



**AL-FARABI KAZAKH NATIONAL UNIVERSITY
FACULTY OF BIOLOGY AND BIOTECHNOLOGY
DEPARTMENT OF BOTANY AND AGROECOLOGY**

LECTURE 10

**Review of endemic and relict plants of the
Northern Tien Shan mountains**

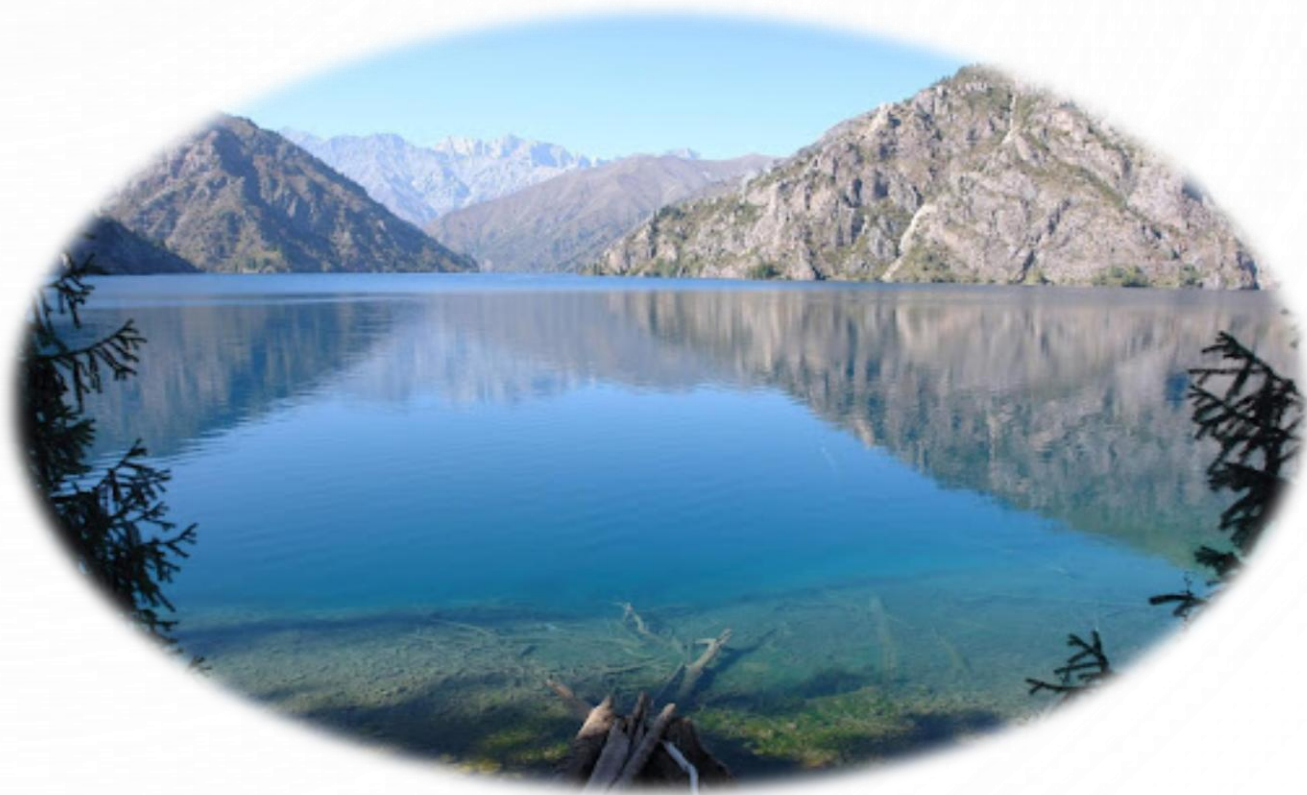
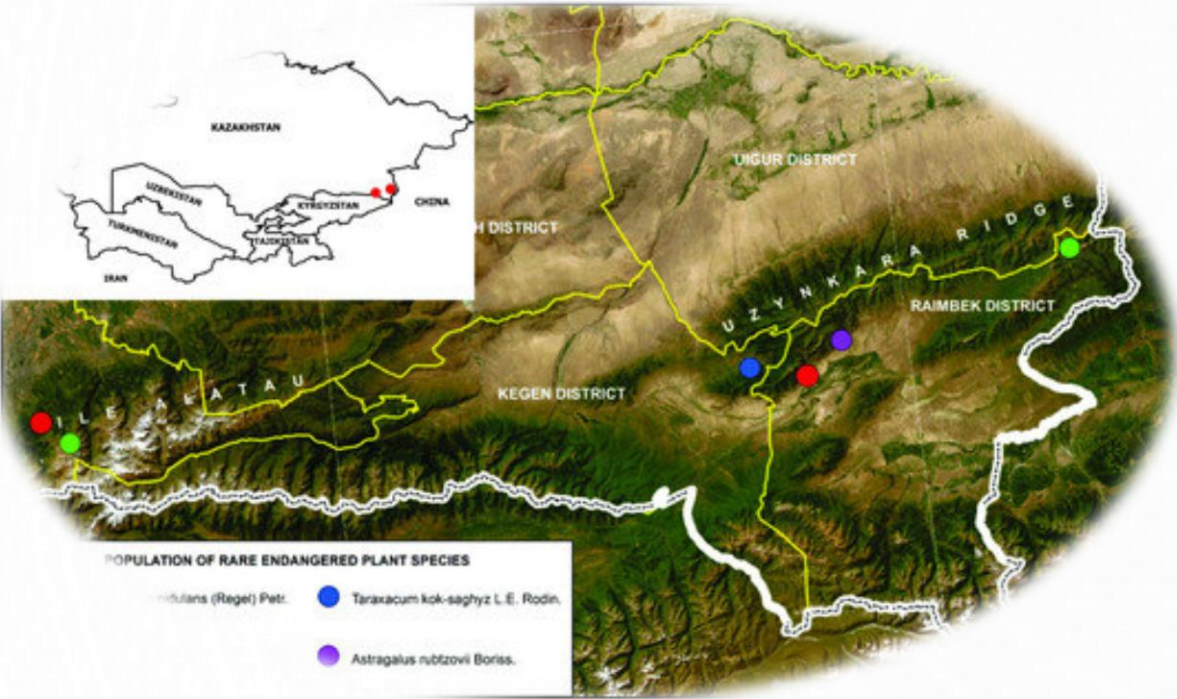


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Course title: Conservation of Rare and Endangered
Plant Species**

Endemic and Relict Plants of the Northern Tien Shan Mountains

A Comprehensive Review of Central Asia's Botanical Treasures

The Northern Tien Shan mountains represent one of the world's most remarkable botanical repositories, harbouring extraordinary concentrations of endemic and relict plant species. This comprehensive review examines the biodiversity, conservation status, and evolutionary significance of the flora that has thrived in these isolated alpine ecosystems since the Tertiary period.



The Northern Tien Shan: A Biodiversity Hotspot

The Northern Tien Shan mountains form a botanical treasure trove of extraordinary significance. The region supports over 6,000 vascular plant species concentrated within Kazakhstan's borders, with nearly 8% of these taxa being endemic to this exclusive alpine zone. This exceptional concentration of endemism reflects the region's unique geological and climatic characteristics, which have created isolated habitat islands where plant evolution has proceeded independently for millions of years.

The region's extraordinarily complex topography generates diverse microclimates and substrate conditions. Elevation gradients spanning from 600 metres to over 3,000 metres create distinct ecological zones, from steppe grasslands through mixed forests to alpine tundra and rocky alpine communities. This vertical stratification, combined with variation in aspect, moisture availability, and soil composition, produces countless microhabitats where specialised plant communities flourish. The mountain ridges, particularly the Ile Alatau and Ketmen ranges, form natural barriers that have isolated populations for millions of years.

Critically, these mountains contain relict species that have survived since the Tertiary period—over 25 million years ago—making them invaluable for understanding plant evolution, adaptation, and biogeographic history. Living alongside these ancient relicts are numerous endemic species found nowhere else on Earth, representing unique evolutionary experiments driven by geographic isolation and environmental pressures.

Endemism in Numbers: Kazakhstan's Vascular Plants

451

Endemic Taxa

Concentrated throughout Kazakhstan, with significant clusters in Northern Tien Shan ridges

7.97%

Endemism Percentage

Of the country's total vascular plant diversity across all regions

408

Perennial Herbs

The dominant life form among endemic taxa, adapted to alpine conditions

Kazakhstan's endemic vascular flora represents a significant portion of Central Asia's biological distinctiveness, with 451 endemic taxa formally recognised within the nation's borders. The Northern Tien Shan mountains account for the vast majority of this endemism, particularly along high-altitude ridges such as the Ile Alatau and Ketmen ranges, where harsh environmental conditions and geographic isolation have fostered the evolution of unique plant lineages.

The structural composition of endemic flora reveals important ecological patterns. Perennial herbs dominate with 408 taxa, reflecting adaptation to alpine conditions where seasonal cycles are compressed and growing seasons extremely brief. These herbaceous endemics exhibit remarkable morphological specialisations including reduced stature, cushion growth forms, and enhanced reproductive strategies. Additionally, a smaller but significant contingent of endemic shrubs and trees persists in refugial habitats, representing relictual elements from warmer, wetter climates of the Tertiary period.

This biodiversity pattern demonstrates that endemism is not randomly distributed but rather concentrated in areas of greatest environmental heterogeneity and topographic complexity—precisely where ecological isolation most strongly drives speciation and population divergence.

ENDEMISM IN NUMBERS: KAZAKHSTAN'S VASCULAR PLANTS

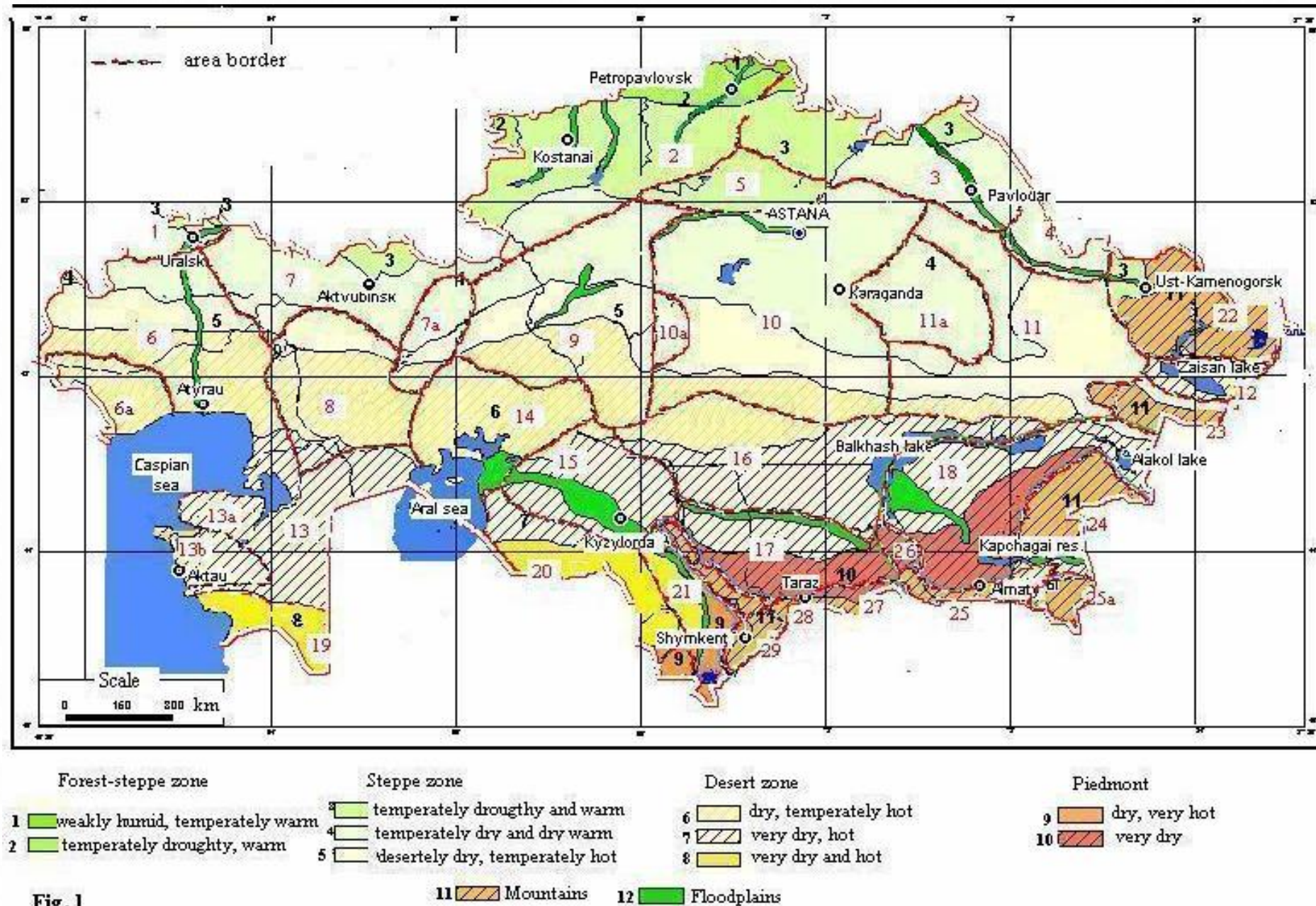


Fig. 1

Relict Species: Living Links to the Past

Sergia regelii

A Tertiary relict endemic exclusively to the Tian Shan mountains, this ancient species occupies lower-elevation refugia with relatively mesic (moderately moist) conditions. Recent climate modelling predicts significant habitat loss at its current elevational range as temperatures increase, forcing potential range shifts upslope and into fragmented high-altitude refugia.

Sergia sewerzowii

The sister species occupies higher, cooler alpine environments and demonstrates divergent ecological requirements from *S. regelii*. Climate scenarios project northward range expansion as conditions warm, yet this expansion faces barriers imposed by the mountain's geographic boundaries and by potential unsuitable intermediate habitats.

These two *Sergia* species exemplify the profound vulnerability of alpine relict flora to contemporary climate change. Their Tertiary origin—surviving three major glacial cycles and climate fluctuations—demonstrates their resilience to past environmental changes. However, the unprecedented speed of current warming, combined with habitat fragmentation by human land use, may exceed these species' adaptive capacity and dispersal capabilities.

Palaeobotanical evidence indicates these species occupied much broader ranges during warmer intervals of the Tertiary and earlier Quaternary periods. Their current restriction to isolated Tian Shan localities represents range contraction spanning millions of years. Future climate projections threaten further compression and potential extinction, particularly if lower-elevation populations succumb to warming and higher-elevation refugia become unavailable due to geographic constraints.

Spotlight on Four Rare Endemic Species



Taraxacum kok-saghyz

This remarkable endemic dandelion maintains mature populations displaying robust vegetative and reproductive stages. Its roots produce a latex compound previously investigated for industrial applications, making it scientifically and economically significant.



Astragalus rubtzovii

Exhibits stable age structure distribution, indicating sustainable population dynamics. The species demonstrates exceptional physiological adaptation to the Northern Tien Shan's severe alpine conditions, including frost tolerance and drought resistance mechanisms.

Chasmophytic Vegetation: Specialists of Rocky Alpine Habitats

Chasmophytic vegetation—plants specialising in rocky fissures, ledges, and cliff faces—represents one of the Northern Tien Shan's most distinctive and scientifically intriguing plant communities. Comprehensive floristic surveys have identified 16 distinct plant associations occupying these restrictive microhabitats, each displaying characteristic species combinations and community structure adapted to specific substrate and microclimate conditions.

Microclimatic Specialisation

Alpine rock habitats create unique microclimatic conditions including enhanced wind exposure, extreme temperature fluctuations, rapid moisture drainage, and intense solar radiation. Plants colonising these sites exhibit convergent morphological adaptations including reduced size, dense growth forms, and waxy or pubescent leaf surfaces.

Substrate-Specific Assemblages

Different rock types (granite, limestone, metamorphic) create chemically distinct substrates supporting distinct plant communities. Limestone fissures support alkaliphile species, whilst granite cliffs host acidophile specialists, demonstrating fine-scale ecological sorting driven by chemical weathering products.

High Endemism Concentrations

These chasmophytic communities display extraordinarily high proportions of endemic species—often exceeding 40% of the flora. This concentration reflects the extreme habitat specialisation and geographic isolation of rocky cliff habitats, which restrict dispersal and promote local speciation.

Newly documented associations including *Crepidifolio tenuifolii-Stipetum tianschanicae* represent previously unknown plant communities, indicating that chasmophytic vegetation remains incompletely surveyed. These newly described associations often contain undocumented endemic species, suggesting significant taxonomic diversity still awaits scientific characterisation. The microhabitat specificity of chasmophytic communities makes them particularly vulnerable to habitat degradation and climate-driven changes in precipitation and snowpack patterns.

Threats to Endemic and Relict Flora

1 Anthropogenic Pressures

Intensive livestock grazing in accessible lowland and mid-elevation zones has degraded vast areas of steppe and montane meadow communities. Selective herbivory by goats and sheep eliminates palatable endemic species whilst promoting weedy, disturbance-tolerant taxa. Additionally, agricultural expansion, mining activities, and infrastructure development continue fragmenting habitats and destroying key populations of rare species.

2 Climate Warming and Range Shifts

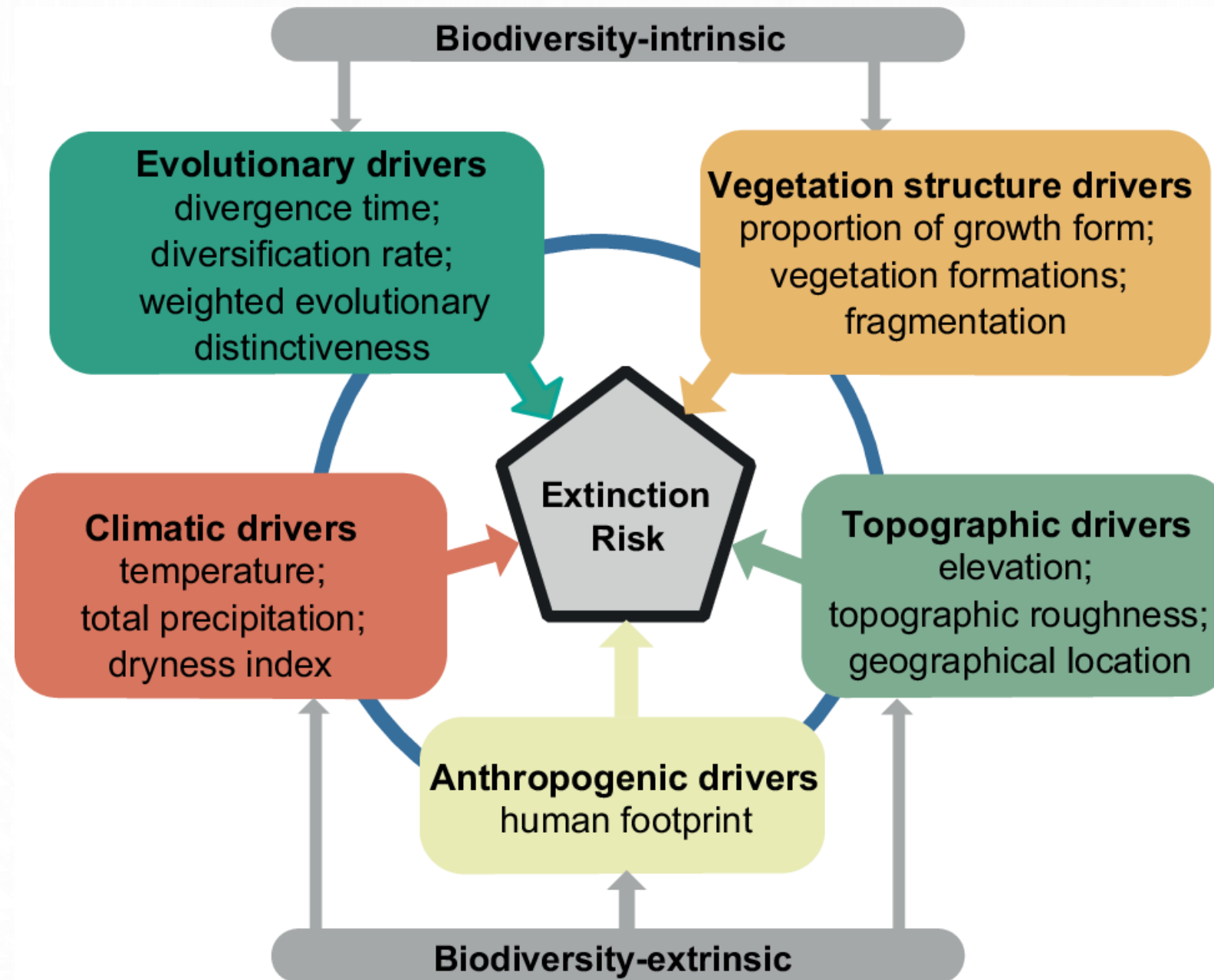
Accelerating temperatures are driving altitudinal range contractions for species restricted to cool habitats. Species like *Sergia regelii* face steep habitat loss at lower elevations, whilst mountain-top endemics face "nowhere to run" as suitable habitats disappear. Snowpack reduction threatens species dependent on sustained moisture from snowmelt during growing seasons.

3 Genetic Diversity Decline

Fragmentation of populations into small, isolated patches increases genetic drift and reduces effective population size. This erosion of genetic diversity reduces adaptive potential, increases inbreeding depression, and heightens extinction risk. Many endemic species already exist in extremely limited populations numbering only dozens of individuals.

The combination of these threat vectors creates a perfect ecological storm. Overgrazing and habitat fragmentation reduce population sizes and genetic diversity, simultaneously reducing adaptive capacity precisely when climate change demands rapid evolutionary response. Alpine specialists face compression from below (warming and land-use change at lower elevations) and from above (decreasing habitat availability at mountaintops). This vice-like pressure threatens to squeeze many endemic species into extinction within coming decades absent intensive conservation intervention.

THREATS TO ENDEMIC AND RELICT FLORA



Conservation Efforts and Important Plant Areas

Important Plant Areas (IPAs)

Systematic identification of biodiversity-rich localities in the Peri-North Tien Shan region has enabled strategic prioritisation of conservation resources. These IPAs represent ecological hotspots harbouring exceptional concentrations of endemics, relicts, and threatened species. Designation of IPAs provides a science-based framework for guiding land-use planning, protecting critical habitats, and justifying conservation investment in regions with limited resources.

IPA criteria specifically target regions supporting globally threatened species, endemic species concentrations, and ecologically distinctive habitats. The Northern Tien Shan qualifies under all criteria, making it a top global conservation priority.

Legal Protection and Red Book Status

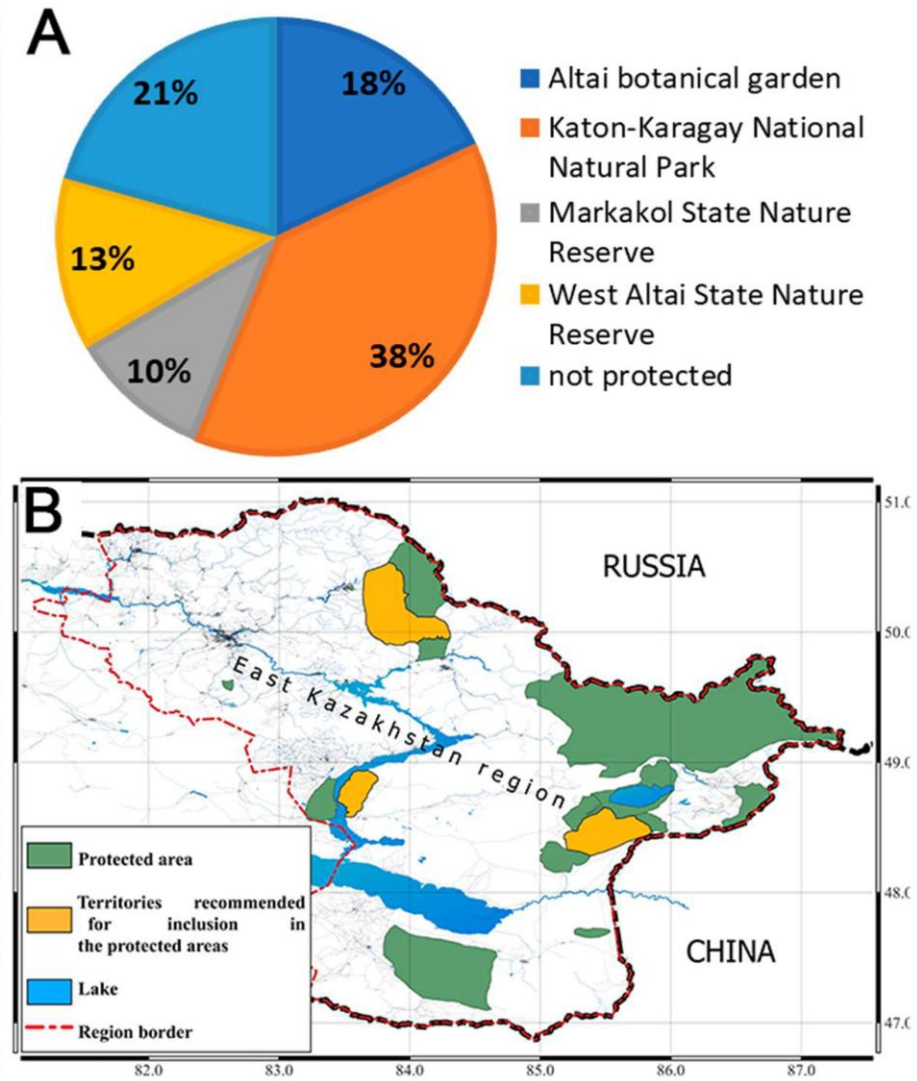
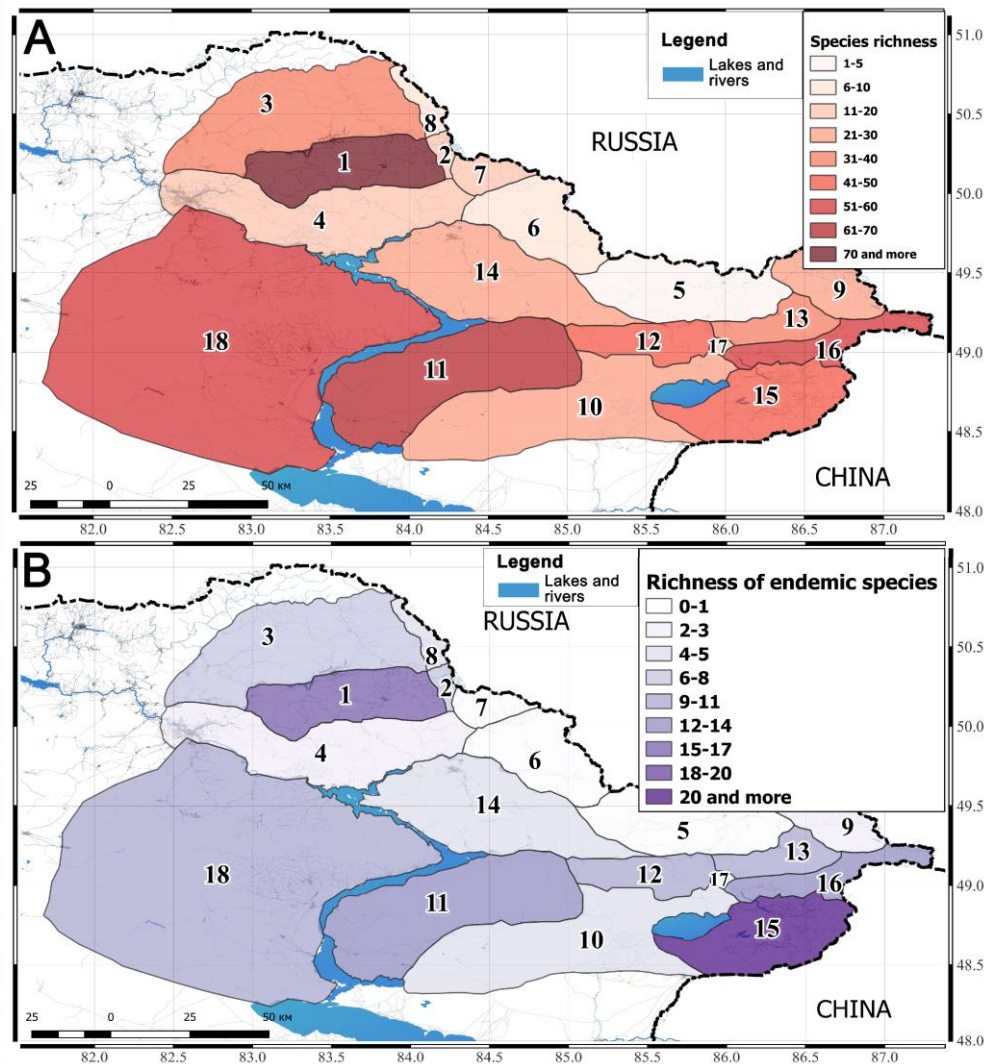
Kazakhstan's Red Book—the nation's official register of threatened species—includes legal protection for 107 endemic plant species, encompassing many Northern Tien Shan endemics. Red Book designation prohibits unauthorised collection, provides penalties for habitat destruction, and mandates population monitoring.

Whilst legal protections provide essential safeguards, their effectiveness depends upon enforcement capacity, stakeholder compliance, and sustainable management of protected lands. Many protected species still face population declines due to inadequate resources for enforcement and monitoring.

Ex Situ Conservation Success

Botanical gardens and seed banks provide complementary protection through cultivation of threatened species outside their natural habitats. The successful introduction and adaptation of *Aflatunia ulmifolia*, an extremely rare endemic, in botanical garden collections demonstrates ex situ conservation viability. Living collections preserve genetic diversity, enable research into species biology and cultivation requirements, and provide insurance against complete wild extinction.

CONSERVATION EFFORTS AND IMPORTANT PLANT AREAS



The Path Forward: Research and Management Priorities



Continuous Monitoring

Implement systematic population monitoring using genomic tools and demographic analysis. Track genetic diversity changes, allele frequency shifts, and population viability across decades. Genomic sequencing reveals evolutionary processes and informs adaptive management decisions.



Habitat Restoration

Restore degraded habitats through targeted vegetation management, removal of invasive species, and artificial regeneration where necessary. Prioritise restoration in key refuge areas and corridors connecting fragmented populations, enabling gene flow and range expansion.



Sustainable Grazing

Implement rotational grazing systems, establish grazing exclusion zones around critical endemic populations, and promote alternative livelihood strategies for pastoralists. Sustainable grazing balances traditional land use with biodiversity protection.



Transboundary Cooperation

Coordinate conservation across international borders through multilateral agreements. The Tien Shan spans Kazakhstan, Kyrgyzstan, and China; integrated management ensures species protection across their entire ranges and prevents range-expansion constraints imposed by political boundaries.

These research and management priorities demand coordinated international effort, sustained financial investment, and institutional capacity building. Achieving these objectives requires establishing long-term funding mechanisms, training Central Asian botanists and conservation professionals, and developing monitoring infrastructure. Climate-adapted conservation strategies must anticipate future conditions, implementing assisted migration where natural dispersal cannot track rapid climate change. Integrating indigenous knowledge systems with Western scientific approaches creates culturally appropriate and ecologically effective conservation solutions.

Conclusion: Preserving the Northern Tien Shan's Botanical Heritage

The Northern Tien Shan mountains harbour an irreplaceable botanical heritage of global significance. The region's 451 endemic taxa, combined with Tertiary relict species surviving millions of years of environmental upheaval, represent unique evolutionary legacies found nowhere else on Earth. This flora embodies millions of years of adaptive evolution, specialisation, and biogeographic history—a living library of plant adaptation to extreme alpine environments.

Biodiversity Irreplaceability

Endemic and relict species cannot be replaced or recovered once extinct. Their loss represents permanent erasure of evolutionary information and ecosystem services accumulated across geological time scales.

Ecological Resilience

Complex, biodiverse ecosystems demonstrate greater functional redundancy and resilience to environmental perturbations. Protecting this flora maintains ecosystem services including water regulation, soil stabilisation, and carbon sequestration vital for regional and global environmental function.

Conservation Urgency

Accelerating climate change and anthropogenic pressure create unprecedented urgency for conservation action. Species facing range compression, habitat fragmentation, and genetic erosion require intensive management intervention now to prevent extinction cascades.

Protecting the Northern Tien Shan's endemic and relict flora demands urgent, targeted conservation actions combining legal protection, habitat restoration, sustainable resource management, and international cooperation. Investment in botanical research, conservation capacity building, and monitoring infrastructure provides essential foundations for effective long-term protection. By safeguarding these ancient plants and their evolutionary legacies, we ensure the survival of irreplaceable biodiversity and maintain the ecological resilience of Central Asian mountain ecosystems for future generations. The Northern Tien Shan's botanical treasures represent a global heritage deserving comprehensive conservation commitment.