Integrated approaches to understanding Svalbard's terrestrial ecosystems

Pete Convey
pcon@bas.ac.uk
www.bas.ac.uk

Overview

- Brief background on general features of terrestrial ecosystems and biodiversity
- Biodiversity drivers – extreme environments, but primarily water and nutrients
- Transfer from sea to land (and v.v.), positive and negative impacts on biodiversity
- Other linkages – glacier ecosystems and melt, freshwater systems
- Human impacts

Svalbard – High Arctic

Terrestrial and Freshwater Food Webs

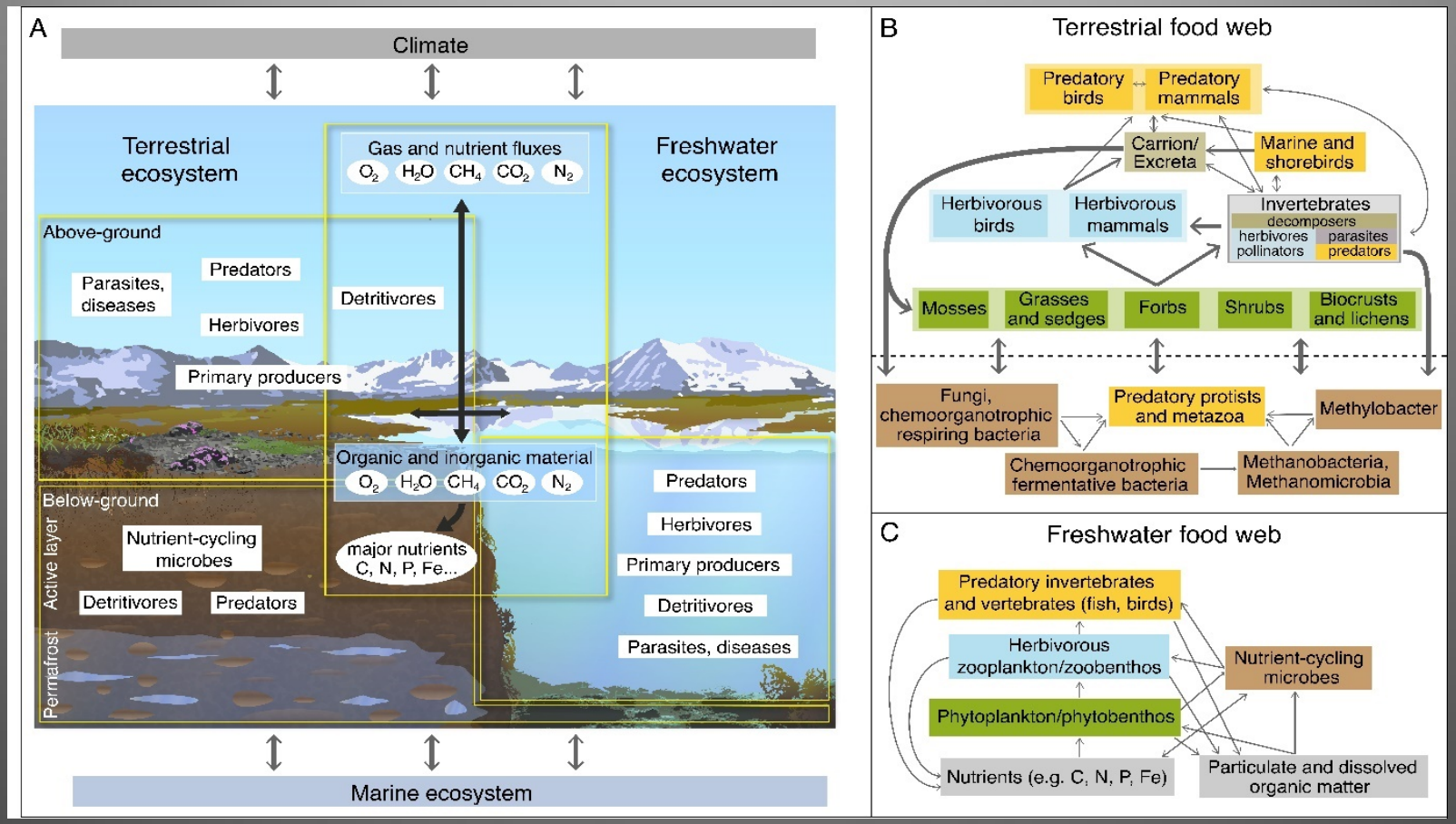


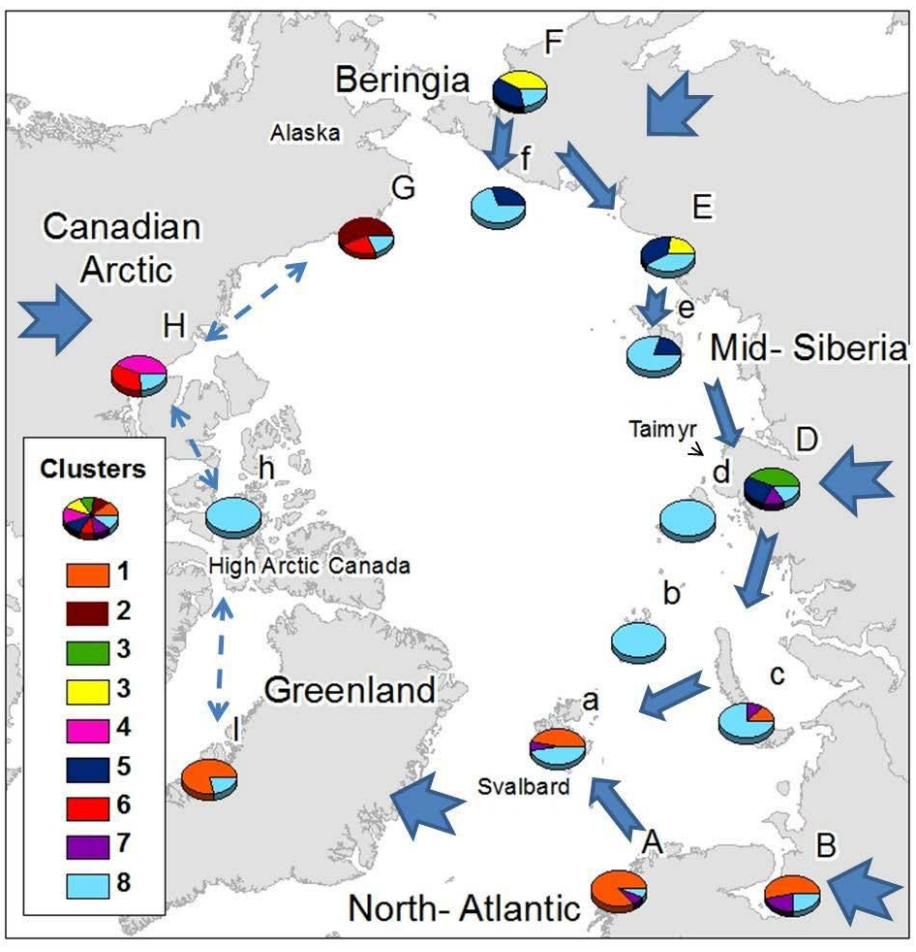
Figure by Elise Biersa; Pedersen et al. In review Polar Res; all rights reserved

Terrestrial Biodiversity Drivers

- Polar environments generally considered extreme, with physical environmental stressors more important than biological; esp water availability, snow cover, temperature, change trends
- Soils generally poorly developed and nutrient poor
- Large expanses technically deserts, low precipitation, high desiccation
- Range of biological factors can be influential, often at smaller physical scales – nutrient enrichment, grazing, competition (though predation/parasitism poorly characterised), human impacts (e.g. trampling, fragmentation, invasions)

History of Svalbard Biodiversity

- Across Arctic, generally accepted view is that terrestrial biota is relatively rich and diverse, but of recent origin
- Successive cycles of postglacial S-N movement from refugia; also patterns indicative of ocean and wind currents
- Suggestions of regional refugia – Beringia, Siberia, Canada, Greenland; but very few fine-scaled studies
- Evidence for ice-free ground, plants (Westergaard et al. 2011 Molec Ecol) and freshwater habitats on Svalbard....
- V rapid post-glacial colonisation on land and fw ?implies local refugia, but low endemism implies reverse
- Molecular phylogeography yet to be applied widely…



Avila-Jimenez 2011 PhD; Avila-Jimenez & Coulson 2012 *Insects*

Climate Change

Svalbard, particularly western Spitsbergen, experiencing considerable changes in multiple environmental variables of biological relevance; Example of ‘polar amplification’

Key include warming, changed precipitation, increased rainfall, ‘rain on snow’ events in winter, depth and duration of snow cover

Multiple biological impacts observed at different levels of organisation, from cellular processes to ecosystems and biogeography

Potential ‘step change’ in microbial community composition with soil warming

Svalbard a ‘canary in the coalmine’ for Arctic change responses

REMUS experiment (Newsham) – warming and precipitation effects on soil microbial community and plant interactions

Changing snow depth strongly influences soil temperature, likely to influence invertebrate winter survival and distribution Convey et al. 2015 J. Thermal Biol

Photos Elise Biersma, Steve Coulson, all rights reserved

Links Between Sea and Land

- Seaspray
- Marine vertebrates – scale from point source to vast colonies
- Fertilisation and mechanical disturbance – intense manuring severely restricts biodiversity, tails off with distance
- Eutrophication in freshwater systems

‘Point’ Sources of Nutrients

Vertebrate Aggregations

RESEARCH/REVIEW ARTICLE

Is ornithogenic fertilization important for collembolan communities in Arctic terrestrial ecosystems?

Katarzyna Zmudczyńska-Skarbek,[1] Adrian Zwolicki,[1] Peter Convey,[2] Mateusz Barcikowski[1] & Lech Stempniewicz[1]

Polar Rese

Polar Biol
DOI 10.1007/s00300-012-1169-4

ORIGINAL PAPER

Influence of allochtonous nutrients delivered by colonial seabirds on soil collembolan communities on Spitsbergen

Katarzyna Zmudczyńska · Izabela Olejniczak · Adrian Zwolicki · Lech Iliszko · Peter Convey · Lech Stempniewicz

Polar Biol (2015) 38:1645–1655
DOI 10.1007/s00300-015-1730-z

ORIGINAL PAPER

Seabird colony effects on soil properties and vegetation zonation patterns on King George Island, Maritime Antarctic

Adrian Zwolicki[1] · Mateusz Barcikowski[1] · Adam Barcikowski[2] · Mariusz Cymerski[4] · Lech Stempniewicz[1] · Peter Convey[3]

Fertilisation effects on High Arctic vegetation widely appreciated, ‘bird cliffs’ – exceptional biomass of subset of plant species; often combined with microclimate

Clear association with invertebrate abundance and diversity, some species only found in such habitats

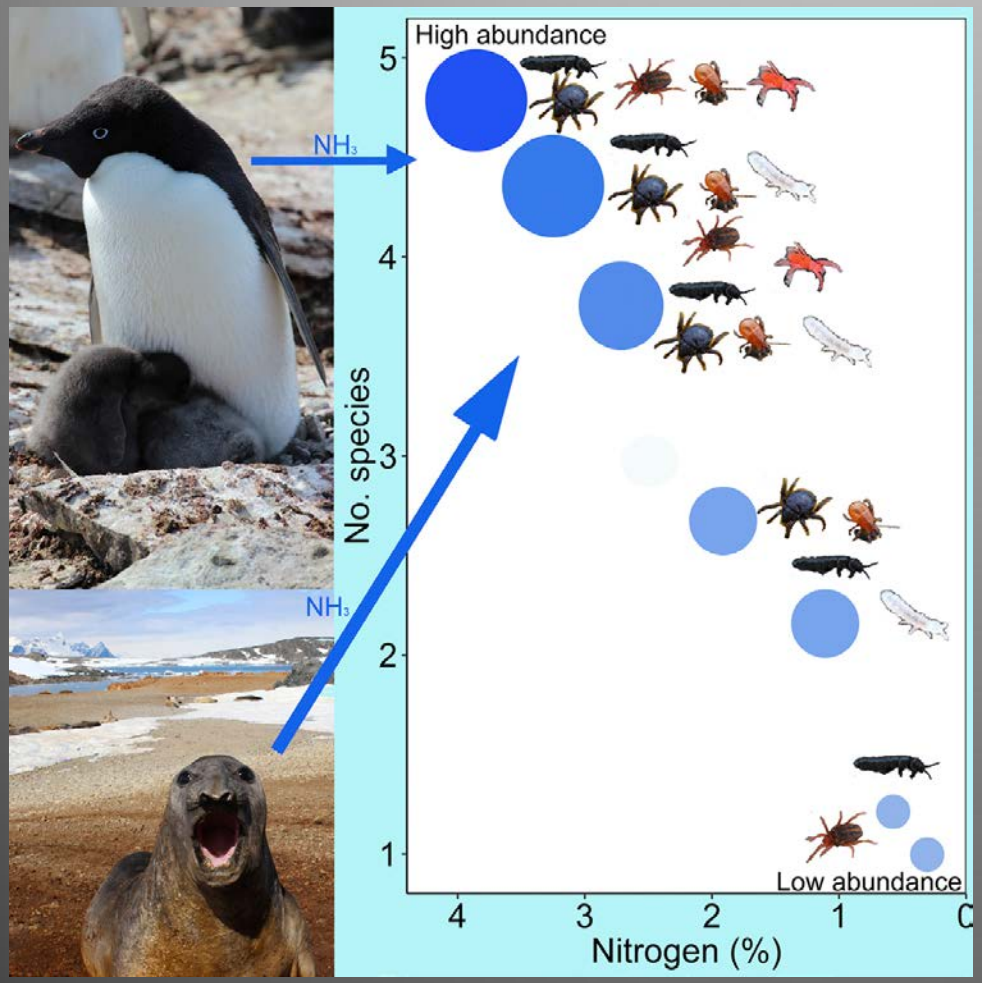
Few attempts as yet to trace flow of nutrients into and through terrestrial systems

At v small scale certain lichens associated with point ornithogenic nutrient source (e.g. *Xanthoria*). Could even underlie well-known patchiness of tundra vegetation and fauna

Report

Current Biology

Nitrogen Inputs by Marine Vertebrates Drive Abundance and Richness in Antarctic Terrestrial Ecosystems



- Antarctic penguins and elephant seals transfer nitrogen from the sea to land
- Antarctic vegetation is nitrogen enriched well beyond the colony borders
- Terrestrial biodiversity is higher within the nitrogen enrichment footprint
- Stable isotopes confirm flow into and through terrestrial foodweb
- Biodiversity hotspots can be predicted from penguin and elephant seal presence

Bokhorst et al. 2007 Polar Biol, 2019 Curr Biol, 2019 Polar Res

Back to the Sea?

Despite clear isotopic enrichment of terrestrial vegetation, effect of runoff in adjacent sea less clear, may be through pelagic-benthic coupling, not on benthos directly

An assessment of seabird influence on Arctic coastal benthic communities

Katarzyna Zmudczyńska-Skarbek [a,*], Piotr Balazy [b], Piotr Kuklinski [b,c]

Don't underestimate snow algae – in some areas significant biomass and production … runoff fertilises and possibly inoculates adjoining terrestrial and marine habitats

https://doi.org/10.1038/s41467-020-16018-w OPEN

Remote sensing reveals Antarctic green snow algae as important terrestrial carbon sink

Andrew Gray [1,2✉], Monika Krolikowski [1], Peter Fretwell[3], Peter Convey [3], Lloyd S. Peck [3], Monika Mendelova [4], Alison G. Smith [1] & Matthew P. Davey [1✉]

Melt and Freshwater Runoff

Snow and glacial melt carries suspended sediments, nutrients, biological material (inc. microbes) and pollutants between ecosystems

Glacial to terrestrial, freshwater and marine

Source of diversity in glacier forelands

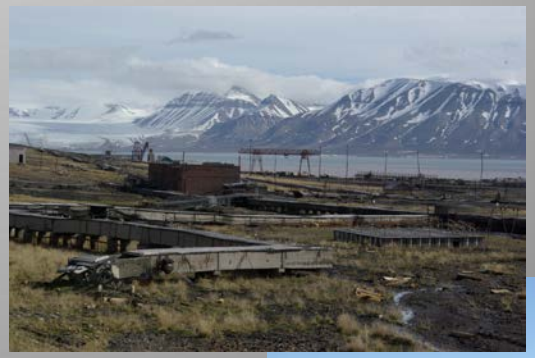
Potentially significant fixation of nutrients and carbon by glacier surface (cryoconite) communities

Tangential Thoughts…

Marine vertebrates transfer more than nutrients: can concentrate heavy metals, and also transfer microbial diversity, at least as far as colony soils.

Long-range atmospheric or marine transport of pollutants, can enter and be concentrated in both marine and terrestrial food chains

Also Svalbard-specific sources of local pollution, generally from historic mining, also shipping, oil spills; heavy metals released and enter terrestrial and nearshore marine foodwebs



Yew et al. 2017 Polar Biol; Pedersen et al. In review Polar Res.

Biological Invasions

- Humans are primary source of new colonists in polar regions
- Multiple viable plant seeds confirmed in surveys of arriving passengers at Longyearbyen
- Known plant and invertebrate introductions currently few on Svalbard, limited to settlements (esp. Barentsburg, Pyramiden), but little survey effort to date
- Hypothesised association with wholesale import of continental soil to those mining settlements

Ware et al 2011 Biol Invasions; Coulson et al.2013 Biol Invasions, 2015 Polar Res; Bartlett et al. 2021 Ecol Solutions Evidence

Overview

- Svalbard has well developed terrestrial diversity and ecosystems, though in reality much baseline survey data is still required
- Key location for understanding impacts of multiple aspects of climate change and their synergies on terrestrial ecosystems
- Marine-derived nutrients arrive on land primarily via marine vertebrates, physical scale of fertilised areas can be v small (single nest, carcass, defecation event), to v large colonies
- Clear but poorly quantified links between glacial, terrestrial, freshwater and nearshore marine ecosystems through water movement, transferring nutrients, biological material, pollutants etc
- Need for more integrated approaches across multiple ecosystem components and drivers
- Human impacts apparent but as yet mostly localised, specifically from mining history and introduction of non-native species

Unashamed Plug!!

Polar Biology Special Issue open for submissions (closes October 2021):

Pathways and impacts of biotically-mediated marine and other stored nutrient transfer between polar ecosystems

Eds. K. Zmudczyńska-Skarbek, S. Bokhorst, P. Convey


Thank you!