



Herbivory in changing northern and alpine environments

Workshop, Helsinki 9 April 2014

Title of workshop: Herbivory in changing northern and alpine environments

Organizers: Isabel C Barrio, C Guillermo Bueno, David Hik, Ingibjörg Svala Jónsdóttir, Martin Moersdorf, Virve Ravolainen

Location and date: Helsinki, Finland, 9 April 2014

Sponsors of the Workshop: IASC Terrestrial Working Group, Asociación Española de Ecología Terrestre

Workshop summary

The aim of the workshop was to bring together researchers to investigate the role of herbivory in changing northern and alpine ecosystems across large spatial scales, with the goal of laying the foundation for a plant-herbivore interaction-focused research network. 32 researchers from different circum-arctic regions attended this meeting. Overall, there was a broad agreement on the need to consolidate such a research network that, in addition to serving as a platform for communication and exchange among researchers, should be focused on developing common research interests. A fair amount of time during the workshop was devoted to trying to define a common conceptual model, identifying the knowledge gaps of the field and formulating an overarching research question that a collaborative effort may be able to answer. For addressing this question a common, standardized protocol is needed, based on a well-replicated, relatively simple experimental design. The first steps towards this protocol were defined during the workshop. Other points were also discussed at the meeting, including the possibility of writing a multi-authored opinion paper on the workshop outcomes, further development of a manuscript that was presented at the meeting, and the possibility of a joint funding application.

Aim and Motivation

Ongoing changes in the composition of plant and herbivore communities are likely to have a large impact on the dynamics of northern and alpine ecosystems and their ability to respond to changes. However, the impacts of herbivory and its relevance to ecosystem processes have shown wide regional variability, suggesting the importance of other drivers, like cryosphere feedbacks, human management, or other biotic interactions. For example, recent studies have shown that mammalian herbivory may modulate the responses of tundra plant communities and buffer them against the destabilizing effects of climate change. It has also been suggested that grazing management could be used as a strategy to counteract the effects of warming on tundra plant communities. How widespread and how relevant to different herbivore and plant communities this phenomenon is remains unknown. Coordinated efforts are needed to address these questions across different sites and, more importantly, at different spatial scales and from different perspectives. In particular, large scale but region-specific studies can help us further the understanding of the relative roles of the many factors in play, and research networks can facilitate addressing common questions and the use of common protocols to answer them. Plant-herbivore interactions are particularly suited to this effort, given our current understanding of the elements involved.

The aim of the workshop was to bring together researchers from arctic and alpine regions, to lay the foundations of a research network to investigate the role of herbivory in changing northern and alpine terrestrial ecosystems,

across large spatial scales. This network will foster collaborations within and across disciplines and facilitate multi-site comparisons. Ultimately, this collaborative effort will assist in understanding the complexity and variability of the responses of these ecosystems to different drivers of change. Although the idea of this network had been discussed for a long time, it began taking shape during the last ITEX meeting in September 2013, and has been realized now with the organization of this workshop. The workshop had great acceptance among the experts we contacted (88 in total) and, although not all could attend the one-day meeting in Helsinki, most have shown their interest in the follow-up activities of this initiative. In total, 32 participants from 9 different countries attended the workshop; 20 of the participants were early career scientists (17 of them being supported by the Terrestrial Working Group of IASC through Early Career Grants).

Organising this workshop was possible thanks to the support of the Terrestrial Working Group of IASC and the Spanish Ecological Society (AEET). The organising committee was formed by 4 early career researchers and two senior researchers. The logistics of organizing the workshop were greatly facilitated by running the event as part of the Arctic Science Summit Week and the Arctic Observing Summit 2014. The agenda of the workshop included several activities, some of them based on materials that the participants had to prepare in advance. For example, participants were asked to provide feedback on general questions about what they thought should be the priorities of the network, or what will be the main research questions in the field of plant-herbivore interactions in the next 10 years. This information was summarized and presented at the workshop as a starting point for discussions. Also, participants were requested to read two documents that were presented and discussed at the workshop.

Main outcomes and post-workshop activities

As part of the post-workshop activities, we will prepare a multi-authored opinion paper based on the workshop outcomes, a proposal for establishing the Herbivory Network for consideration by IASC, an experimental protocol for monitoring and research of plant-herbivore interactions at different sites, and a manuscript on herbivore hotspots in the Arctic. These activities were initiated during the workshop and will be further developed within the coming months. Potentially, another meeting will be organised as part of the Arctic Biodiversity Conference in Trondheim (Norway), December 2014.

Workshop report

Based on the fruitful discussions held at the workshop, an additional effort will be put into writing a multi-authored opinion paper on the role of herbivory in tundra ecosystems. One of the main points discussed was the broad regional variability of the impacts of herbivores on tundra plant communities, and our lack of understanding of which factors are driving this variability. We also identified important knowledge gaps in this field, such as the relative role of vertebrate and invertebrate herbivores.



Figure 1. The Herbivory Network should focus on research. Word cloud based on participants' feedback on what they considered should be the priorities of the Herbivory Network (<https://www.jasondavies.com/wordcloud/>).

Herbivory Network

Overall, there was a broad agreement among workshop participants on the need of collaborative efforts to address relevant questions across different sites and at different spatial scales, and thus the necessity of consolidating the Herbivory Network. Prior to the workshop a number of priorities for the research network were identified by participants (**Figure 1**). Although it was broadly recognized that the network should serve as a communication platform and favour scientific exchange among researchers, there was a generalized consensus that the Herbivory Network should focus on research and be driven by common scientific goals. It was therefore of utmost importance to identify the common scientific interests during the workshop. A set of criteria were identified to define the main research lines for the Herbivory Network, including the need to address questions with simple, replicated experiments over broad spatial gradients, and to focus on processes for which mechanisms are better understood to gauge the causes of temporal and spatial variation more efficiently.

During the workshop, participants broke up into four smaller discussion groups to define a common conceptual model and an overarching research question for the Herbivory Network. The common conceptual model is shown in **Figure 2**. Plant-herbivore interactions (as depicted by the green inner circle in Figure 2) govern or modify core processes that are fundamental to the functioning of tundra ecosystems: i) biodiversity (*sensu lato*), ii) energy flows and iii) nutrient cycling. In turn, plant-herbivore interactions are deeply affected by environmental change and other external drivers. Plant-herbivore interactions have long been studied in the North, and the general finding is that the role of herbivory is modified by ecosystem-specific ecological conditions, including human pressure. Taking together the importance of herbivory and the context-dependency of the outcomes of this interaction, it is truly a paradox that there are no coordinated, pan-arctic efforts to data collection, and virtually no data layers exist that are comparable on a global scale (and in most cases not even at a regional scale). There is therefore an urgent need to understand the role of herbivory in the pan-arctic north, and to answer the question of how herbivores modulate the responses of tundra environments to rapid environmental change, and more specifically, how does the (temporal and spatial) variability in plants and herbivores affect each other. All these are questions of high relevance to northern people. From one side, herbivory plays a role for northern communities, as many of the herbivorous species are subject to subsistence hunting and herding, and the modifications in ecosystem structure and function that come about due to herbivory will also have consequences to humans. On the other hand, many of the herbivorous animals or their habitats are under human management, hence the herbivory-people relationship is bidirectional. These questions can only be answered through coordinated data collection that focuses on common questions and that targets similar plant-herbivore interactions throughout the pan-arctic. One advantage is that for the natural sciences part of the topic, known methodologies for studying this interaction exist for many organisms, and there are examples of local, landscape and regional scale study designs that have proven to work and that can be –and need to be– modified to harmonise at a global scale. For the social sciences part of the general framework, there are also examples of regional and international research collaborations that focus on ecosystem services such as subsistence hunt and reindeer herding, whose expertise we can build upon.

Overall, two main research questions were thus identified, a broader one relating to the relation of herbivory and the main external drivers and ecosystem processes, and another one which is more focused on herbivory itself:

- 1) How do herbivores modulate the responses of tundra environments to rapid environmental change?
- 2) How does the (temporal and spatial) variability in plants and herbivores affect each other?

A proposal will be written for consideration by IASC to formally establish the Herbivory Network in the next Arctic Science Summit Week 2015 in Toyama (Japan).

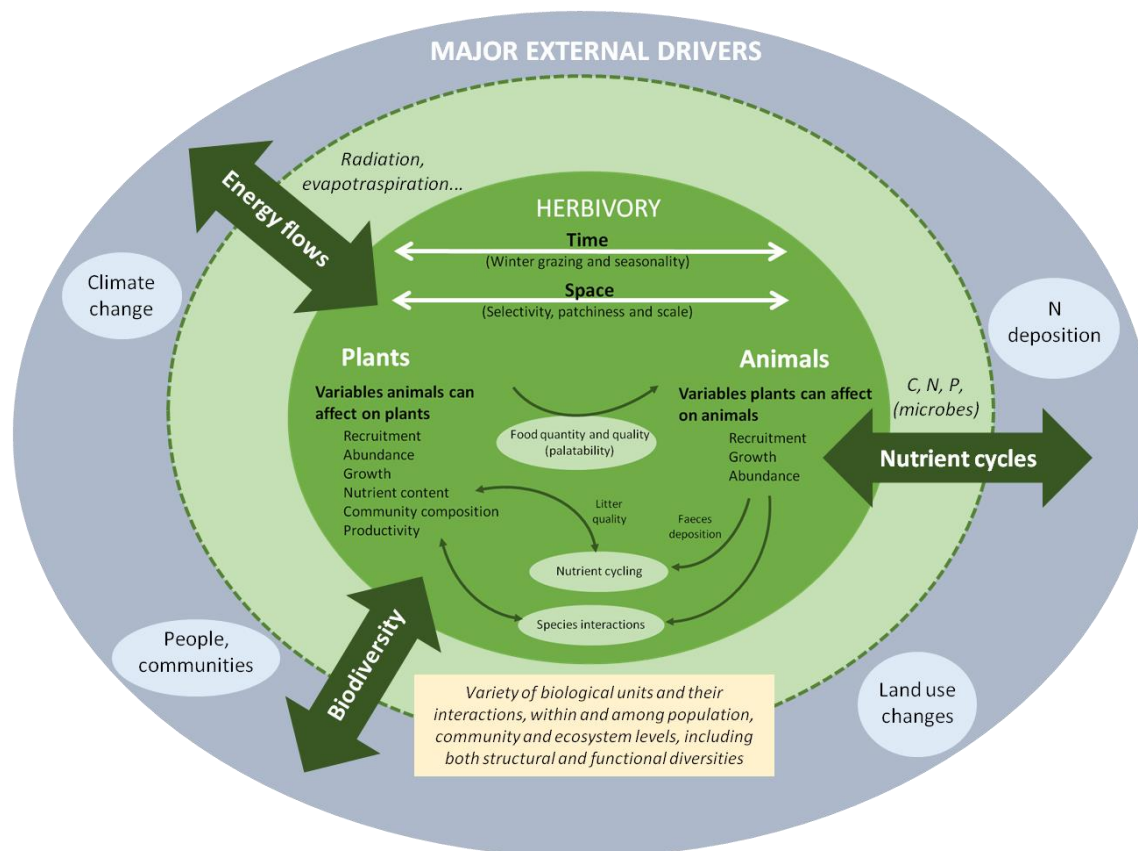


Figure 2. Conceptual framework of the Herbivory Network. The main research questions to be addressed by the Herbivory Network relate to the relationship between herbivory and broad ecosystem processes (and how this is affected by external drivers; outer circles), and to the temporal and spatial variability of the plant-animal interaction (inner circle).

Common experimental protocol

Many participants expressed the need of a common, standardized method to monitor herbivory and its impacts on tundra ecosystems. Based on the research questions defined above, there is consensus that we need a well-replicated experimental approach, over several locations throughout the Arctic (with potential expansion to other alpine sites). There was general agreement on the use of exclosures to manipulate and assess the effects of herbivory. The experiment should focus on some (few) manipulations according to the main herbivores present and be replicated within the landscape, at different sites. Agreeing on where to actually set up the plots in the landscape can be challenging and some guidelines need to be explicitly stated in the protocol. Broadly, locations should cover gradients (i.e. topographic entities, replicated units in comparable habitats but different habitat conditions) and choose habitats representative for the landscape. At the experimental sites, basic measurements of herbivory would be taken from exclosures and 'control' plots (with herbivores), both from the plant and the animal perspective. As an add-on to the basic protocol, other measures could be taken, including soil nutrients and meteorological data to evaluate energy fluxes.

'Herbivore hotspots' manuscript

At the workshop, a brief presentation introduced the idea of defining hotspots of herbivore diversity in the Arctic. So far, this analysis has only been pursued for mammals and birds, because comparable information for invertebrate herbivores at such a broad spatial scale is lacking. The immediate question is what explains the occurrence of these hotspots of herbivore species richness, and a first approach is to use the Normalized Difference Vegetation Index (NDVI) as a surrogate of plant productivity. Overall, some trends are found: herbivore

species richness is related to NDVI, but this relationship is not obvious for the Subarctic. Also, these relationships are slightly different for bird and mammal herbivores. Participants provided some input on what they felt was missing in the analyses and could explain the observed trends. This idea will be developed after the workshop by a core writing group, but contributions of other workshop participants are welcome. Further contributions will be done after the workshop by e-mail.



Herbivory workshop at ASSW-AOS 2014 (Photo: Maite Gartzia).

Appendices

- Appendix 1. Workshop agenda
- Appendix 2. List of participants
- Appendix 3. PowerPoint slides on the aim and outcomes of the workshop

Appendix 1. Workshop agenda

Herbivory in changing northern and alpine environments

WORKSHOP AGENDA – 9 April 2014	
	DYNAMICUM Rooms Aqua/Terra
9:00-10:30	Opening of Herbivory Workshop: presentation and overview of workshop goals Brief presentation of ongoing research questions by workshop participants
10:30-11:00	COFFEE BREAK
11:00-12:00 12:00-12:30	Key research questions and topics, geographic and scientific knowledge gaps Setting the network's scientific strategy, aims and priority research questions
12:30-14:00	LUNCH
14:00-15:00	Herbivore hotspots (and coldspots) in the Arctic <ul style="list-style-type: none">• Can we find such? Presenting and discussing an idea for a collaborative review
15:00-15:30	Towards standardized, adaptable protocol(s) for measuring herbivory <ul style="list-style-type: none">• What are we already measuring? – responses to the questionnaire• What is the purpose of the upcoming protocol?
15:30-16:00	COFFEE BREAK
16:00-16:30	Roadmap for the protocol – work <ul style="list-style-type: none">• What needs to be measured (and how)?• Main caveats and how to address them – the issues of scale
16:30-17:30	Practical organisation of a network <ul style="list-style-type: none">• Working groups, funding opportunities and partnerships
19:00	(Optional) post-workshop dinner

Advance materials for workshop participants

- **Presentation and feedback slides:** workshop participants will be asked to send to the organizers some slides in advance of the meeting. These slides will be based on a template and will involve answering some questions and a one-slide presentation of their study site and research questions. Feedback slides will be used as feedback for the 'Key research questions' session in the morning; participants will have 1-2 min to briefly introduce their presentation slide in the first morning session.
- **Readings:** one week before the workshop, participants will receive two documents (a preliminary assessment of herbivore hotspots in the Arctic and an example of herbivory protocol), which will serve as a starting point for discussions in the early afternoon sessions.

Appendix 2. List of participants

Participant	country	affiliation	email	stage
Isabel C Barrio	CA	University of Alberta	icbarrio@gmail.com	EC*
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NOTE: S: senior researcher, EC: early career researcher, * supported by TWG IASC early career grants

Appendix 3. PowerPoint slides



Herbivory in changing northern and alpine environments

Workshop goals

- ✓ Identify knowledge gaps
- ✓ Develop consistent experimental protocols
- ✓ Establish research priorities for the network



... and expected outcomes

- Workshop report** multi-authored opinion paper?
- Hotspots analysis** further analyses, core writing group
- Protocol** → field validation during summer 2014?
- ... and a **network!!**




ASSW-AOS 2014 Helsinki
April 9, 2014

How all this got started...

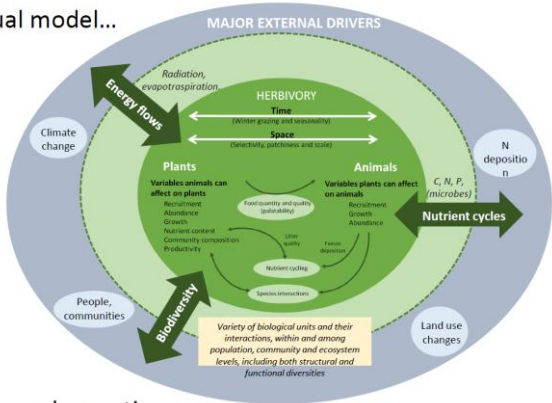



Isabel C Barrio Guillermo Bueno David Hik Ingibjörg Svála Jónsdóttir Martin Moersdorf Virve Ravolainen



September 2013 April 2014

Conceptual model...



MAJOR EXTERNAL DRIVERS

- Climate change (Energy flows: Radiation, evapotranspiration)
- People, communities (Biodiversity)
- Land use changes (Nutrient cycles)
- N deposition

HERBIVORY

- Time (Winter grazing and spawning)
- Space (Density, patchiness and size)

Plants

- Variables animals can affect on plants: Recruitment, Abundance, Growth, Nutrient content, Community composition, Productivity

Animals

- Variables plants can affect on animals: Food quantity and quality (palatability), Recruitment, Growth, Abundance
- Other factors: Live quality, Feces, Mortality, Species interactions, Nutrient cycling

Nutrient cycles (C, N, P, (microbes))

Variety of biological units and their interactions, within and among populations, community and ecosystem levels, including both structural and functional diversities

...and research questions

- How do herbivores modulate the responses of tundra environments to rapid environmental change?
- How does the (temporal and spatial) variability in plants and herbivores affect each other?