WWF

SUMMARY REPORT 2017

GUARDIANS OF THE HEADWATERS II:

Biodiversity, water, and climate in six snow leopard landscapes

USAID
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ACKNOWLEDGEMENTS

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ACCOMPANYING MAP BOOK

This document is a brief summary of the full 2017 map book, **Guardians of the Headwaters II: Biodiversity, Water, and Climate in Six Snow Leopard Landscapes.** This map book follows a 2014 regional assessment, **Guardians of the Headwaters I: Snow leopards, Water Provision, and Climate Vulnerability, Maps and Analysis.** To download the full reports, and for more on methods, analyses, findings, and maps, please go to www.thirdpolegeolab.org.

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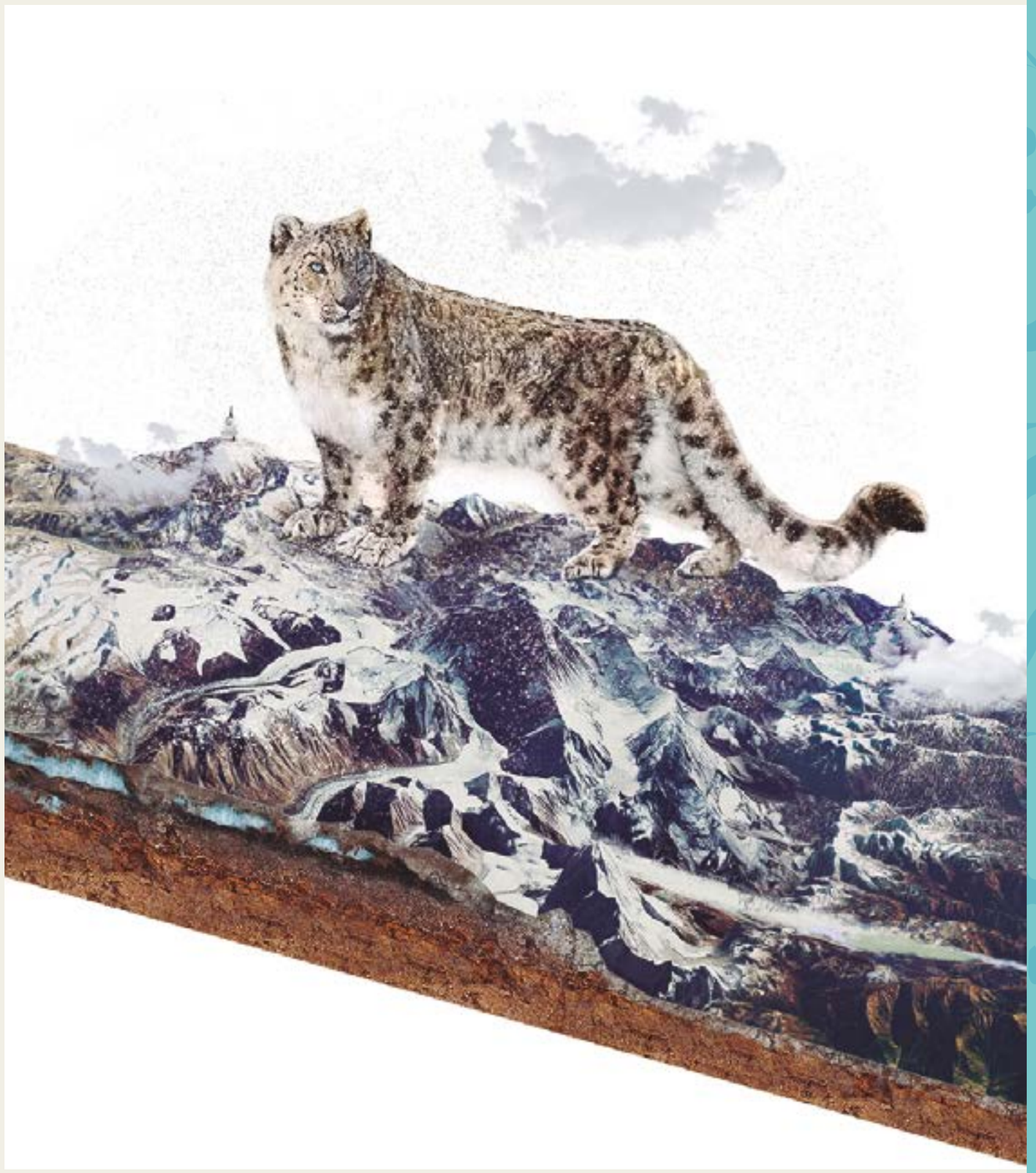


GUARDIANS OF THE HEADWATERS II:

Biodiversity, water, and climate in six snow leopard landscapes

INTRODUCTION

To advance climate-smart natural resource management planning in snow leopard landscapes, we mapped and overlaid snow leopard habitat, current and potential human impacts, protected areas, selected water resources, and climate vulnerabilities in six snow leopard conservation landscapes in high Asia. These landscapes are recognized as priorities of the Global Snow Leopard and Ecosystem Protection Program (GSLEP) and the USAID-WWF project, Conservation and Adaptation in Asia's High Mountain (AHM) Landscapes and Communities. The AHM project is supporting field-based conservation, climate change adaptation, and sustainable development efforts in high mountain communities. The focal landscapes include:

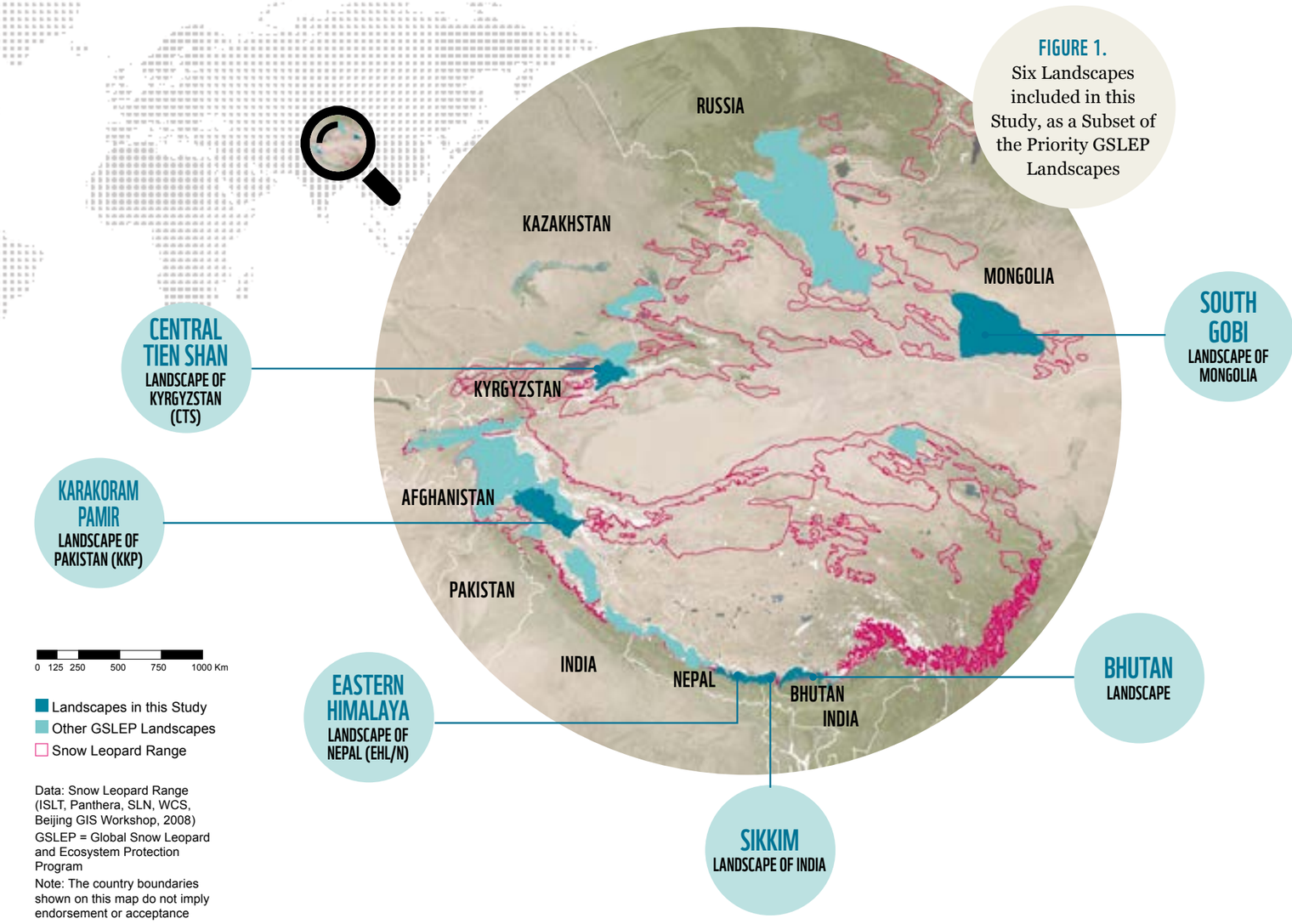
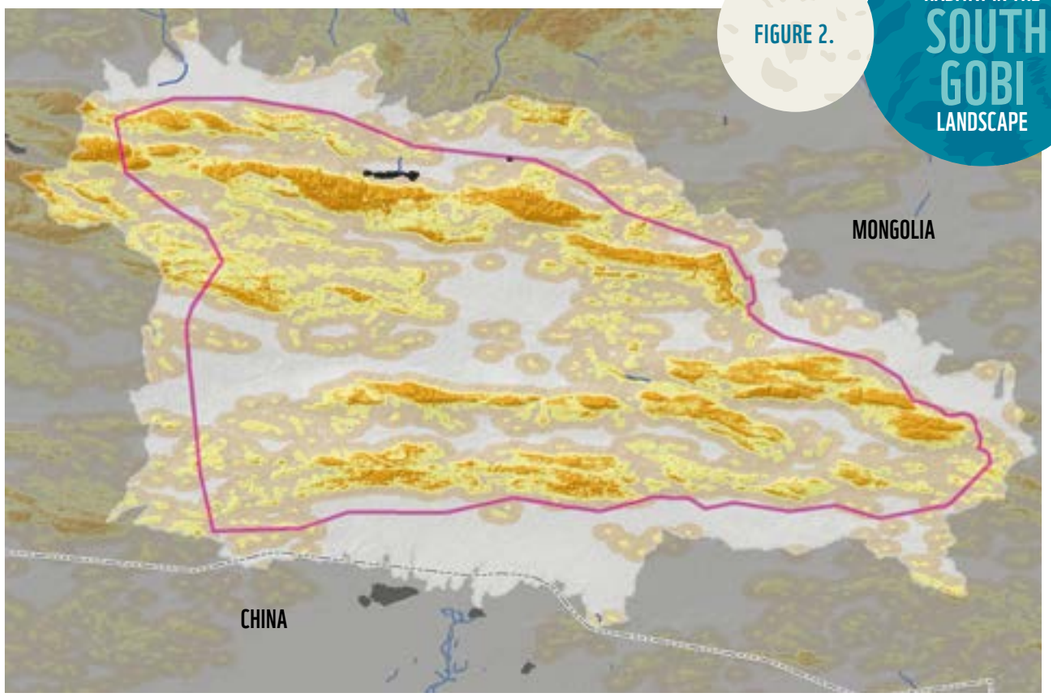


FIGURE 1. Six Landscapes included in this Study, as a Subset of the Priority GSLEP Landscapes

SNOW LEOPARD HABITAT

Snow leopards require vast, rugged areas to survive. In the set of six landscapes that we studied, five landscapes have areas in the range of 3,000 km² to 8,000 km², with an average size of just under 6,000 km². The sixth landscape in the set, the South Gobi, has an estimated habitat area of over 68,000 km². They range from extremely rugged, high alpine areas above tree line in the Himalaya and Karakoram Pamir Mountain ranges, to the high mountains and sweeping valleys of the Central Tien Shan, to harsh desert steppe punctuated by rugged, elevated mountains in the South Gobi. Snow leopards have been observed to travel hundreds of kilometers, necessitating such large areas (McCarthy, et al., 2005; Government of Nepal and World Wildlife Fund, 2016).

FIGURE 2. SNOW LEOPARD HABITAT IN THE SOUTH GOBI LANDSCAPE



Potential snow leopard habitat in the South Gobi Landscape.

0 40 80 120 160 Km

Snow Leopard Habitat

- Optimal Habitat
- Suboptimal Habitat
- Movement Habitat
- Non-Habitat
- South Gobi Landscape
- Hydrological Sub-Basin
- Open Water
- Country Boundaries

POTENTIAL SNOW LEOPARD HABITAT, CORRIDORS, AND CRITICAL CONSERVATION AREAS OF EASTERN NEPAL

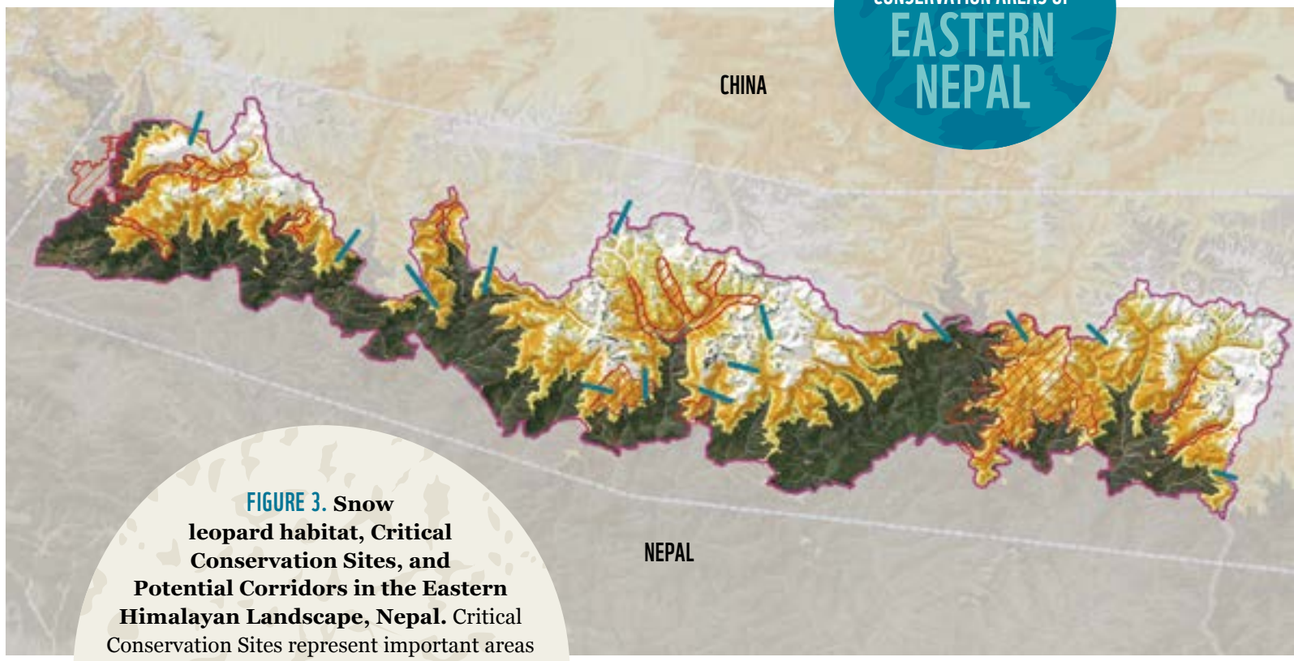


FIGURE 3. Snow leopard habitat, Critical Conservation Sites, and Potential Corridors in the Eastern Himalayan Landscape, Nepal. Critical Conservation Sites represent important areas of snow leopard habitat that are at-risk due to high human activity and/or lack of adequate protection. Potential Corridors represent the most likely path where snow leopards move in close proximity to mountain peaks, human dominated landscapes, or extensive forests patches.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 10 20 30 40 Km

Potential Snow Leopard Habitat

- Good Habitat
- Fair Habitat
- Potential Corridors
- Critical Conservation Sites
- Eastern Himalaya Landscape
- Glaciers
- Analysis Extent: 90 m Model of Snow Leopard Habitat

Successful snow leopard conservation will require effective transboundary management. All landscapes in this series abut international boundaries. Habitat across these boundaries is required to ensure internal landscape connectivity in two landscapes (Nepal and Bhutan). In all landscapes, cross-border habitats support connectivity to the broader snow leopard metapopulation. Snow leopards have been confirmed to travel long distances across international boundaries (Government of Nepal 2016).

POTENTIAL FOR DEGRADATION AND HUMAN INFLUENCE IN SNOW LEOPARD HABITAT

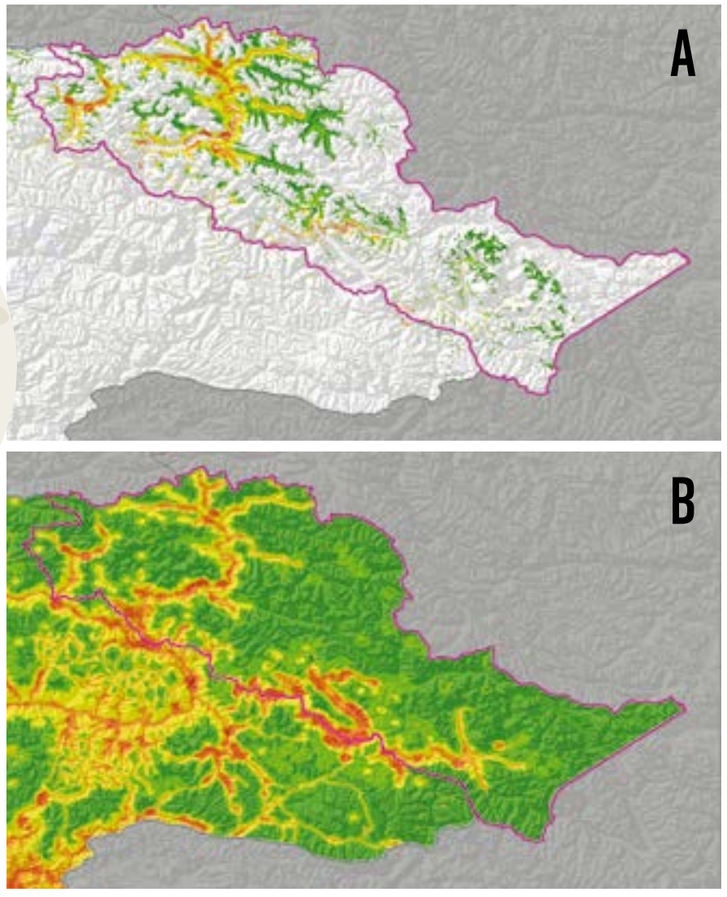


FIGURE 4. This map shows areas of potential degradation and human influence in the Karakoram-Pamir Landscape. The highest levels of human access and potential degradation also coincide with the largest and most centrally located habitats along the Khunjerab River.

Potential degradation and human influence in snow leopard habitat, derived from current land cover and land use, cost distance to roads, and populated place density. Map A shows potential human influence in snow leopard habitat, and Map B shows human influence across the broader landscape.

Snow leopards and humans share landscapes, and the risk of habitat fragmentation is generally a greater threat overall than habitat loss from direct human impacts.

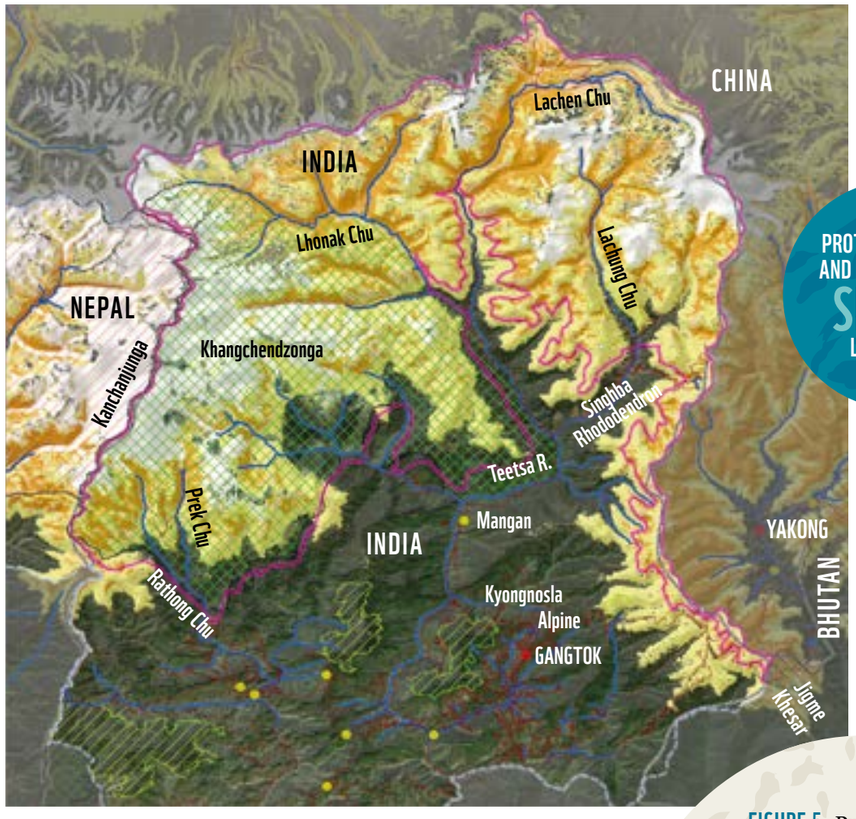
The landscapes of the eastern Himalayas have the highest number of pinch points to habitat connectivity (5 to 9) from roads, population centers, and land use. The Karakoram-Pamir and the Central Tien Shan have fewer, but no less significant pinch points. The South Gobi does not appear to have any bottlenecks to habitat connectivity at this time due to low human population density and nomadic cultures. In all landscapes, livestock compete with snow leopard prey for valuable grasslands. This can lead to habitat degradation in some cases, and spur human-wildlife conflict. Illegal hunting of snow leopards and prey is also an issue in most landscapes, and this risk can be higher along roads and access routes.

Snow-leopard friendly land-use zoning, management and smart infrastructure are effective approaches for maintaining connected and resilient landscapes.

Snow leopard habitats tend to be well-protected, but all landscapes have critical gaps.

Snow leopard habitats in the landscapes we studied range from 33% to 92% protected, with an average and median percent protected around 50%. However, each landscape has important gaps in the protected area and/or corridor system that omits crucial areas, particularly for securing habitat connectivity. Snow leopard habitat needs to be protected by a seamless network of protected areas, corridors, and multiple use zones that are snow leopard and prey-friendly.

PROTECTED AREAS AND PLACES OF THE SIKKIM LANDSCAPE



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/ Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Protected areas, roads, major rivers, and populated places of the Sikkim Landscape.

Potential Snow Leonard Habitat
- High Probability of Occurrence
- Moderate Probability of Occurrence
- Connectivity Habitat
- Sikkim Landscape
- Analysis Extent

Protected areas
- National Park
- Conservation Area
- Sanctuary
- Strict Nature Reserve

Populated Places
- City
- Town
- Roads

FIGURE 5. Protected areas cover over 1120 km² or 37% of potential snow leopard habitat in Sikkim. Nearly 1900 km² of habitat remains unprotected, particularly along the northern and eastern parts of the State that forms a connection to habitats in China and Bhutan. Human presence in the landscape is mainly concentrated in a few river valleys, particularly the Teetsa/Lachen Chu and Lachung Chu, which are also underprotected.

WATER

Snow leopard landscapes provide vital ecosystem services, including water storage and regulation from snow and glacier melt, methane storage in permafrost, pasture for livestock grazing, aesthetic and biodiversity values for tourism, and medicinal plants. These landscapes do not tend to offer a significant water tower function in terms of direct runoff from precipitation to their surrounding sub-basins, with the exception of the Central Tien Shan. But, **all landscapes, except the South Gobi, offer a service to their surrounding basins from snowmelt, particularly at the driest times of year**. Water flows from snow leopard landscapes are important to seasonal water availability, but are also linked to risks of downstream floods and water shortages. The flows of water in four of the landscapes (the Himalayan landscapes and the Central Tien Shan) cross international boundaries.

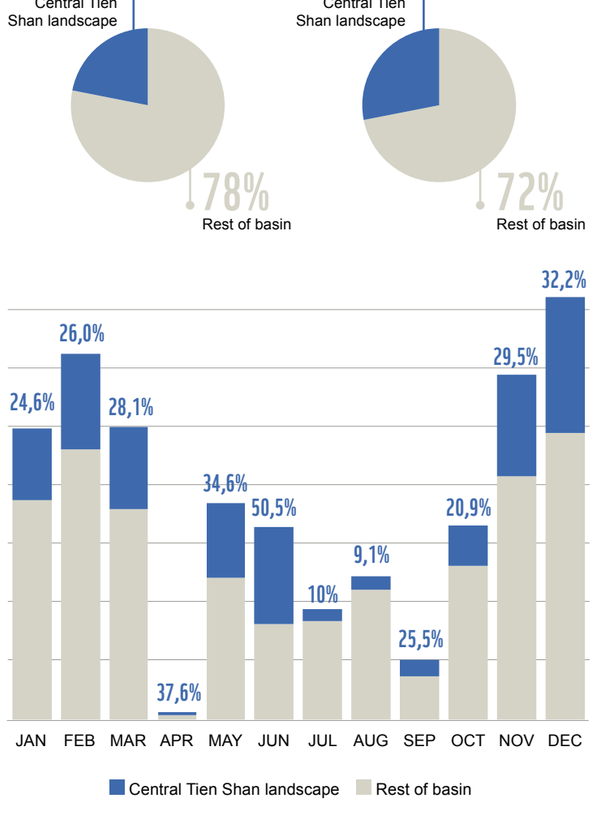
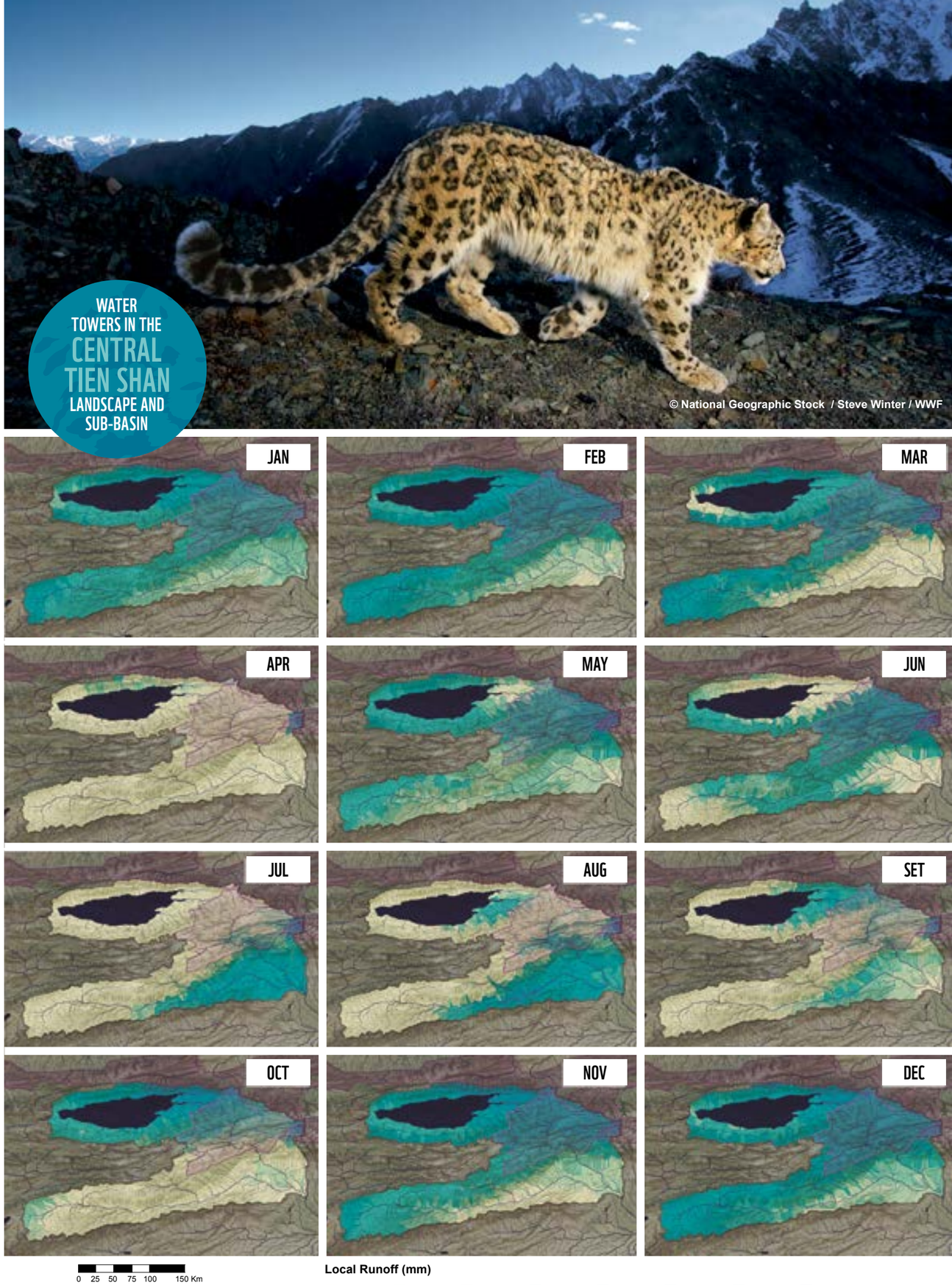


FIGURE 6. In the Central Tien Shan landscape of Kyrgyzstan acts as a water tower to downstream communities in May and June, when demand for water downstream is greatest. During other months of the year, the landscape generates less runoff than downstream areas of the basin, when downstream water demands are limited. Much winter precipitation falls as snow and runs off during the spring, increasing the amount of water available from the landscape in the spring.



Global climate change will affect all landscapes. All landscapes are expected to become warmer.

The amount of warming will range from about 2°C above average annual baseline temperatures by mid-century in the Eastern Himalayan landscapes (range = 1.7 °C to 2.5°C), to 3.0 or even 3.5°C above baseline temperatures (range = 1.9 °C to 3.6°C) in the landscapes to the north and west. All landscapes are also likely to experience modest to extreme increases in precipitation. The monsoon in the Eastern Himalayan landscapes is likely to become heavier, and there will likely be more snowfall in the Karakoram-Pamir. Precipitation increases in the Central Tien Shan and South Gobi are likely to be more modest, where the baseline precipitation is already close to zero (Peters et al. 2017).

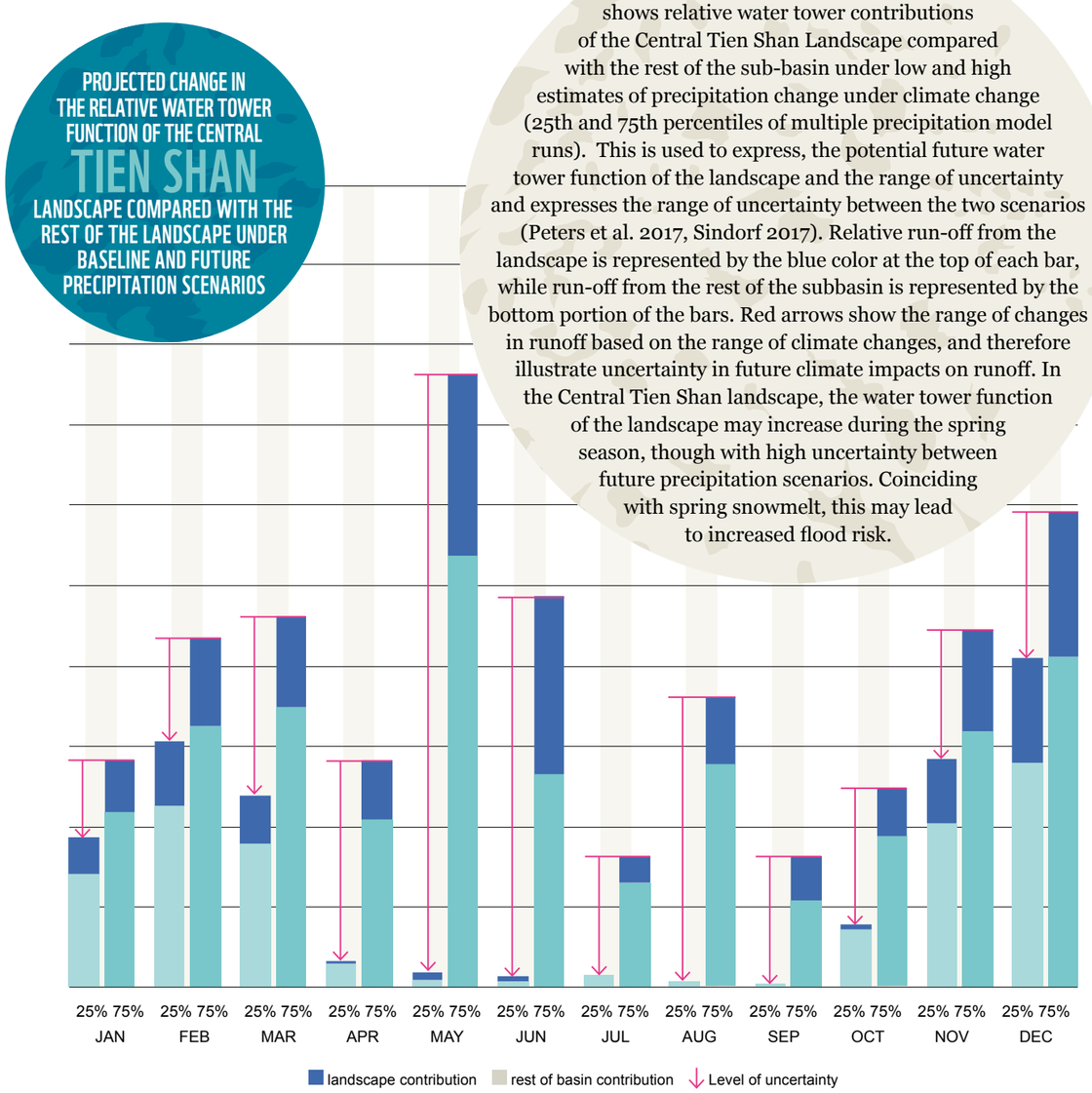
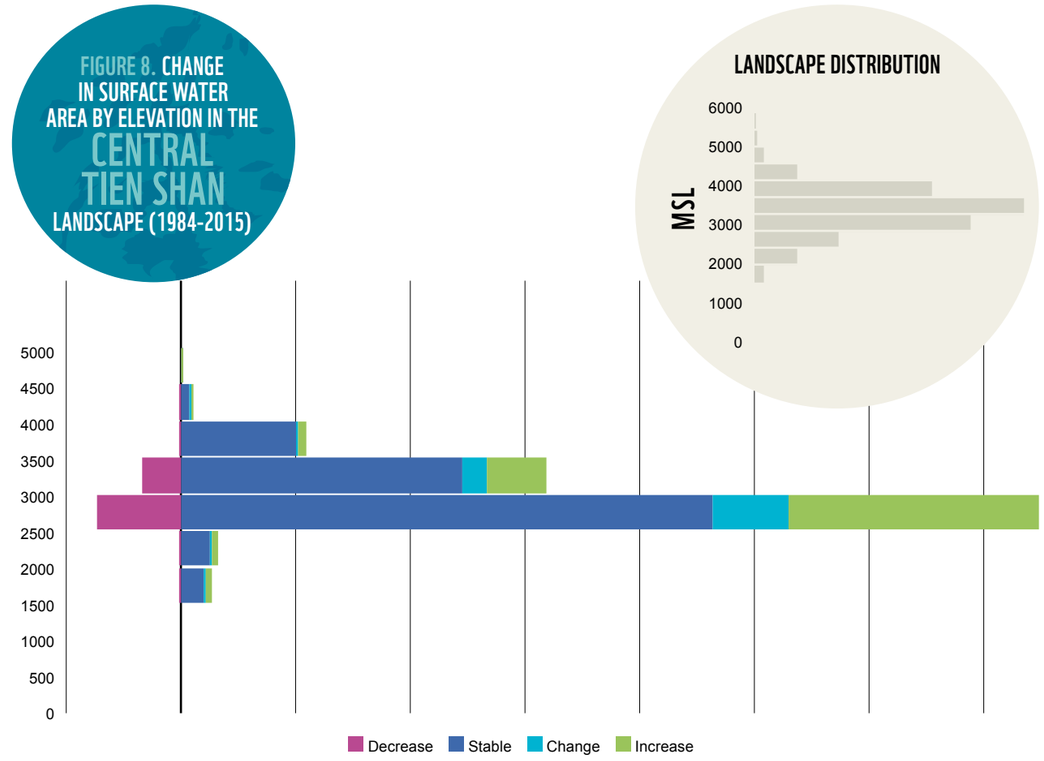
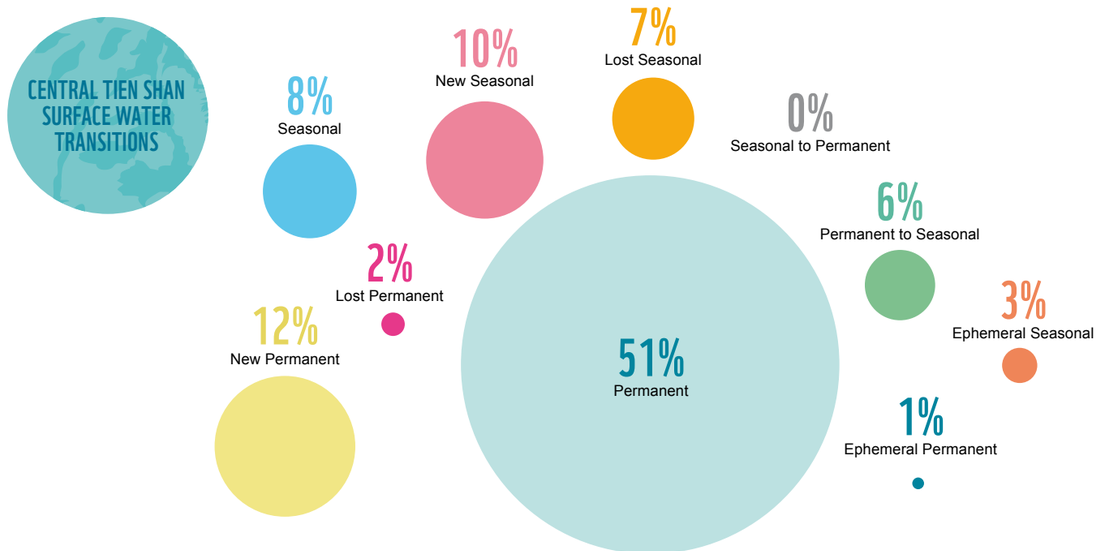


FIGURE 7. shows relative water tower contributions of the Central Tien Shan Landscape compared with the rest of the sub-basin under low and high estimates of precipitation change under climate change (25th and 75th percentiles of multiple precipitation model runs). This is used to express, the potential future water tower function of the landscape and the range of uncertainty and expresses the range of uncertainty between the two scenarios (Peters et al. 2017, Sindorf 2017). Relative run-off from the landscape is represented by the blue color at the top of each bar, while run-off from the rest of the subbasin is represented by the bottom portion of the bars. Red arrows show the range of changes in runoff based on the range of climate changes, and therefore illustrate uncertainty in future climate impacts on runoff. In the Central Tien Shan landscape, the water tower function of the landscape may increase during the spring season, though with high uncertainty between future precipitation scenarios. Coinciding with spring snowmelt, this may lead to increased flood risk.



Open surface water in the 2,500-3,500 meters elevation belt has experienced a dramatic increase in the 21 year observation period, indicating a likely increase in glacial fed lakes and floodplains.

This trend may continue with warming temperatures, accompanied by an increased risk of glacial lake outburst floods (GLOFs). (Pekel et al., 2016).

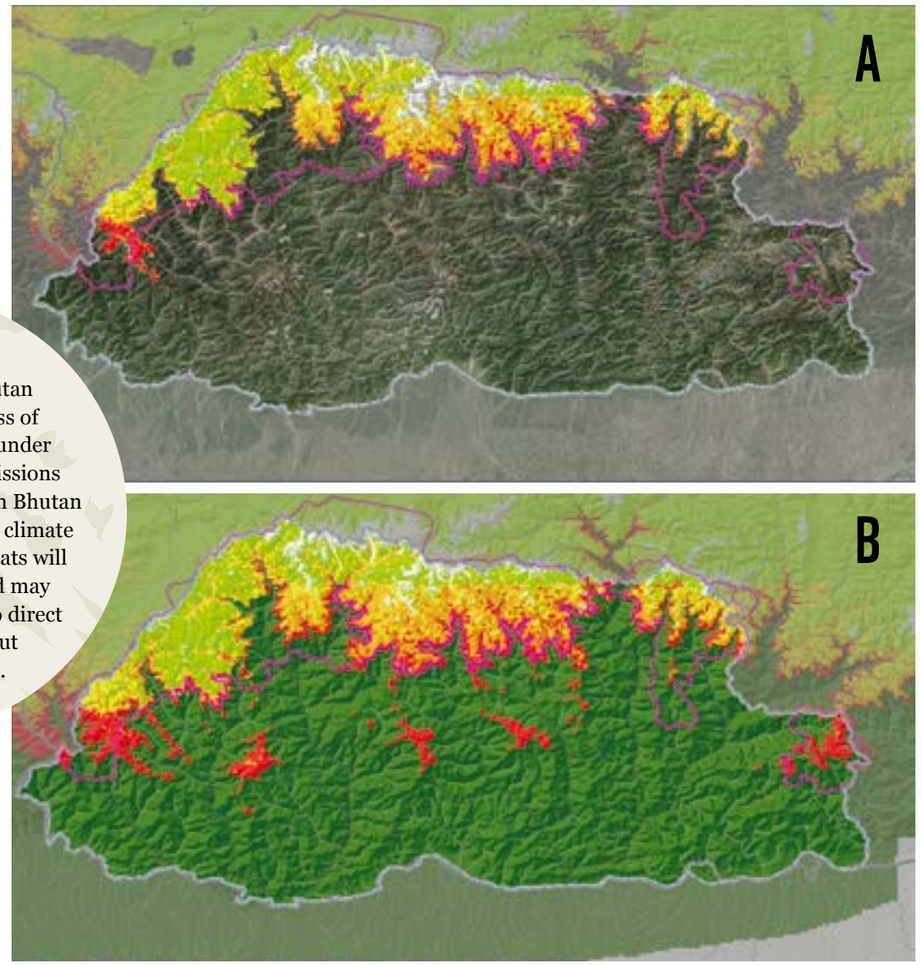


CLIMATE

Key climate risks to the snow leopard range from ecosystem shifts, to changes in ecological communities, habitat loss and degradation from permafrost melt, and land use change in response to new climates.

The landscapes in the Eastern Himalayas may see 60 to 80% of existing snow leopard habitats transition from a climate zone favoring alpine grasslands to a climate zone favoring forest ecosystems. The Karakoram-Pamir may experience a more modest change from alpine to forest climate zone (12%), but with a fragmenting effect on key habitat areas.

VULNERABILITY OF SNOW LEOPARD HABITAT TO TREELINE SHIFT IN BHUTAN



Vulnerability of Alpine Zone to Treeline Shift

- Current Alpine Zone - No Change Anticipated
- Less Vulnerable / Change under High (A2) Emissions
- Moderately Vulnerable / Change under Moderate (A1B) Emissions
- Most Vulnerable / Change under Low (B1) Emissions
- Current Forest Zone - No Change Anticipated
- Bhutan Landscape
- Analysis Extent: 90 m Snow Leopard Habitat Model

FIGURE 9. The snow leopard habitats in Bhutan could see a predicted loss of 60% of existing habitats under a high greenhouse gas emissions scenario. Habitats in western Bhutan are most likely to remain as climate refugia, though these habitats will likely decrease in size and may become fragmented due to direct human impacts without proper management.

Vulnerability of snow leopard habitat to climate-change induced treeline shift. Map A shows the projected change of snow leopard habitat to forest under climate change. Map B shows the projected change in the distribution of forest and alpine zones across the study area.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

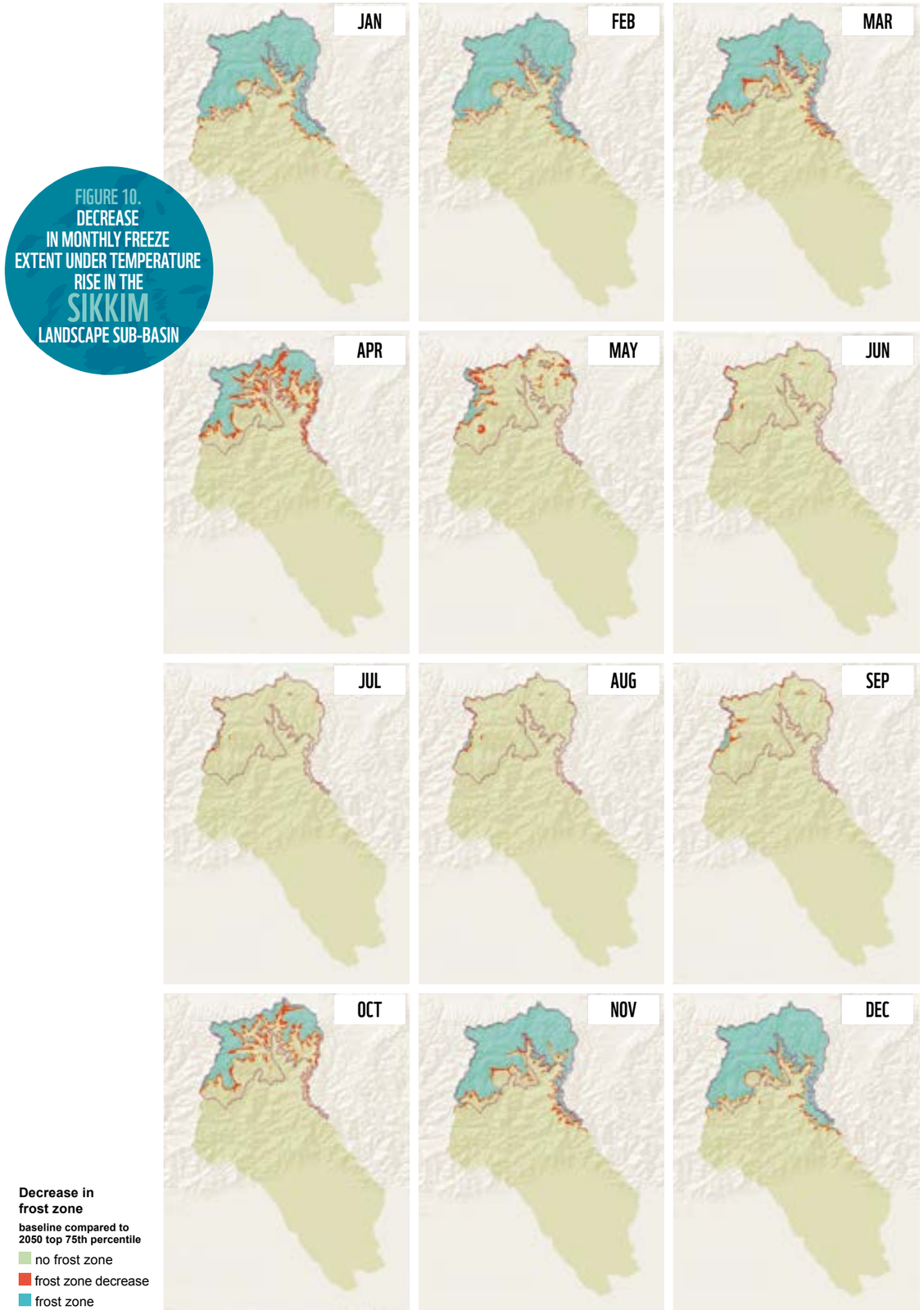
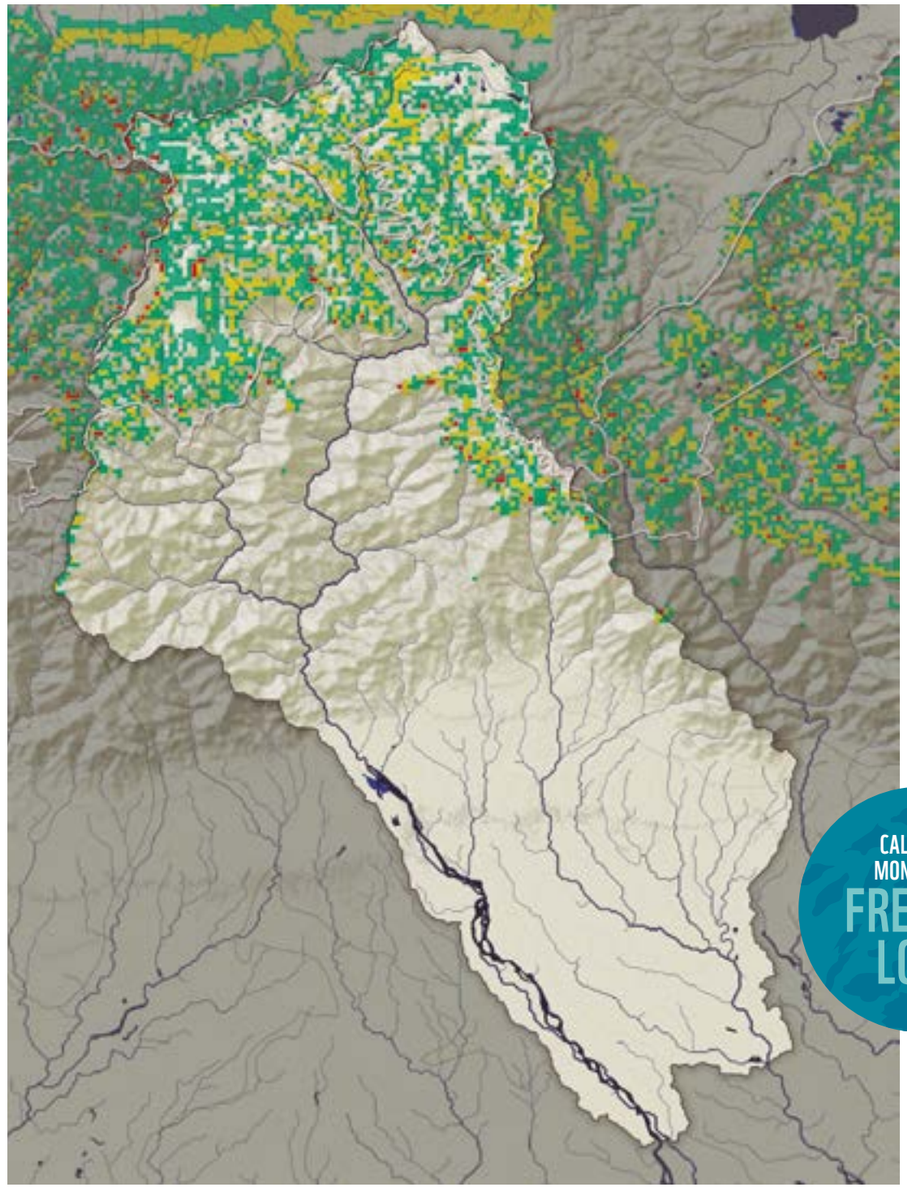


FIGURE 10. DECREASE IN MONTHLY FREEZE EXTENT UNDER TEMPERATURE RISE IN THE SIKKIM LANDSCAPE SUB-BASIN

All landscapes will experience a decrease in the length of winter, ranging from one to three months. This will affect the timing of ecological processes, and ultimately change ecological community composition to species that prefer warmer climates and longer growing seasons. All landscapes have permafrost (ranging from a few mountaintops in the South Gobi to 54% total coverage in the Central Tien Shan), and melting may lead to habitat loss and degradation.



CONSERVATION PRIORITIES

We developed summary maps of conservation importance and potential impacts in each landscape to express overall risk and guide management interventions. Conservation importance is represented in these maps by snow leopard habitat suitability. Potential impacts are expressed by the human footprint and climate change vulnerability. In the resulting maps, areas in bright green represent the most valuable habitats at low risk from climate change and human access. These areas also include the most pristine climate refugia in the landscape. Areas in dark blue represent important habitats at high risk from these same factors. Interventions are highly dependent on the underlying factors in each place, but one approach managers can choose to select is an inside-out approach. As such, managers may select interventions that first seek to maintain conservation priority areas at low and moderate risk, and then focus on the connecting higher risk areas. Higher risk areas may have a limited time scale for intervention (if long-term climate change is a factor), higher economic cost associated (if human presence or infrastructure is high), or a lower certainty of success. In order to identify appropriate management interventions, maps of underlying factors should be evaluated independently (see full report). Managing all habitat for resilience and connectivity is critical to ensure snow leopard metapopulation persistence.

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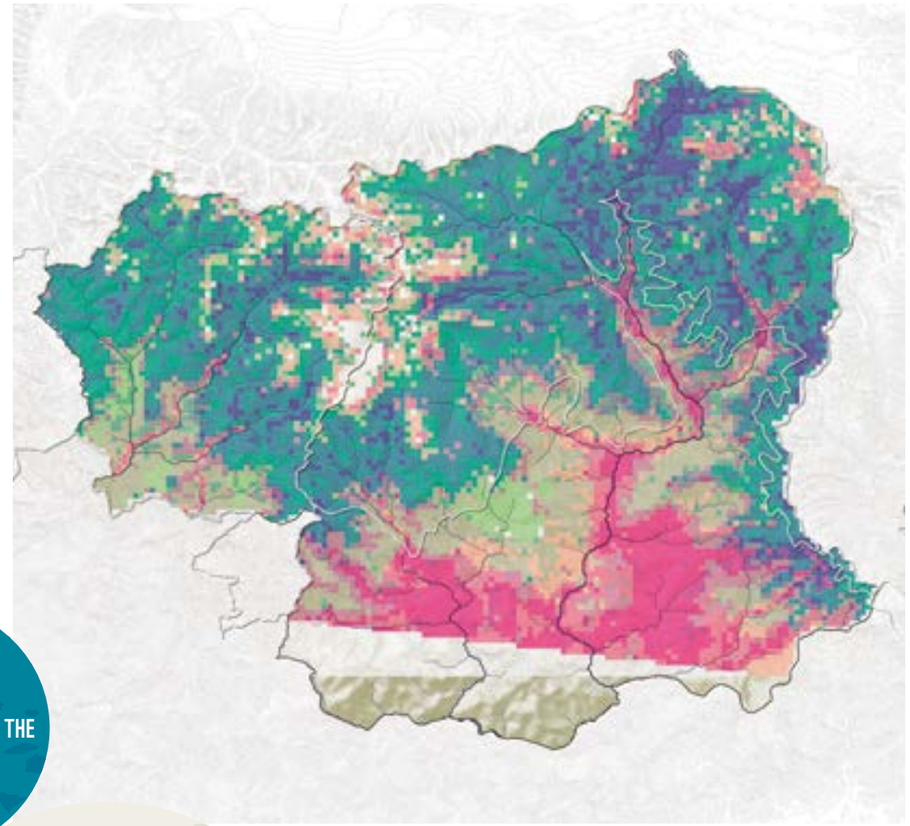


SUMMARY OF CONSERVATION IMPORTANCE AND POTENTIAL IMPACTS IN THE SIKKIM LANDSCAPE

FIGURE 11. In the Sikkim landscape, much of the important habitat is under high risk of impact (dark blue). This is particularly evident in the eastern side of the landscape, where human access is highest. The habitats of high conservation importance in the western part of the landscape are subject to slightly lower cumulative risk (medium blue and green) and may be more resilient in the long term.

SUMMARY OF CONSERVATION IMPORTANCE AND POTENTIAL IMPACTS IN THE EHL/N LANDSCAPE

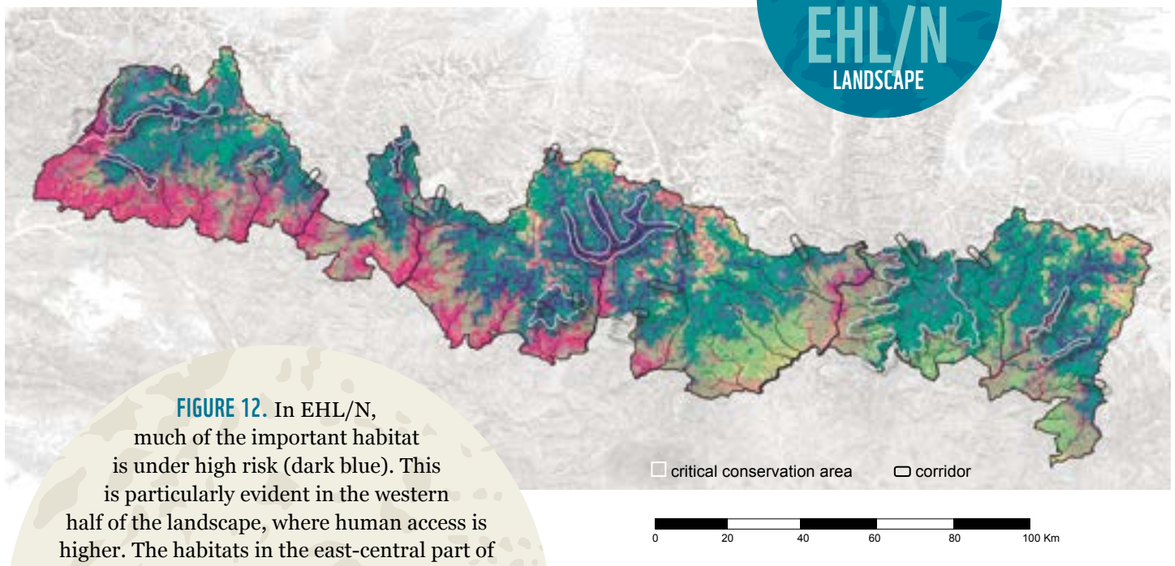


FIGURE 12. In EHL/N, much of the important habitat is under high risk (dark blue). This is particularly evident in the western half of the landscape, where human access is higher. The habitats in the east-central part of the landscape are under moderate risk (medium blue-green), where human impacts are currently low and climate risk is also relatively low. The far eastern side of the EHL/N has high risk due to climate vulnerability. Areas of important habitat at low risk (bright green) are rare and quite fragmented by higher risk areas. These areas tend to be at the highest elevations of snow leopard habitat.

SUMMARY OF CONSERVATION IMPORTANCE AND POTENTIAL IMPACTS IN THE BHUTAN LANDSCAPE

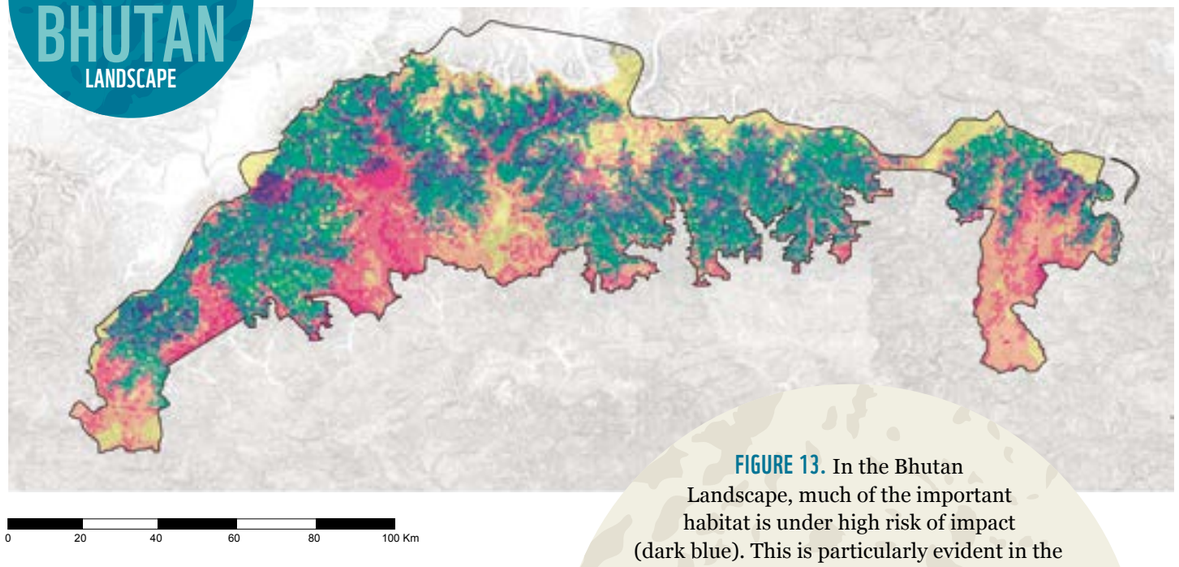


FIGURE 13. In the Bhutan Landscape, much of the important habitat is under high risk of impact (dark blue). This is particularly evident in the southern and western side of the landscape as well as the far eastern edge, where human access is relatively high. The habitats of high conservation importance in the central part of the landscape are subject to slightly lower cumulative risk (medium blue and green) and may be more resilient in the long term. Areas of important habitat at low risk (bright green) are located on isolated mountain tops. These low risk areas tend to be fragmented by habitats at higher risk, requiring management across threat levels to maintain habitat and metapopulation connectivity.

SUMMARY OF CONSERVATION IMPORTANCE AND POTENTIAL IMPACTS IN THE CENTRAL TIEN SHAN LANDSCAPE

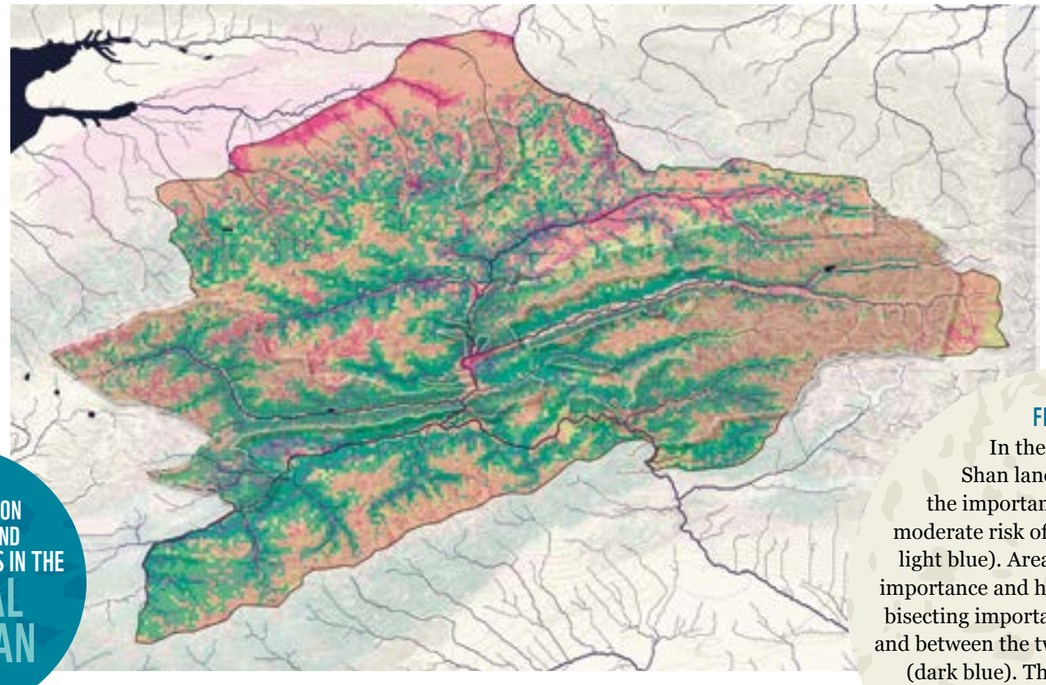
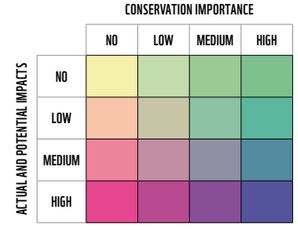


FIGURE 14. In the Central Tien Shan landscape, much of the important habitat has low to moderate risk of loss (darker green and light blue). Areas of high conservation importance and high risk tend to be found bisecting important habitats, along roads and between the two major protected areas (dark blue). These high-risk habitats have the potential to fragment important habitats that may at first glance be at lower direct risk of loss.



SUMMARY OF CONSERVATION IMPORTANCE AND POTENTIAL IMPACTS IN THE KARAKORAM-PAMIR LANDSCAPE

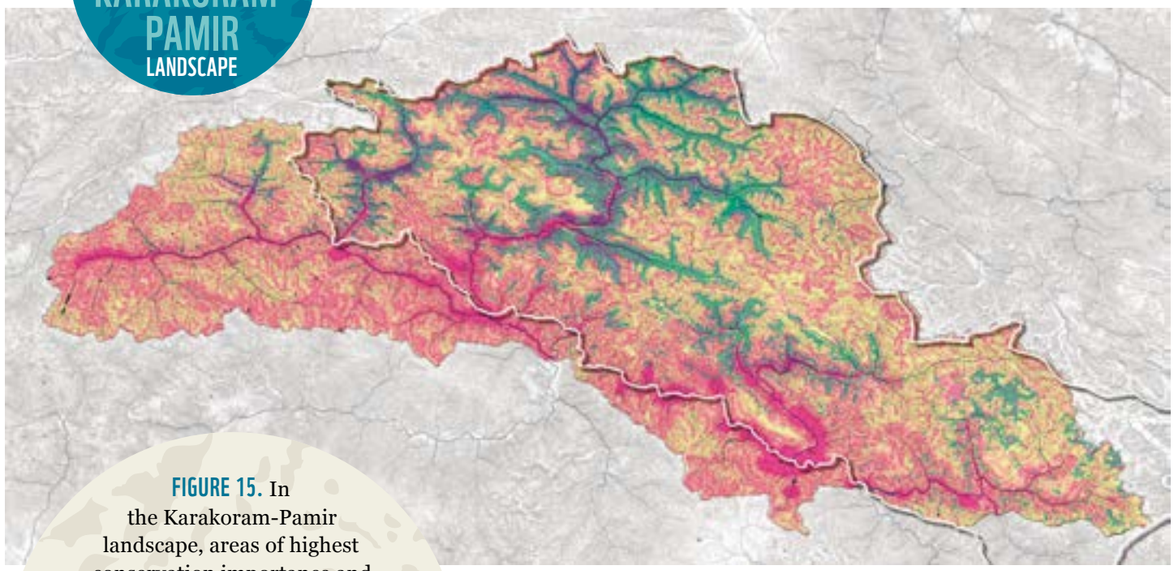


FIGURE 15. In the Karakoram-Pamir landscape, areas of highest conservation importance and impact (dark blue) are along the Khunjerab river corridor. Areas of high conservation importance but lower impact (in lighter blue and bright green) are located upstream along its tributaries. But, these areas will become fragmented if the heavily impacted area along the river is not conserved.

REFERENCES

Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community. 2017. ESRI World Imagery. ArcGIS Online.

Forrest, J.L., Sindorf, N., Bartlett, R., 2017. *Guardians of the Headwaters II: Biodiversity, water, and climate in six snow leopard landscapes*., Washington, D.C.: WWF.

Forrest, J.L, Wikramanayake, E., Shrestha, R., Areendran, A., and Gyeltshen, K. 2012. "*Conservation and Climate Change : Assessing the Vulnerability of Snow Leopard Habitat to Treeline Shift in the Himalaya.*" Biological Conservation 150(2012): 129-135.

Government of Nepal and World Wildlife Fund. (2016). Snow leopard observation and collar data for Kanchenjunga Conservation Area, Nepal. 2015-2016.

ICIMOD. 2007. Protected Areas of Hindu Kush Himalayan (HKH) Region. Kathmandu, Nepal: ICIMOD.

McCarthy, T. M., Fuller, T. K., & Munkhtsog, B. (2005). Movements and activities of snow leopards in Southwestern Mongolia. Biological Conservation, 124, 527-537.

OpenStreetMap. 2016. Open Street Map v. 2016-04-12T19:14:02Z. Downloaded from http://download.geofabrik.de/ on April 12, 2016.

Peters, D., Bader, D., McKenna, Marconi, B., M., Shrestha, R., Bartlett, R., Lesk, C., De Mel, M., and Horton, R. 2017. *Climate Change in the Snow Leopard Landscapes of Asia's High Mountains: Technical Report*. New York, NY, USA: Center for Climate Systems Research and Columbia University and WWF-US.

Pekel, J.-F., Cottam, A., Gorelick, N. & Belward, A. S, High-resolution mapping of global surface water and its long-term changes, Nature 540, 418–422 (2016). https://global-surface-water.appspot.com/

Sindorf, N., Forrest, J. L. & Arakwiye, B., 2014. *Guardians of the Headwaters: Snow Leopards, Water Provision, and Climate Vulnerability*., Washington, D.C.: WWF.