Warming up: Arctic and sub-arctic freshwater ecosystems as sentinels for climate change

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Arctic Biodiversity Congress, Trondheim 2-4 December 2014

Warming up; ……..

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2012 was in top 10 warmest on record

By Matt McGrath
Environment correspondent, BBC News

Despite a record hot year in the US, the rest of the world did not follow

US scientists say that 2012 was among the 10 warmest years the world has experienced since 1880.

Nasa researchers said it was the ninth warmest year while experts from another American agency said it was the 10th.

Both teams said that temperatures would have been higher if it had not been for the La Nina weather pattern that brought cooling to some regions.

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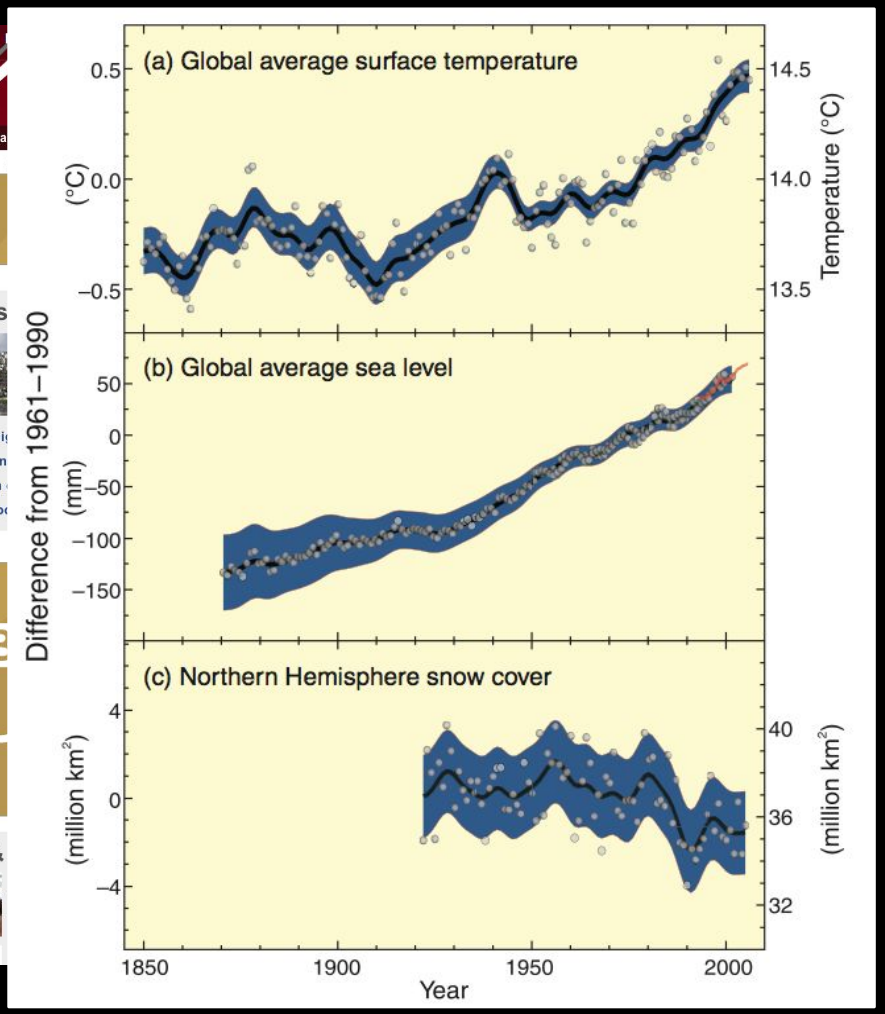

IPCC (2007)

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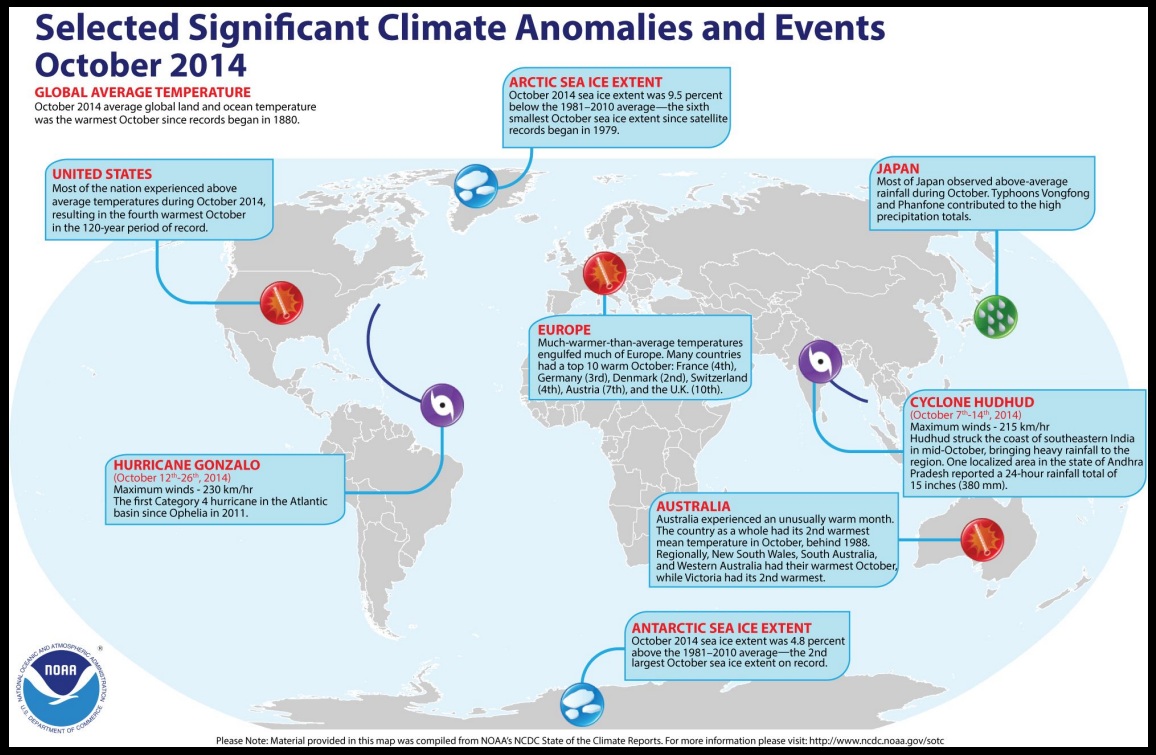


<u>Global temperature highlights:</u>
January–October 2014
Land and Ocean Combined:

January-October was the warmest such period on record, with a combined global land and ocean average surface temperature 1.22°F (0.68°C) above the 20th century average of 57.4°F (14.1°C), surpassing the previous record set in 1998 and 2010 by 0.02°C (0.04°F). 2014 is currently on track to be the warmest year on record. The margin of error is +/- 0.20°F (0.11°C).

www.ncdc.noaa.gov/sotc

Warming up; ……..

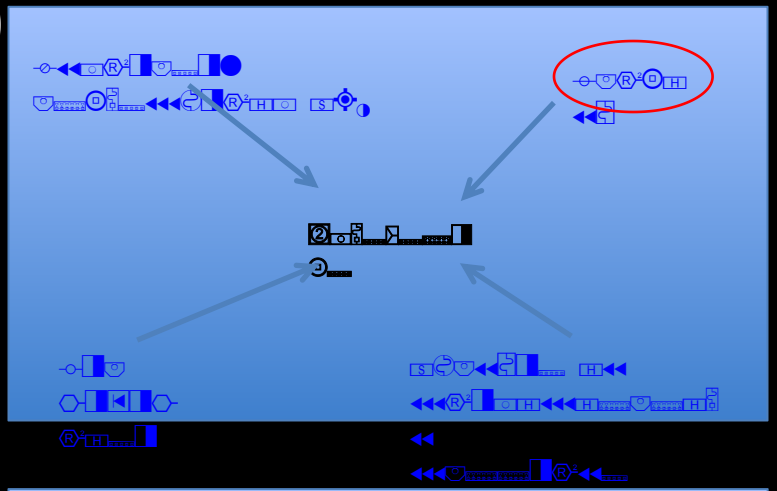
- The impacts on the planet's diverse ecosystems will be profound
- Studies focused on the impacts at the lower levels of biological organization e.g. range shifts in species populations
- When communities or ecosystems are subjected to environmental stress they can behave in ways that cannot be predicted from studying single species in isolation, due to the complex array of species interactions within the ecological network (e.g. Raffaelli, 2004; Woodward, 2009).
- Important to considers the higher levels of organization to complement existing approaches to predicting climate change impacts in these complex natural systems.
- Many studies on the effects of warming on natural systems are hampered by confounding latitudinal (or altitudinal) gradients (e.g. Jacobsen et al., 1997), often making it impossible to disentangle the effects of biogeography and temperature.

Warming up; ……..

- Changes in community composition with latitude may occur for many reasons other than differences in temperature: the interplay between additional environmental gradients (e.g. pH, nutrient concentrations, etc,), hydrology, geology, evolutionary history and dispersal constraints will all influence the composition of the local and regional species pools.
- Similar limitations can also apply when temporal correlations are used to infer biological responses to temperature change (e.g. Ponds et al., 1999; Durance & Ormerod, 2007, 2009).
- In contrast to large-scale latitudinal surveys, most experimental studies of warming have been restricted to small laboratory microcosms (e.g. Petchey et al., 1999) or pond mesocosms (e.g. McKee et al, 2002a,b, 2003; Moss et al., 2003), largely due to the logistic and financial challenges of heating large systems.

Warming up; ecosystem function

(1)



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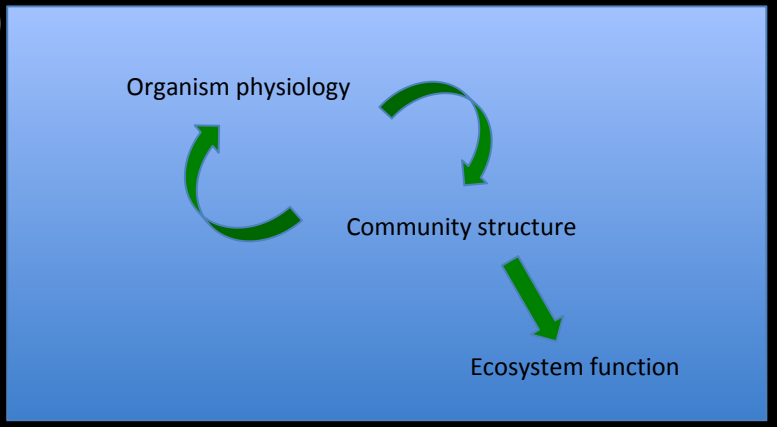
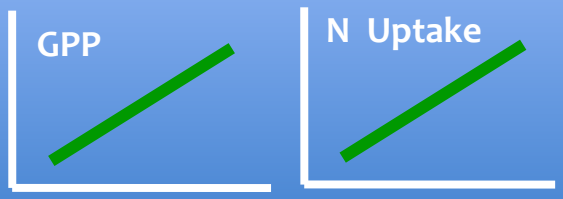


(3)

Predictions:
Under N-limited conditions with fixed N supply



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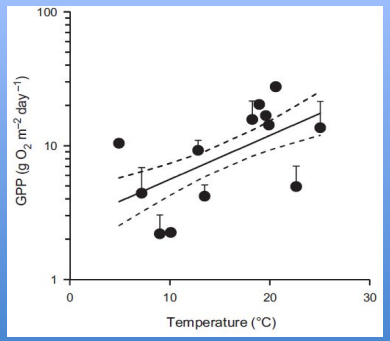

Demars et al. 2011, Freshwater Biology

Uhhh…..yes it appears to be

Work still in progress

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PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

Phil. Trans. R. Soc. B (2010) **365**, 2093–2106
doi:10.1098/rstb.2010.0055

Review

Climate change and freshwater ecosystems: impacts across multiple levels of organization

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PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

Phil. Trans. R. Soc. B (2010) **365**, 2117–2126
doi:10.1098/rstb.2010.0038

Warming alters the metabolic balance of ecosystems

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4NS, UK
ford,

Global Change Biology

Global Change Biology (2014) **20**, 3291–3299, doi: 10.1111/gcb.12602

OPINION

Climate change and geothermal ecosystems: natural laboratories, sentinel systems, and future refugia

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Global Change Biology

Global Change Biology (2010) **16**, 1979–1991, doi: 10.1111/j.1365-2486.2009.02052.x

Sentinel systems on the razor's edge: effects of warming on Arctic geothermal stream ecosystems

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Increased Stream Productivity with Warming Supports Higher Trophic Levels ☆

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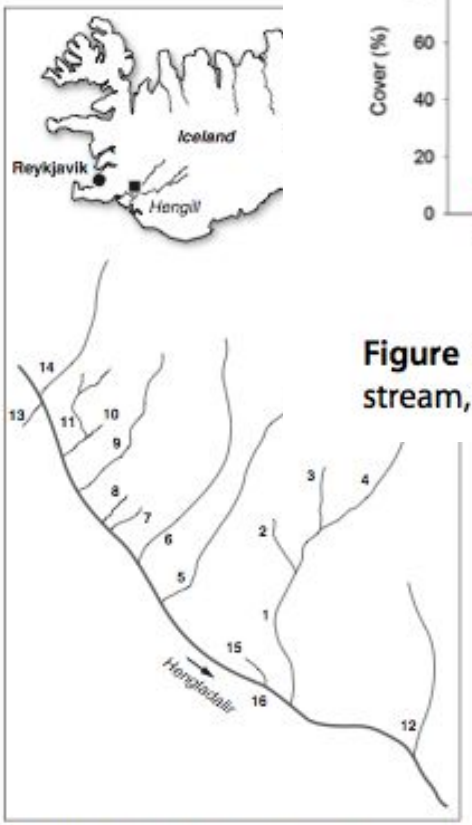

Fig. 1 Map of the 15 streams within the geothermal Hengill region of Iceland. Stream numbers are annotated on the map, with associated mean temperatures given in Table 1.

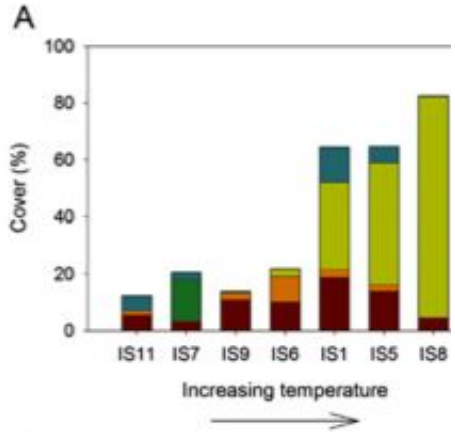

Figure 2 Average annual (A) stream, showing the dominan

6	19.5	18.8								
7	7.7	7.1								
8	23.5	23.4								
9	14.9	14.0								
10	4.7	4.7								
11	11.2	10.5								
12	14.8	13.50 (0.54)	7.8	165	107.6	10.10	0.022	0.017	9.06	43
13	6.8	6.71 (0.02)	7.7	175	24.3	10.10	0.015	0.013	13.78	78
14	9.5	8.44 (0.33)	8.2	182	28.3	11.10	0.015	0.010	9.22	0
15	43.0	43.00 (NA*)	7.5	512	1.8	5.71	0.050	0.069	2.79	100

*Single spot sample, due to instrument failure over the full sampling period.

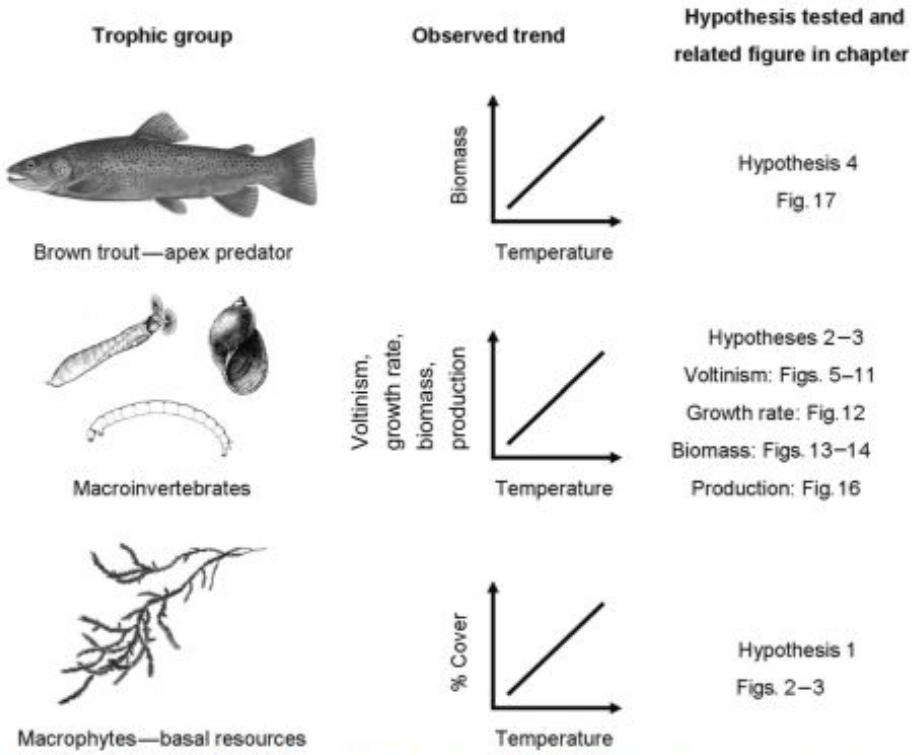

Figure 18 Conceptual figure highlighting the main findings of the study. The general response to temperature for key characteristics of three major trophic groups are provided: fish, macroinvertebrates and basal resources (ordered by trophic height in the figure). The hypotheses tested in each case are listed, mapping onto the numbers provided at the end of the introduction. A list of figures relating to each observed trend is also shown. *Line drawings adapted from images on Wikimedia Commons.*

Warming up; tipping point

review article

Catastrophic shifts in ecosystems

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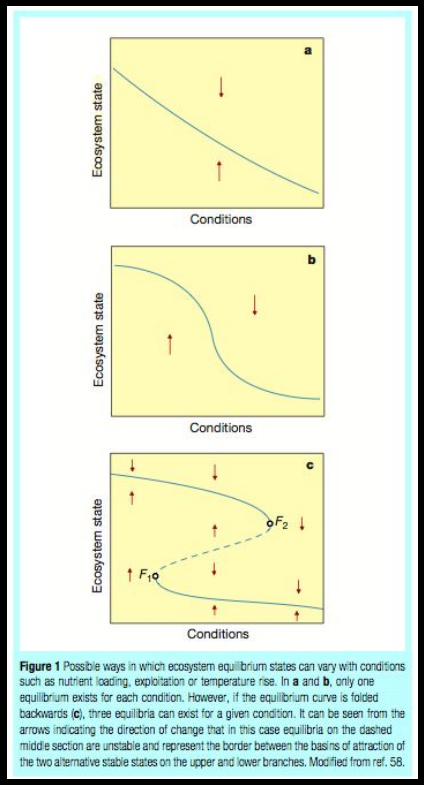
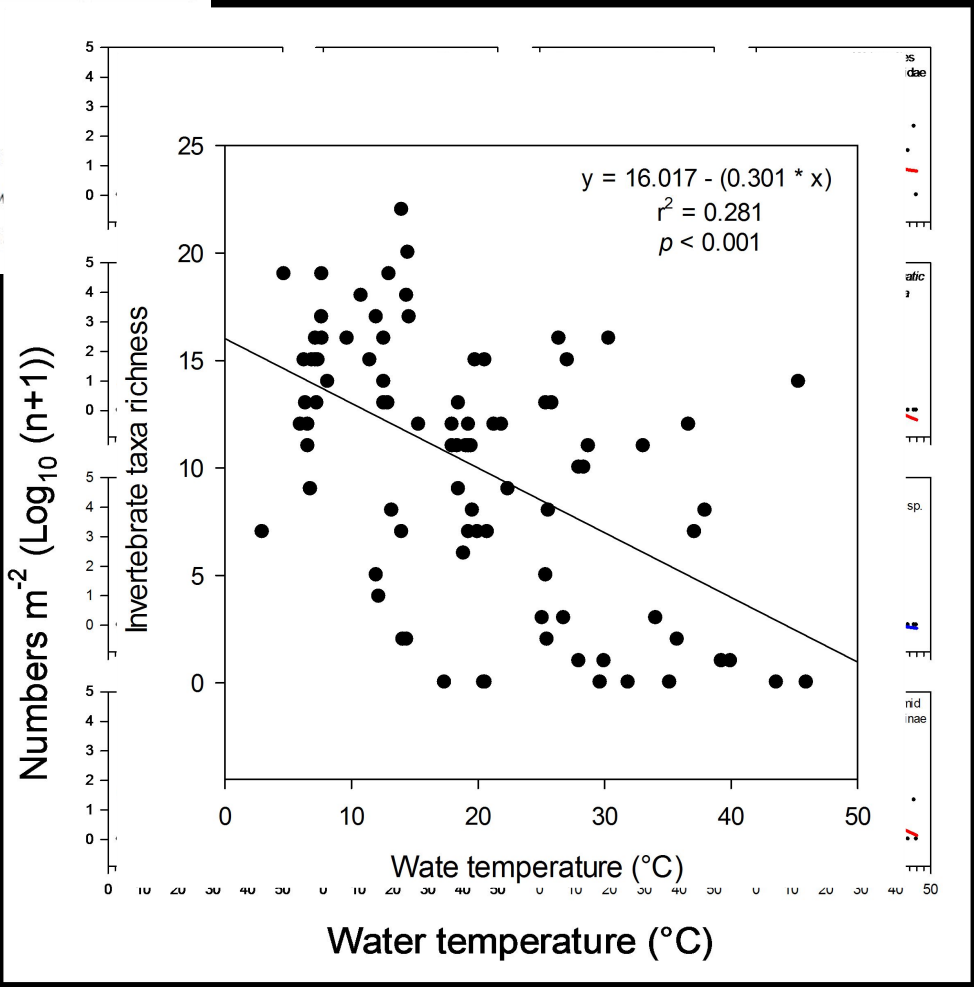
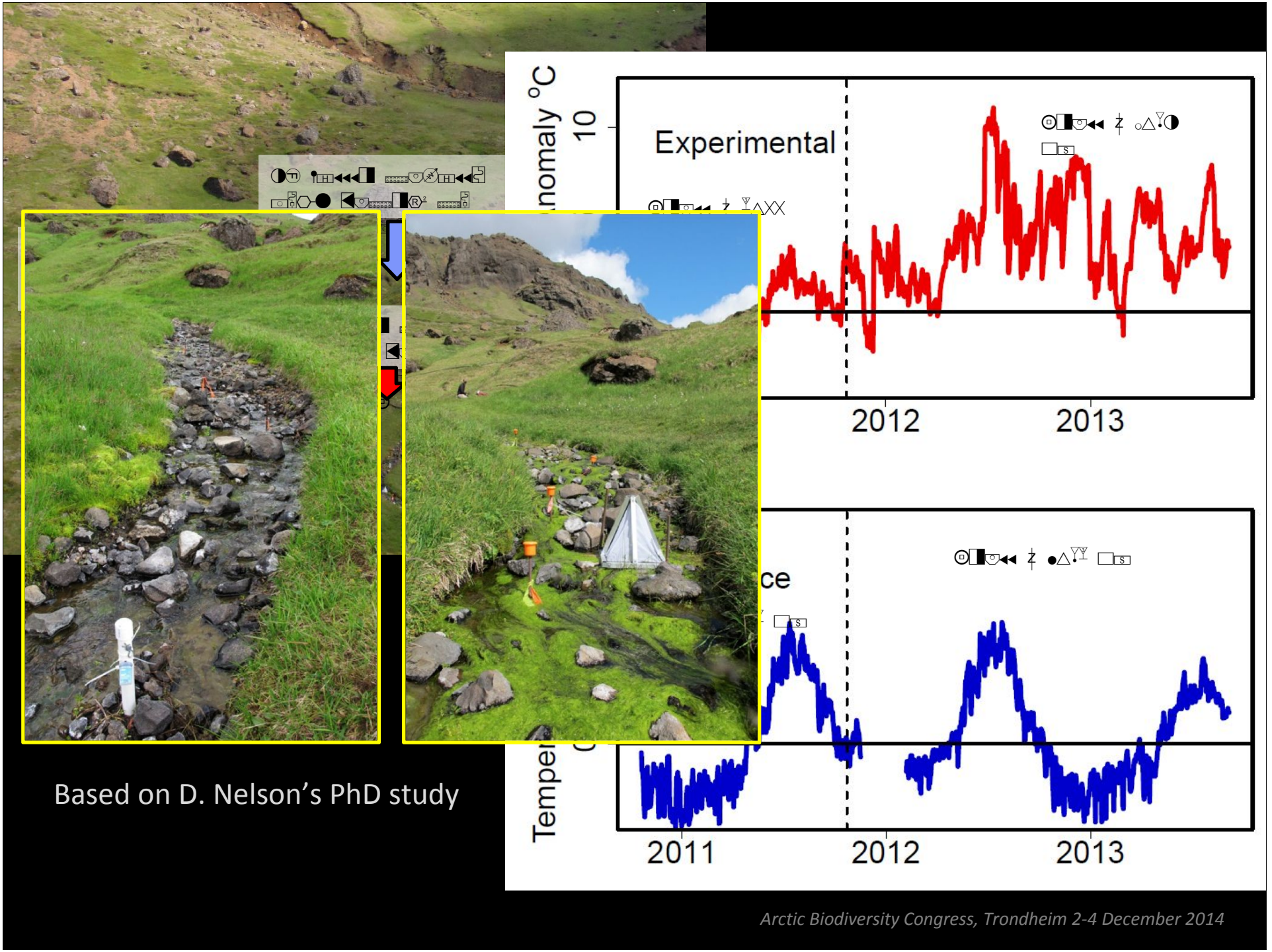


Figure 1 Possible ways in which ecosystem equilibrium states can vary with conditions such as nutrient loading, exploitation or temperature rise. In **a** and **b**, only one equilibrium exists for each condition. However, if the equilibrium curve is folded backwards (**c**), three equilibria can exist for a given condition. It can be seen from the arrows indicating the direction of change that in this case equilibria on the dashed middle section are unstable and represent the border between the basins of attraction of the two alternative stable states on the upper and lower branches. Modified from ref. 58.



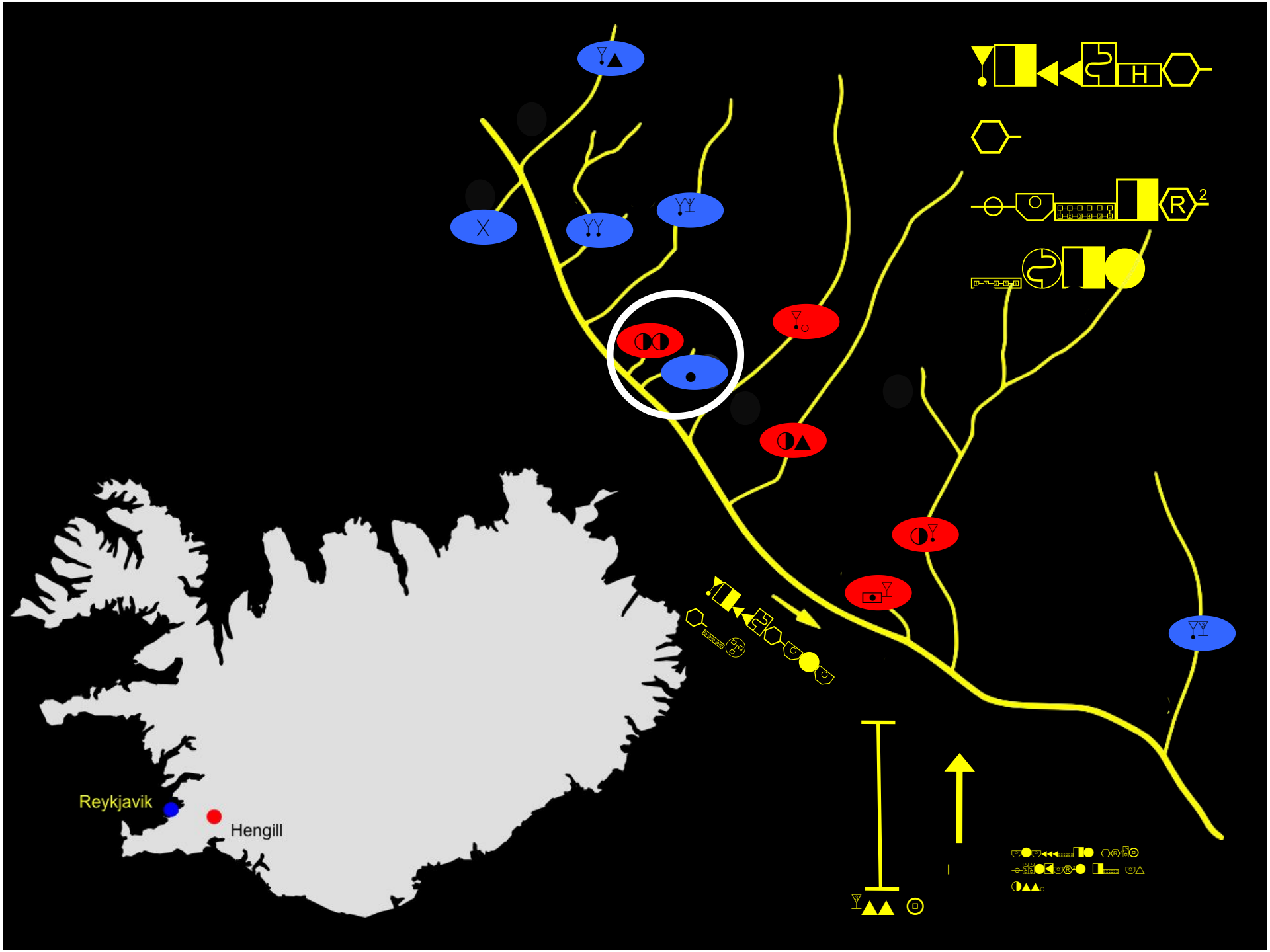
Olafsson et al. 2010



Based on D. Nelson's PhD study

Warming up; take home message

- Descriptive studies and monitoring
- Predictions - models
- Experiments
- Communities, ecosystems and ecosystem function
- Rapid changes – tipping point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Hengill