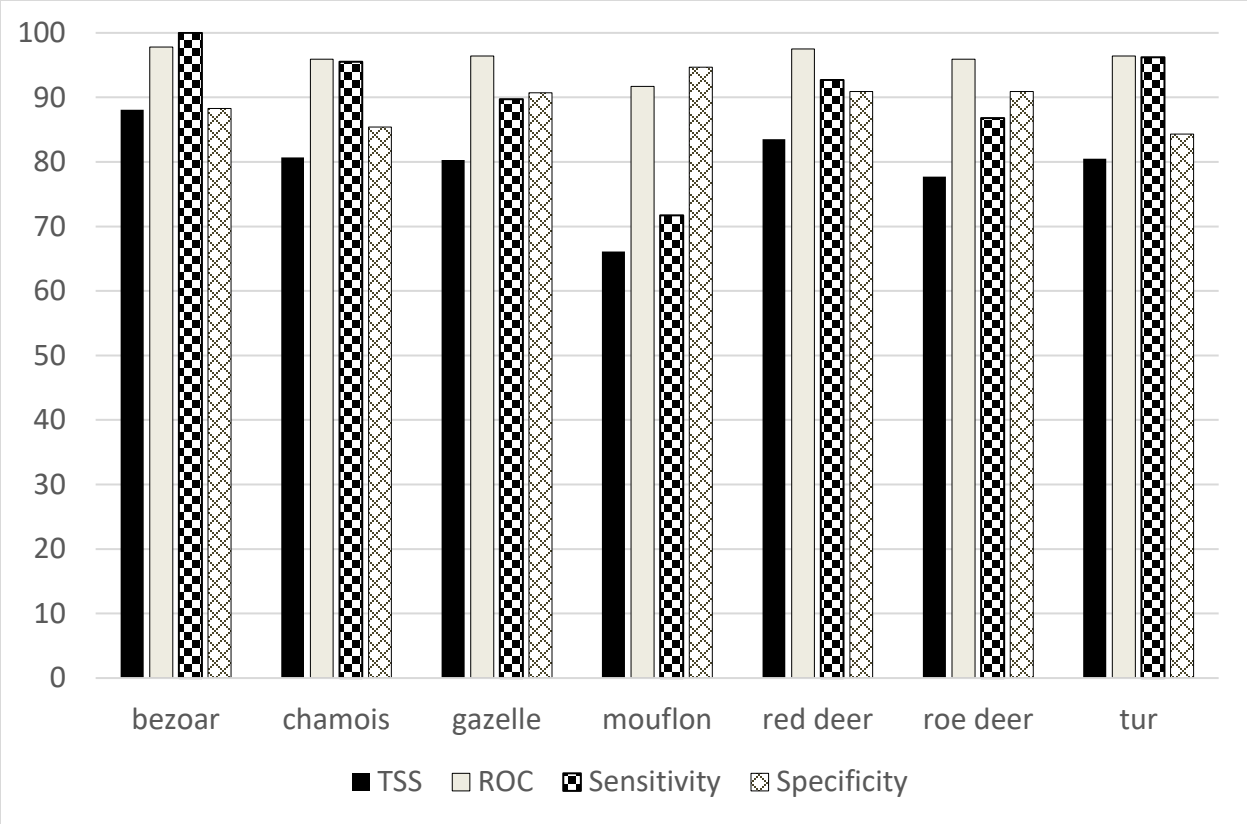


Figure 3.5: Results of ensemble model assessments constructed for 2021, representing the final TSS, AUC, sensitivity, and specificity for each species

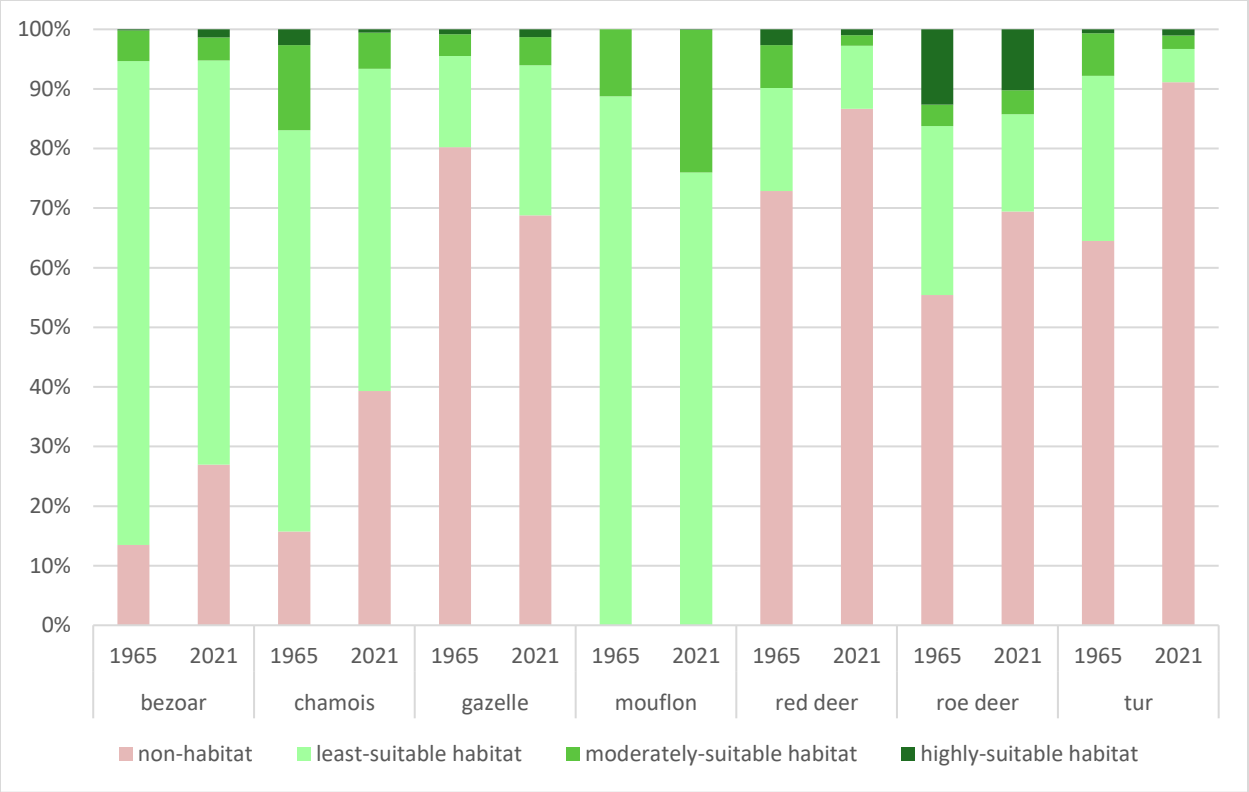


Figure 3.6: Proportions of potential habitat categories for each species within the entire study area in years 1965 and 2021

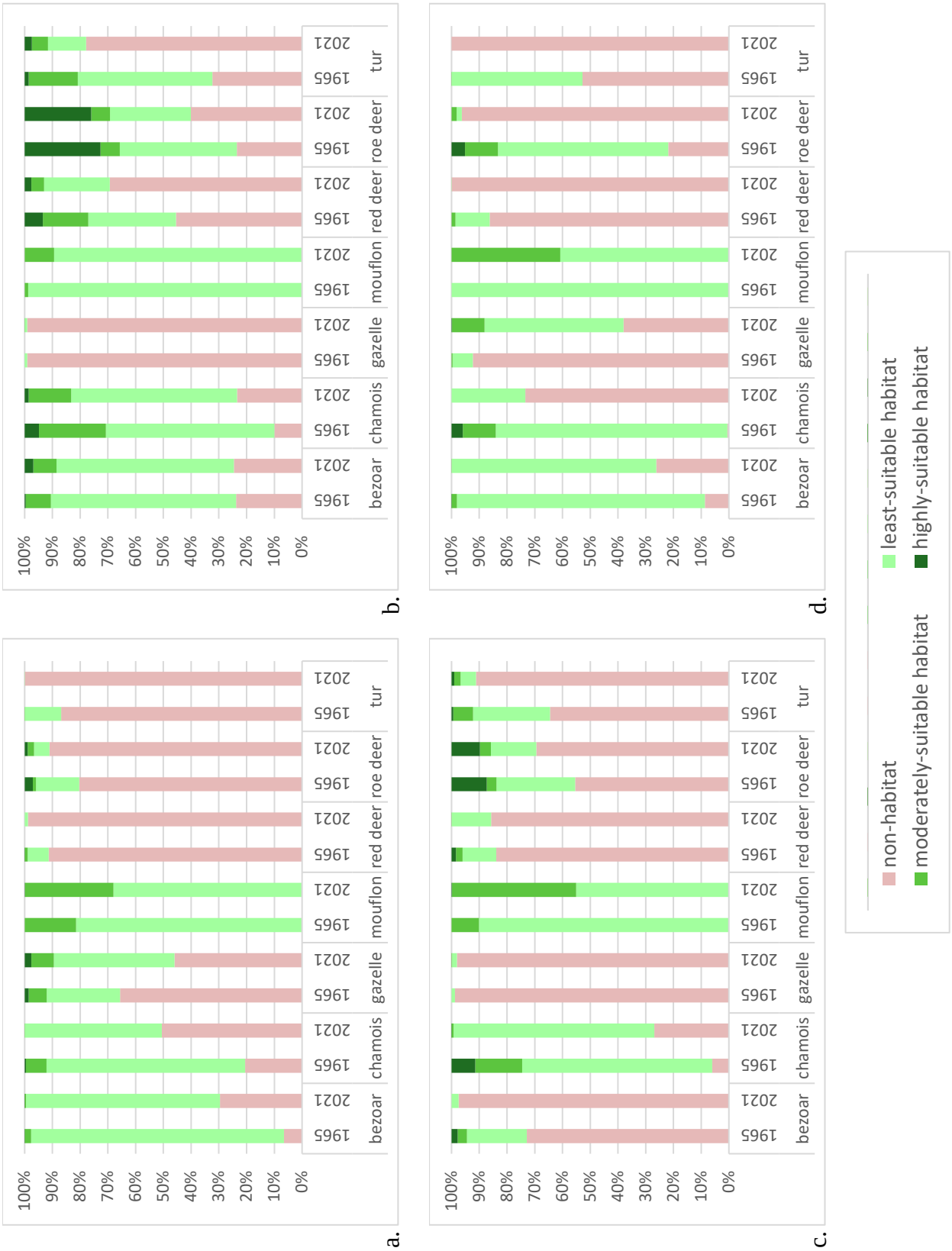

a.
b.
c.
d.
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
bezoar
chamois
gazelle
mouflon
red deer
roe deer
tur
1965
2021
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat

Figure 3.7: Proportions of potential habitat categories within Olson biomes for each species in 1965 and 2021, presented in the following order, which corresponds to the size of each biome in our study area, from largest to smallest: a. Azerbaijan shrub desert and steppe; b. Caucasus mixed forests; c. Eastern Anatolian montane steppe; d. Caspian Hyrcanian mixed forests. The biomes correspond to those in Figure 3.3

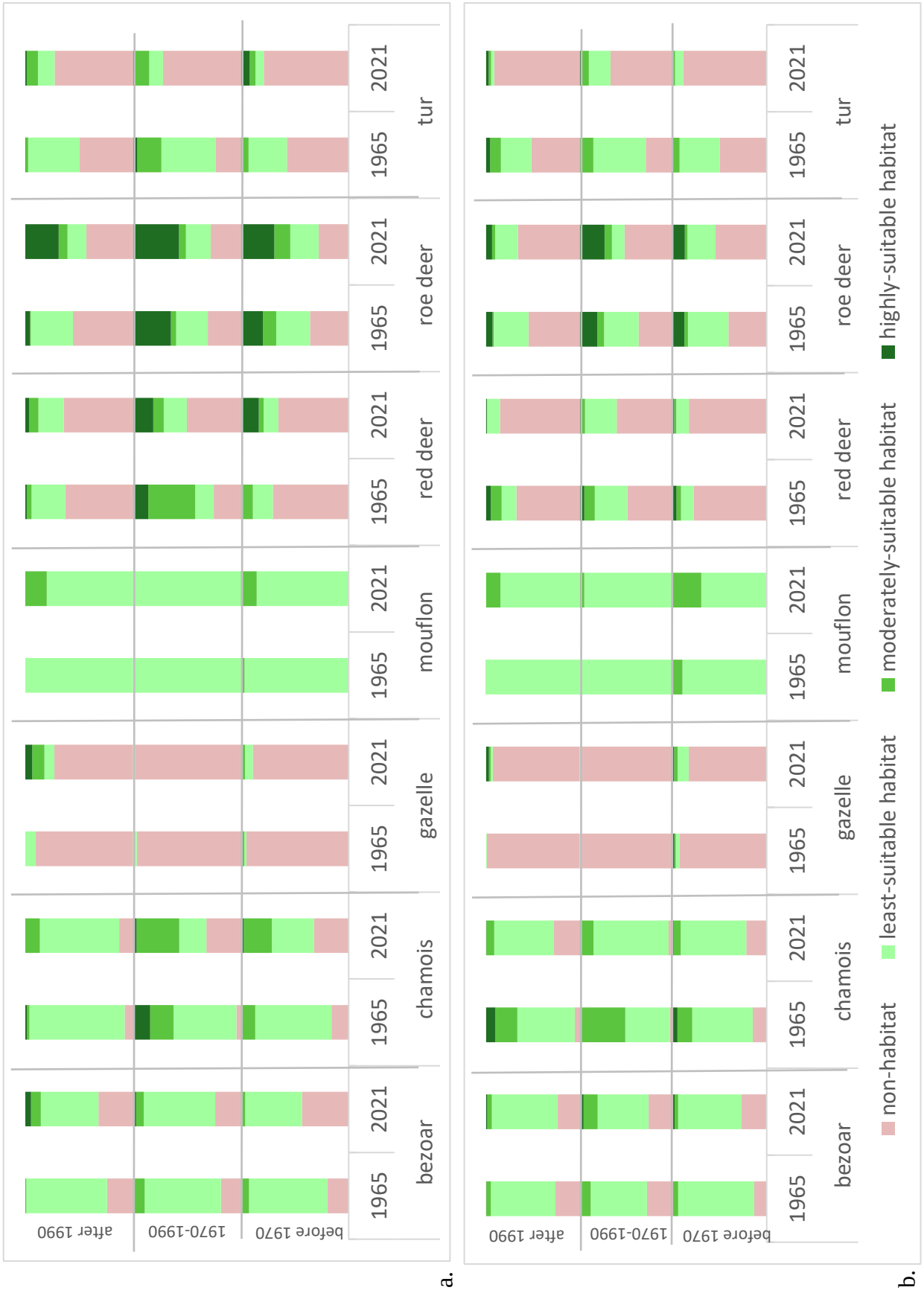

a.
b.
bezoar
chamois
gazelle
mouflon
red deer
roe deer
tur
1965
2021
before 1970
1970-1990
after 1990
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat

Figure 3.8: Proportions of potential habitat categories for each species in 1965 and 2021 within protected areas by IUCN management status: a) I-II; and b) III-VI. To assess how successful were the protected areas in conserving and restoring wildlife habitats based on their establishment dates, they are categorized into three groups: those established before 1970, between 1970-‘90, and after 1990. The protected areas correspond to those in Appendix 3.2

Appendix

Appendix 3.1: Sets of quadrature data generated for each species based on the number of presence data and the total resulting number

bezoar	Presence	Quadrature	Total
100s	52	100	152
1k	52	1,000	1,052
5k	52	5,000	5,052
max	52	8,525	8,577

chamois	Presence	Quadrature	Total
100s	44	100	144
1k	44	1,000	1,044
max*	44	4,895	4,939

gazelle	Presence	Quadrature	Total
100s	323	350	673
1k	323	1,000	1,323
5k	323	5,000	5,323
max	323	7,140	7,463

mouflon	Presence	Quadrature	Total
100s	53	100	153
1k	53	1,000	1,053
5k	53	5,000	5,053
max	53	5,692	5,745

redDeer	Presence	Quadrature	Total
100s	137	150	287
1k	137	1,000	1,137
5k	137	5,000	5,137
max	137	6,681	6,818

roeDeer	Presence	Quadrature	Total
100s	125	150	275
1k	125	1,000	1,125
5k	125	5,000	5,125
10k**	125	10,000	10,125
max**	125	20,998	21,123

tur	Presence	Quadrature	Total
100s	185	200	385
1k	185	1,000	1,185
5k	185	5,000	5,185
max	185	6,724	6,909

* due to low number of presence points, and their location at relatively close distances from each other, the maximum number of quadrature points for chamois was 4,895, which we used as “max” for further tests.

** due to high number of presence points, and their location at relatively far distances from each other, the maximum number of quadrature points for roe deer was 21,000. Hence, we used 10,000 quadrature points as “max” for further tests.

Appendix 3.2: List of protected areas within our study area: a. IUCN category I-II; b. IUCN category III-VI. Highlighted in blue are the protected areas established before 1970; in red – between 1970 and 1990; in green – after 1990. In red font are the protected areas that are within the entire study area, but did not overlap with study area for change assessment

a. IUCN category I-II

Name	Status	IUCN category	Year of establishment	Country	Area, km^2	Used for change assessment?
Lagodekhi	Strict Nature Reserve	Ia	1912	Georgia	197.6	yes
Zagatala	Strict Nature Reserve	Ia	1929	Azerbaijan	474.1	yes
Gizilagaj	National Park (2018)	II	1929	Azerbaijan	990.7	no
Vashlovani	Strict Nature Reserve	Ia	1957	Georgia	99.7	yes
Khosrov Forest	State Reserve	Ia	1958	Armenia	228.7	yes
Shikahogh	State Reserve	Ia	1958	Armenia	121.7	yes
Turyanchay	Strict Nature Reserve	Ia	1958	Azerbaijan	230.8	yes
Garayazi	Strict Nature Reserve	Ia	1964	Azerbaijan	96.8	yes
Shirvan	Strict Nature Reserve	Ia	1969	Azerbaijan	64.5	yes
Basitchai	Strict Nature Reserve	Ia	1974	Azerbaijan	1.7	yes
Sevan	National Park	II	1978	Armenia	1,510.7	yes
Ilisu	Strict Nature Reserve	Ia	1987	Azerbaijan	175.1	yes
Gara gol	Strict Nature Reserve	Ia	1987	Azerbaijan	0.5	yes
Dilijan	National Park	II	2002	Armenia	392.2	yes
Zangezur	National Park	II	2003	Azerbaijan	412.7	yes
Shirvan	National Park	II	2003	Azerbaijan	542.5	yes
Ag Gol	National Park	II	2003	Azerbaijan	179.8	yes
Vashlovani	National Park	II	2003	Georgia	250.3	yes
Eldar shami	Strict Nature Reserve	Ia	2004	Azerbaijan	17.5	yes
Altiagach	National Park	II	2004	Azerbaijan	115.1	yes
Hirkan	National Park	II	2004	Azerbaijan	405.8	no
Absheron	National Park	II	2005	Azerbaijan	7.8	yes

Shahdag	National Park	II	2006	Azerbaijan	1,333.6	yes
Mud volcanos of Baku and Absheron peninsula	Strict Nature Reserve	Ia	2007	Azerbaijan	122.7	yes
Korchay	Strict Nature Reserve	Ia	2008	Azerbaijan	48.4	yes
Goy Gol	National Park	II	2008	Azerbaijan	129.6	yes
Arevik	National Park	II	2009	Armenia	315.5	yes
Samur-Yalama	National Park	II	2012	Azerbaijan	117.8	yes
Samurskij	National Park	II	2019	Russia	541.2	yes

b. IUCN category III-VI

Name	Status	IUCN category	Year of establishment	Country	Area, km^2	Used for change assessment?
Herher Open Forests	Sanctuary	IV	1958	Armenia	28.1	yes
Arjatkhleni Hazel-Nut	Sanctuary	IV	1958	Armenia	0.4	yes
Plane Grove	Sanctuary	IV	1958	Armenia	0.7	yes
Juniper Open Forests	Sanctuary	IV	1958	Armenia	32.1	yes
Akhnabat Yew Grove	Sanctuary	IV	1958	Armenia	0.3	yes
Jermuk Forest	Sanctuary	IV	1958	Armenia	36.5	yes
Goravan Sands	Sanctuary	IV	1959	Armenia	1.0	yes
Korchay	Sanctuary (Managed Reserve)	IV	1961	Azerbaijan	150.8	yes
Bandovan	Sanctuary (Managed Reserve)	IV	1961	Azerbaijan	46.1	yes
Lachyn	Sanctuary (Managed Reserve)	IV	1961	Azerbaijan	200.9	yes
Shamkir	Sanctuary (Managed Reserve)	IV	1964	Azerbaijan	101.0	yes
Gusar	Sanctuary (Managed Reserve)	IV	1964	Azerbaijan	150.7	yes
Agstafa	Sanctuary (Managed Reserve)	IV	1964	Azerbaijan	95.9	yes

Gil adasi	Sanctuary (Managed Reserve)	IV	1964	Azerbaijan	4.3	yes
Sheki	Sanctuary (Managed Reserve)	IV	1964	Azerbaijan	103.9	yes
Barda	Sanctuary (Managed Reserve)	IV	1966	Azerbaijan	77.7	yes
CHarodinskij	State Natural Zakaznik	IV	1967	Russia	551.6	yes
Marakan	Protected Area	V	1967	Iran	1,041.2	no
Gubadli	Sanctuary (Managed Reserve)	IV	1969	Azerbaijan	201.3	yes
Ismayily	Sanctuary (Managed Reserve)	IV	1969	Azerbaijan	234.9	yes
Ordubad	Sanctuary (Managed Reserve)	IV	1969	Azerbaijan	278.2	yes
Ijevan	Sanctuary	IV	1971	Armenia	61.6	yes
Getik	Sanctuary	IV	1971	Armenia	42.4	yes
Gandzakar	Sanctuary	IV	1971	Armenia	41.6	yes
Goris	Sanctuary	IV	1972	Armenia	18.4	yes
Lavandavil	Wildlife Refuge	IV	1973	Iran	10.7	no
Arasbaran	Protected Area	V	1973	Iran	853.9	no
Kasumkentskij	State Natural Zakaznik	IV	1974	Russia	247.8	yes
Kiamaky	Wildlife Refuge	IV	1975	Iran	942.8	no
Dashalti	Sanctuary (Managed Reserve)	IV	1981	Azerbaijan	4.5	yes
Samurskij	State Natural Zakaznik	VI	1982	Russia	23.0	yes
Gizilja	Sanctuary (Managed Reserve)	IV	1984	Azerbaijan	51.4	yes
Tlyaratinskij	State Natural Zakaznik	VI	1986	Russia	649.9	yes
Kosobsko-Kelebskij	State Natural Zakaznik	IV	1987	Russia	816.3	yes
Boghaqar	Sanctuary	IV	1989	Armenia	27.3	yes
Arazboyu (Zangilan)	Sanctuary (Managed Reserve)	IV	1993	Azerbaijan	22.0	yes

Gabala	Sanctuary (Managed Reserve)	IV	1993	Azerbaijan	148.5	yes
Lake Sevan	Ramsar Site, Wetland of International Importance	Not Reported	1993	Armenia	4,741.2	yes
Chachuna	Managed Reserve	IV	1996	Georgia	50.4	yes
Gardabani	Managed Reserve	IV	1996	Georgia	37.4	yes
Iori	Managed Reserve	IV	1996	Georgia	21.3	yes
Khorugi	Managed Reserve	IV	1996	Georgia	17.2	yes
Sev Lich	Sanctuary	IV	2001	Armenia	3.7	yes
Alazani Flood Plane Forests	Natural Monument	III	2003	Georgia	2.0	yes
Eagle Canyon	Natural Monument	III	2003	Georgia	1.0	yes
Takhti-Tefa	Natural Monument	III	2003	Georgia	0.1	yes
Lagodekhi	Managed Reserve	IV	2003	Georgia	45.0	yes
Gakh	Sanctuary (Managed Reserve)	IV	2003	Azerbaijan	371.7	yes
Zuvand	Sanctuary (Managed Reserve)	IV	2004	Azerbaijan	145.4	no
Arazboyu (Nakhchivan)	Sanctuary (Managed Reserve)	IV	2005	Azerbaijan	95.0	no
Hirkan	Sanctuary (Managed Reserve)	IV	2005	Azerbaijan	23.2	no
Khor Virap	Sanctuary	IV	2007	Armenia	1.6	yes
Zagatala	Sanctuary (Managed Reserve)	IV	2008	Azerbaijan	69.6	yes
Jermuk Hydrological	Sanctuary	IV	2009	Armenia	173.7	yes
Rvarud	Sanctuary (Managed Reserve)	IV	2009	Azerbaijan	5.1	no
Zangezur	Sanctuary	IV	2009	Armenia	173.1	yes
Arpachay	Sanctuary (Managed Reserve)	IV	2009	Azerbaijan	695.8	yes
Zikatar	Sanctuary	IV	2010	Armenia	1.5	yes
Caucasus Wildlife Refuge	Privately Protected Area	VI	2011	Armenia	360.4	yes

Appendix 3.3: Results of tests conducted to select the most optimal number of quadrature points and the best predictor variables using stepwise selection. Highlighted in green are the best results among the sets of quadrature data. Highlighted in red are the best predictor variables among those tested for each specific case. The number of quadrature points correspond to those in Appendix 3.1. The predictor variables correspond to those in Table 3.1

Bezoar models with Slope, selecting between Precipitation, DFWOS, and DSC							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
DFWOS	100s	96.2	90.0	92.2			
	1k	91.3	89.7	88.0			
	5k	91.3	90.3	89.0	93.3	91.0	90.4
	max	94.2	93.8	92.4			
DSC	100s	95.2	89.5	91.2			
	1k	95.7	90.1	91.6			
	5k	99.0	89.1	93.0	97.5	88.9	92.0
	max	100.0	86.9	92.3			
Precipitation	100s	93.3	85.0	86.7			
	1k	92.3	91.2	89.6			
	5k	93.3	91.1	90.8	93.8	88.3	89.0
	max	96.2	86.1	89.0			

Bezoar models with TRI selecting between Precipitation, DFWOS, and DSC							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
DFWOS	100s	95.2	87.0	89.5			
	1k	98.1	88.3	92.0			
	5k	95.2	89.8	91.3	95.0	89.3	90.7
	max	91.3	92.3	90.1			

DSC	100s	92.3	93.0	91.5			
	1k	95.2	90.2	91.3			
	5k	98.1	92.3	94.4	95.2	91.1	92.0
	max	95.2	89.0	90.8			
Precipitation	100s	88.5	89.0	86.4			
	1k	95.2	80.4	85.1			
	5k	93.3	87.3	87.8	93.3	85.9	87.3
	max	96.2	86.7	89.7			

Chamois models with Slope, selecting between Precipitation, DFWOS, DSC, as well as Distance to urban and Distance to water							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
Precipitation and urban	100s	89.8	91.0	88.2			
	1k	95.5	89.3	91.1	91.5	90.9	89.3
	max	89.2	92.3	88.6			
Precipitation and water	100s	95.5	74.8	82.0			
	1k	84.1	89.4	83.4	92.0	79.5	82.4
	max	96.6	74.4	82.0			
DSC and urban	100s	95.5	84.0	87.4			
	1k	89.8	91.8	88.6	92.0	87.7	87.4
	max	90.9	87.4	86.1			
DSC and water	100s	94.3	78.5	81.9			
	1k	88.6	89.3	86.4	92.0	81.0	82.7
	max	93.2	75.2	79.8			
DFWOS and urban	100s	90.9	79.5	82.0			
	1k	97.7	82.0	87.6	93.2	81.0	84.0
	max	90.9	81.4	82.5			
DFWOS and water	100s	62.5	79.0	57.1			
	1k	91.5	78.4	81.4	80.1	80.7	73.2

	max	86.4	84.6	81.2			

Chamois models with TRI, selecting between Precipitation, DFWOS, DSC, as well as Distance to urban and Distance to water							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
Precipitation and urban	100s	94.3	91.0	91.1			
	1k	86.4	93.7	87.8	92.0	91.3	89.9
	max	95.5	89.1	90.8			
Precipitation and water	100s	87.5	88.0	85.2			
	1k	89.8	89.5	87.0	88.6	88.7	86.1
	max	88.6	88.6	86.0			
DSC and urban	100s	95.5	80.8	85.8			
	1k	90.9	93.2	90.7	93.9	86.1	88.1
	max	95.5	84.3	87.8			
DSC and water	100s	90.9	76.0	78.8			
	1k	84.1	85.4	81.2	87.5	81.3	80.2
	max	87.5	82.4	80.6			
DFWOS and urban	100s	89.8	79.5	81.3			
	1k	97.2	83.9	88.4	94.5	80.9	85.0
	max	96.6	79.3	85.4			
DFWOS and water	100s	85.2	77.8	76.4			
	1k	88.6	69.3	72.5	87.1	74.0	74.9
	max	87.5	74.8	75.7			

Gazelle models, selecting between Slope and TRI							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
Slope	100s	93.9	83.5	86.4			
	1k	93.5	86.0	87.7			
	5k	93.2	82.3	85.5	93.6	83.7	86.4

	max	93.8	83.1	86.2			
TRI	100s	92.4	87.1	87.7			
	1k	92.5	85.8	86.9			
	5k	92.6	84.2	86.2	92.4	86.2	87.2
	max	92.3	87.7	88.1			

Mouflon models, selecting between Slope and TRI							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
Slope	100s	80.2	75.0	68.2			
	1k	88.2	72.4	74.9			
	5k	81.1	79.5	74.3	83.6	76.3	72.9
	max	84.9	78.4	74.4			
TRI	100s	87.7	90.5	86.3			
	1k	88.7	80.1	80.9			
	5k	91.5	75.3	77.8	89.2	80.8	80.4
	max	88.7	77.4	76.8			

Mouflon models with TRI, selecting between Precipitation and Temperature							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
Precipitation	100s	82.1	84.8	79.6			
	1k	84.0	85.8	81.3	84.6	83.0	79.7
	5k	87.7	78.4	78.2			
Temperature	100s	77.3	86.0	74.5			
	1k	86.4	85.6	81.9	83.6	78.9	74.8
	5k	87.3	65.2	67.9			

Red deer models with slope, selecting between DFWOS and DSC							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy

DFWOS	100s	88.3	95.3	90.6			
	1k	90.1	93.0	90.0			
	5k	91.2	91.7	90.1	89.8	93.2	90.2
	max	89.6	93.0	90.1			
DSC	100s	92.0	94.7	92.7			
	1k	95.3	92.0	92.6			
	5k	92.7	92.8	91.7	93.5	93.0	92.3
	max	94.0	92.4	92.3			

Red deer model with TRI, selecting between DFWOS and DSC							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
DFWOS	100s	88.0	97.0	90.5			
	1k	92.0	90.9	90.1			
	5k	91.6	91.8	90.3	90.1	93.3	90.2
	max	89.1	93.3	89.9			
DSC	100s	91.2	93.7	91.4			
	1k	92.7	94.5	92.8			
	5k	95.6	90.6	92.4	92.8	93.4	92.2
	max	91.6	95.0	92.4			

Roe deer models, selecting between Slope and TRI							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
Slope	100s	88.2	93.3	89.1			
	1k	88.4	90.5	87.5			
	5k	95.6	82.8	87.3	89.5	89.7	87.7
	max	85.6	92.3	87.1			
TRI	100s	90.0	92.6	90.0			
	1k	88.0	90.5	87.3			
	5k	90.8	86.5	86.7	90.7	88.5	87.8

	max	94.0	84.5	87.4			

Tur models, selecting between Slope and TRI							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
Slope	100s	91.9	93.4	91.7			
	1k	89.2	95.2	91.1			
	5k	88.9	94.4	90.5	89.5	94.3	90.8
	max	88.1	94.1	89.8			
TRI	100s	91.5	92.8	91.0			
	1k	90.0	93.8	90.7			
	5k	94.6	90.7	91.6	92.7	91.5	90.9
	max	94.6	88.7	90.3			

Tur models with TRI, selecting between DFWOS and DSC							
		Sensitivity	Specificity	Average AUC and TSS	Average sensitivity	Average specificity	Average accuracy
DFWOS	100s	92.4	88.5	88.9			
	1k	90.4	89.3	88.2	92.2	87.1	87.9
	5k	93.8	83.4	86.7			
DSC	100s	98.4	85.5	90.6			
	1k	89.3	92.0	89.1	93.6	88.1	89.4
	5k	93.0	86.8	88.4			

Appendix 3.4: Variance Inflation Factor of each predictor variable obtained from linear models, when: a. all variables are included in models; b. only selected variables are included in models. The predictor variables correspond to those in Table 3.1. Highlighted are the values above 10. The two shades of red indicate the values 10-15 for lighter red and those above 15 for darker red

a.	bezoar	chamois	gazelle	mouflon	red deer	roe deer	tur
Land cover	1.3	1.7	1.1	1.2	1.6	1.3	1.8
Temperature	4.7	4.0	5.8	14.3	2.6	1.5	3.3
Precipitation	21.5	24.4	8.4	24.1	21.6	17.1	15.8
DSC	17.3	16.5	10.1	39.7	12.8	8.0	9.2
DFWOS	13.2	5.4	3.5	39.9	3.9	1.5	3.9
Elevation	11.7	12.8	8.1	11.9	14.5	12.3	10.0
Slope	40.9	24.5	34.5	39.5	42.4	47.3	28.6
Aspect	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TRI	40.1	22.6	33.8	38.2	39.9	47.0	27.5
Distance to urban	2.0	2.3	1.2	1.9	2.6	2.1	2.3
Distance to water	1.2	1.3	1.5	1.2	1.2	1.2	1.3

b.	bezoar	chamois	gazelle	mouflon	red deer	roe deer	tur
Land cover	1.1	1.4	1.0	1.2	1.3	1.1	1.6
Temperature	-	-	2.3	-	-	-	-
Precipitation	-	3.1	-	1.7	-	-	9.0
DSC	1.5	-	-	-	2.7	2.0	6.5
DFWOS	-	-	1.9	-	-	1.3	-
Elevation	-	-	-	-	-	-	-
Slope	-	-	-	-	-	-	-
Aspect	-	-	1.0	-	1.0	1.0	1.0
TRI	1.1	1.6	1.1	1.3	1.7	1.5	1.4
Distance to urban	1.5	2.0	1.1	1.4	1.9	1.8	2.1
Distance to water	1.1	-	1.4	1.2	1.1	1.0	1.2

Appendix 3.5: Total area in potential habitat within Azerbaijan in 1965 and 2021 for each species in km^2, as well as area change and percent change for potential highly-suitable, potential moderately-suitable, potential least-suitable habitats and potential non-habitats. All potentially suitable habitats include potential highly-suitable, moderately-suitable, and least-suitable habitats. The total areas and changes are also summarized by IUCN categories of protected areas (I-II and III-VI), and total within all protected areas

	bezoar				chamois				gazelle			
Potential habitats	overall	I-II	III-VI	all PAs	overall	I-II	III-VI	all PAs	overall	I-II	III-VI	all PAs
highly-suitable 1965	167	27	137	164	2,398	191	327	517	733	143	21	164
highly-suitable 2021	1,252	160	1,090	1,250	521	38	30	68	1,192	195	88	283
area change	1,084	133	953	1,086	-1,877	-153	-297	-449	459	52	67	119
percent change	648	491	696	662	-78	-80	-91	-87	63	36	321	73
moderately-suitable 1965	4,640	357	4,884	5,242	12,965	731	1,394	2,126	3,300	237	28	265
moderately-suitable 2021	3,469	306	3,755	4,061	5,469	693	489	1,182	4,209	345	111	456
area change	-1,171	-51	-1,130	-1,181	-7,495	-38	-906	-944	909	108	83	191
percent change	-25	-14	-23	-37	-58	-5	-65	-44	28	45	293	72
least-suitable 1965	73,363	2,726	75,702	78,428	61,084	2,734	3,158	5,892	13,697	270	94	363
least-suitable 2021	61,276	2,139	63,583	65,721	49,097	2,522	3,673	6,195	22,621	333	269	602
area change	-12,087	-588	-12,119	-12,707	-11,987	-212	515	303	8,925	63	175	238
percent change	-16	-22	-16	-38	-20	-8	16	5	65	23	187	66
non-suitable 1965	12,185	840	13,125	13,965	14,296	322	426	747	72,029	3,330	5,155	8,486
non-suitable 2021	24,359	1,346	25,220	26,566	35,655	724	1,113	1,838	61,737	3,108	4830	7,938
area change	12,174	506	12,095	12,602	21,359	403	688	1,090	-10,292	-223	-325	-548
percent change	100	60	92	152	149	125	162	146	-14	-7	-6	-7
all suitable habitat 1965	78,171	3,111	80,723	83,834	76,447	3,656	4,879	8,535	17,730	650	143	793
all suitable habitat 2021	65,997	2,605	68,427	71,032	55,087	3,253	4,191	7,444	28,022	873	468	1,341
area change	-12,174	-506	-12,296	-12,802	-21,359	-403	-688	-1,090	10,292	223	325	548
percent change	-16	-16	-15	-15	-28	-11	-14	-13	58	34	228	69

	mouflon				red deer				roe deer			
	overall	I-II	III-VI	all PAs	overall	I-II	III-VI	all PAs	overall	I-II	III-VI	all PAs
highly-suitable 1965	0	0	0	0	2,384	320	235	555	11,364	1,029	586	1,615
highly-suitable 2021	55	8	0	8	869	289	44	333	9,159	1,262	670	1,933
area change	55	8	0	8	-1,515	-31	-191	-221	-2,204	234	84	318
percent change	NA	NA	0	NA	-64	-10	-81	-39	-19	23	14	20
moderately-suitable 1965	10,219	367	177	544	6,439	506	493	999	3,214	376	178	554
moderately-suitable 2021	21,732	694	953	1,647	1,607	311	101	412	3,615	375	219	593
area change	11,513	327	776	1,103	-4,832	-194	-392	-587	401	-1	40	39
percent change	113	89	438	203	-75	-38	-80	-59	12	0	23	7
least-suitable 1965	80,524	3,611	5,128	8,738	15,537	961	1,019	1,980	25,451	1,106	2,080	3,186
least-suitable 2021	68,956	3,275	4,352	7,627	9,499	841	947	1,788	14,643	784	1,274	2,058
area change	-11,568	-335	-776	-1,112	-6,037	-120	-72	-193	-10,808	-321	-806	-1,128
percent change	-14	-9	-15	-13	-39	-12	-7	-10	-42	-29	-39	-35
non-suitable 1965	0	0	0	0	65,399	2,194	3,551	5,745	49,731	1,470	2,454	3,924
non-suitable 2021	0	0	0	0	77,784	2,539	4,206	6,745	62,342	1,559	3,135	4,694
area change	0	0	0	0	12,385	345	655	1,000	12,612	89	682	770
percent change	0	0	0	0	19	16	18	17	25	6	28	20
all suitable habitat 1965	90,742	3,977	5,305	9,282	24,360	1,787	1,747	3,534	40,029	2,,510	2,845	5,355
all suitable habitat 2021	90,742	3,977	5,305	9,282	11,975	1,441	1,092	2,533	27,417	2421	2,163	4,584
area change	0	0	0	0	-12,385	-345	-655	-1,000	-12,612	-89	-682	-770
percent change	0	0	0	0	-51	-19	-38	-28	-32	-4	-24	-14

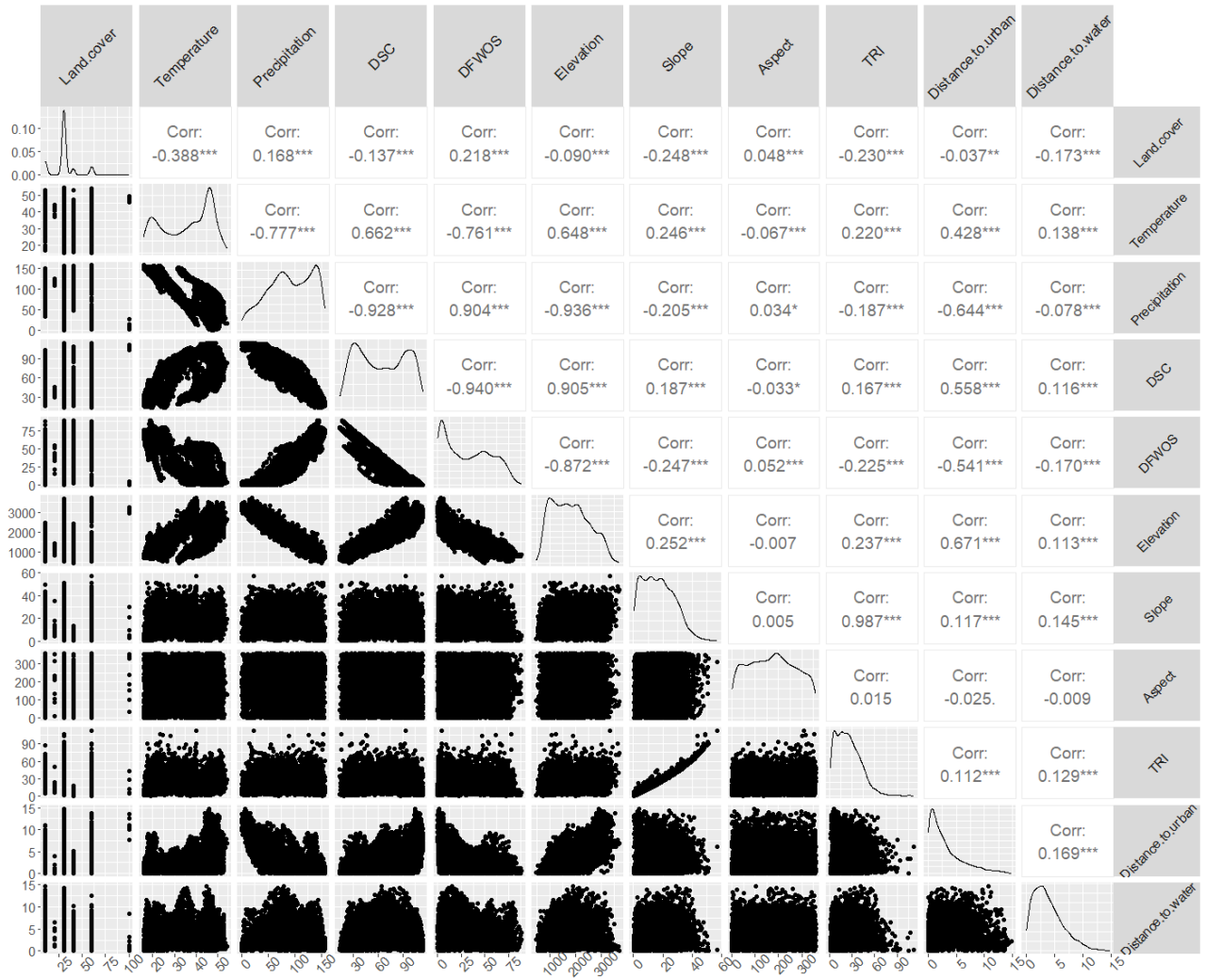
	tur			
	overall	I-II	III-VI	all PAs
highly-suitable 1965	575	45	118	163
highly-suitable 2021	909	112	97	209
area change	334	67	-21	46
percent change	58	149	-18	28
moderately-suitable 1965	6,417	638	544	1,182
moderately-suitable 2021	2,061	376	171	547
area change	-4,356	-262	-373	-635
percent change	-68	-41	-69	-54
least-suitable 1965	24,870	1,566	2,173	3,739
least-suitable 2021	4,975	545	501	1,047
area change	-19,895	-1,021	-1,672	-2,693
percent change	-80	-65	-77	-72
non-suitable 1965	57,897	1,731	2,462	4,194
non-suitable 2021	81,814	2,947	4,528	7,475
area change	23,917	1,215	2,066	3,282
percent change	41	70	84	78
all suitable habitat 1965	31,862	2,249	2,836	5,085
all suitable habitat 2021	7,945	1,034	770	1,803
area change	-23,917	-1,215	-2,066	-3,282
percent change	-75	-54	-73	-65

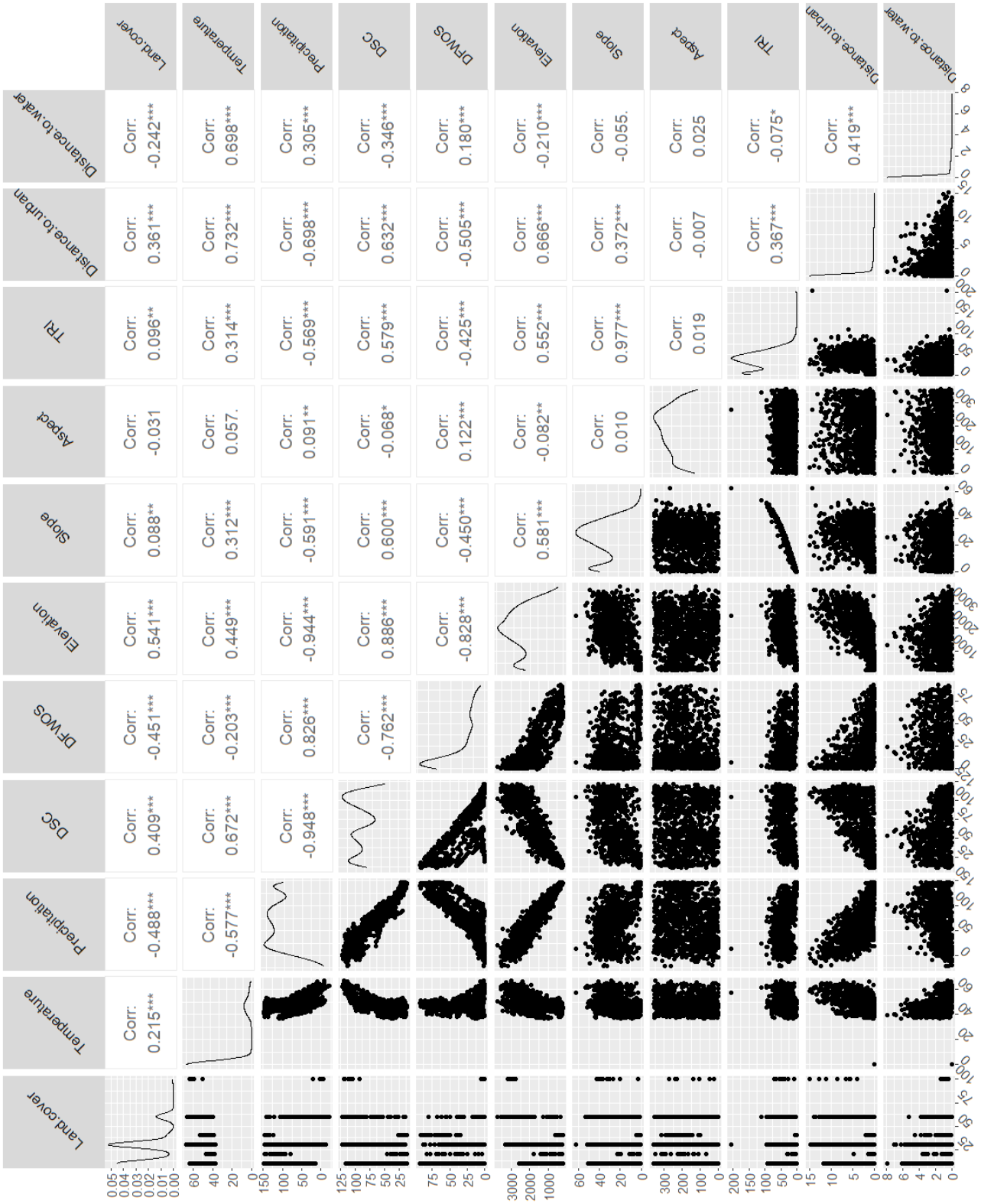
Appendix 3.6: Area changes in potential suitable habitats of each species within protected areas of IUCN categories I-II, established before 1970, between 1970-'90, and after 1990

		before 1970	1970-1990	after 1990
	1965	683.5	182.6	1972.7
bezoar	2021	482.8	170.6	1951.4
	percent change	-29.4	-6.6	-1.1
	1965	718.9	218.9	2080.3
chamois	2021	579.7	155.3	2518.1
	percent change	-19.4	-29.1	21.0
	1965	44.1	8.1	245.3
gazelle	2021	96.0	4.8	772.0
	percent change	117.8	-41.6	214.7
	1965	854.6	228.2	2556.6
mouflon	2021	854.6	228.2	2894.5
	percent change	0.0	0.0	13.2
	1965	254.8	182.1	898.1
red deer	2021	299.9	121.2	1020.2
	percent change	17.7	-33.4	13.6
	1965	551.8	168.2	860.8
roe deer	2021	620.8	174.9	1625.5
	percent change	12.5	4.0	88.8
	1965	366.6	186.6	1200.8
tur	2021	183.7	67.4	782.5
	percent change	-49.9	-63.9	-34.8
	Average of change	7.1	-24.4	45.1

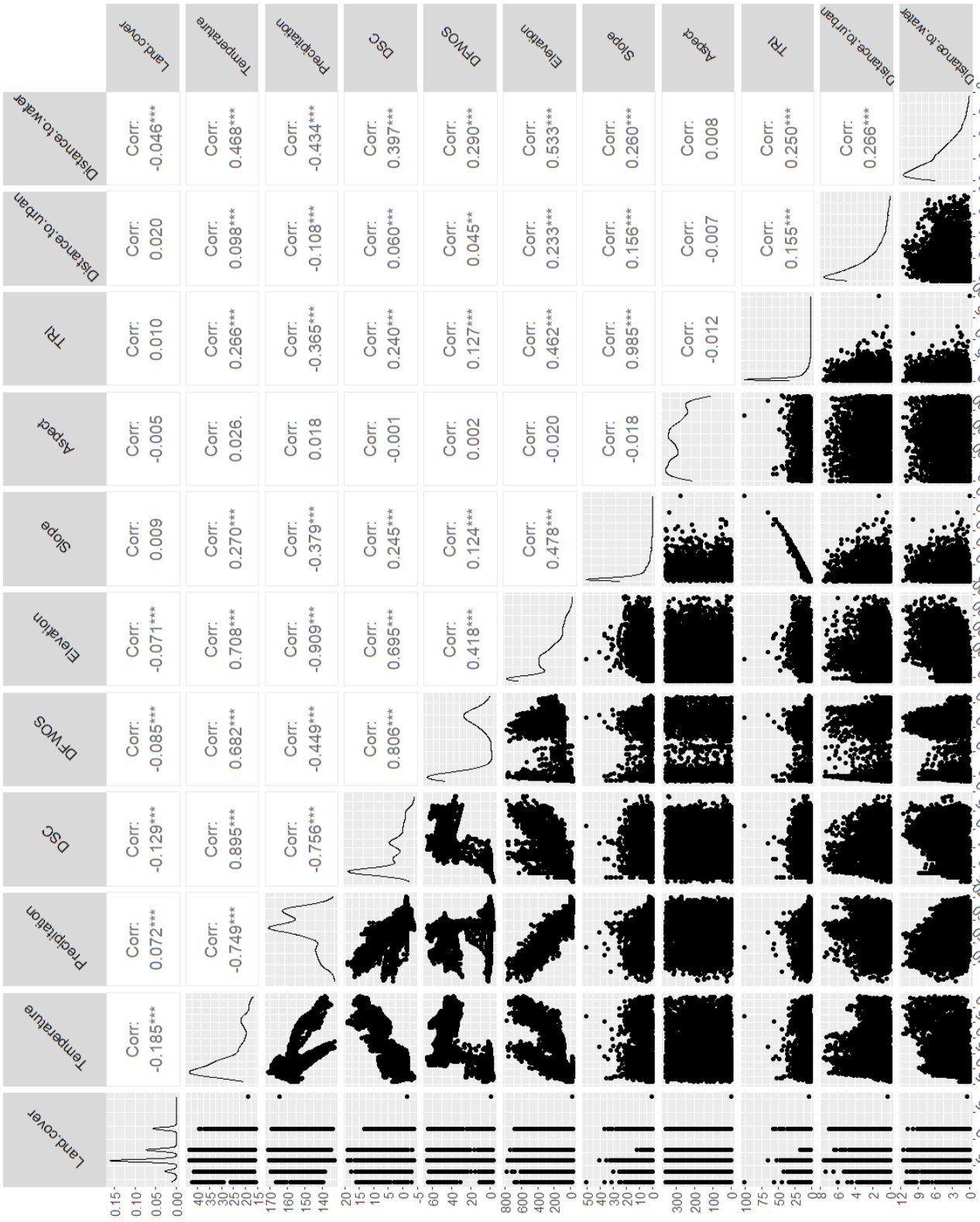
Appendix 3.7: Correlation plots obtained from linear models with: 1. all variables in model, 2. only selected variables, for a. bezoar; b. chamois; c. gazelle; d. mouflon; e. red deer; f. roe deer; g. tur. All predictor variables and their measurement units correspond to those in Table 3.1. The numeric class code in Land Cover map corresponds to that in Appendix 3.9

1.a.

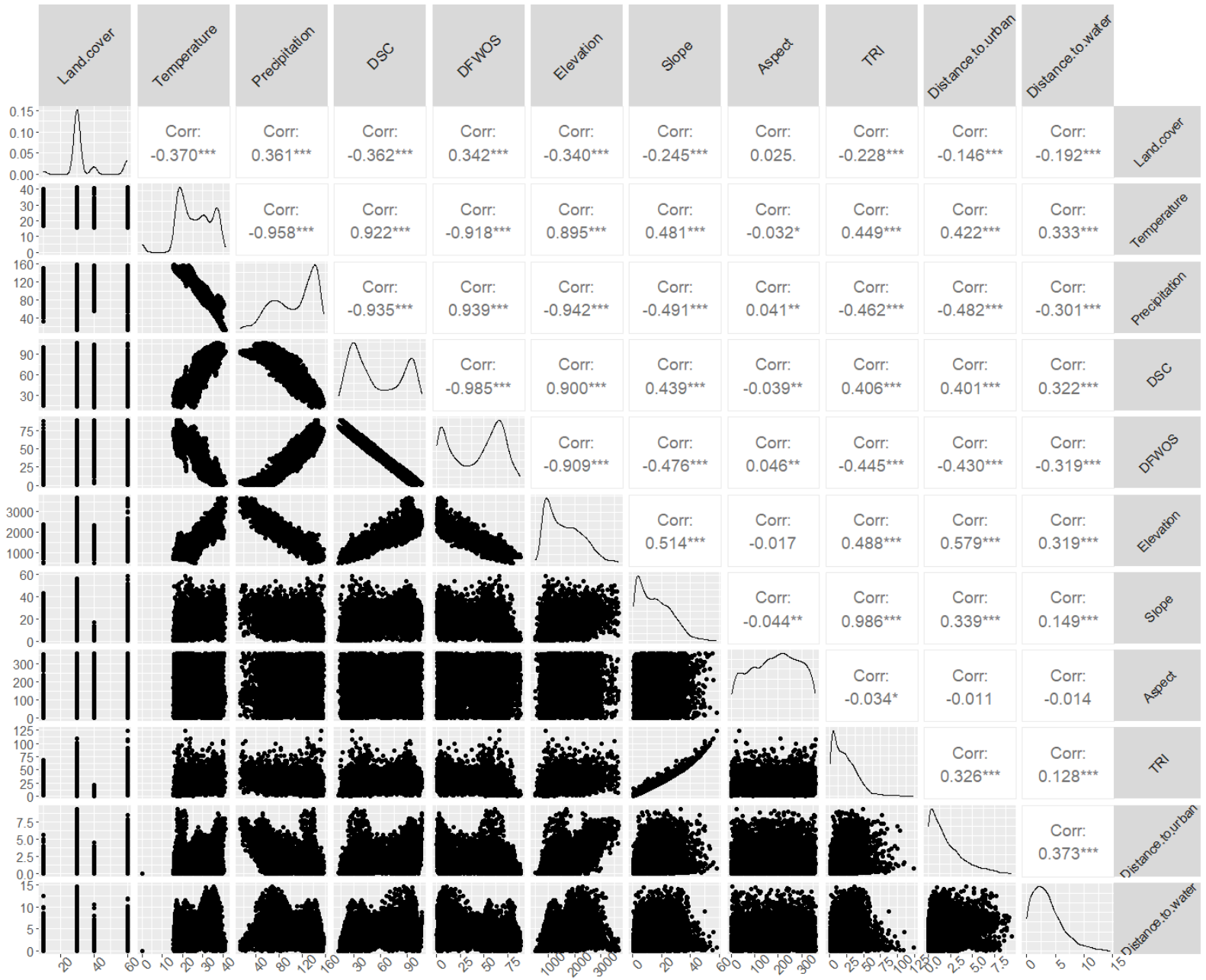



Land.cover
Temperature
Precipitation
DSC
DFWOS
Elevation
Slope
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: 0.215***
Corr: -0.488***
Corr: 0.409***
Corr: -0.451***
Corr: 0.541***
Corr: 0.088**
Corr: -0.031
Corr: 0.096**
Corr: 0.361***
Corr: -0.242***
Corr: -0.577***
Corr: 0.672***
Corr: -0.203***
Corr: 0.449***
Corr: 0.312***
Corr: 0.057.
Corr: 0.314***
Corr: 0.732***
Corr: 0.698***
Corr: -0.948***
Corr: 0.826***
Corr: -0.944***
Corr: -0.591***
Corr: 0.091**
Corr: -0.569***
Corr: -0.698***
Corr: 0.305***
Corr: -0.762***
Corr: 0.886***
Corr: 0.600***
Corr: -0.068*
Corr: 0.579***
Corr: 0.632***
Corr: -0.346***
Corr: -0.828***
Corr: -0.450***
Corr: 0.122***
Corr: -0.425***
Corr: -0.505***
Corr: 0.180***
Corr: 0.581***
Corr: -0.082**
Corr: 0.552***
Corr: 0.666***
Corr: -0.210***
Corr: 0.010
Corr: 0.977***
Corr: 0.372***
Corr: -0.055.
Corr: 0.019
Corr: -0.007
Corr: 0.025
Corr: 0.367***
Corr: -0.075*
Corr: 0.419***

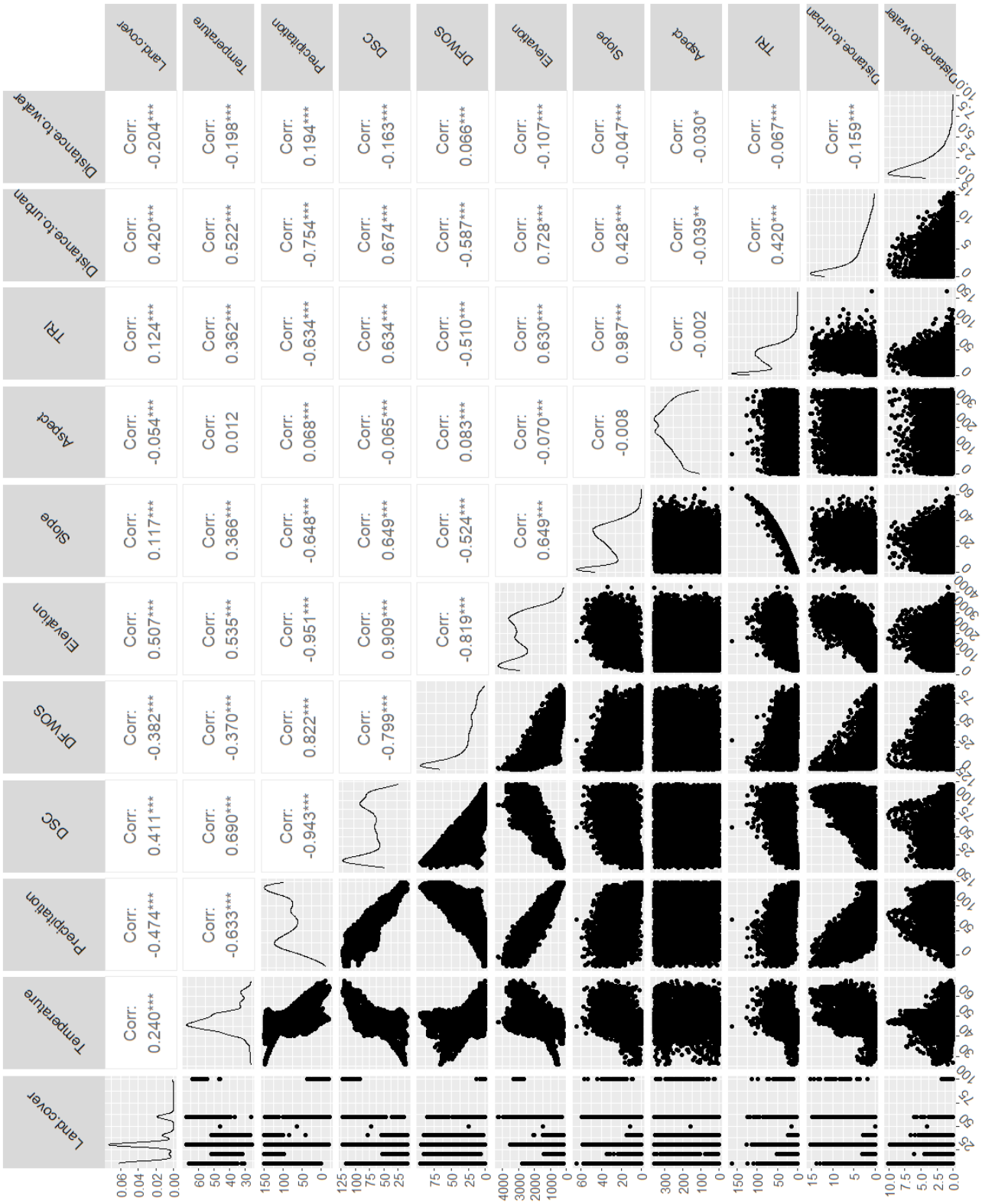
1.b.


Land.cover
Temperature
Precipitation
DSC
DFWOS
Elevation
Slope
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: -0.185***
Corr: 0.072***
Corr: -0.129***
Corr: -0.085***
Corr: -0.071***
Corr: 0.009
Corr: -0.005
Corr: 0.010
Corr: 0.020
Corr: -0.046***
Corr: -0.749***
Corr: 0.895***
Corr: 0.682***
Corr: 0.708***
Corr: 0.270***
Corr: 0.026.
Corr: 0.266***
Corr: 0.098***
Corr: 0.468***
Corr: -0.756***
Corr: -0.449***
Corr: -0.909***
Corr: -0.379***
Corr: 0.018
Corr: -0.365***
Corr: -0.108***
Corr: -0.434***
Corr: 0.806***
Corr: 0.695***
Corr: 0.245***
Corr: -0.001
Corr: 0.240***
Corr: 0.060***
Corr: 0.397***
Corr: 0.418***
Corr: 0.124***
Corr: 0.002
Corr: 0.127***
Corr: 0.045**
Corr: 0.290***
Corr: 0.478***
Corr: -0.020
Corr: 0.462***
Corr: 0.233***
Corr: 0.533***
Corr: -0.018
Corr: 0.985***
Corr: 0.156***
Corr: 0.260***
Corr: -0.012
Corr: -0.007
Corr: 0.008
Corr: 0.155***
Corr: 0.250***
Corr: 0.266***

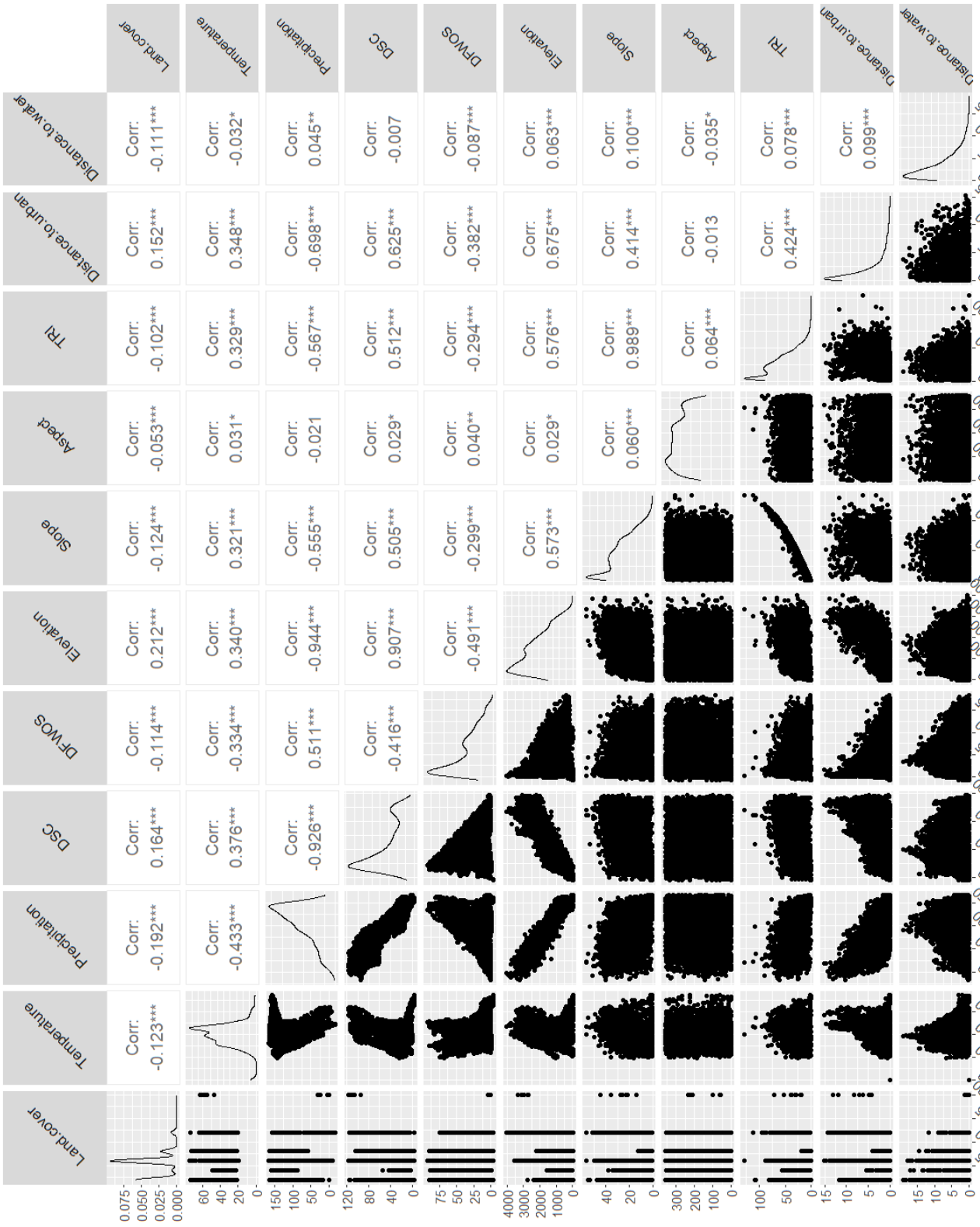
1.c.


Land.cover
Temperature
Precipitation
DSC
DFWOS
Elevation
Slope
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: -0.370***
Corr: 0.361***
Corr: -0.362***
Corr: 0.342***
Corr: -0.340***
Corr: -0.245***
Corr: 0.025.
Corr: -0.228***
Corr: -0.146***
Corr: -0.192***
Corr: -0.958***
Corr: 0.922***
Corr: -0.918***
Corr: 0.895***
Corr: 0.481***
Corr: -0.032*
Corr: 0.449***
Corr: 0.422***
Corr: 0.333***
Corr: -0.935***
Corr: 0.939***
Corr: -0.942***
Corr: -0.491***
Corr: 0.041**
Corr: -0.462***
Corr: -0.482***
Corr: -0.301***
Corr: -0.985***
Corr: 0.900***
Corr: 0.439***
Corr: -0.039**
Corr: 0.406***
Corr: 0.401***
Corr: 0.322***
Corr: -0.909***
Corr: -0.476***
Corr: 0.046**
Corr: -0.445***
Corr: -0.430***
Corr: -0.319***
Corr: 0.514***
Corr: -0.017
Corr: 0.488***
Corr: 0.579***
Corr: 0.319***
Corr: -0.044**
Corr: 0.986***
Corr: 0.339***
Corr: 0.149***
Corr: -0.034*
Corr: -0.011
Corr: -0.014
Corr: 0.326***
Corr: 0.128***
Corr: 0.373***

1.d.


Land.cover
Temperature
Precipitation
DSC
DFWOS
Elevation
Slope
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: 0.240***
Corr: -0.474***
Corr: 0.411***
Corr: -0.382***
Corr: 0.507***
Corr: 0.117***
Corr: -0.054***
Corr: 0.124***
Corr: 0.420***
Corr: -0.204***
Corr: -0.633***
Corr: 0.690***
Corr: -0.370***
Corr: 0.535***
Corr: 0.366***
Corr: 0.012
Corr: 0.362***
Corr: 0.522***
Corr: -0.198***
Corr: -0.943***
Corr: 0.822***
Corr: -0.951***
Corr: -0.648***
Corr: 0.068***
Corr: -0.634***
Corr: -0.754***
Corr: 0.194***
Corr: -0.799***
Corr: 0.909***
Corr: 0.649***
Corr: -0.065***
Corr: 0.634***
Corr: 0.674***
Corr: -0.163***
Corr: -0.819***
Corr: -0.524***
Corr: 0.083***
Corr: -0.510***
Corr: -0.587***
Corr: 0.066***
Corr: 0.649***
Corr: -0.070***
Corr: 0.630***
Corr: 0.728***
Corr: -0.107***
Corr: -0.008
Corr: 0.987***
Corr: 0.428***
Corr: -0.047***
Corr: -0.002
Corr: -0.039**
Corr: -0.030*
Corr: 0.420***
Corr: -0.067***
Corr: -0.159***

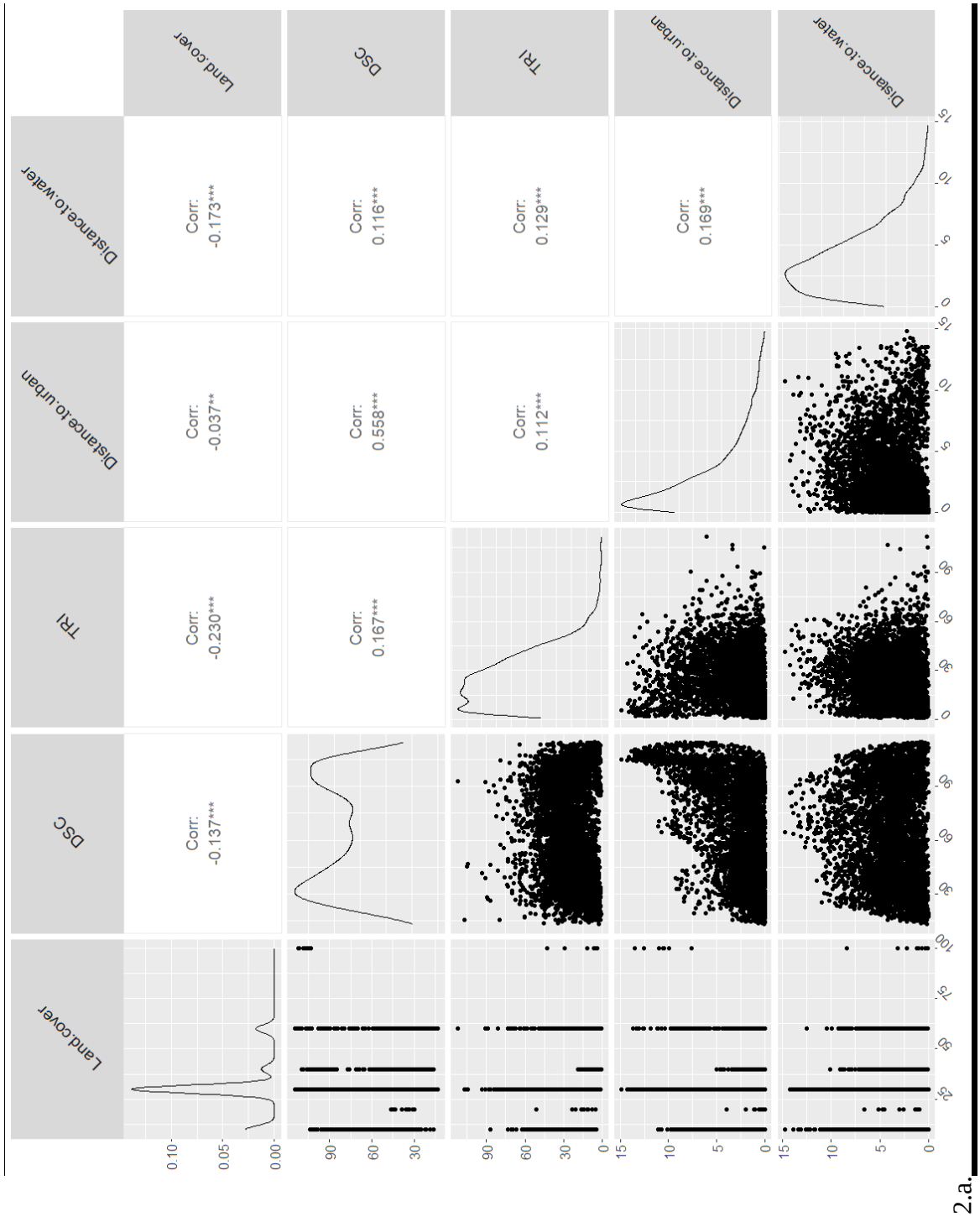
1.e.


Land.cover
Temperature
Precipitation
DSC
DFWOS
Elevation
Slope
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: -0.123***
Corr: -0.192***
Corr: 0.164***
Corr: -0.114***
Corr: 0.212***
Corr: -0.124***
Corr: -0.053***
Corr: -0.102***
Corr: 0.152***
Corr: -0.111***
Corr: -0.433***
Corr: 0.376***
Corr: -0.334***
Corr: 0.340***
Corr: 0.321***
Corr: 0.031*
Corr: 0.329***
Corr: 0.348***
Corr: -0.032*
Corr: -0.926***
Corr: 0.511***
Corr: -0.944***
Corr: -0.555***
Corr: -0.021
Corr: -0.567***
Corr: -0.698***
Corr: 0.045**
Corr: -0.416***
Corr: 0.907***
Corr: 0.505***
Corr: 0.029*
Corr: 0.512***
Corr: 0.625***
Corr: -0.007
Corr: -0.491***
Corr: -0.299***
Corr: 0.040**
Corr: -0.294***
Corr: -0.382***
Corr: -0.087***
Corr: 0.573***
Corr: 0.029*
Corr: 0.576***
Corr: 0.675***
Corr: 0.063***
Corr: 0.060***
Corr: 0.989***
Corr: 0.064***
Corr: 0.414***
Corr: 0.100***
Corr: -0.013
Corr: -0.035*
Corr: 0.424***
Corr: 0.078***
Corr: 0.099***

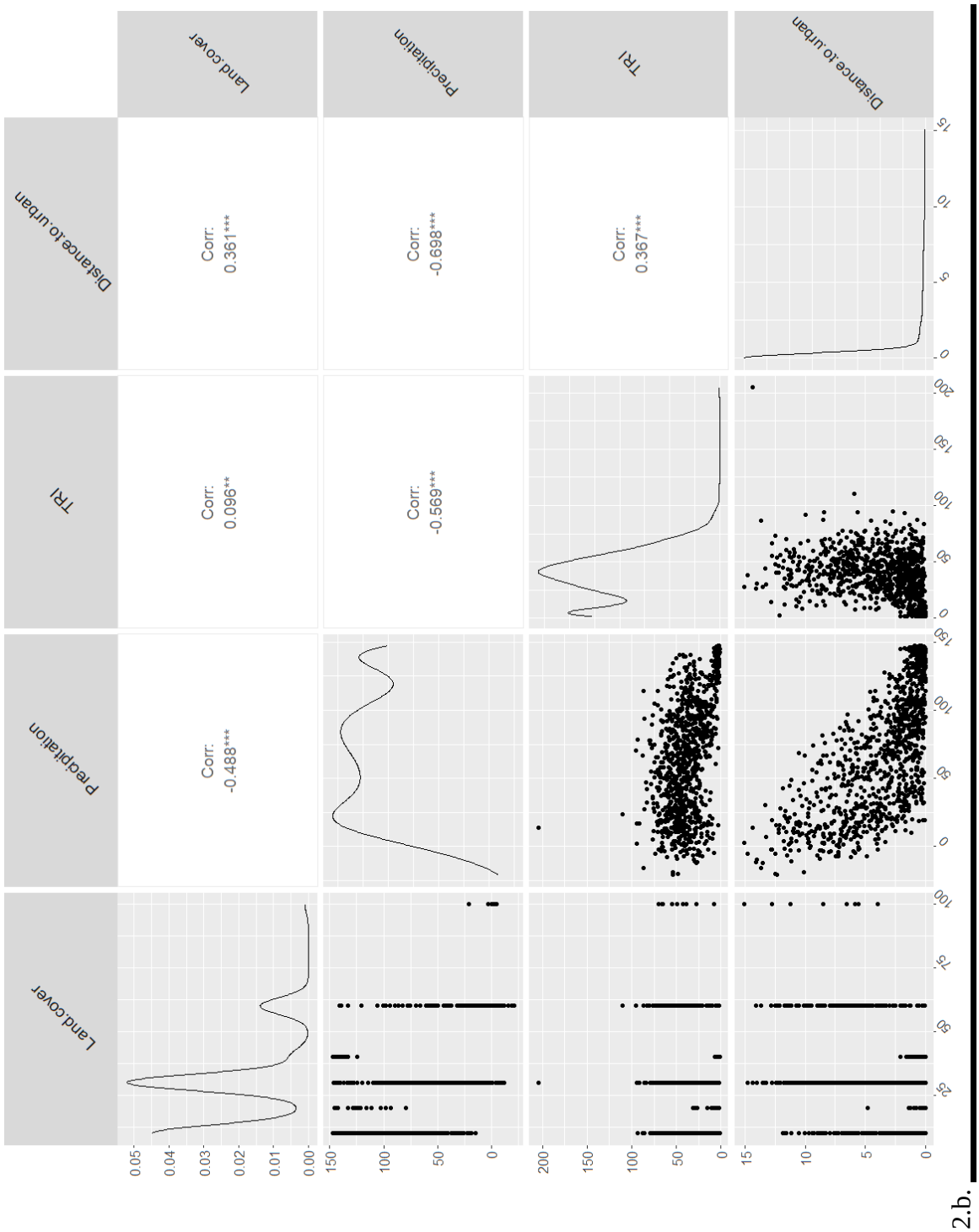
1.f.


Land.cover
Temperature
Precipitation
DSC
DFWOS
Elevation
Slope
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: 0.264***
Corr: -0.560***
Corr: 0.477***
Corr: -0.443***
Corr: 0.608***
Corr: 0.098***
Corr: -0.020
Corr: 0.104***
Corr: 0.436***
Corr: -0.261***
Corr: -0.584***
Corr: 0.669***
Corr: -0.187***
Corr: 0.437***
Corr: 0.265***
Corr: 0.017
Corr: 0.267***
Corr: 0.510***
Corr: -0.364***
Corr: -0.915***
Corr: 0.777***
Corr: -0.927***
Corr: -0.480***
Corr: 0.072***
Corr: -0.465***
Corr: -0.715***
Corr: 0.336***
Corr: -0.717***
Corr: 0.850***
Corr: 0.484***
Corr: -0.055***
Corr: 0.470***
Corr: 0.613***
Corr: -0.350***
Corr: -0.781***
Corr: -0.367***
Corr: 0.102***
Corr: -0.348***
Corr: -0.496***
Corr: 0.180***
Corr: 0.478***
Corr: -0.060***
Corr: 0.457***
Corr: 0.672***
Corr: -0.230***
Corr: 0.028*
Corr: 0.981***
Corr: 0.317***
Corr: -0.112***
Corr: 0.034*
Corr: -0.014
Corr: -0.036*
Corr: 0.306***
Corr: -0.121***
Corr: -0.234***

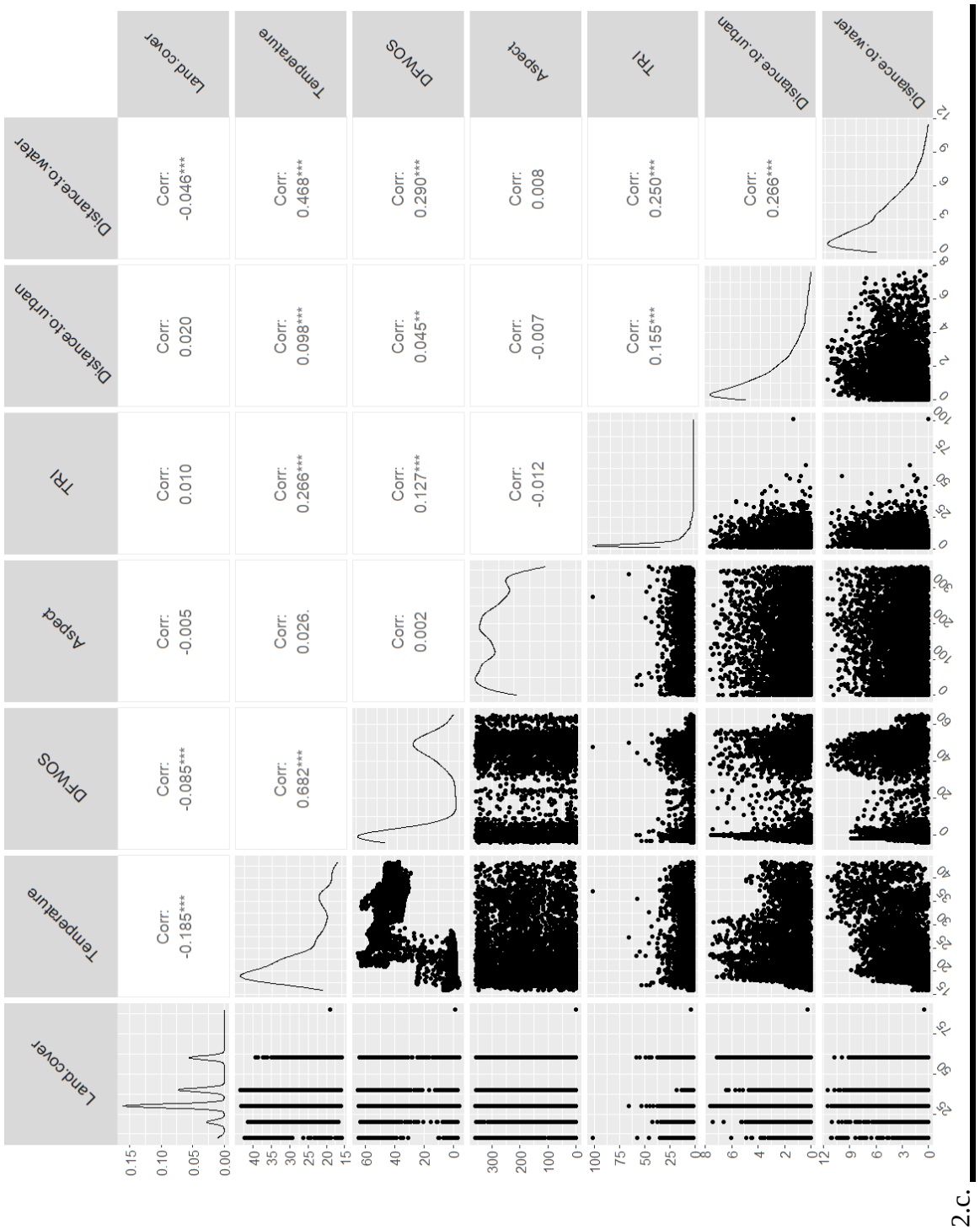
1.g.


Land.cover
DSC
TRI
Distance.to.urban
Distance.to.water
Corr:
-0.137***
Corr:
-0.230***
Corr:
-0.037**
Corr:
-0.173***
Corr:
0.167***
Corr:
0.558***
Corr:
0.112***
Corr:
0.116***
Corr:
0.129***
Corr:
0.169***

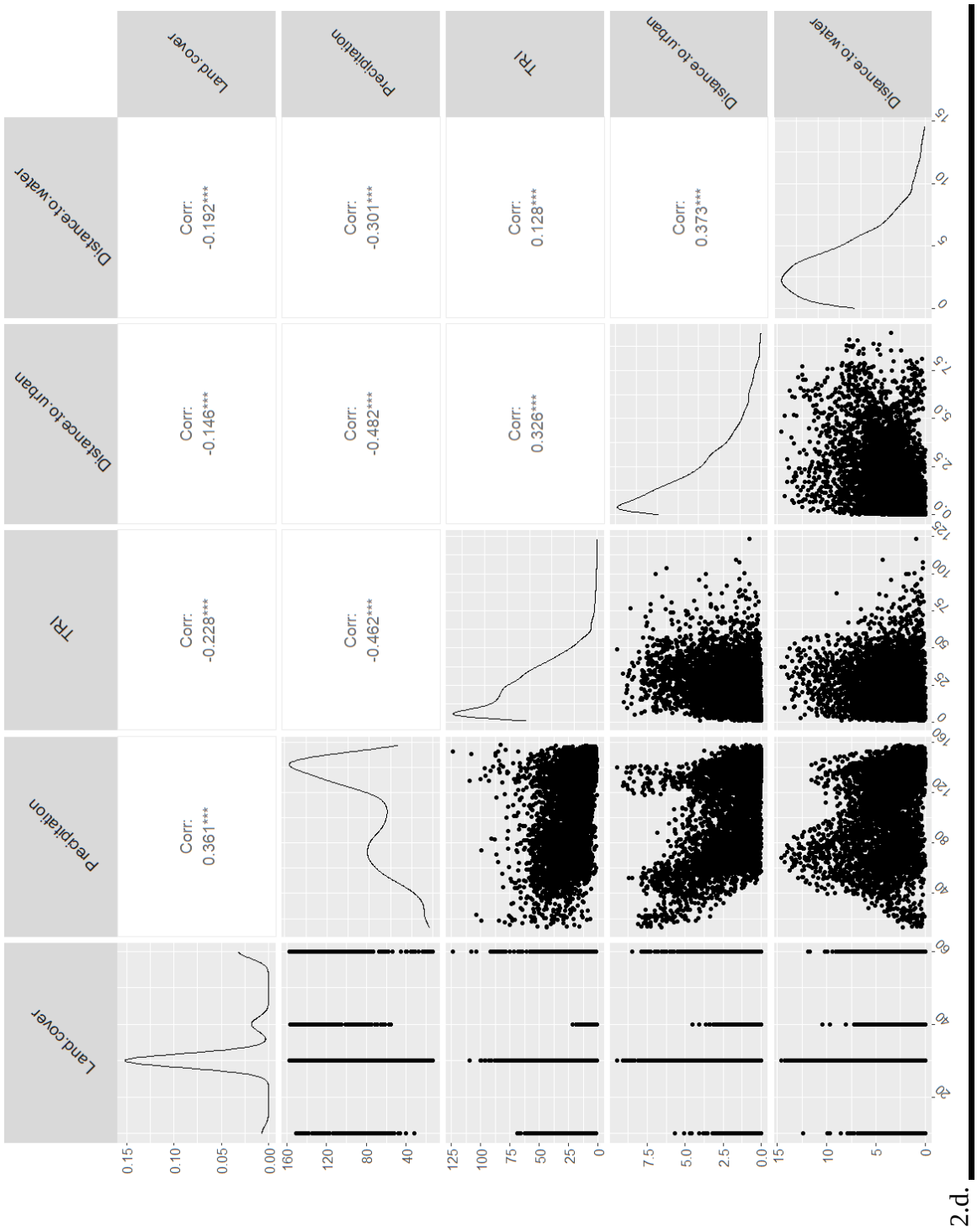
2.a.


Land.cover
Precipitation
TRI
Distance.to.urban
Corr:
0.361***
Corr:
-0.698***
Corr:
0.367***
Corr:
0.096**
Corr:
-0.569***
Corr:
-0.488***

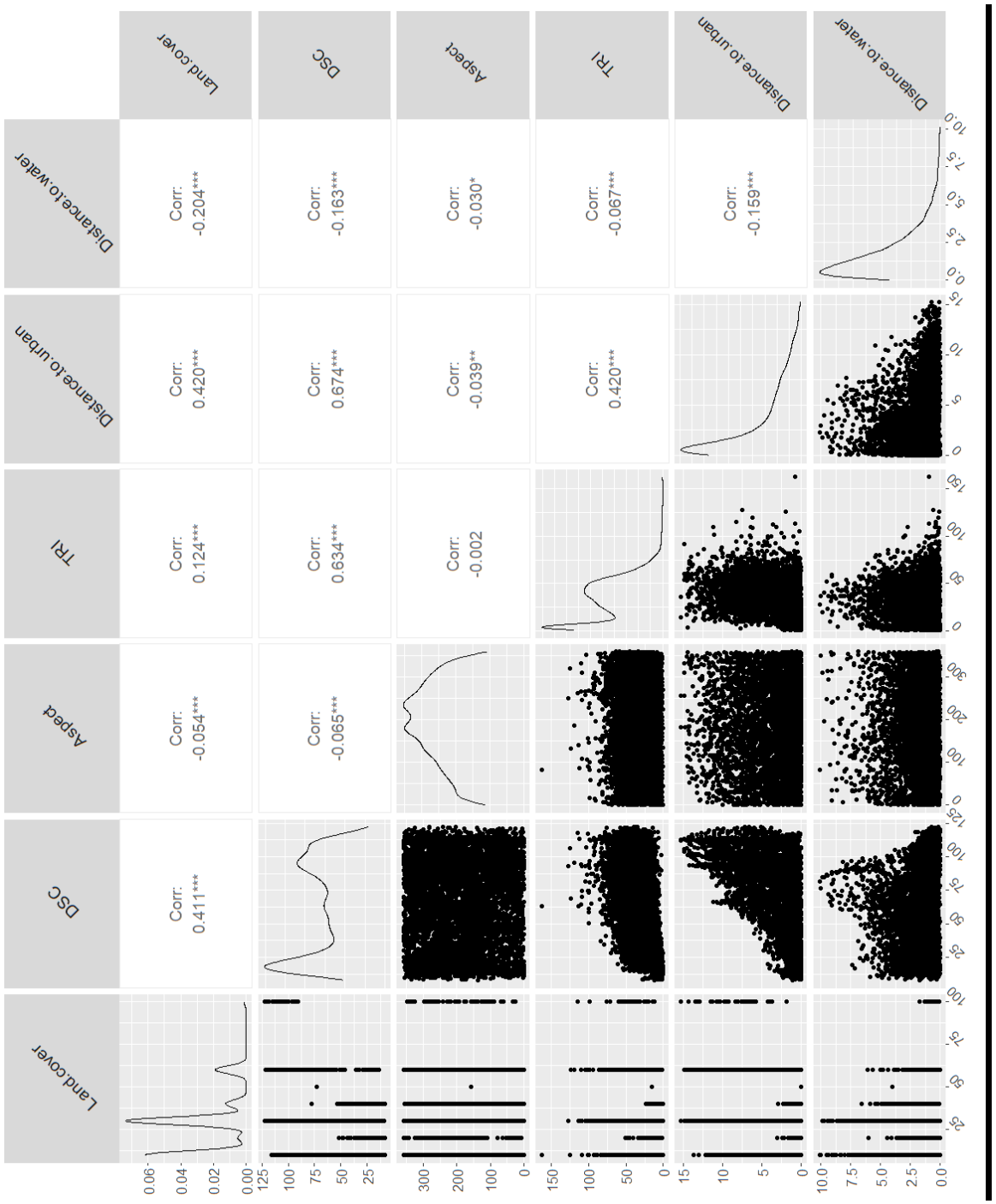
2.b.


Land.cover
Temperature
DFWOS
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: -0.185***
Corr: -0.085***
Corr: 0.682***
Corr: -0.005
Corr: 0.026.
Corr: 0.002
Corr: 0.010
Corr: 0.266***
Corr: 0.127***
Corr: -0.012
Corr: 0.020
Corr: 0.098***
Corr: 0.045**
Corr: -0.007
Corr: 0.155***
Corr: 0.266***
Corr: -0.046***
Corr: 0.468***
Corr: 0.290***
Corr: 0.008
Corr: 0.250***
Corr: 0.266***

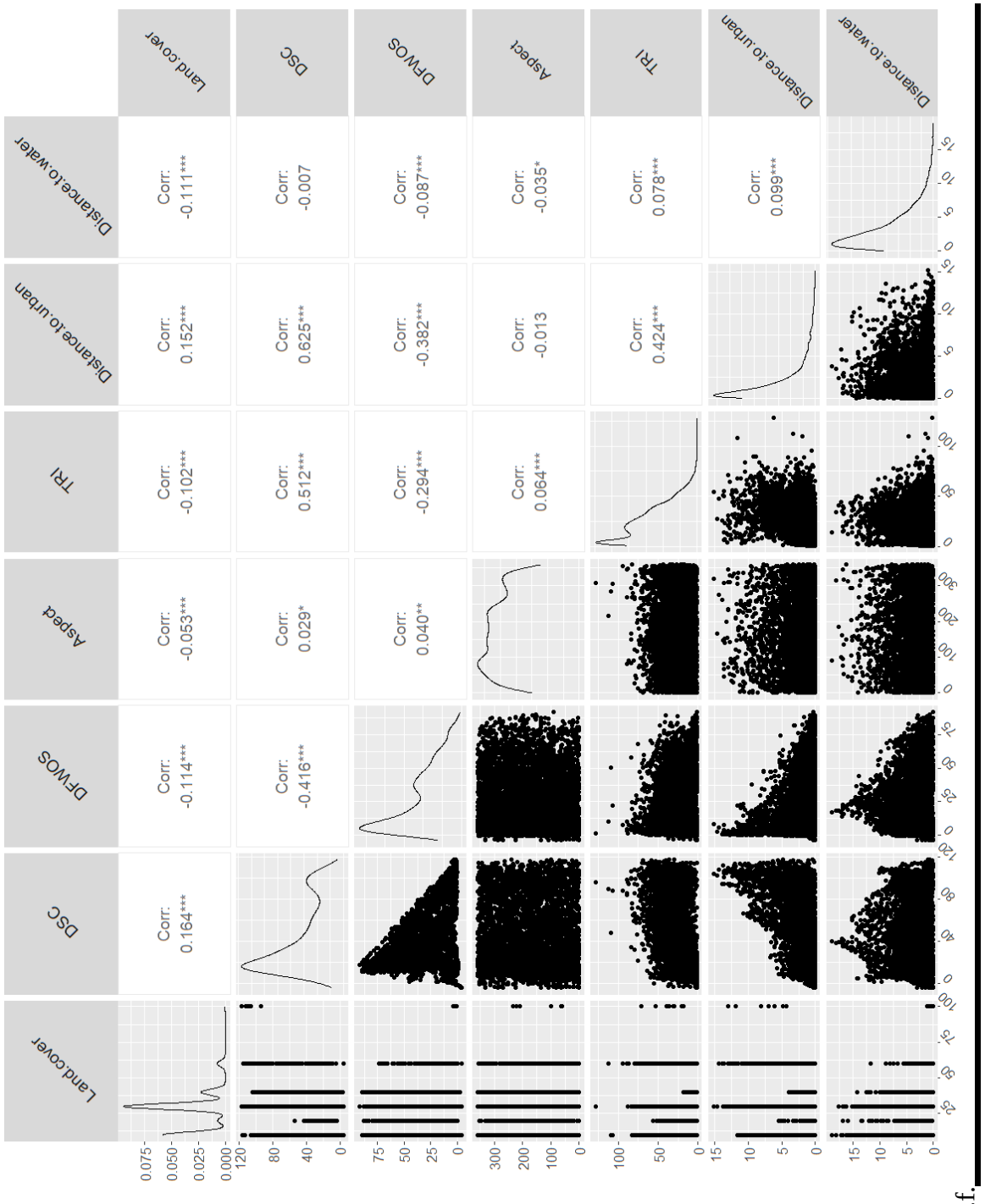
2.c.


Land.cover
Precipitation
TRI
Distance.to.urban
Distance.to.water
Corr: 0.361***
Corr: -0.228***
Corr: -0.462***
Corr: -0.146***
Corr: -0.482***
Corr: 0.326***
Corr: -0.192***
Corr: -0.301***
Corr: 0.128***
Corr: 0.373***

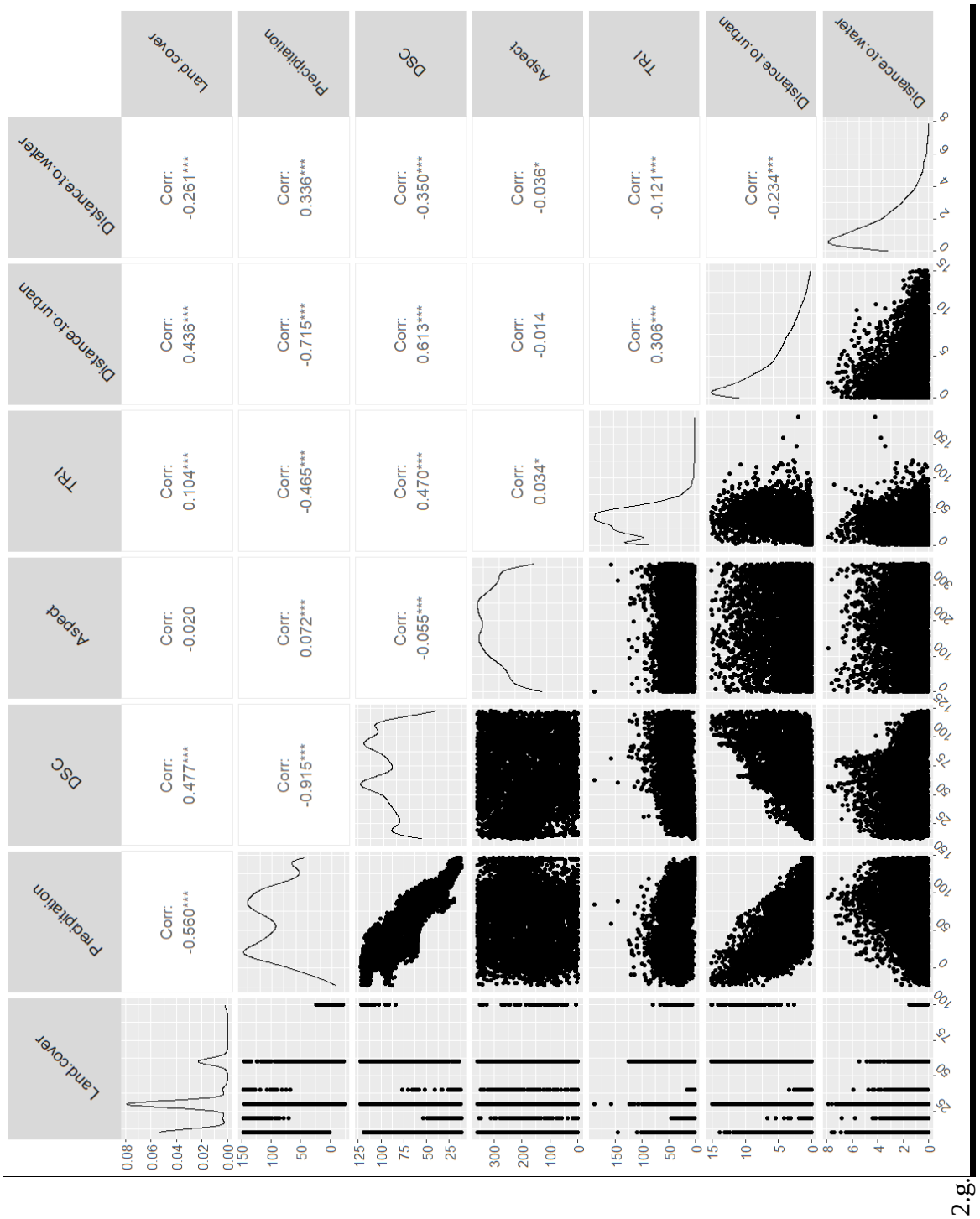
2.d.


Land.cover
DSC
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: 0.411***
Corr: -0.054***
Corr: 0.124***
Corr: 0.420***
Corr: -0.204***
Corr: -0.065***
Corr: 0.634***
Corr: 0.674***
Corr: -0.163***
Corr: -0.002
Corr: -0.039**
Corr: -0.030*
Corr: 0.420***
Corr: -0.067***
Corr: -0.159***

2.e.


Land.cover
DSC
DFWOS
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: 0.164***
Corr: -0.111***
Corr: -0.007
Corr: -0.087***
Corr: -0.035*
Corr: 0.078***
Corr: 0.099***
Corr: 0.152***
Corr: 0.625***
Corr: -0.382***
Corr: -0.013
Corr: 0.424***
Corr: -0.102***
Corr: 0.512***
Corr: -0.294***
Corr: 0.064***
Corr: -0.053***
Corr: 0.029*
Corr: 0.040**
Corr: -0.114***
Corr: -0.416***

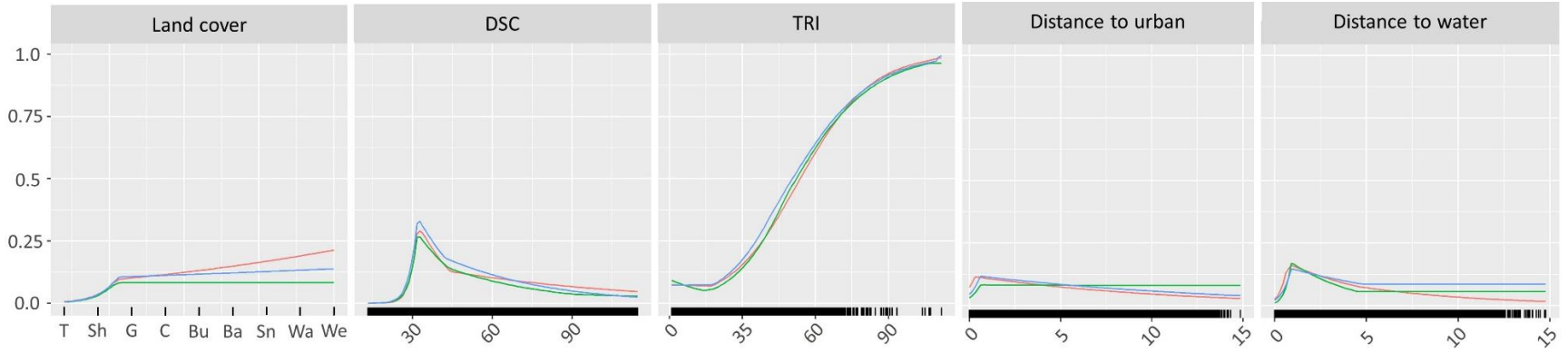
2.f.


Land.cover
Precipitation
DSC
Aspect
TRI
Distance.to.urban
Distance.to.water
Corr: -0.261***
Corr: 0.336***
Corr: -0.350***
Corr: -0.036*
Corr: -0.121***
Corr: -0.234***
Corr: 0.436***
Corr: -0.715***
Corr: 0.613***
Corr: -0.014
Corr: 0.306***
Corr: 0.104***
Corr: -0.465***
Corr: 0.470***
Corr: 0.034*
Corr: -0.020
Corr: 0.072***
Corr: -0.055***
Corr: 0.477***
Corr: -0.915***
Corr: -0.560***

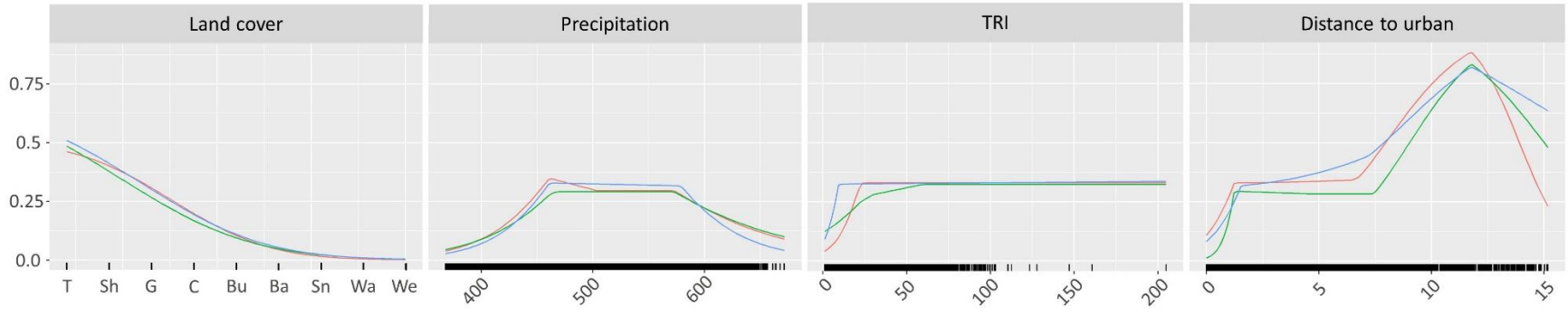
2.g.

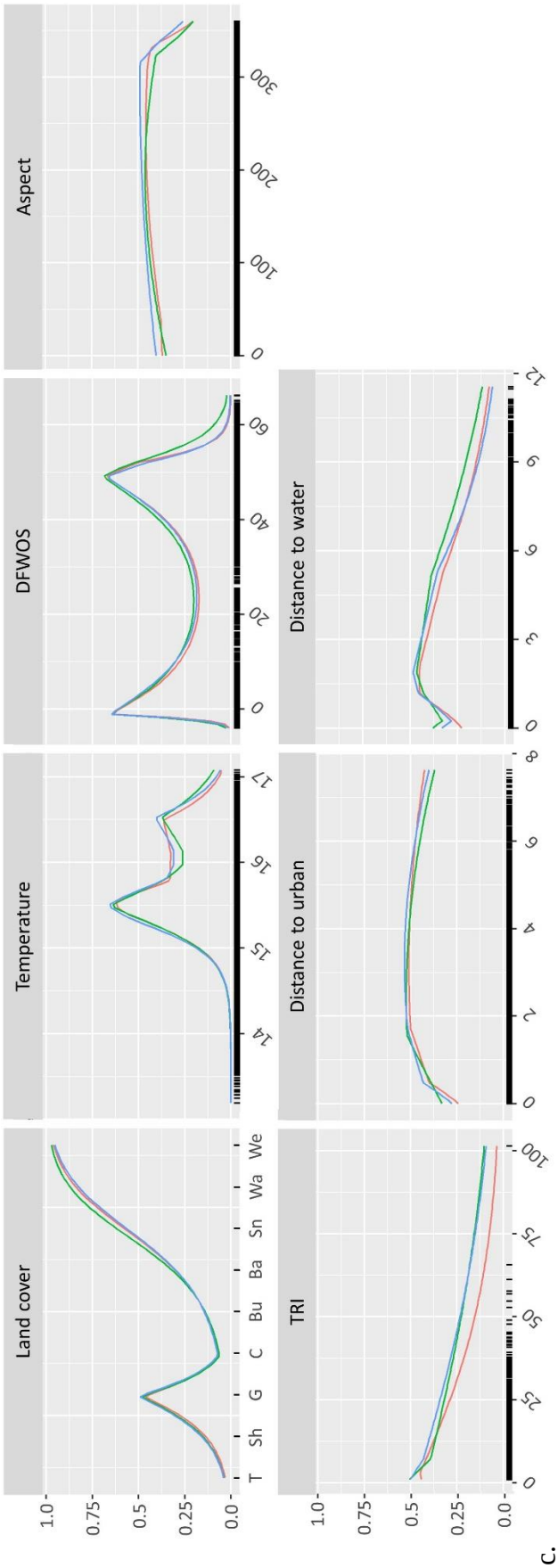
Appendix 3.8: Response plots obtained from generalized linear models for each predictor variable used to construct habitat models for a. bezoar; b. chamois; c. gazelle; d. mouflon; e. red deer; f. roe deer; g. tur. The three lines in all plots represent the three runs of models that we performed (red for Run1, green for Run2, blue for Run3). All predictor variables and their measurement units correspond to those in Table 3.1. The alphabetic class code in Land Cover map corresponds to that in Appendix 3.9

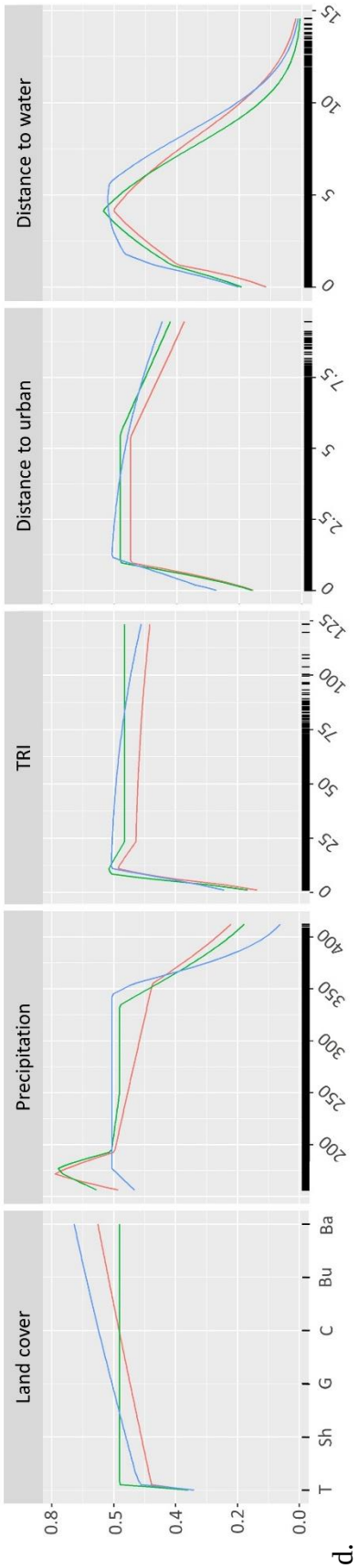
a.

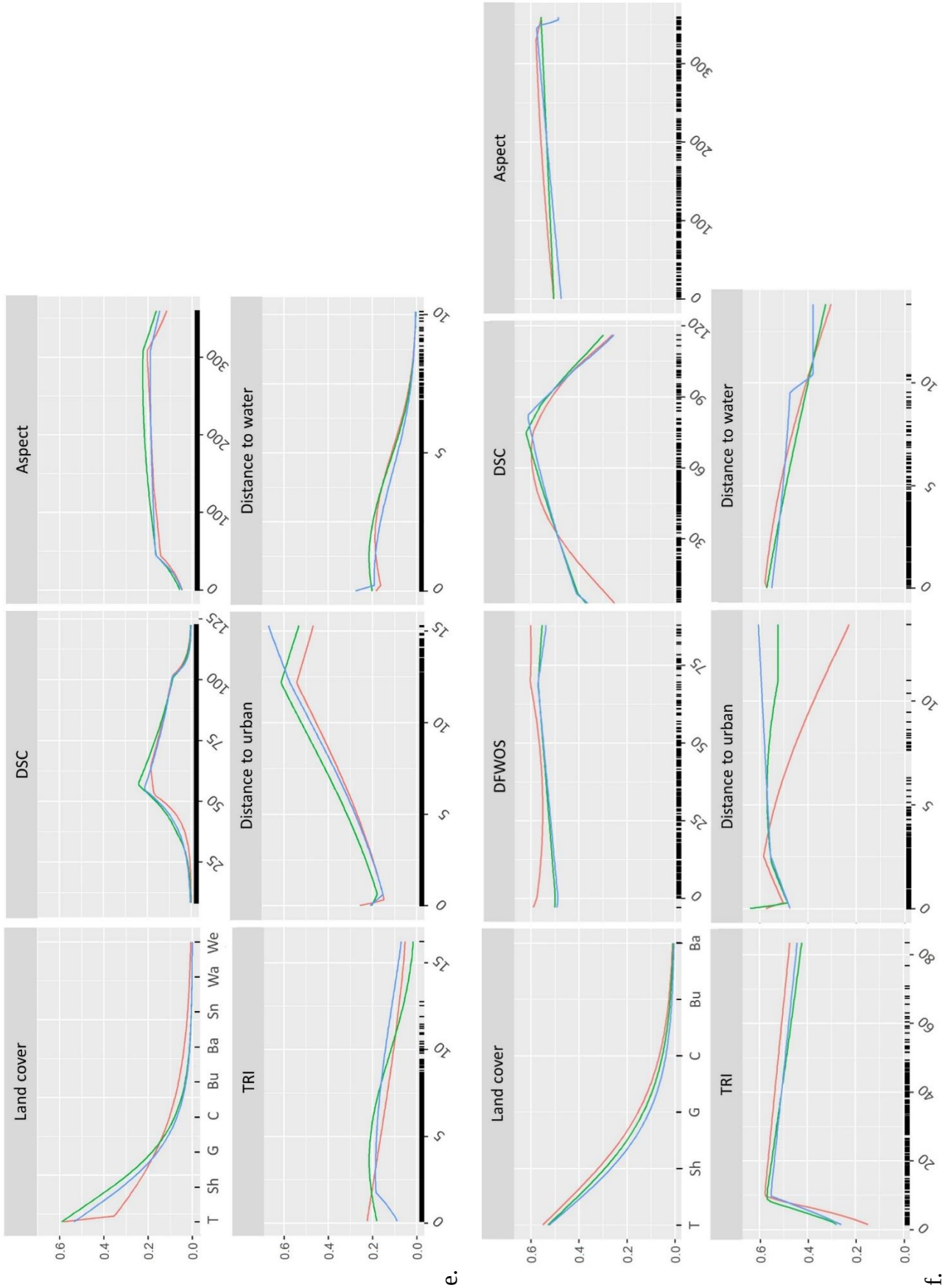


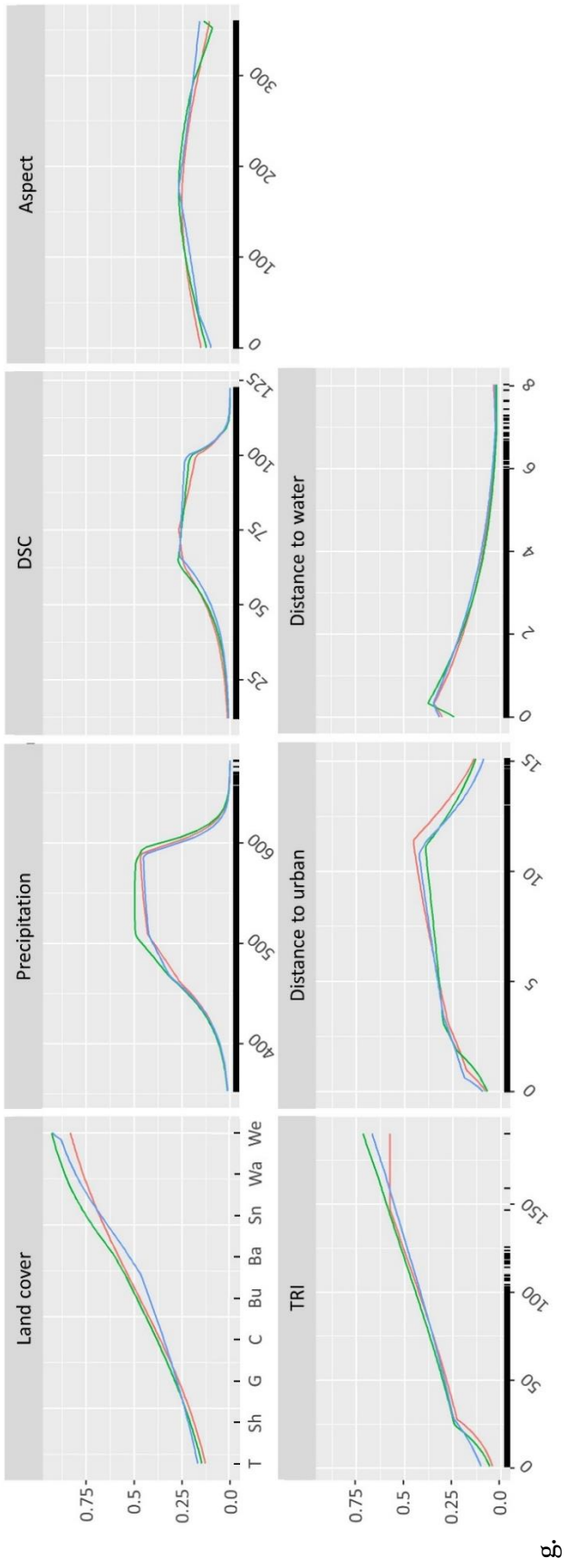
b.




Land cover
Temperature
DFWOS
Aspect
Distance to urban
Distance to water
TRI
T
Sh
G
C
Bu
Ba
Sn
Wa
We
c.


Land cover
Precipitation
TRI
Distance to urban
Distance to water
T
Sh
G
C
Bu
Ba
d.


Land cover
DSC
Aspect
TRI
Distance to urban
Distance to water
DFWOS
T
Sh
G
C
Bu
Ba
Sn
Wa
We
e.
f.


Land cover
Precipitation
DSC
Aspect
Distance to water
Distance to urban
TRI
T
Sh
G
C
Bu
Ba
Sn
Wa
We
0.0
0.25
0.5
0.75
400
500
600
25
50
75
100
125
0
100
200
300
0
2
4
6
8
0
5
10
15
0
50
100
150

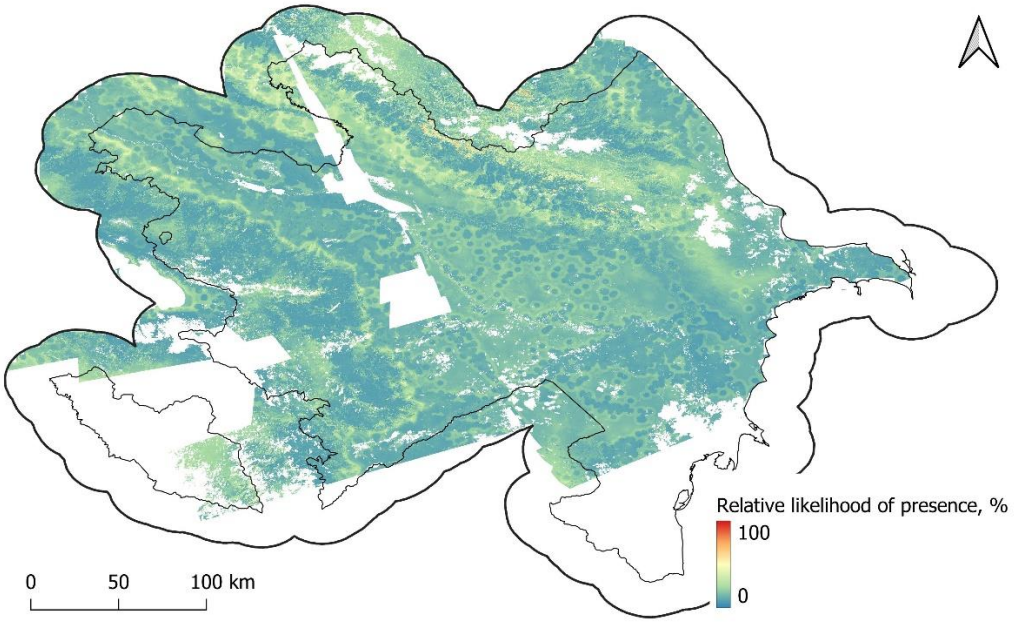
g9

Appendix 3.9. Land cover classes and their corresponding alphabetic and numeric encoding in 1965 and 2021 land cover maps. The numeric encoding corresponds to that used in the source of the 2021 land cover map (Zanaga et al., 2022)

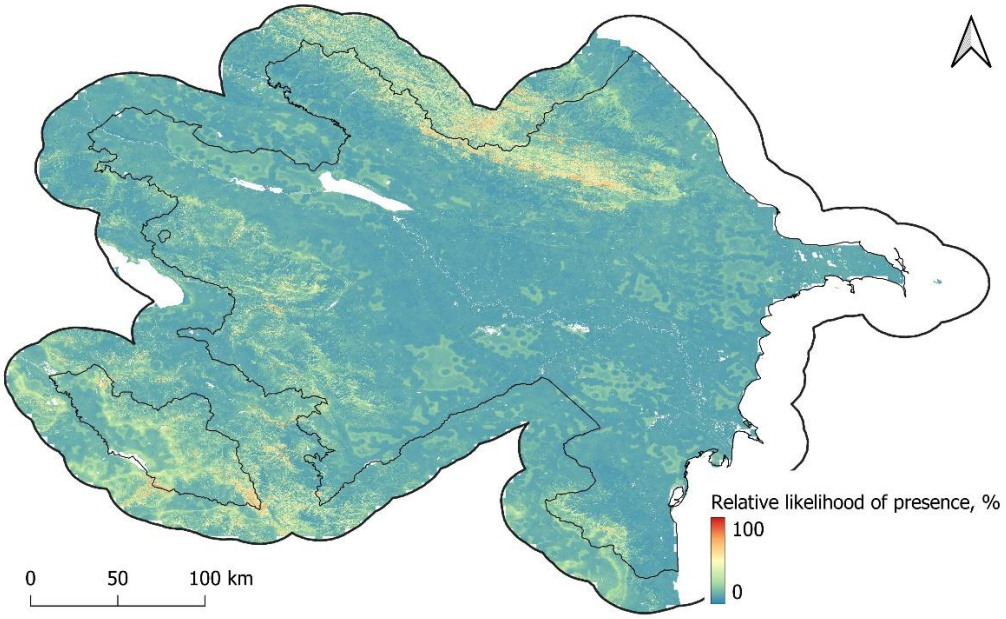
Land cover class	Alphabetic encoding	Numeric encoding
Tree cover	T	10
Shrubland	Sh	20
Grassland	G	30
Cropland	C	40
Built-up	Bu	50
Bare	Ba	60
Snow and ice	Sn	70
Water	Wa	80
Wetland	We	90

Appendix 3.10: a. 1965 and b. 2021 continuous maps representing relative likelihood of species presences for: 1. bezoar; 2. chamois; 3. gazelle; 4. mouflon; 5. red deer; 6. roe deer; 7. tur. In all maps, the thin border represents the political boundaries of Azerbaijan and the thick border represents the boundaries of our study area

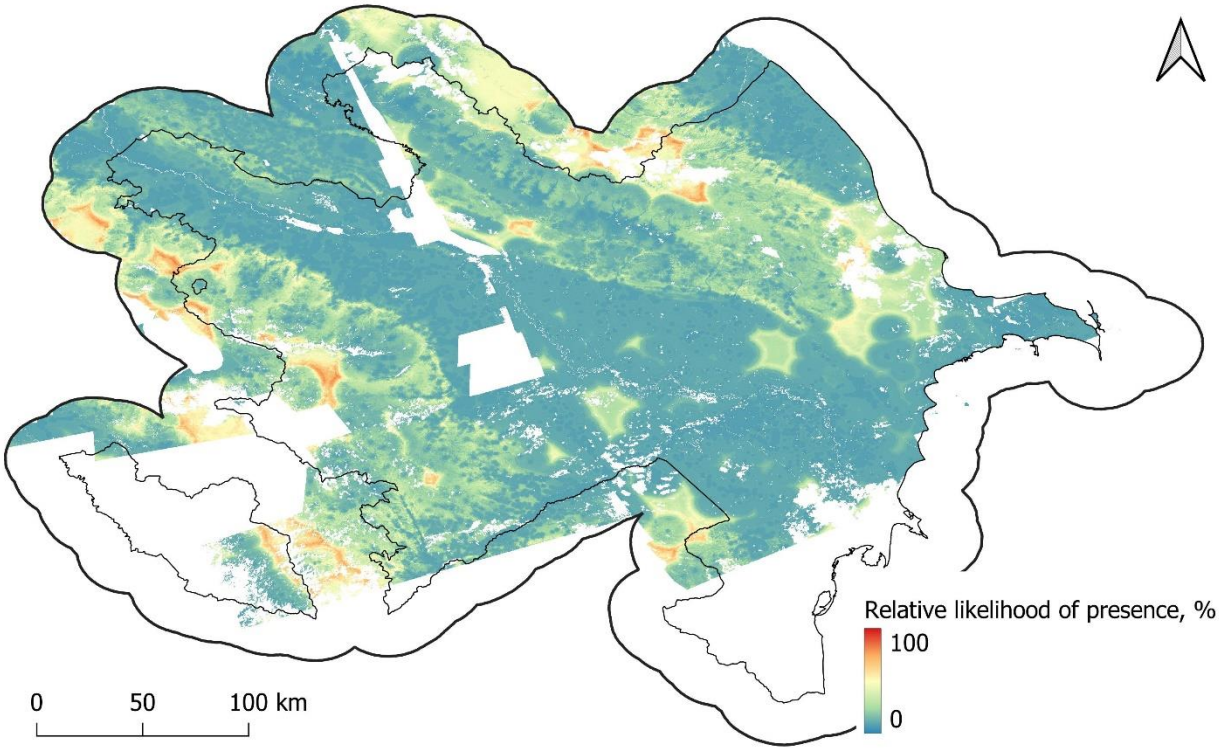
1.a.



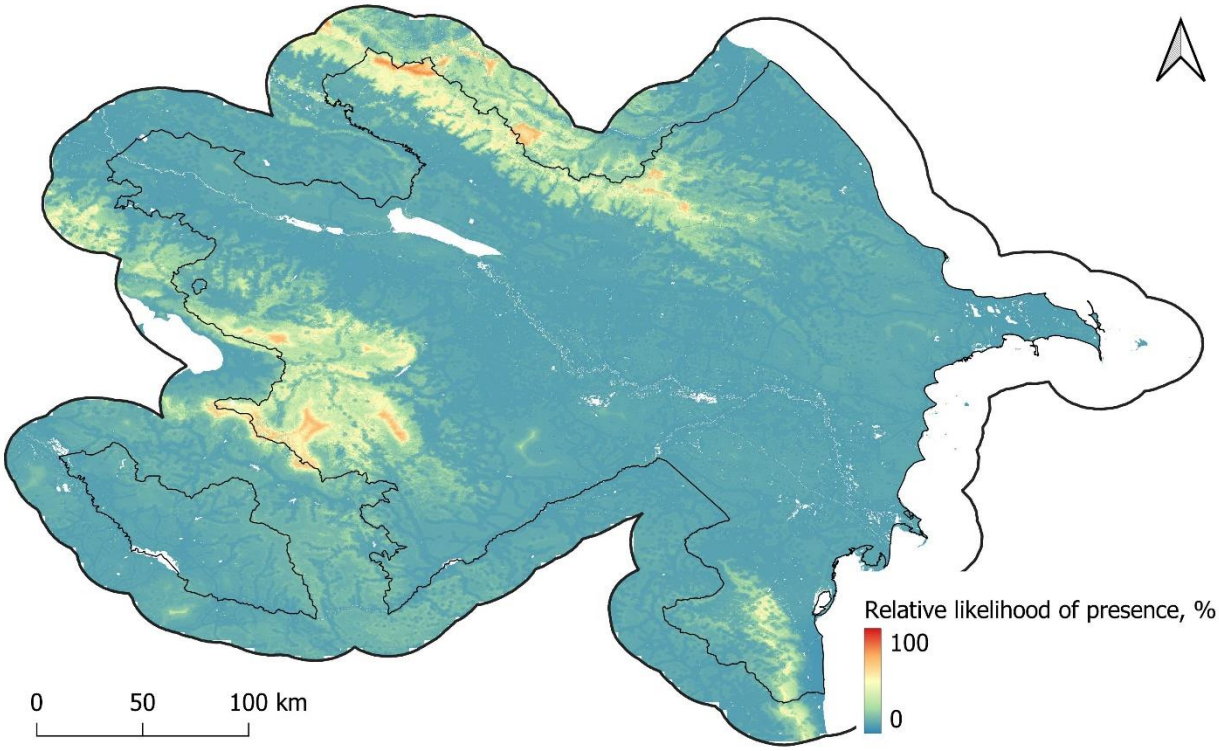
1.b.



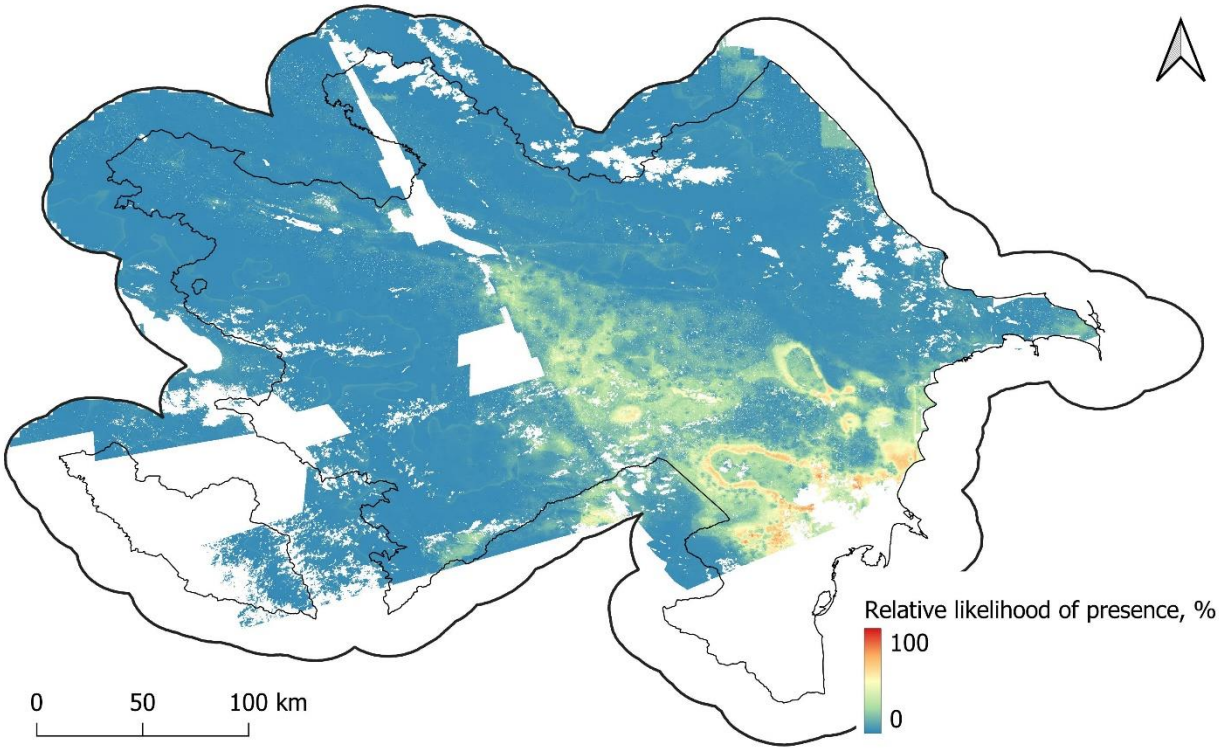
2.a.


Relative likelihood of presence, %
100
0
0
50
100 km

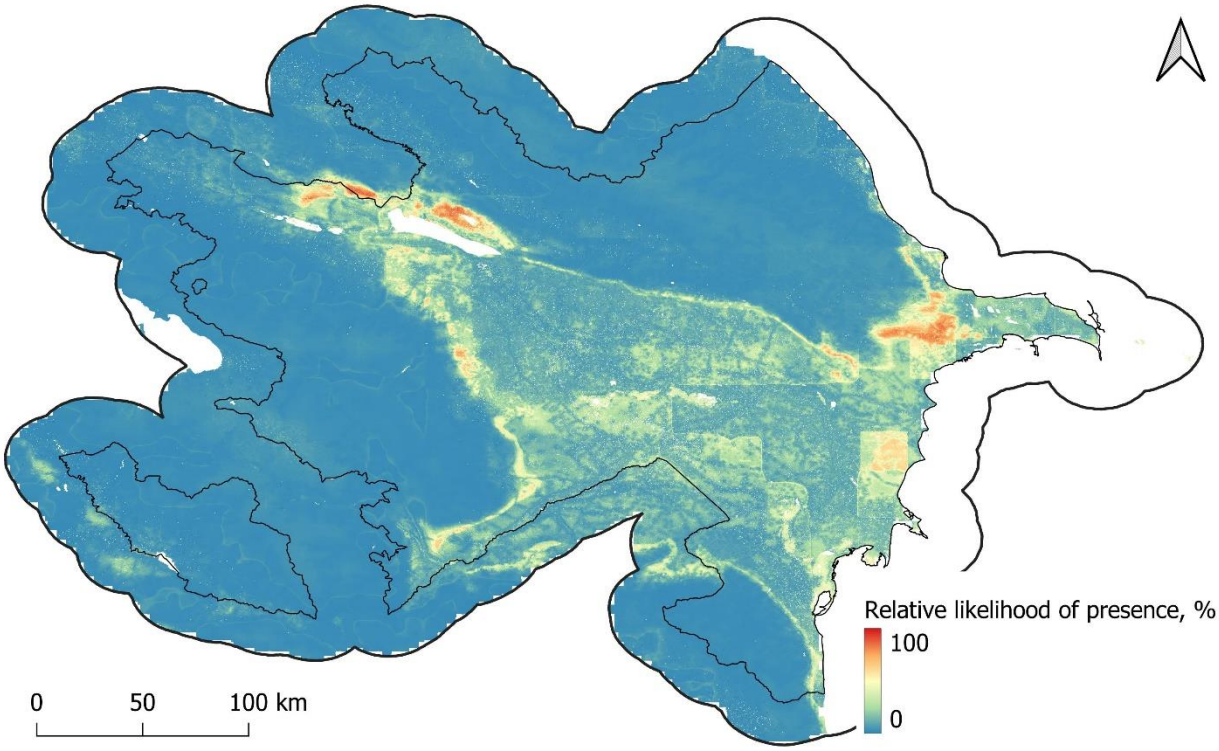
2.b.


Relative likelihood of presence, %
100
0
0
50
100 km

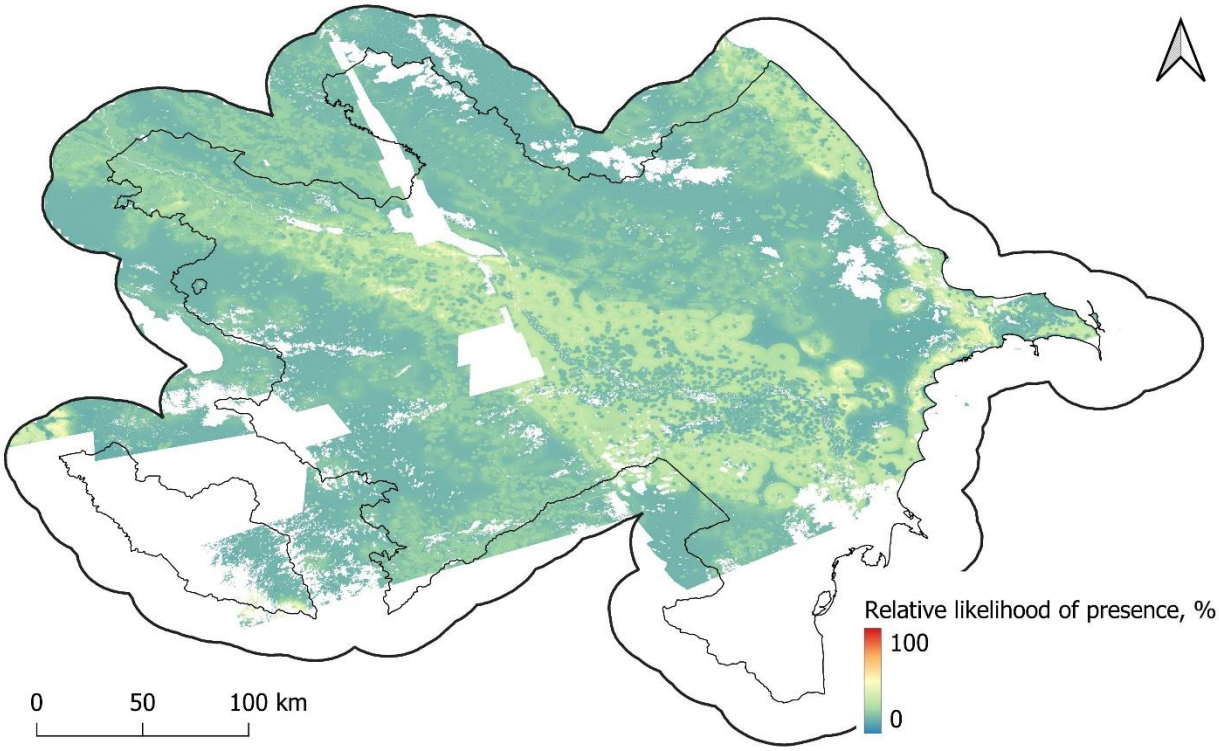
3.a.


Relative likelihood of presence, %
100
0
0
50
100 km

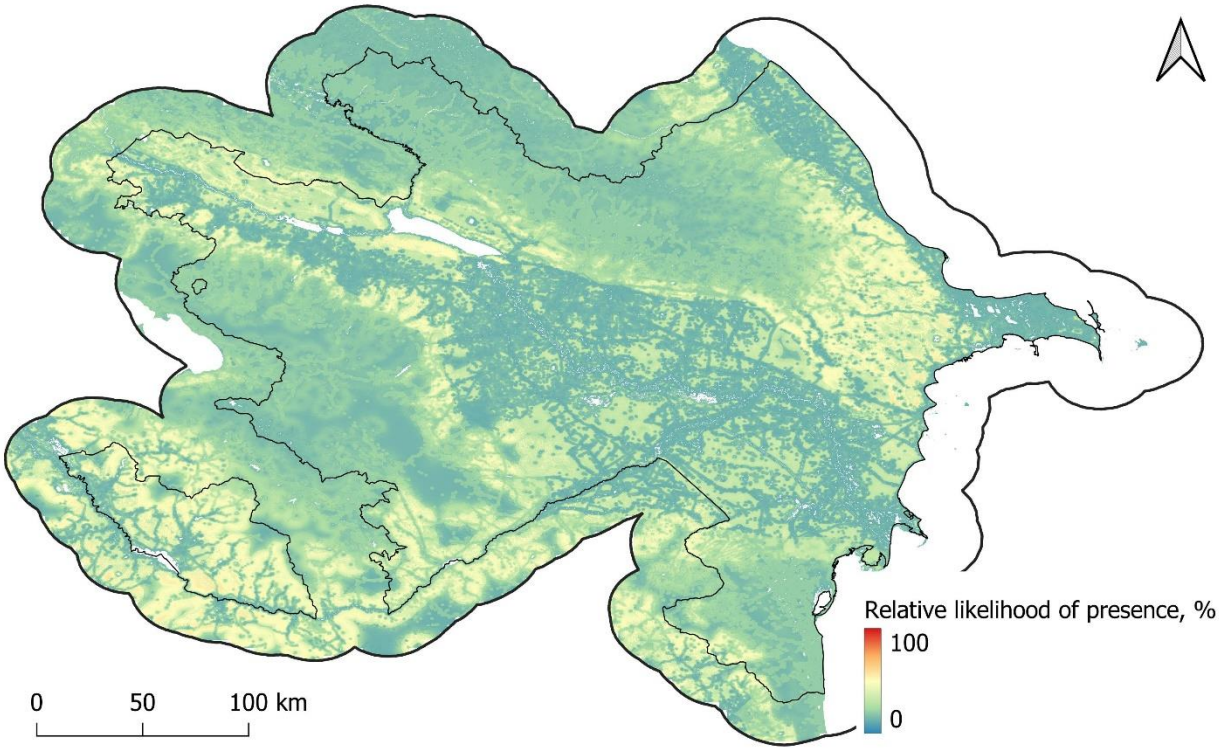
3.b.


Relative likelihood of presence, %
100
0
0
50
100 km

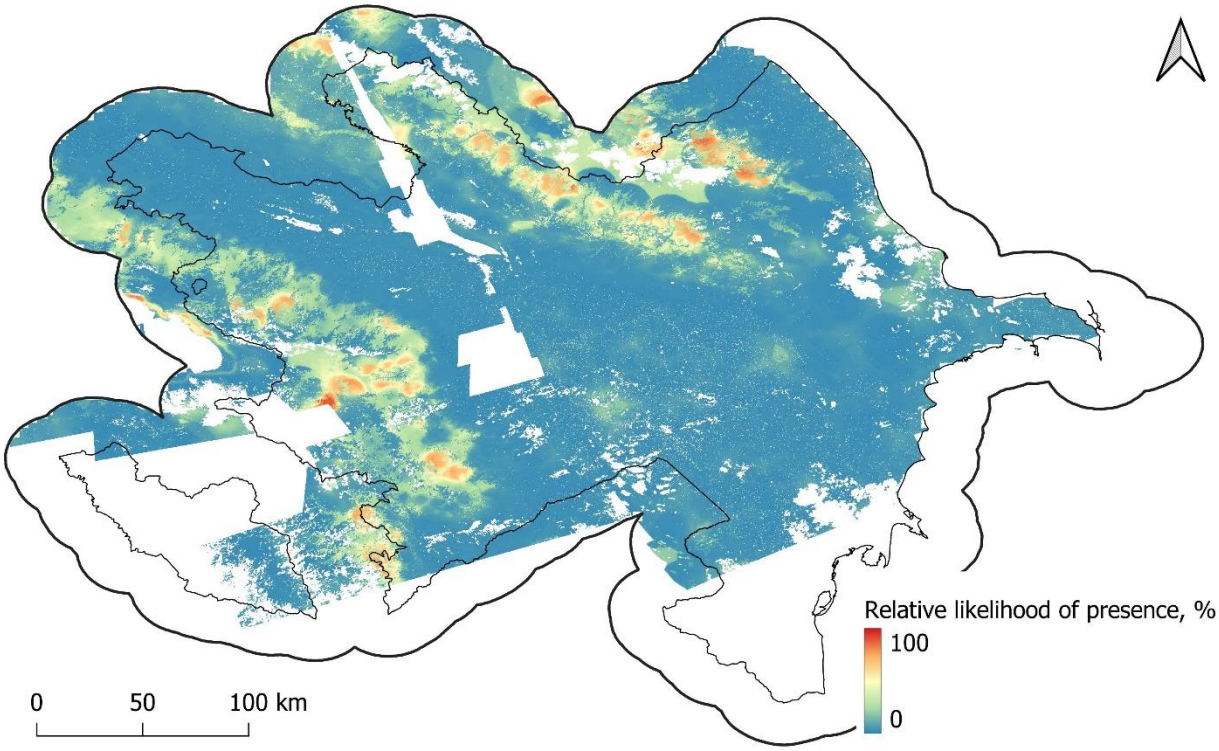
4.a.


Relative likelihood of presence, %
100
0
0
50
100 km

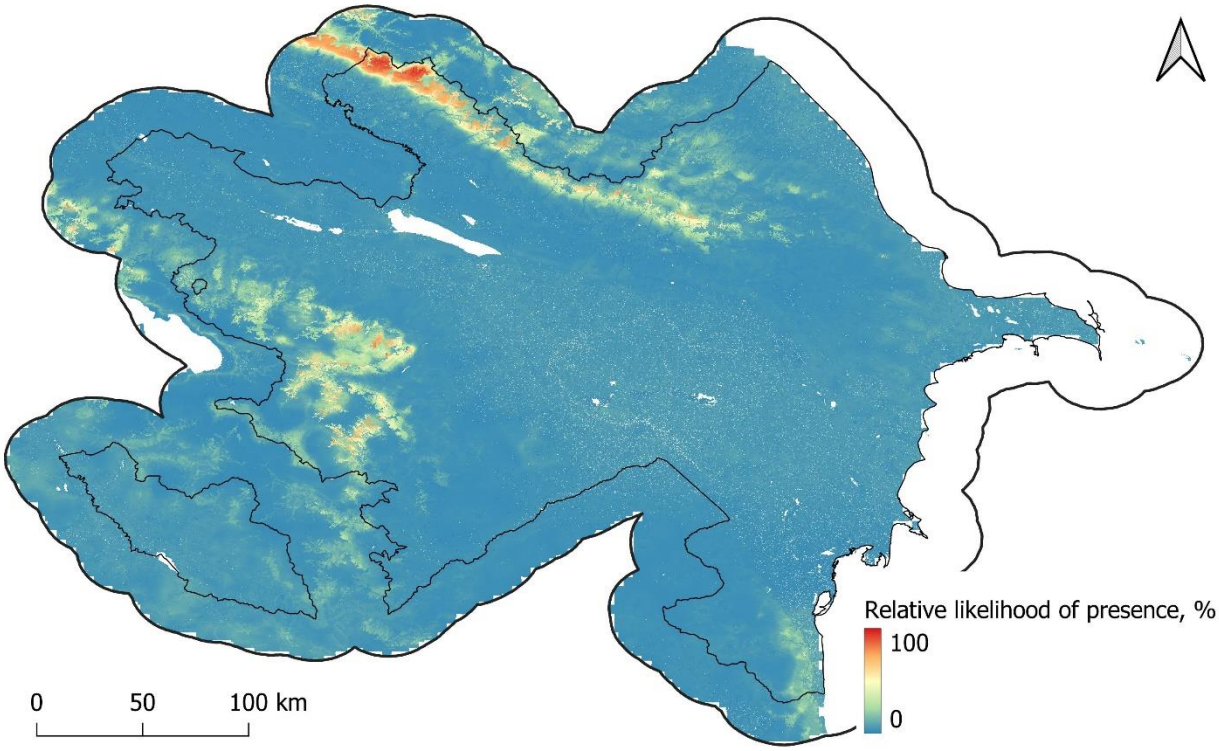
4.b.


Relative likelihood of presence, %
100
0
0
50
100 km

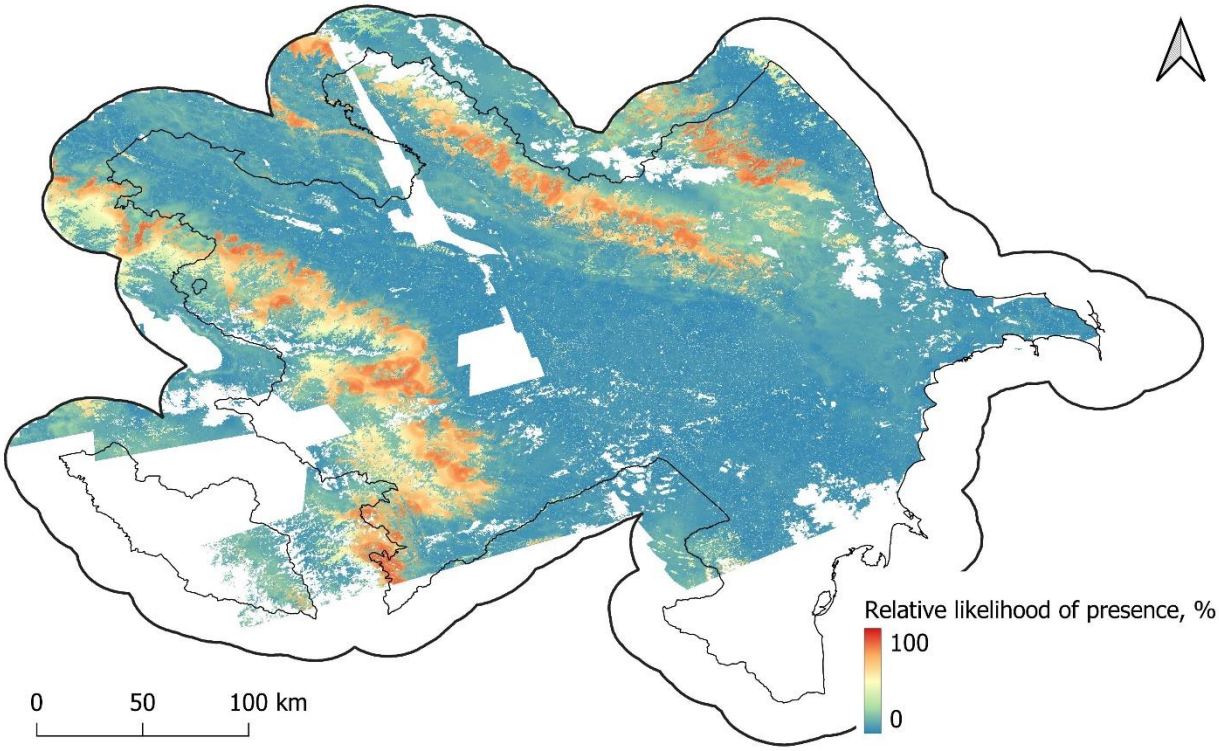
5.a.


Relative likelihood of presence, %
100
0
0
50
100 km

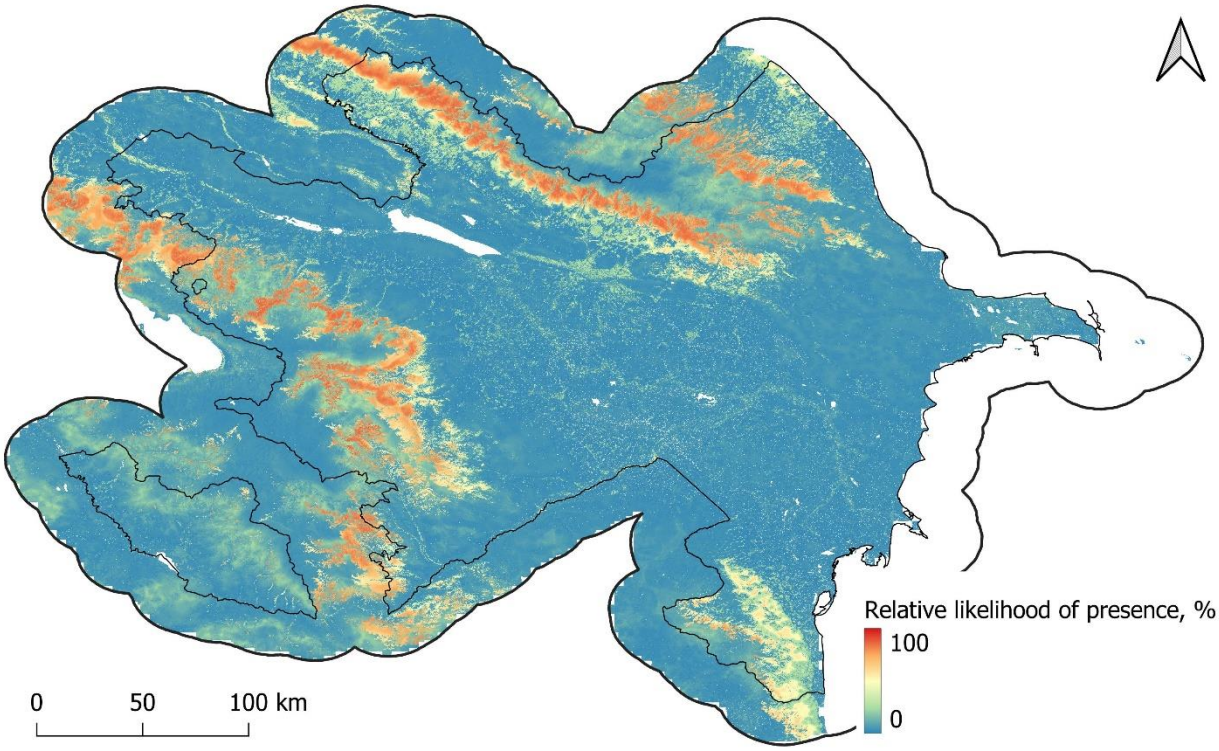
5.b.


Relative likelihood of presence, %
100
0
0
50
100 km

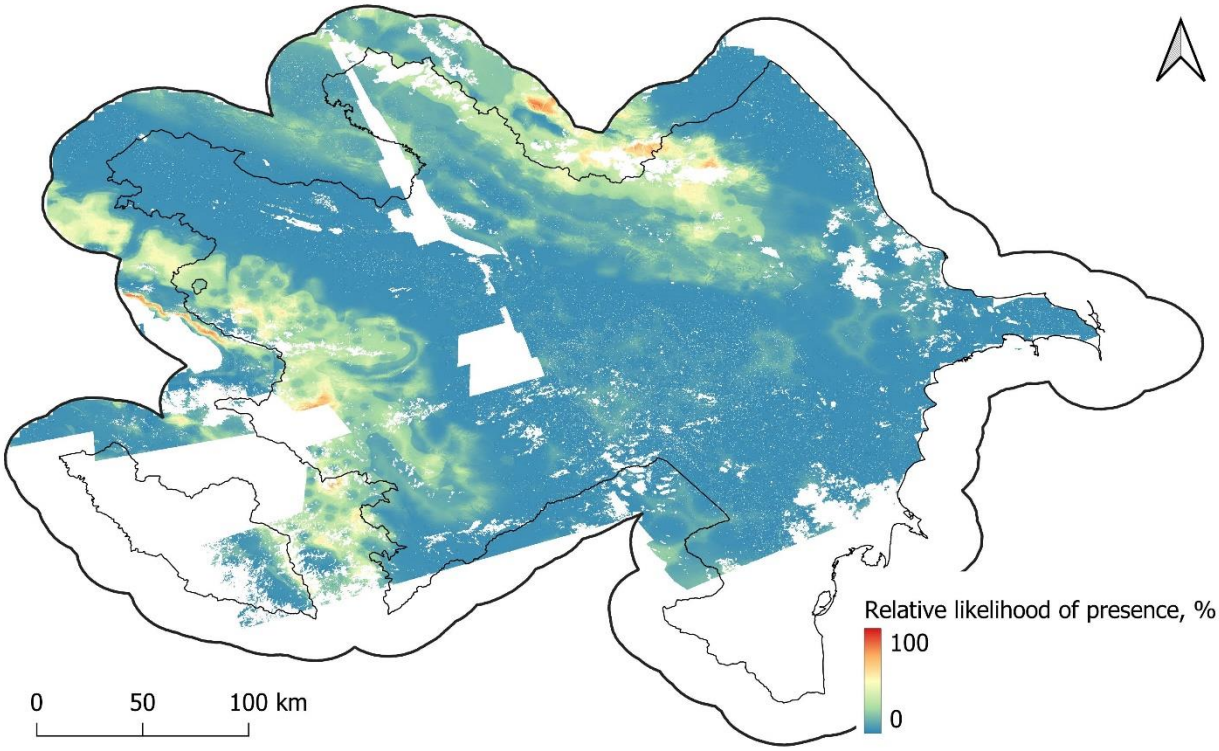
6.a.


Relative likelihood of presence, %
100
0
0
50
100 km

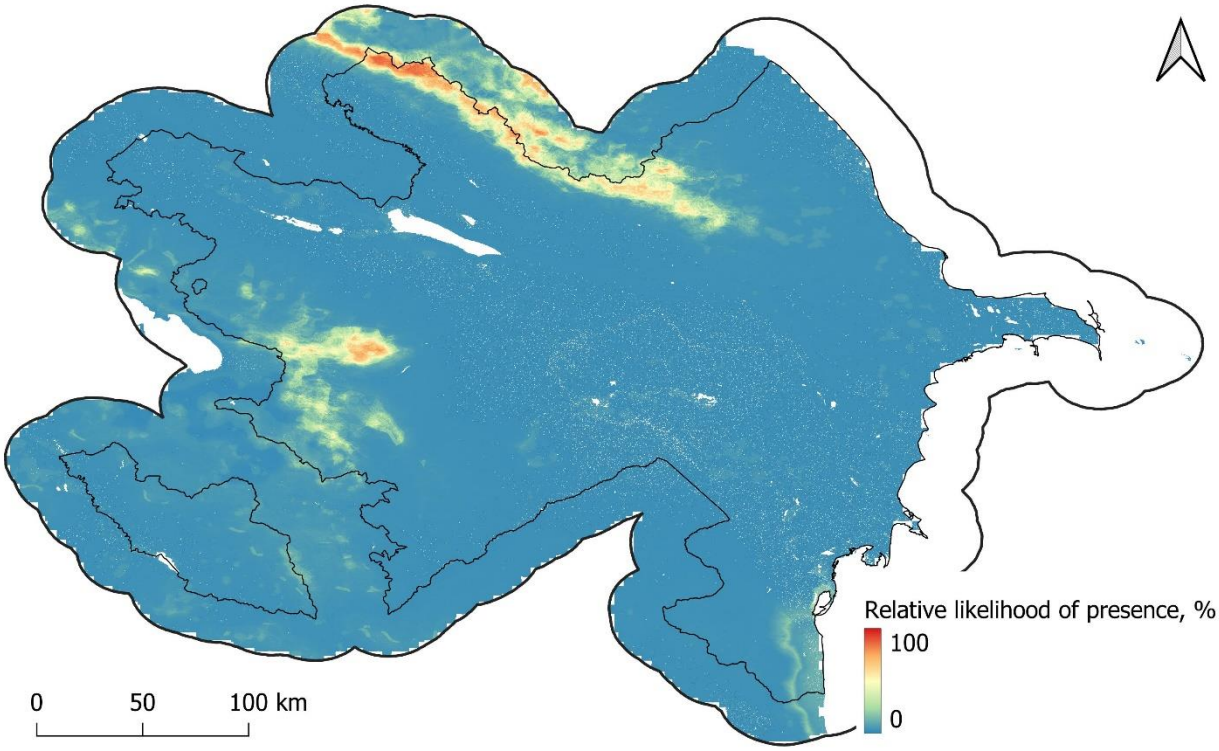
6.b.


Relative likelihood of presence, %
100
0
0
50
100 km

7.a.

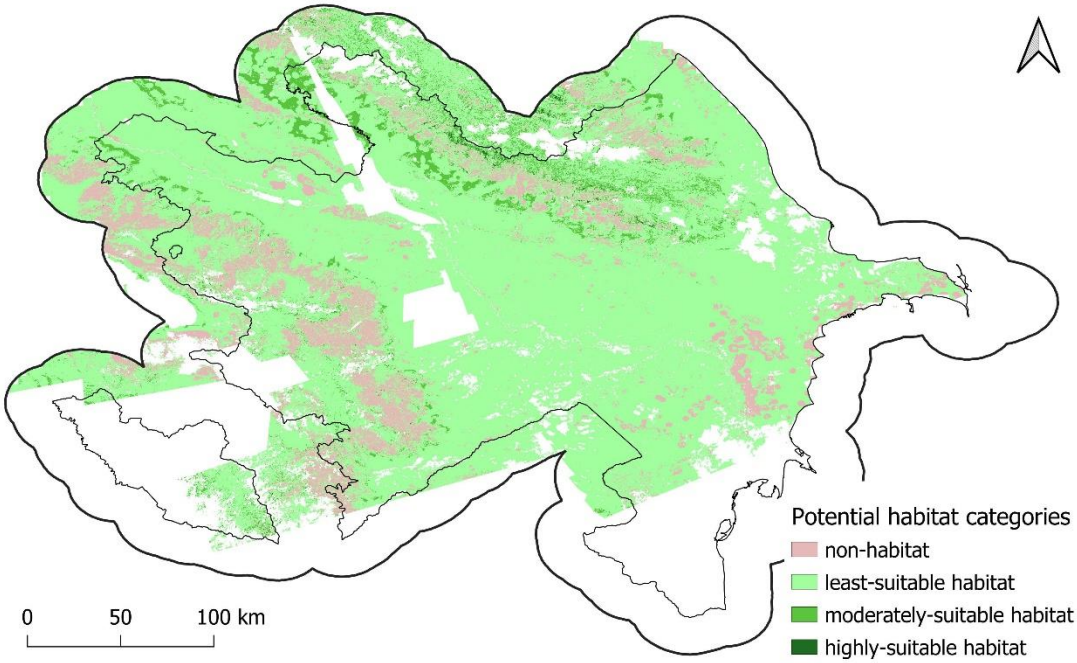

Relative likelihood of presence, %
100
0
0
50
100 km

7.b.

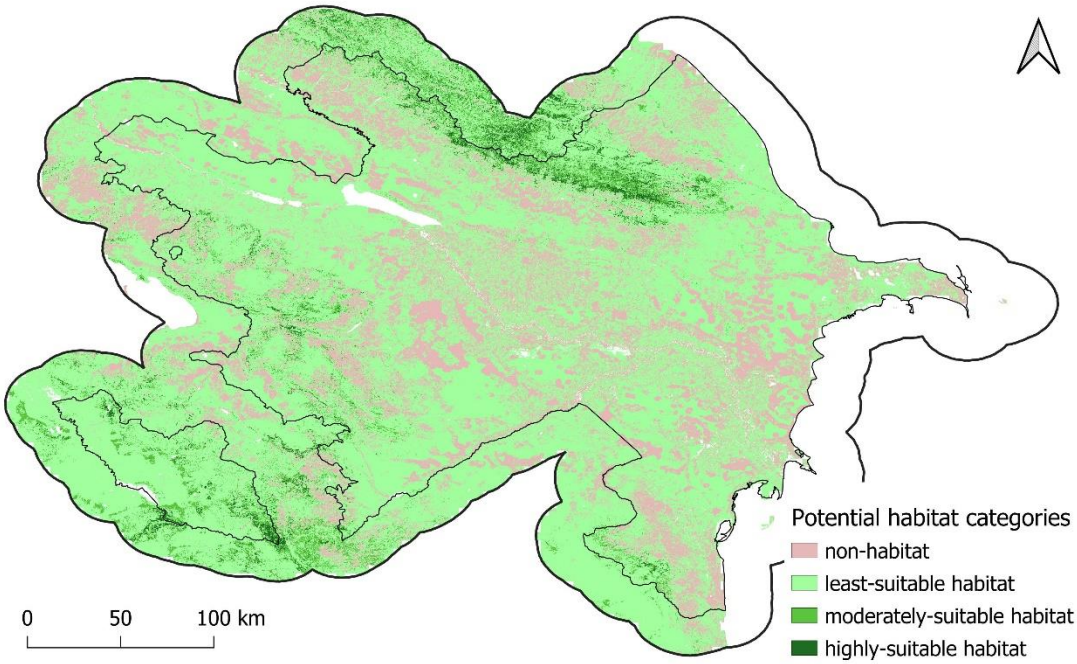

Relative likelihood of presence, %
100
0
0
50
100 km

Appendix 3.11: a. 1965 and b. 2021 categorical maps representing potential habitat for: 1. bezoar; 2. chamois; 3. gazelle; 4. mouflon; 5. red deer; 6. roe deer; 7. tur. In all maps, the thin border represents the political boundaries of Azerbaijan and the thick border represents the boundaries of our study area

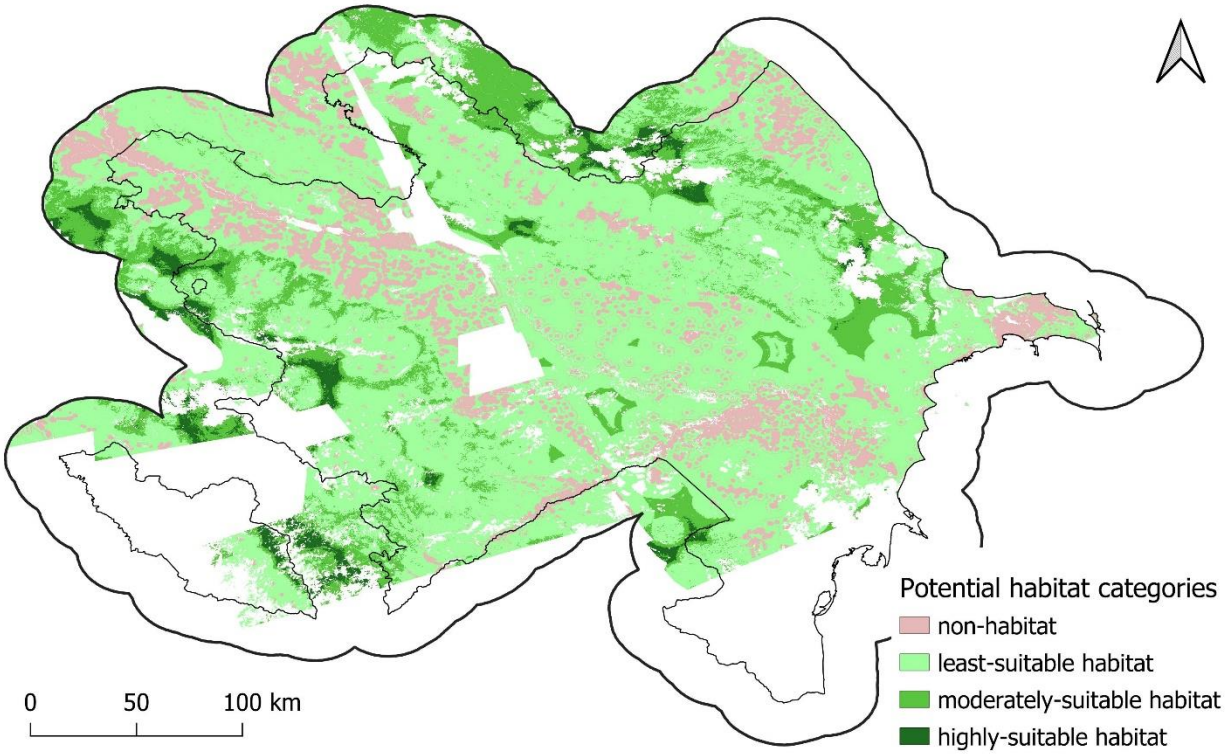
1.a.



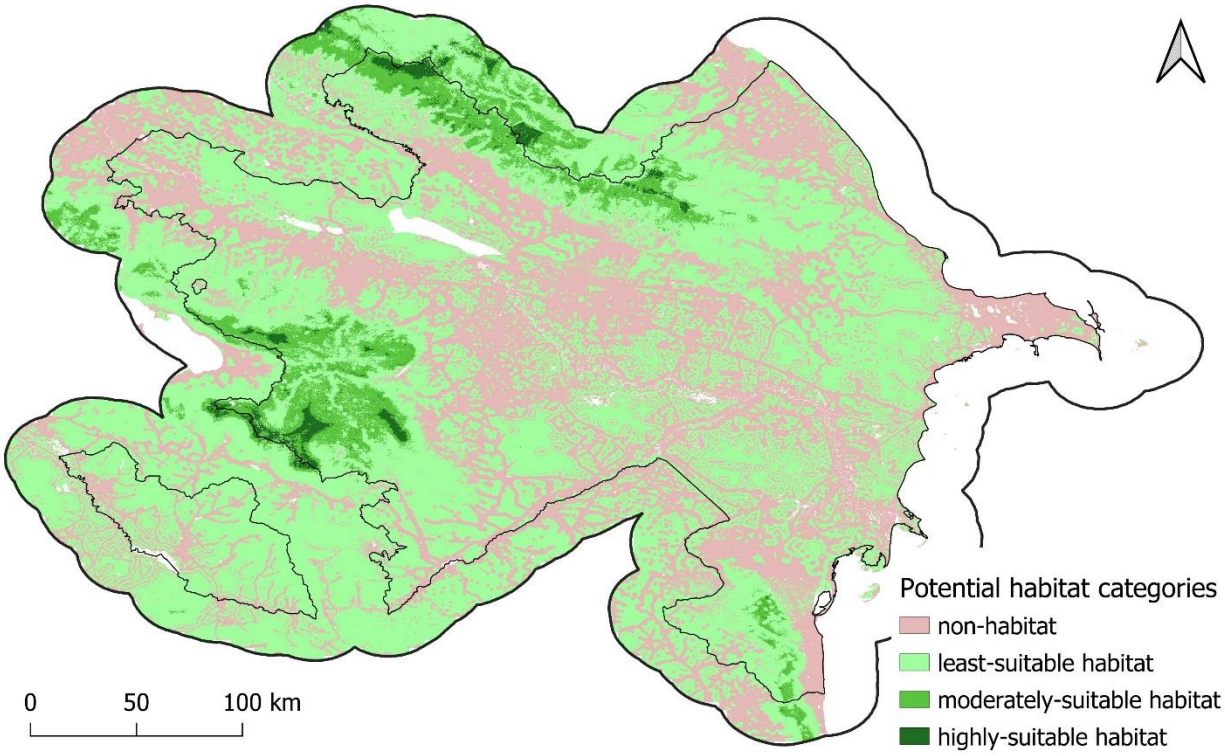
1.b.



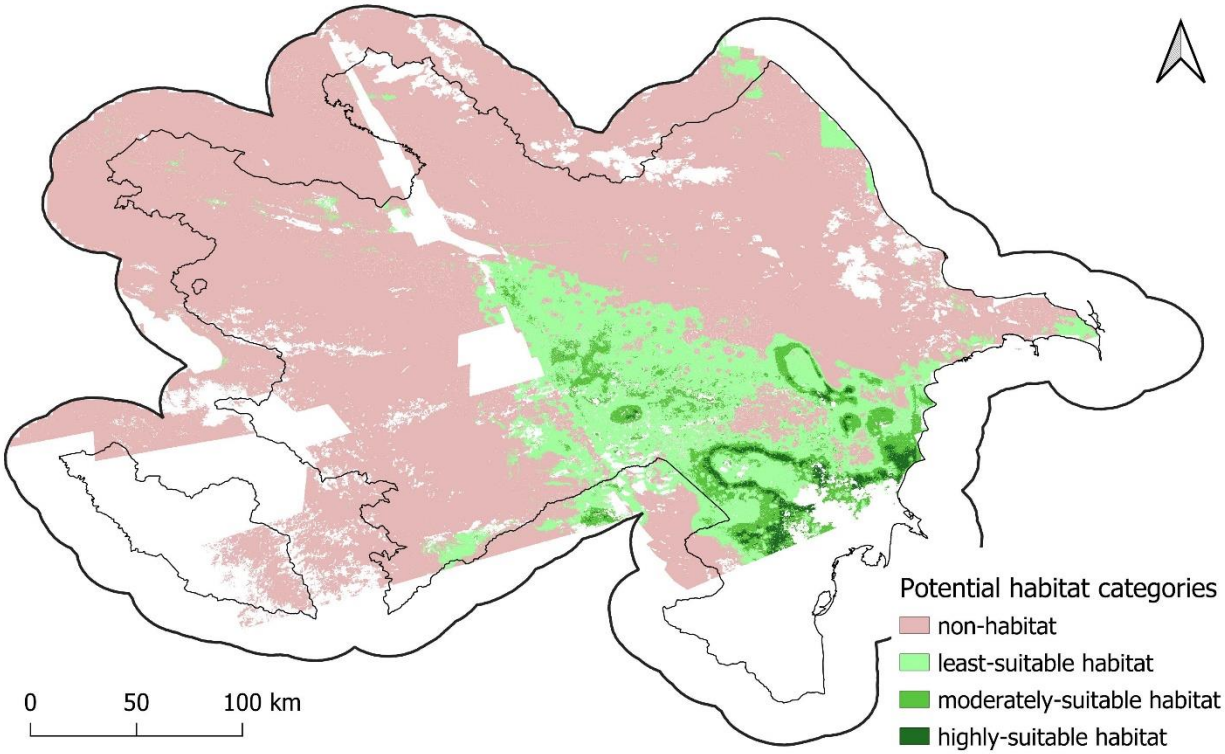
2.a.


0
50
100 km
Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat

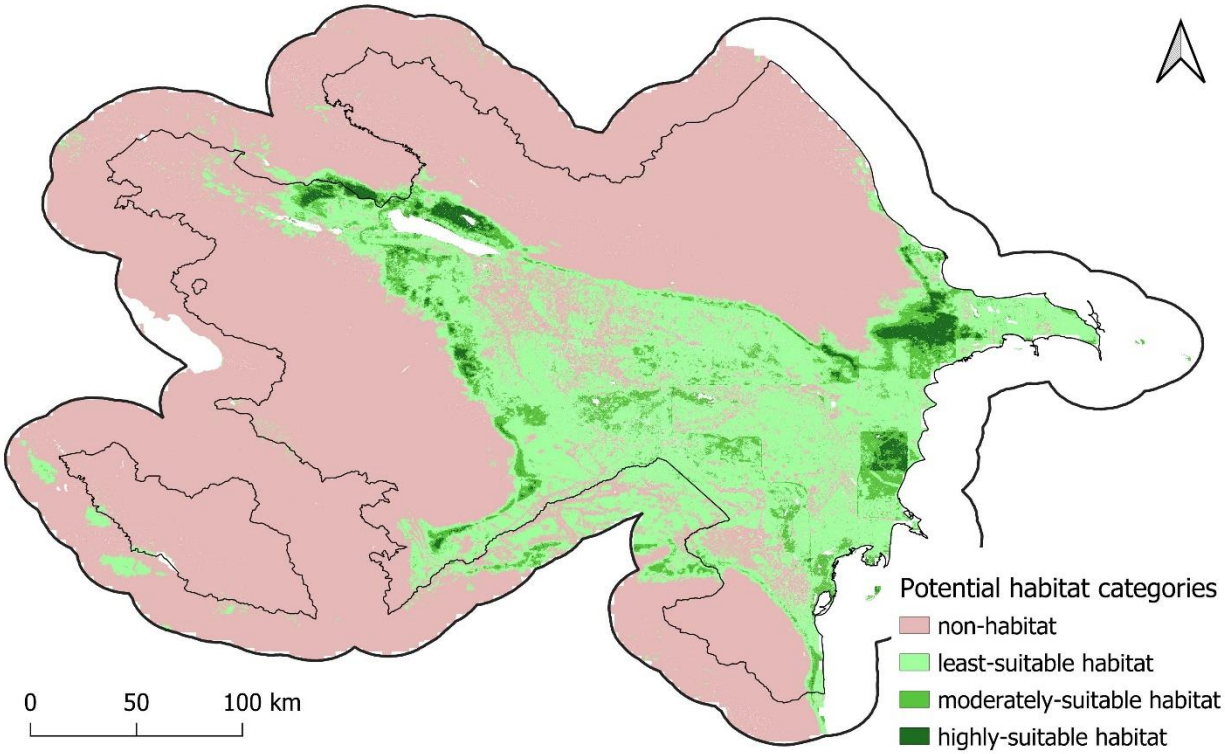
2.b.


0
50
100 km
Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat

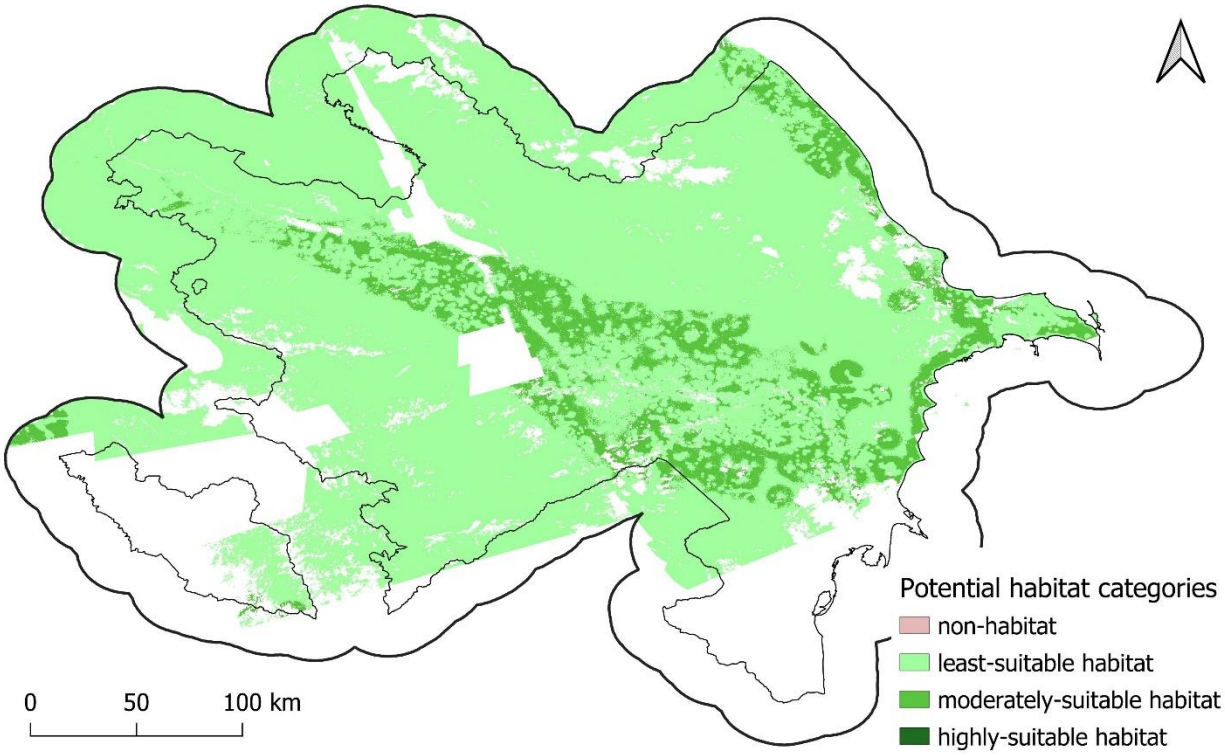
3.a.


Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

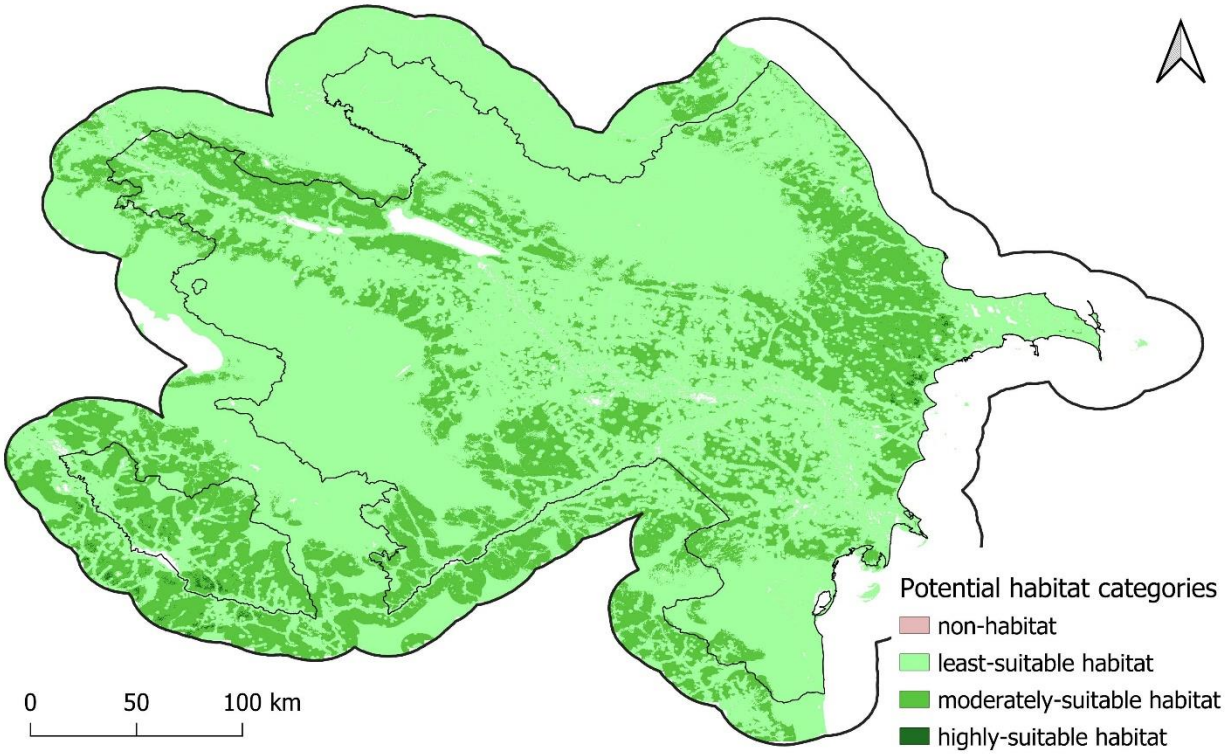
3.b.


Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

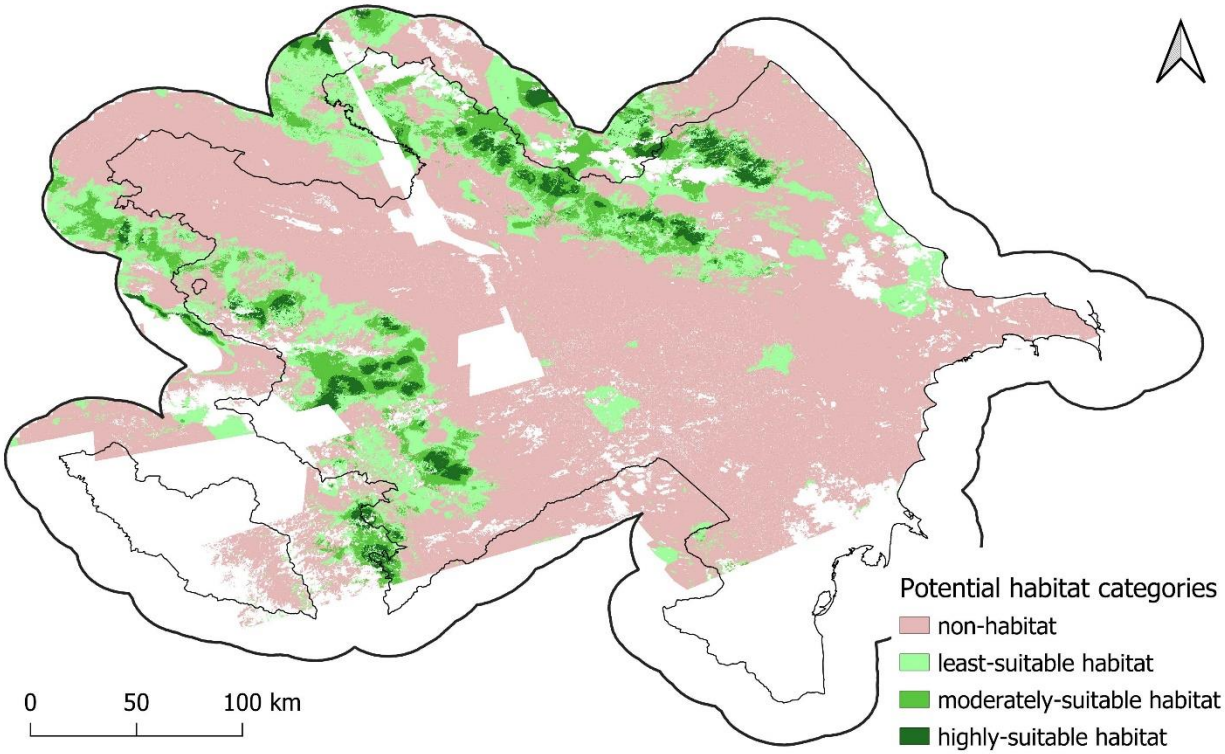
4.a.


Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

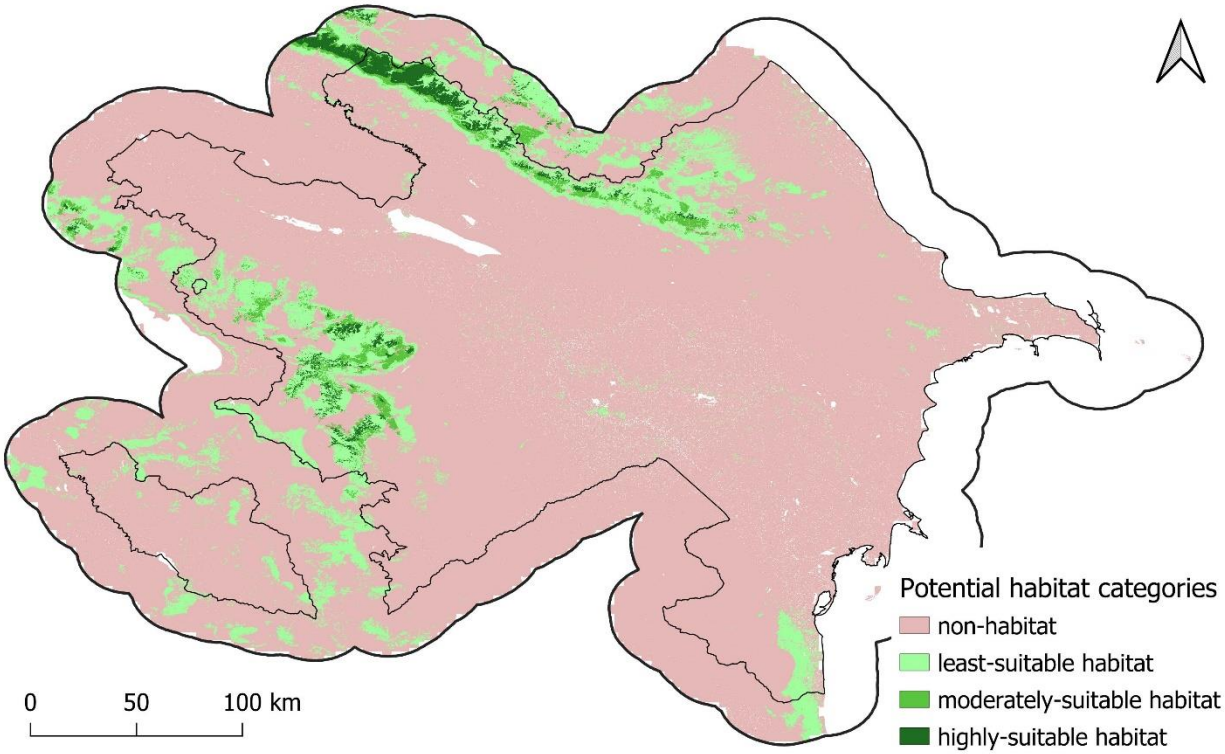
4.b.


Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

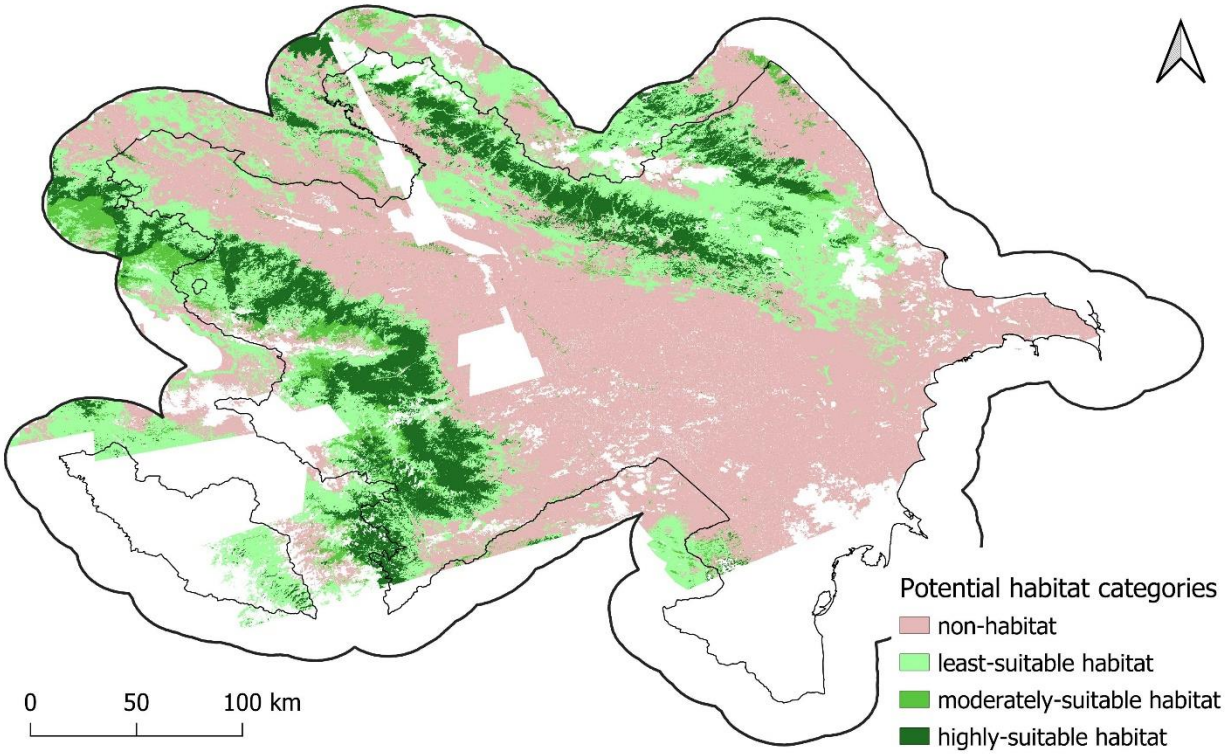
5.a.


Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

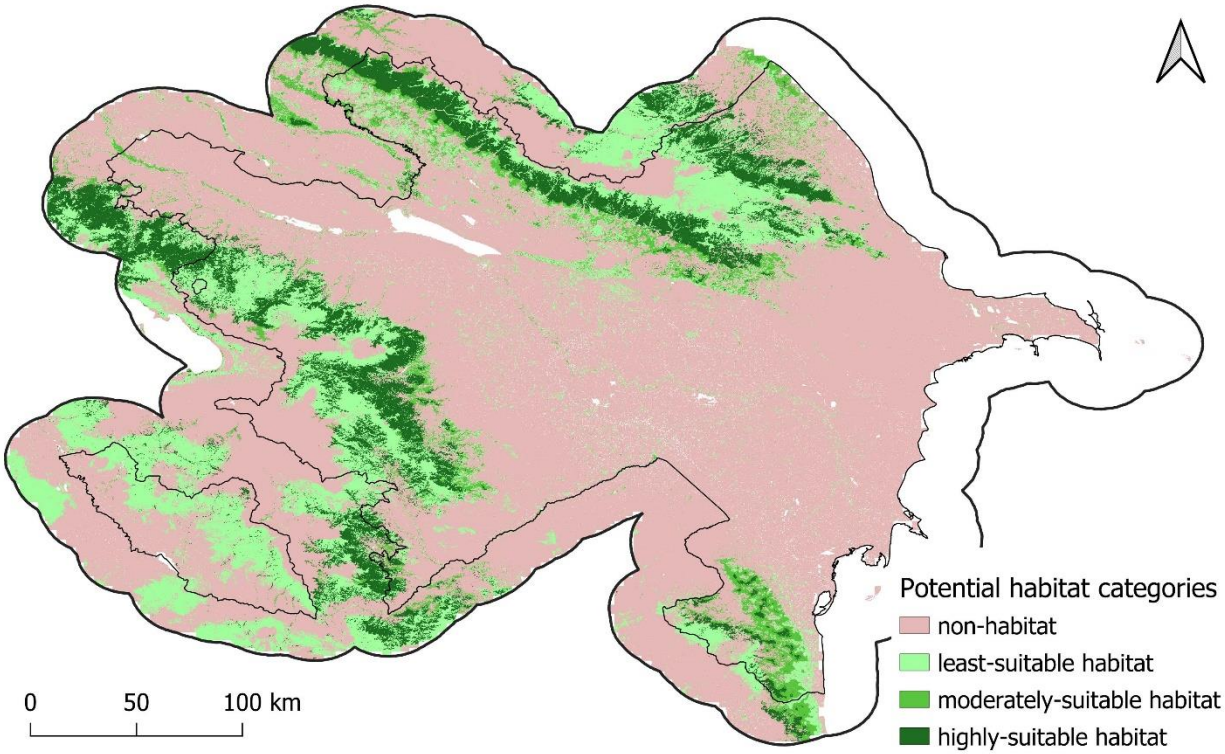
5.b.


Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

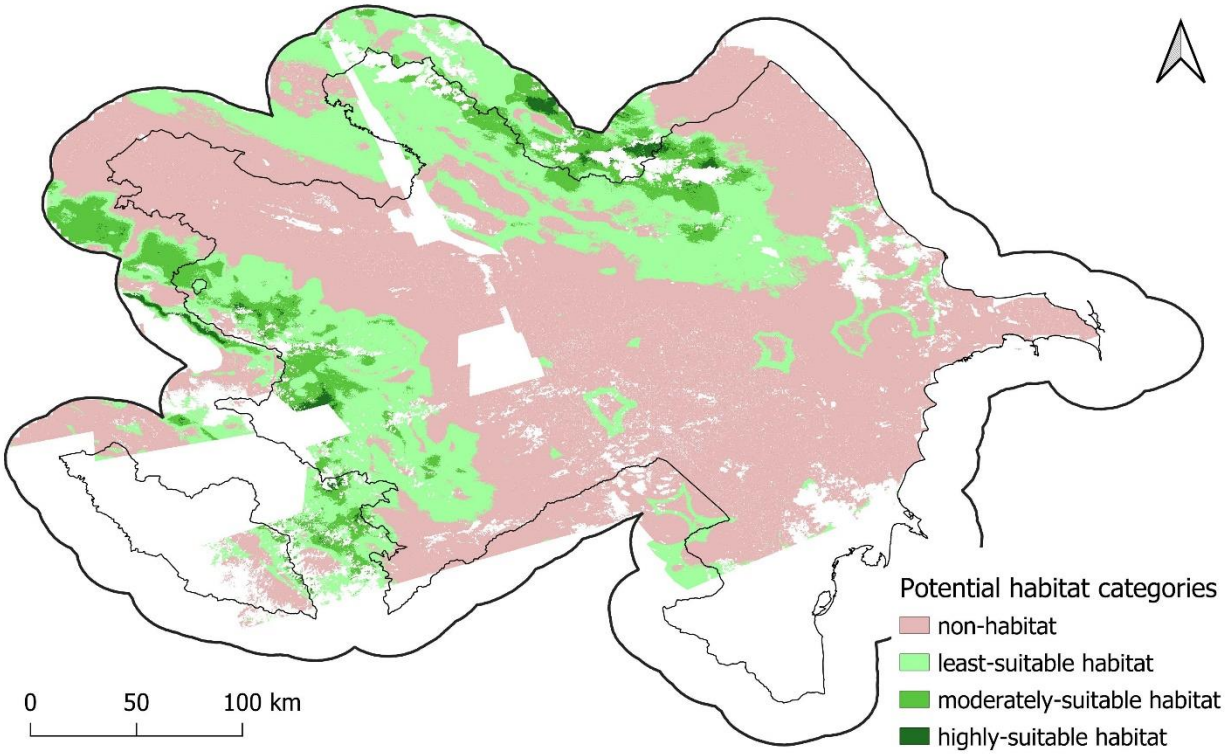
6.a.


Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

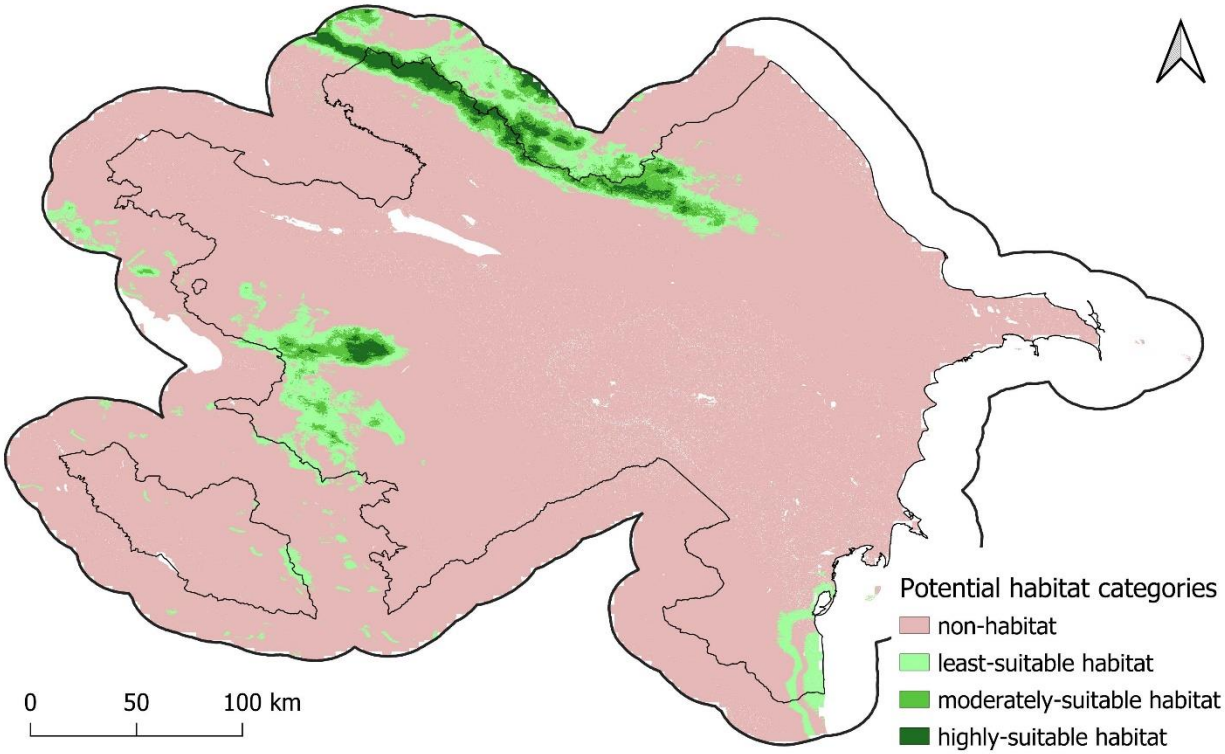
6.b.


Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

7.a.

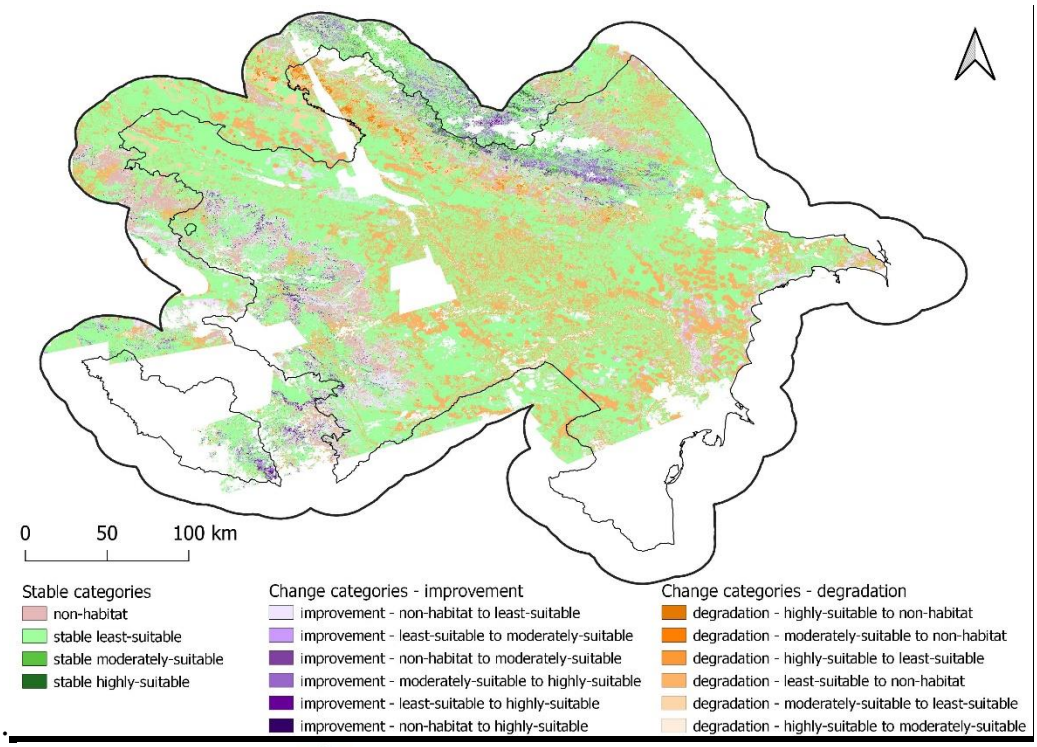

Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

7.b.

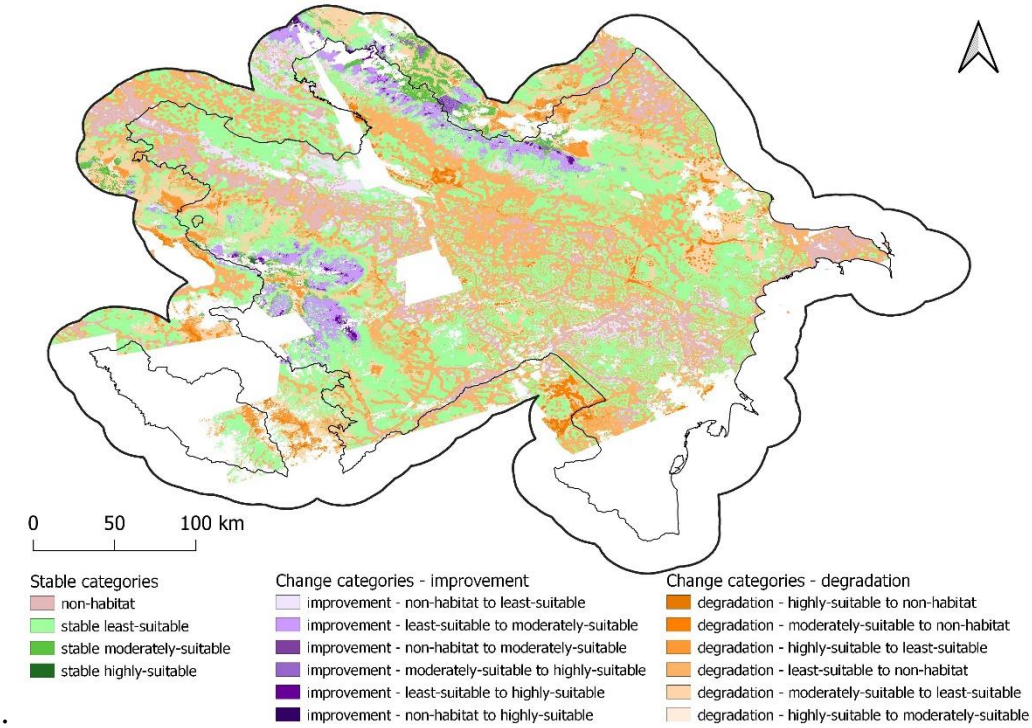

Potential habitat categories
non-habitat
least-suitable habitat
moderately-suitable habitat
highly-suitable habitat
0
50
100 km

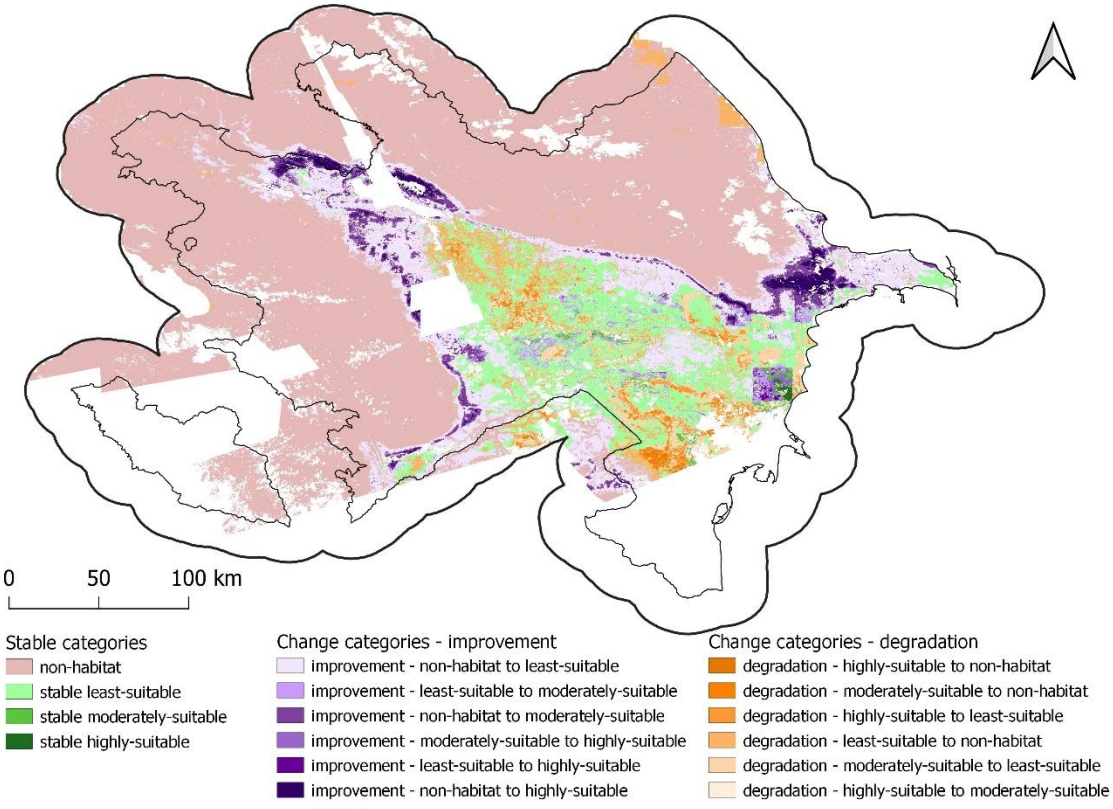
Appendix 3.12: 1965-2021 potential habitat change maps for: 1. bezoar; 2. chamois; 3. gazelle; 4. mouflon; 5. red deer; 6. roe deer; 7. tur. In all maps, the thin border represents the political boundaries of Azerbaijan and the thick border represents the boundaries of our study area

1.

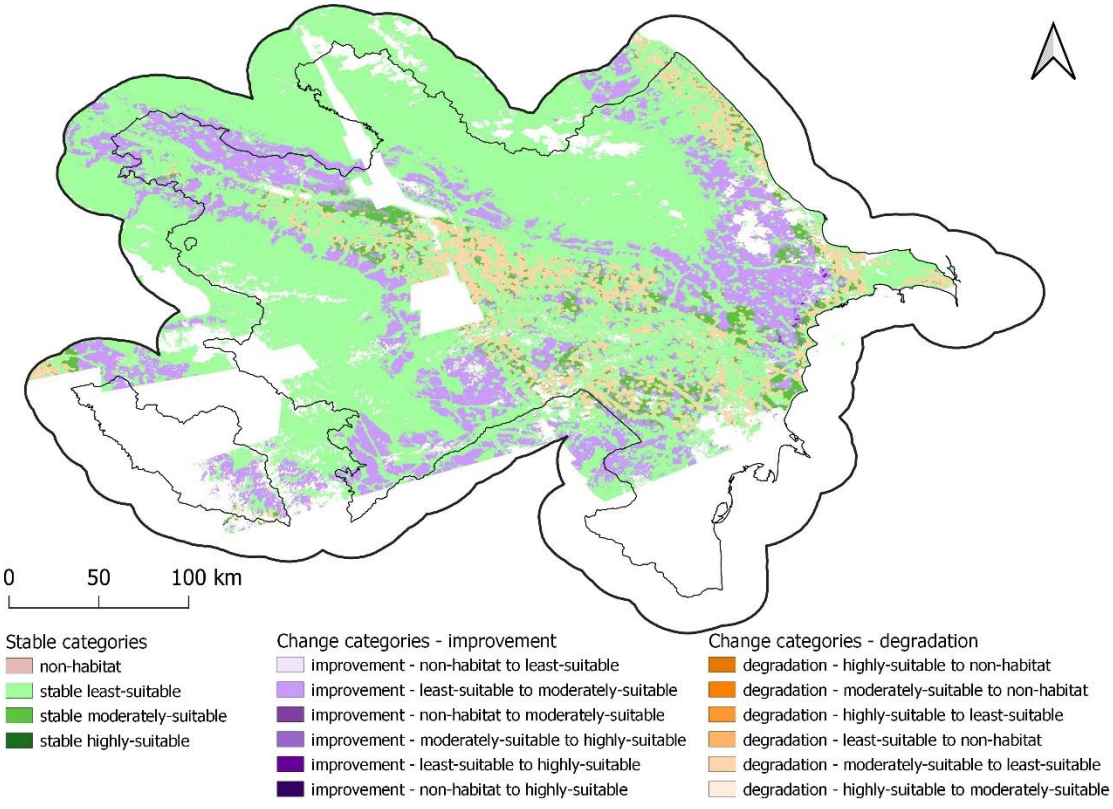


2.

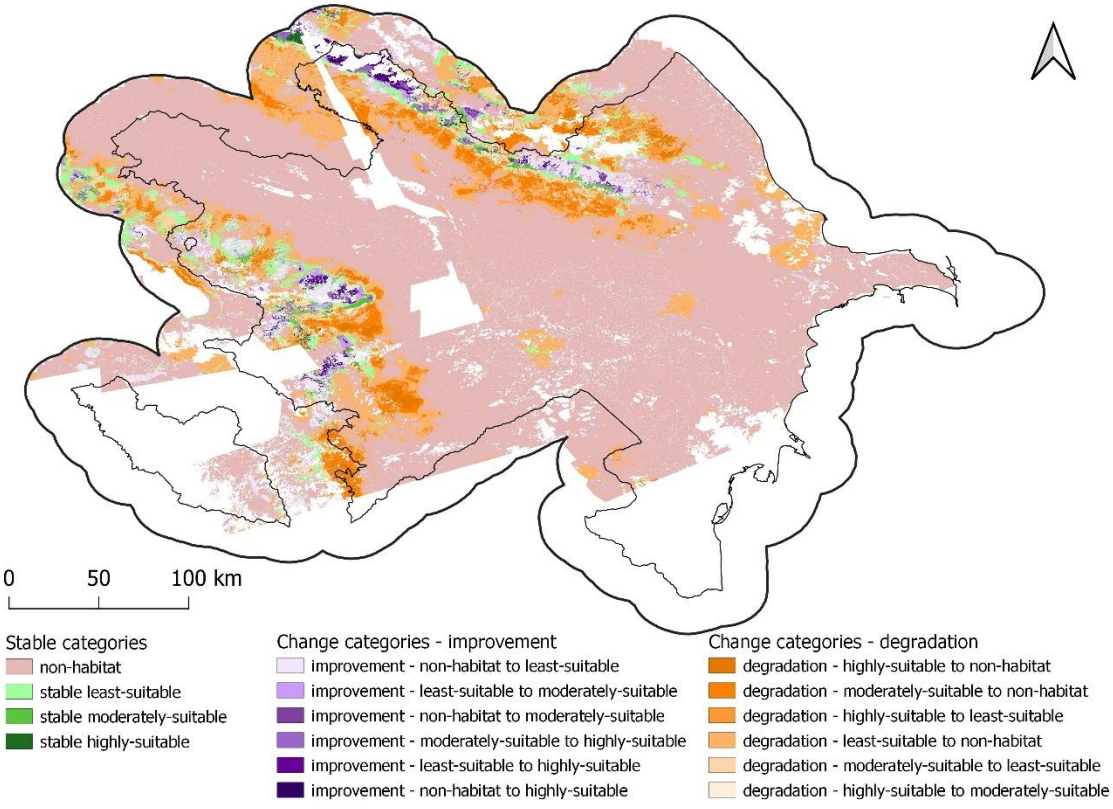



0 50 100 km
Stable categories
non-habitat
stable least-suitable
stable moderately-suitable
stable highly-suitable
Change categories - improvement
improvement - non-habitat to least-suitable
improvement - least-suitable to moderately-suitable
improvement - non-habitat to moderately-suitable
improvement - moderately-suitable to highly-suitable
improvement - least-suitable to highly-suitable
improvement - non-habitat to highly-suitable
Change categories - degradation
degradation - highly-suitable to non-habitat
degradation - moderately-suitable to non-habitat
degradation - highly-suitable to least-suitable
degradation - least-suitable to non-habitat
degradation - moderately-suitable to least-suitable
degradation - highly-suitable to moderately-suitable

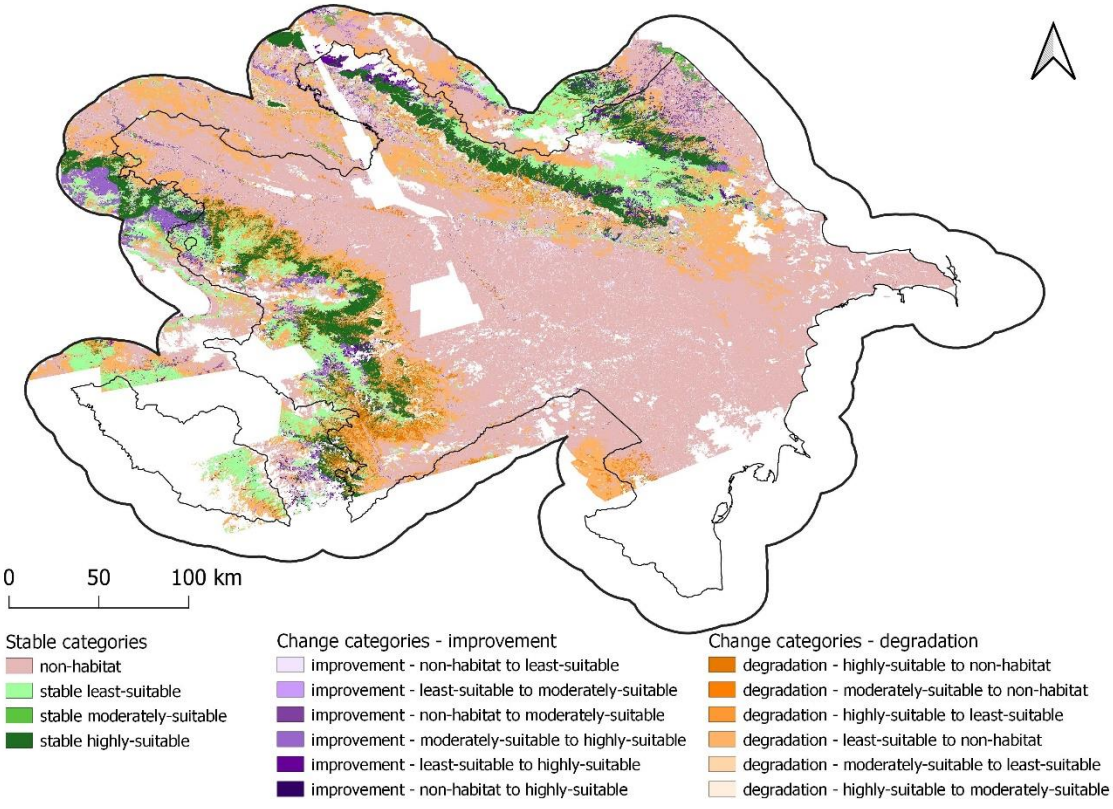
3.


0 50 100 km
Stable categories
non-habitat
stable least-suitable
stable moderately-suitable
stable highly-suitable
Change categories - improvement
improvement - non-habitat to least-suitable
improvement - least-suitable to moderately-suitable
improvement - non-habitat to moderately-suitable
improvement - moderately-suitable to highly-suitable
improvement - least-suitable to highly-suitable
improvement - non-habitat to highly-suitable
Change categories - degradation
degradation - highly-suitable to non-habitat
degradation - moderately-suitable to non-habitat
degradation - highly-suitable to least-suitable
degradation - least-suitable to non-habitat
degradation - moderately-suitable to least-suitable
degradation - highly-suitable to moderately-suitable

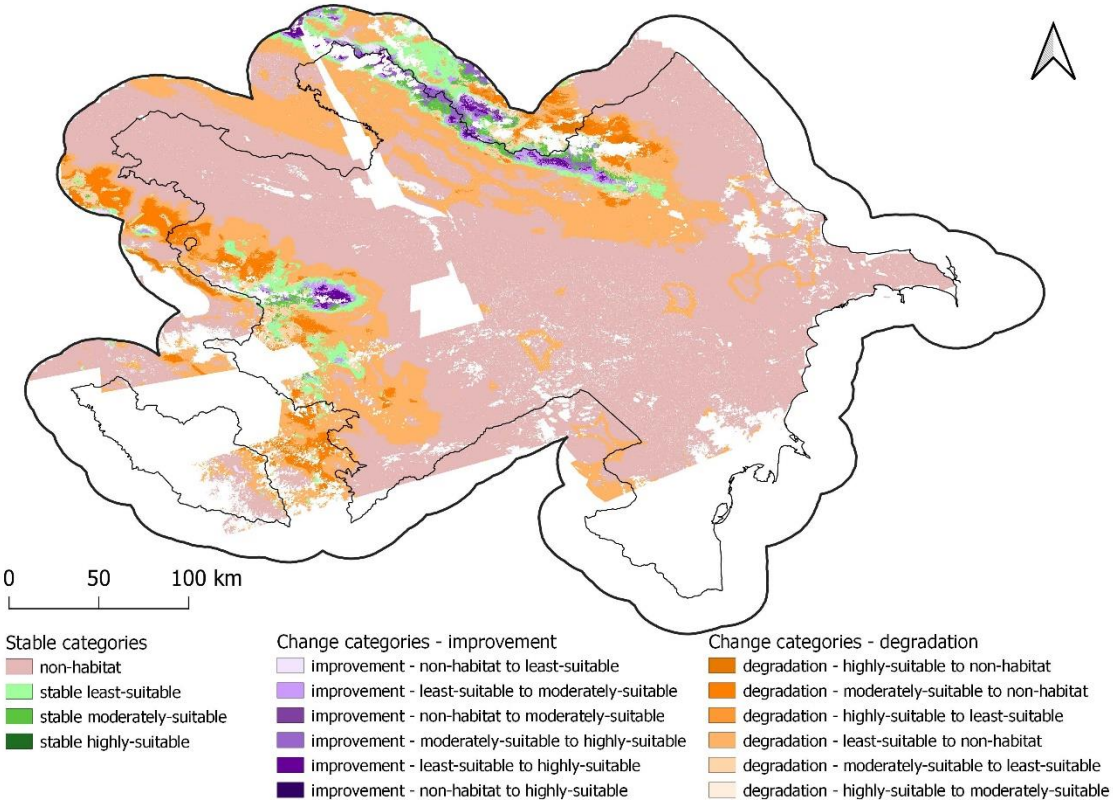
4.


0
50
100 km
Stable categories
non-habitat
stable least-suitable
stable moderately-suitable
stable highly-suitable
Change categories - improvement
improvement - non-habitat to least-suitable
improvement - least-suitable to moderately-suitable
improvement - non-habitat to moderately-suitable
improvement - moderately-suitable to highly-suitable
improvement - least-suitable to highly-suitable
improvement - non-habitat to highly-suitable
Change categories - degradation
degradation - highly-suitable to non-habitat
degradation - moderately-suitable to non-habitat
degradation - highly-suitable to least-suitable
degradation - least-suitable to non-habitat
degradation - moderately-suitable to least-suitable
degradation - highly-suitable to moderately-suitable

5.


0
50
100 km
Stable categories
non-habitat
stable least-suitable
stable moderately-suitable
stable highly-suitable
Change categories - improvement
improvement - non-habitat to least-suitable
improvement - least-suitable to moderately-suitable
improvement - non-habitat to moderately-suitable
improvement - moderately-suitable to highly-suitable
improvement - least-suitable to highly-suitable
improvement - non-habitat to highly-suitable
Change categories - degradation
degradation - highly-suitable to non-habitat
degradation - moderately-suitable to non-habitat
degradation - highly-suitable to least-suitable
degradation - least-suitable to non-habitat
degradation - moderately-suitable to least-suitable
degradation - highly-suitable to moderately-suitable

6.


0
50
100 km
Stable categories
non-habitat
stable least-suitable
stable moderately-suitable
stable highly-suitable
Change categories - improvement
improvement - non-habitat to least-suitable
improvement - least-suitable to moderately-suitable
improvement - non-habitat to moderately-suitable
improvement - moderately-suitable to highly-suitable
improvement - least-suitable to highly-suitable
improvement - non-habitat to highly-suitable
Change categories - degradation
degradation - highly-suitable to non-habitat
degradation - moderately-suitable to non-habitat
degradation - highly-suitable to least-suitable
degradation - least-suitable to non-habitat
degradation - moderately-suitable to least-suitable
degradation - highly-suitable to moderately-suitable

7.