Shaping Forces of Biodiversity in the Arctic

IASC workshop, Reykjavík January 21-22, 2013 - Workshop Summary

Aim and Motivation:

Knowledge on Biodiversity in the Arctic is still rather fragmented, but both documentation and monitoring is gaining increasing attention by various organisations and research groups (CAFF/CBMP, INTERACT, and others). Through these activities we will gradually gain understanding of biodiversity patterns within various groups of organisms and, eventually, how they change in response to different drivers. Some of these initiatives mention a plethora of forces that shape biodiversity, ranging from global scale factors such as climate change to local scale processes such as various biotic interactions. However, not much focus has been put on identification of possible commonalities and patterns in this plethora of shaping forces.

A coherent approach to studies of shaping forces of biodiversity across various organism groups and scales would provide a deeper understanding of what drives diversifying processes and how they interact. Such understanding will greatly improve design of adaptive monitoring and management plans in the face of climate change as well as increased human impact in the Arctic.

The aim of the workshop was to outline the shaping forces of biodiversity in the Arctic across temporal and spatial scales in search for commonalities across biological hierarchies and organism groups.

The questions set out for discussion were

- What shapes biodiversity in the Arctic?
- Are the shaping forces/factors different according to:
  - Organism groups?
  - Taxonomic levels within organism groups?
  - Habitats?
  - Ecological function?
  - Spatial scales?
  - Temporal scales?
- Is it possible to build a coherent research framework to address the main question?

Scope of discussion

We used a relatively broad definition of biodiversity: The variety of biological units within and among population, community (species diversity), and

ecosystem levels, including both structural (taxonomic) as well as functional diversities (functional groups, life history traits/ strategies). The discussion encompassed both the Arctic as defined by the Circumpolar Arctic Vegetation Map (Walker et al. 2005) as well as the Subarctic.

We agreed on focusing on processes that affect diversity at different biological hierarchies and the forces (internal/biotic and external) that affect the processes at various spatial and temporal scales. Using such a broad definition of biodiversity demands that we identify both ecological and evolutionary processes that affect diversity. However, the main focus was on ecological time scales although historical processes were taken into account when relevant.

Workshop outcome

A large number of potential shaping forces were discussed and at which scales they operate in space and time. A special emphasis was on distinguishing between external and internal forces, how they interact and whether they differ between small and large organisms. Some of these forces are listed below according to the spatial scale at which they are most likely to operate. The list is by far complete but may serve as a first step in identifying the key shaping forces.

A variety of conceptual models were discussed to link the spatial and temporal scales at which the different forces operate. These models considered aspects like differences between internal and external shaping forces among organism groups, modes of colonisation (arrival, establishment, extinction) and the speed of change (force operation) in combination with spatial scales.

Many un-answered questions related to shaping forces of biodiversity were brought up, such as:

- Will the temporal and spatial scales at which these forces operate change in the future?
- How will changing external forces (with climate change) affect the importance of internal forces?
- Are the processes that shaped current patterns (historically) the same as the processes that are currently operating? Have scales changed, i.e. the speed of change? Have new forces been introduced (the human factor, large scale thermocasts)?
- How can we improve predictions about how biodiversity in the Arctic will change in the future?

Regarding the questions set out for discussion we summarised that there are both commonalities and differences in shaping forces across biological hierarchies or taxons. The commonalities are particularly seen among the internal forces. For instance, microbiological as well as macrobiological systems include predator-prey food web relationships and competition for resources is a shaping force within all organism groups. Differences in organism size and/or mobility are, however, likely to result in differences in external shaping forces.

We also concluded that a coherent research framework with focus on processes that affect diversity and those forces that affect them would be of great value for testing hypothesis about biodiversity trends in the face of climate change and other environmental changes. The group agreed to continue to develop the ideas discussed during the workshop aiming at writing them up in a scientific paper. In that process we will explore the feasibility of using available data to test hypotheses.

List of potential shaping forces

External shaping forces operating at least partly at a circumpolar scale

- Glacial history (the species currently inhabiting the Arctic have a proven ability to recolonize recurrently glaciated areas. Glacial dynamics acts as an environmental filter on the species pool)
- Air temperature
- Evapotranspiration
- Snow/ice
- Hydrology (For instance, microbial diversity may be mainly determined by dynamics of soil water.)
- Aerosols

External shaping forces operating only at regional scale or smaller

- Human activities
    - Land use (e.g. management and conservation)
    - Resource exploitation and utilization (e.g. mining)
    - Human mobility (e.g. tourism, shipping etc)
- Water temperature/sea currents/proximity to the sea
- Connectivity/habitat fragmentation within a system (e.g. terrestrial) and between e.g. terrestrial, freshwater and marine systems
- Regional barriers to dispersal
    - Examples: Brown lemming not in Ellesmere, no lemming or Arctic hare in Iceland, no Arctic hare or large mammal predators in Svalbard, etc.
- Permafrost dynamics (continuous, discontinuous and sporadic in horizontal dimension, variable thickness in vertical dimention)
- Geology, bedrock/pH
- Precipitation patterns
- Nutrients

External shaping forces operating only at a local or smaller scale

- Geochemical influence on soils and freshwater systems
- Stream order and persistence spring, tundra, mountain, larger river (size of catchment; discharge periodicity)
- Landscape mosaics
    - Topography
    - Soil moisture
- Wind
- Ice cover duration and thermal regimes of lakes

- Natural disturbances (erosion, periglacial processes)
- Vertical structure with depth in soil /depth in lakes / altitude
- Microscale variation in physical, chemical and biological properties (1-10 cm)
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Internal to organisms – always happening locally at the different levels of the biological hierarchy

- Mobility
    - Dispersal/establishment limitation
    - Escape from predators/competitors/parasites
    - No dispersal limit for microbes; more limits for plants; much more for animals
- Biotic interactions
    - Horizontal interactions – competition (low-arctic) and facilitation (high-arctic), (which may be more important in the Arctic than elsewhere)
    - Vertical interactions – trophic interactions (predator-prey, mutualism and parasitism)
    - Vegetation communities (shrubs dominance)
    - Animal communities (e.g. bird colonies and nests)
    - Herbivory as disturbance
    - Invasive species
- Evolutionary processes: Adaptation – abilities of species to adapt to environmental change
- Buffering capacities of biodiversity

Feedbacks between biotic and abiotic shaping forces

- Plant change soils, which in turn changes diversity (ecosystem engineers).
    - Shrubs
    - Mosses
- Seabirds as transporters of nutrients and contaminants from sea to land.

Are the forces the same in the Low Arctic and the High Arctic?

- Facilitation is likely to be of greater importance in the High Arctic as opposed to competition in the Low Arctic.
- Strong environmental filters are likely to operate in the High Arctic while biotic interactions may be stronger in the Low Arctic.

Are the factors that shape diversity in small organisms the same as those that affect large organisms?

Processes that affect small species (microbes, micro-invertebrates) are likely to be affected by forces that operate at the same spatial scale.

Are there any forces that are specific to the Arctic compared to Antarctica?

The comparison with terrestrial Antarctica helps sharpen the discussion about the shaping forces of biodiversity in the Arctic.

- Lower terrestrial connectivity in Antarctica. Humans are linking parts of the Arctic to a greater degree than in Antarctica for example through increasing human mobility and access to the Arctic.
- Permafrost dynamics
- Temperate species (birds) migrating to the Arctic
- Migration routes

Short description of the Workshop aims and outcome

The aim of the workshop was to outline the shaping forces of biodiversity in the Arctic across temporal and spatial scales in search for commonalities across biological hierarchies and organism groups. The workshop identified a large number of potential shaping forces and discussed at which scales they operate in space and time. A special emphasis was on distinguishing between external and internal forces, how they interact and whether they differ between small and large organisms. A variety of conceptual models were discussed.

The workshop concluded that there are both commonalities and differences in shaping forces across biological hierarchies and taxons and the commonalities are particularly seen among the internal forces. For instance, microbiological as well as macrobiological systems include predator-prey food web relationships and competition for resources is a shaping force within all organism groups. Differences in organism size and/or mobility are, however, likely to result in differences in external shaping forces. It was also concluded that a coherent research framework with focus on processes that affect diversity and those forces that affect them would be of great value for testing hypotheses about biodiversity trends in the face of climate change and other environmental changes. It was agreed to continue to develop the ideas brought up during the workshop, aiming at writing them up in a scientific paper. In that process we will explore the feasibility of using available data to test hypotheses.

Attached:

- Workshop Agenda
- List of participants
- Three PowerPoint slides on the aim and outcomes of the workshop