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

LECTURE 6

Analysis of endemic and relict plants of the sandy desert

Lecturer: Doctor of Biological Sciences, Professor Kurmanbayeva M.S.

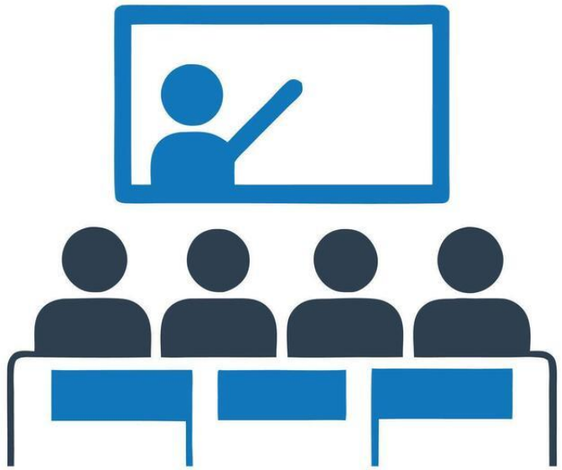
Course title:Conservation of Rare and Endangered Plant Species

LESSON PLAN (50 MIN)

1. INTRODUCTION (5 MIN)
Topic and goals of the lesson.
Distribution of sandy deserts (kyzylkum, moyynkum, aral karakum).
Importance of desert ecosystems.
2. Main part (35 min)
Key terms (5 min): endemic, relict, xerophyte.
Environmental features (5 min): high temperature, aridity, sandy soils.
Examples of species (20 min):

Endemic: calligonum leucocladum, ammodendron conollyi, tulipa buhseana.
Relict: haloxylon persicum, ephedra lomatolepis.
Adaptations: deep roots, reduced leaves, water storage tissues.

Conservation (5 min): threats (overgrazing, desertification), protected areas (altyn-emel, barsakelmes).
3. Conclusion (10 min)
Summary of key ideas.
Discussion: “how do plants survive in sandy deserts?”
Homework: short report on one endemic or relict desert plant.



Chesneya dshungarica — P.P. Smirn

Allium inderiense Regel

Endemic and Relict Plants of the Sandy Desert

Survival, Adaptation, and Conservation in Earth's Most Extreme Environments

Grass Aloe L

Understanding Endemic and Relict Plants

Desert ecosystems harbour two extraordinary categories of plants that represent millions of years of evolutionary history and climatic change. These botanical treasures reveal how life persists and adapts in the harshest terrestrial environments on Earth.

Endemic Plants

Species that are native to and found exclusively within a specific geographic region, typically a desert area or mountain range. They represent unique evolutionary lineages shaped by millions of years of geographic isolation and local environmental pressures.

Relict Plants

Ancient survivors from past climates and geological periods, persisting in protected microhabitats long after their original range has disappeared. They are living fossils, connecting modern deserts to tropical or subtropical vegetation belts of the Tertiary period.

Both groups are crucial for understanding desert biodiversity and ecosystem stability. Endemic plants reflect current adaptive radiation and speciation, whilst relict plants demonstrate the remarkable persistence of life across profound environmental transitions. Together, they form the botanical foundation of desert ecosystems and provide invaluable insights into climate change resilience.

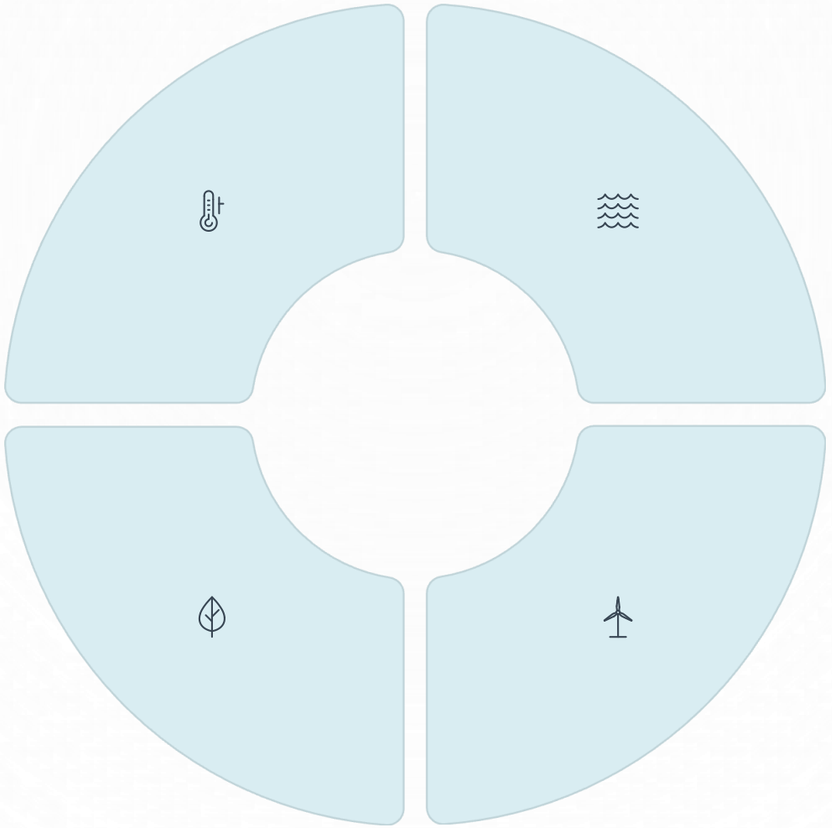
Understanding Endemic and Relict Plants

Plant Co*astal Cliffs* Coast Caspian Sea Stock

Relict *Trillium* Flower Bud - Encyclopedia of Alabama

Extreme Temperatures

Daily fluctuations exceeding 50°C, with surface temperatures reaching 70°C or higher during summer months



Scarce Water

Annual precipitation often below 100 mm, concentrated in brief seasonal storms with years of drought

Xerophytic Flora

Drought-tolerant shrubs and specialised plants dominate, comprising the dominant vegetation layer

Shifting Sands

Mobile dunes reshape the landscape constantly, creating unstable substrates for plant establishment

THE SANDY DESERT ECOSYSTEM: A HARSH BUT BIODIVERSE HABITAT

- Sandy deserts present some of the most inhospitable conditions on earth, yet paradoxically harbour remarkable botanical diversity. These ecosystems are dominated by a sophisticated array of drought-tolerant shrubs and xerophytes that have evolved extraordinary mechanisms for water conservation and temperature regulation. The extreme environmental pressures—from intense solar radiation and temperature swings to chronic water scarcity—have shaped a unique endemic flora over millennia of isolation and countless climate shifts.
- The sandy desert's apparent barrenness masks a complex network of microhabitats, each supporting specialised plant communities. From interdune depressions where moisture accumulates to windswept crests where only the most resilient species survive, these landscapes support endemic plants found nowhere else on earth. The stability of these microclimates, protected from the harshest conditions by subtle topographic features, has allowed populations to persist and evolve in isolation, generating the extraordinary endemism found throughout the world's sandy deserts.

Case Study: Alashan Desert Shrubs

A comprehensive comparative study examining ten dominant shrub species from Mongolia's Alashan Desert reveals fundamental differences in how relict and endemic plants respond to environmental change. This research provides crucial insights into differential climate vulnerability and evolutionary resilience.

Ammopiptanthus mongolicus (Relict)

- Relict species from Tertiary tropical vegetation
- Shows stable or expanding suitable habitats under climate change scenarios
- Broader geographic range tolerance
- Greater phenotypic plasticity

Kalidium foliatum (Endemic)

- Typical desert endemic with restricted distribution
- Faces significant habitat reduction and northward range shifts
- Narrow climatic tolerance window
- Highly specialised to specific soil and water conditions

The divergent responses reflect a crucial principle: relict plants' longer evolutionary history and survival across multiple climatic cycles grant them broader climate tolerance and greater physiological flexibility. This adaptive capacity enables relicts to persist through environmental change that would extirpate narrowly specialised endemic species. Conversely, endemic plants' tight ecological specialisation, whilst making them superb competitors within their restricted niches, renders them vulnerable to rapid climate shifts that exceed their evolved tolerance ranges.

Pleistocene Refugia: Islands of Stability in an Unstable World

In the southern Central Desert of Oman lies a remarkable hotspot of botanical endemism—a monsoon-influenced refugium that has sheltered ancient plant lineages for millions of years. This small region hosts seven narrow-range endemic plants that exist nowhere else on Earth, maintained by a stable microclimate that has persisted since the Pleistocene epoch.

Ancient Tropical Connection

This refugium represents a remnant of the ancient tropical vegetation belt that once stretched from Africa across Asia. When global climates cooled and dried, most of this belt vanished, but isolated pockets persisted in protected locations with favourable microclimates.

Microclimate Protection

Monsoon influences deliver seasonal moisture, whilst topography and geology create thermal stability. These microclimatic features have remained relatively unchanged for millions of years, allowing endemic lineages to persist in a biological time capsule.

Conservation Implications

Such refugia represent the most vulnerable yet invaluable reservoirs of endemic biodiversity. Their limited extent and dependence on stable microclimates make them exceptionally sensitive to habitat disturbance and climate change impacts.

Spotlight: Incarvillea semiretschenskia

A rare relict species endemic to the Shu-Ile mountains of Kazakhstan exemplifies the precarious existence of many desert endemics in the modern era. This remarkable xerophytic dwarf semishrub represents a living connection to ancient climatic regimes whilst facing contemporary extinction threats.

1

Botanical Description

Incarvillea semiretschenskia grows as a low-growing semishrub, reaching only 70 centimetres in height. Its most distinctive feature is its striking bright pink tubular flowers, which bloom during the brief growing season and attract specialist pollinators adapted to mountain desert conditions.

2

Geographic Isolation

This species occupies an extremely fragmented distribution restricted to high-altitude locations in the Shu-Ile mountains. The fragmentation reflects both natural range limitations and historical habitat loss, isolating populations into discontinuous remnant patches.

3

Threats and Conservation

Human activities including overgrazing, habitat disturbance, and development pose escalating threats. Conservation efforts include seed propagation programmes, cultivation in botanical gardens, and rigorous habitat monitoring to track population dynamics and guide intervention strategies.

Climate Change Impact: Range Shifts and Habitat Fragmentation

Contemporary climate change is fundamentally reshaping the geographic distribution and habitat suitability for desert endemic and relict plants. Research across Egypt and the St. Catherine Protected Area reveals alarming trends in range contraction, habitat loss, and altitudinal shifts that threaten species with restricted distributions.

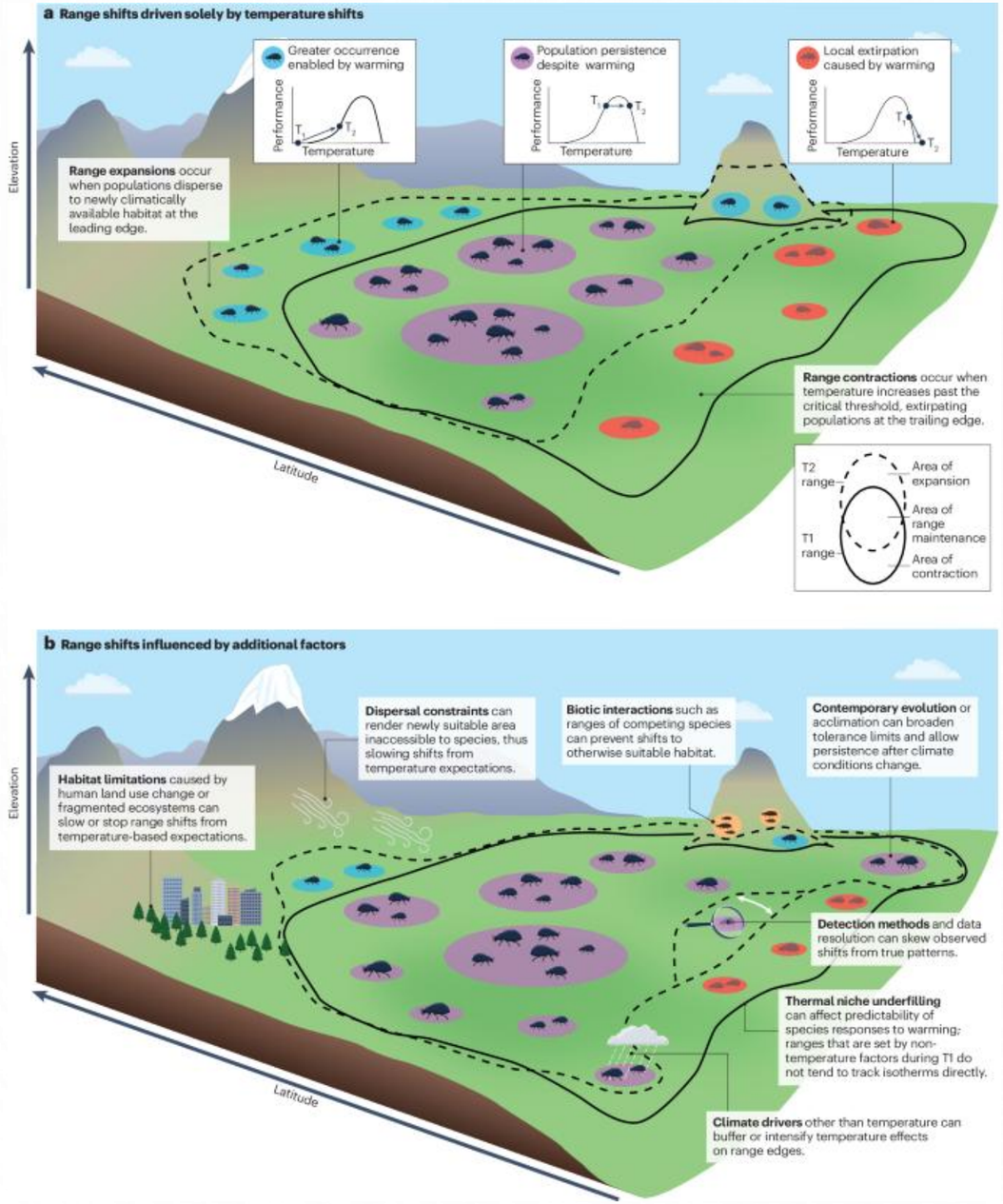
Threats

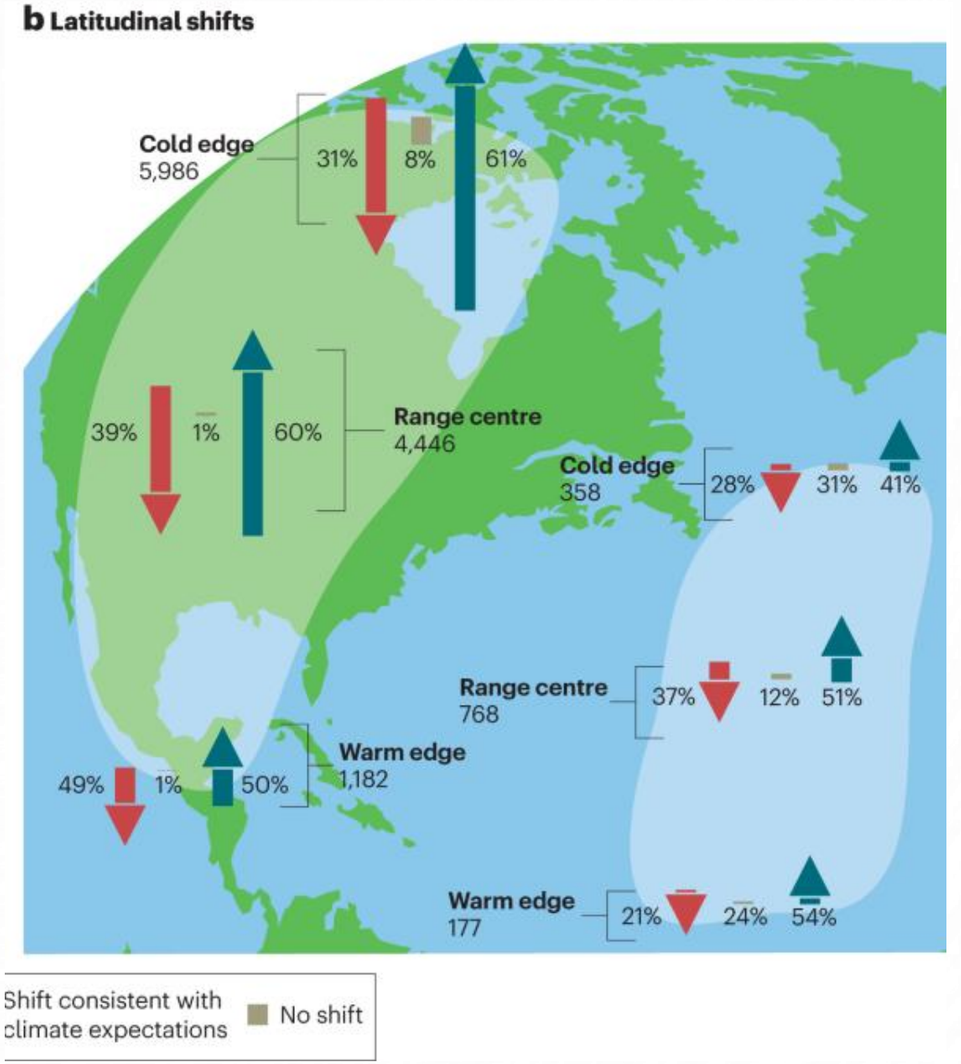
- Altitudinal shifts as species move upslope seeking cooler conditions
- Suitable habitats declining 40% by 2070 for some species
- Range fragmentation isolating populations
- Mismatch between changing climate and species' climatic envelopes

Opportunities

- Some species like Rosa arabica show stable or expanding ranges
- New discoveries expanding known distributions
- Rehabilitation programmes creating habitat corridors
- Refugia provide climate-stable locations for persistence

Species distribution modelling projections reveal a complex future landscape. Whilst many endemic species face significant habitat contraction, particularly those with narrow ecological tolerances, some demonstrate surprising resilience. The capacity for upslope migration, enabled by topographic relief in mountain desert regions, offers some endemic species a potential refuge from warming. However, this adaptation opportunity is constrained by the limited vertical extent of many desert mountains and the availability of suitable microclimates at higher elevations.


a Range shifts driven solely by temperature shifts
Greater occurrence enabled by warming
Population persistence despite warming
Local extirpation caused by warming
Performance
Temperature
Elevation
Latitude
Range expansions occur when populations disperse to newly climatically available habitat at the leading edge.
Range contractions occur when temperature increases past the critical threshold, extirpating populations at the trailing edge.
T2 range
T1 range
Area of expansion
Area of range maintenance
Area of contraction
b Range shifts influenced by additional factors
Dispersal constraints can render newly suitable area inaccessible to species, thus slowing shifts from temperature expectations.
Biotic interactions such as ranges of competing species can prevent shifts to otherwise suitable habitat.
Contemporary evolution or acclimation can broaden tolerance limits and allow persistence after climate conditions change.
Habitat limitations caused by human land use change or fragmented ecosystems can slow or stop range shifts from temperature-based expectations.
Detection methods and data resolution can skew observed shifts from true patterns.
Thermal niche underfilling can affect predictability of species responses to warming; ranges that are set by non-temperature factors during T1 do not tend to track isotherms directly.
Climate drivers other than temperature can buffer or intensify temperature effects on range edges.


b Latitudinal shifts
Cold edge
5,986
31%
8%
61%
39%
1%
60%
Range centre
4,446
Cold edge
358
28%
31%
41%
Range centre
768
37%
12%
51%
Warm edge
1,182
49%
1%
50%
Warm edge
177
21%
24%
54%
Shift consistent with climate expectations
No shift

Conservation Challenges and Strategic Responses

Protecting desert endemic and relict plants requires multifaceted approaches addressing both immediate threats and long-term climate uncertainties. The complexity of these challenges demands integrated strategies combining scientific knowledge, policy instruments, and community engagement.

01

Threat Assessment and Monitoring

Systematic monitoring using species distribution models and field surveys to track population dynamics, range shifts, and habitat condition changes. Early warning systems enable rapid intervention when populations decline below critical thresholds.

02

Protected Area Management

Establish and effectively manage protected areas encompassing representative endemic habitats. Network design should ensure connectivity between refugia and incorporate predicted future suitable habitats to maintain climate-adaptive corridors.

03

Ex-Situ Conservation

Seed banks preserve genetic diversity as insurance against extinction. Botanical garden cultivation maintains viable populations outside wild habitats, enabling future reintroduction programmes and providing material for ecological restoration.

04

Habitat Restoration

Active restoration of degraded habitats through invasive species removal, grazing management, and revegetation. Restoration efforts focus on recreating conditions supporting endemic communities and maintaining ecological corridors.

05

Threat Mitigation

Address anthropogenic pressures including overgrazing, land degradation, and habitat fragmentation through sustainable land management practices and stakeholder engagement.

06

Public Awareness

Education campaigns highlighting the cultural, ecological, and scientific value of desert botanical heritage. Community engagement transforms local populations into conservation partners and stewards.

Protecting Desert Botanical Heritage for the Future

Endemic and relict plants of sandy deserts represent irreplaceable components of Earth's biodiversity and living archives of climatic history. Their survival into the future depends on immediate, coordinated action grounded in scientific understanding and conservation commitment.

Living Links to the Past

These plants represent millions of years of evolutionary history, connecting modern deserts to ancient tropical vegetation belts and revealing how life persists through profound climatic transitions.

Ecosystem Foundations

Endemic and relict species form the structural and functional basis of desert ecosystems, supporting specialist fauna and maintaining ecological processes essential for desert stability.

Scientific Treasures

These plants offer unique insights into adaptation, speciation, and climate resilience, advancing understanding of how life responds to environmental change across evolutionary timescales.

Cultural Heritage

Desert botanical diversity constitutes a global heritage of immeasurable cultural and scientific value, transcending national boundaries and belonging to all humanity.

The path forward requires integrated conservation combining habitat protection, ex-situ preservation, and threat mitigation within a framework of genuine international cooperation. Investment in desert botanical science, protection of critical refugia, and comprehensive threat reduction offers the greatest prospect for ensuring these remarkable plants persist into a rapidly changing future. The endemic and relict flora of sandy deserts deserve recognition as global treasures worthy of our most determined conservation efforts and scientific attention.