Cross-Site Workshop Report
Ecosystem response to diminished snow, ice and permafrost in a warming climate
The Ecosystems Center, MBL
Woods Hole, MA
31 March – 01 April, 2009

This workshop was organized and convened by MCM (Andrew Fountain) and PAL (Hugh Ducklow). The purpose of the workshop was to examine the role of diminished snow and ice on ecosystem structure and function and on ecosystem services across the diverse habitats found in the LTER Network. The longer-term goal is to synthesize existing knowledge and mine available data through follow up working groups (we will propose a session for the ASM). The trends, rates and some causes of loss of the three principal cryosphere elements (snow, ice and permafrost) are well-known. But the ecological and biogeochemical consequences of cryosphere loss are not well-studied, particularly in a synthetic and comprehensive manner. The workshop addressed all three thematic portfolios of the LTER Decadal Plan including land/water use change; climate change; and nutrient mobilization.

The workshop had a day of presentations and a day of breakout group discussion. We had brief site-specific talks and five more comprehensive and synthetic reviews on the major components of the cryosphere (glaciers, snow, permafrost, lake/river and sea ice) (See agenda attached). The Discussions were focused on building a conceptual framework for further investigations, discussions at the upcoming Science Council meeting, and for the envisioned proposal to follow. Powerpoints were collected from all presenters for the plenary talk at the Science Council meeting. We also commissioned each participant to send an annotated bibliography of effects for their site or region.

In discussion we identified several specifically synthetic findings from the workshop. Nutrient (or more broadly, resource, e.g., light and organic matter as well as inorganic nutrients) mobilization appears to follow cryosphere recession across systems, but with earlier snow or ice melt, the phasing or phenology of mobilization events and biological responses appears to be shifting in time. Nitrate pulses in streams follow snowmelt in temperate forests, but with earlier seasonal snow melt, plants may not be able to take advantage of newly-available nitrogen. Decreased snow has caused soil drying and tree root loss, leading to increased nitrate in streams that was not taken up by the missing roots. Sea ice loss has had contrasting effects on marine phytoplankton productivity along a north-south climate gradient off the west Antarctic Peninsula, depending on the initial condition and timing of sea ice retreat, wind and cloud regimes.

Several participants noted that nearly all known climate-ecosystem feedbacks resulting from cryosphere loss are positive (Figure 1): in which warming and melting intensify and promote further warming and cryosphere loss. In other parts of the Earth System, warming can lead to negative feedbacks. For example in tropical oceans, increased stratification fosters growth of pelagic diazotrophs that take up more atmospheric CO_2 than typical phytoplankton. Identifying and modeling cryosphere feedbacks has become a closely-pursued research priority, stimulated by catastrophic Arctic sea ice loss and tundra melting.

Representatives from several sites reported that the occasion of our workshop caused them to think more deeply about the importance of winter conditions and seasonal cryosphere elements, and their loss, even at sites where precipitation and productivity are very much concentrated in warm seasons (e.g., SGS). Andrews and Harvard Forest and Hubbard Brook all reported on new observing or experimental activities aimed at snow loss at their sites.

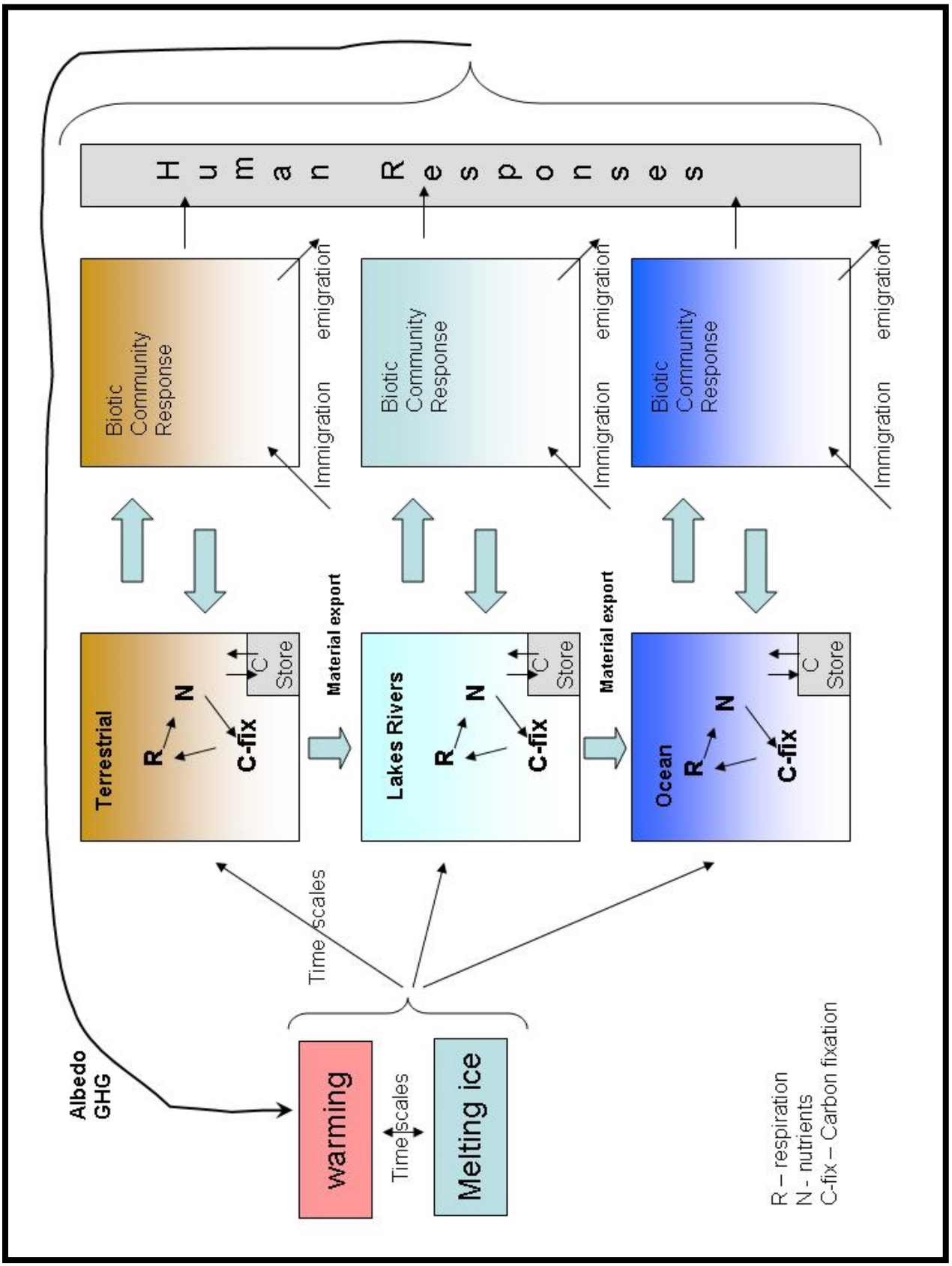
Finally, we produced two synthetic products in the discussion groups. One is a matrix documenting existing knowledge and understanding of diverse ecological, hydrologic and biogeochemical consequences of cryosphere loss across the different cryosphere components (Figure 1). According to one workshop participant, the striking thing about this exercise is the large number of empty or unknown cells in the matrix – indicating the breadth of our ignorance about the consequences of cryosphere loss. The other immediate product of workshop discussions was a synthetic diagram outlining biogeochemical processes across all landscapes (soils, lakes and streams, marine waters).

We intend to write a journal article intended for BioScience, Nature Geosciences or Frontiers in Ecology and the Environment, reviewing the ecological, hydrologic and biogeochemical consequences of cryosphere loss.

Figure 1. A matrix constructed during breakout group discussions, illustrating the ecological, hydrologic and biogeochemical consequences of cryosphere loss, grouped by specific cryosphere elements.

Figure 1.	Nutrients	Trace gases	C cycling	Community	Hydrology	feedbacks
Sea ice	N & P mobilization	Change in ocean CO_2 uptake	Algal changes	Penguins decline	Change in Ocean Currents?	Albedo Heat flux
Glaciers	Dust transport	?	?	Re-vegetation	Quantity Quality	Sea-level rise
Temperate snow	?	?	CH_4 release DOM loss?	Forest structure	ET increase	albedo
Boreal snow	?	?	DOM loss?	Shrubs increase	Quantity quality	albedo
Alpine snow	?	?	DOM loss?	Pika?	Quantity quality	albedo
Permafrost	N & P mobilization	CO_2 and CH_4 release	DOM loss Respiration increase; NEP	Shrubs increase	Hydrologic intensification	Greenhouse gases
Lakes and rivers	N & P mobilization	CO_2 and CH_4 release	Alters C storage & release	decline or loss of ice dependent communities	altered land infiltration and lake evaporation	Complex mix of + and - feedbacks
Seasonally frozen ground	?	?	Respiration increase ?	?	?	?

Figure 2. Conceptual model of the ecological and biogeochemical responses to cryosphere loss, emphasizing feedbacks and including human responses. This figure is modeled on the LTER ISSE conceptual diagrams.



LTER Workshop

Ecosystem response to diminished snow and ice in a warming climate

31 March – 01 April, 2009
The Ecosystems Center, MBL
Starr Building
Woods Hole, MA

AGENDA and PROGRAM

Monday 30 March ARRIVAL
Housing check-in is any time after 2pm; check-out is by 10:00am.
(Note: Swope office is open until 9 PM. After that, use phone by front door and call night watchman.)

Tuesday 31 March:
7:30-8:30 Breakfast at Café Swope (first floor) for those participants staying at Swope

8:30 Start
Site Presentations (10 min + 5 min question/answer):
If there is more than one person from your site, you can decide who presents. Note that sites giving Overview talks are not included here.
0830: Welcome & Introduction (Hugh and Andrew)
0845: AND Anne Nolin
0900: ARC John Hobbie
0915: HBR John Campbell
0930: HFR Bill Sobczak
0945: KBS Phil Robertson
10:00 Coffee break
1045: PIE Will Wolhein
1100: SGS Mike Antolin
1115: ARC Bruce Peterson
1130: Catch-up & Discussion
1200: Lunch in private dining room, second floor of Swope Center

Overview Talks
1330: Disappearance of lake and river ice: John Magnuson NTL
1400: Disappearance of snow: Mark Williams NWT
1430: Disappearance of sea ice: Sharon Stammerjohn PAL
1500: Coffee break
1530: Disappearance of permafrost: Ted Schurr BNZ, John Hobbie ARC
1600: Disappearance of glaciers: Andrew Fountain MCM
1630: DISCUSSION
1700: ADJOURN
1900: Dinner at home of John Hobbie, 52 McCallum Drive, Falmouth
(Rides and directions will be available.)

Wednesday 01 April:

We would like to consider three kinds of products from the Workshop. Ideally, we can produce a review or synthesis article for a journal like Ann Reviews or TREE. At a minimum we would like to assemble an annotated bibliography of references, from which such an article could be written. Finally, we would like to collect your powerpoints, or selected slides from them, to serve on the LTER Network website for presentations on climate change. This is open for discussion or other suggestions.

The presentations and discussions in the Workshop will also inform further discussion and planning to commence at the LTER Science Council Meeting in May. Some background on the SC discussions is appended.

Breakout Working Groups

0900: Charges and Logistics Hugh & Andrew and see below (Products)

0915: Breakout Groups

Polar Starr 3rd floor conference room

Temperate/Alpine Starr 2nd floor classroom

1030: Coffee break

1100: Resume discussions

1200: Lunch, private dining room, Swope Center

1330: Resume discussions

1500: Coffee break

1530: Plenary Discussion

1700: ADJOURN / departures

1900: Dinner, probably Captain Kidd Restaurant, Water Street, Woods Hole

Thursday 02 April DEPART

Proposed Homework to be completed prior by COB March 31:

Annotated Bibliography of references pertinent to your presentation whether it is a site summary or overview presentation.
When organizing your presentation and your thoughts for this workshop please consider the following.

Overarching Questions

1. Although we can (and should) identify specific biologic species response to changing snow and ice conditions (e.g. sea ice loss and reduction in polar bear population) can we identify or anticipate specific ecosystem-wide responses?
2. Although local ecosystem effects are certainly important, are there any downstream effects (or tele-connections) of these processes to ecosystems outside of snow and ice dominated environments (e.g. migrating bird/whale populations)?
3. Can we point to any real or potential effects on specific ecosystem services?
4. Are there any analogues occurring in the climate warming of the 1930s that we can learn from?
5. Our LTER workshop is US-centric, do we see similar responses around the world?

LTER Science Council Meeting (May) Proposed Focus on Proposal Preparation

There will be a one half day session for plenary presentations, and two half day sessions for breakout group discussions. There should be a tight link between the breakout groups and the plenary presentations, i.e. the discussion group organizer, or someone that they designate, should give the plenary presentation to set the stage for the discussion and help people decide which group to participate in. We also need to include reports from the workshops that were funded over the last year in the plenary session.

The objective of the breakout group discussions should be to move towards getting proposals out the door to actualize the LTER Decadal Plan. These proposals could be standard grants to existing LTER programs such as Ecosystem Studies or Coupled Natural Human systems, but they could also be much bigger. The Executive Board had extensive and positive discussions with NSF personnel this week to determine the possibility of bringing larger than normal projects to the agency for funding. To bring these larger efforts forward we would need to work closely with NSF program officers in multiple Directorates, early in the process, and consider engaging other agencies as well.

These proposals need to be developed in close collaboration with social scientists and need to include real social science questions, i.e. not social science in a service role to natural science. These proposals need to really advance the LTER Decadal Plan in novel ways, i.e. they need to be multi-site and multi-disciplinary and highlight the unique strengths of the LTER network.

Science Council Proposed topics and leaders (/these are very preliminary ideas for leaders, feel free to suggest alternatives)/:

- **Sea level rise** (Merryl Alber and/or Chuck Hopkinson).
- **Species change** (Mike Antolin and/or Steward Pickett and/or Scott Collins).

- **Winter climate/cryosphere** (Hugh Ducklow and Andrew Fountain).
- **Precipitation change** (John Blair and/or Alan Knapp)
- **Land change/urbanization** (Morgan Grove and/or Sarah Hobbie and/or David Foster).

Ideas for the plenary session: Five group leader presentations:

- Land change/urbanization presentation should include reports from the Foster et al. "scenarios of land change" and the Larson et al. "residential landscapes" workshops.
- Winter climate/cryosphere presentation should include a report from the Fountain et al. "ecosystem response to changing ice, snow and permafrost" workshop.
- Demonstration of new "collaborative project database" produced by the Obrien/Gries workshop group.
- Report from the Zimmerman et al. "establishing network of socio-ecological research sites" workshop .

Workshop Participants and Guests

Mike Antolin	Short Grass Steppe	Michael.Antolin@ColoState.edu
John Campbell	Hubbard Brook	jlcampbell@fs.fed.us
Hugh Ducklow	Palmer, Antarctica	hducklow@mbl.edu
Andrew Fountain	McMurdo Dry Valleys	andrew@pdx.edu
Anne Giblin	Plum Island	agiblin@mbl.edu
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Ted Schurr	Bonanza Creek	tschuur@ufl.edu
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Mark Williams	Niwot Ridge	markw@culter.colorado.edu
Will Wolhein	Plum Island	wil.wollheim@unh.edu

Guests:

Neil Bettez	Arctic/Toolik	ndb23@cornell.edu
Linda Deegan	Arctic/Toolik	ldeegan@mbl.edu
Chris Neill	MBL Ecosystems	cneill@mbl.edu
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