ESRM 350

Global Climate Change

Autumn 2016

I met a traveler from an antique land
Who said: "Two vast and trunkless legs of stone
Stand in the desert... Near them, on the sand,
Half sunk a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that its sculptor well those passions read
Which yet survive, stamped on these lifeless things,
The hand that mocked them and the heart that fed;
And on the pedestal these words appear:
My name is Ozymandius, King of Kings,
Look on my works, ye Mighty, and despair!
Nothing beside remains. Round the decay
Of that colossal wreck, boundless and bare
The lone and level sands stretch far away.

- Percy Bysshe Shelley, English Romantic Poet

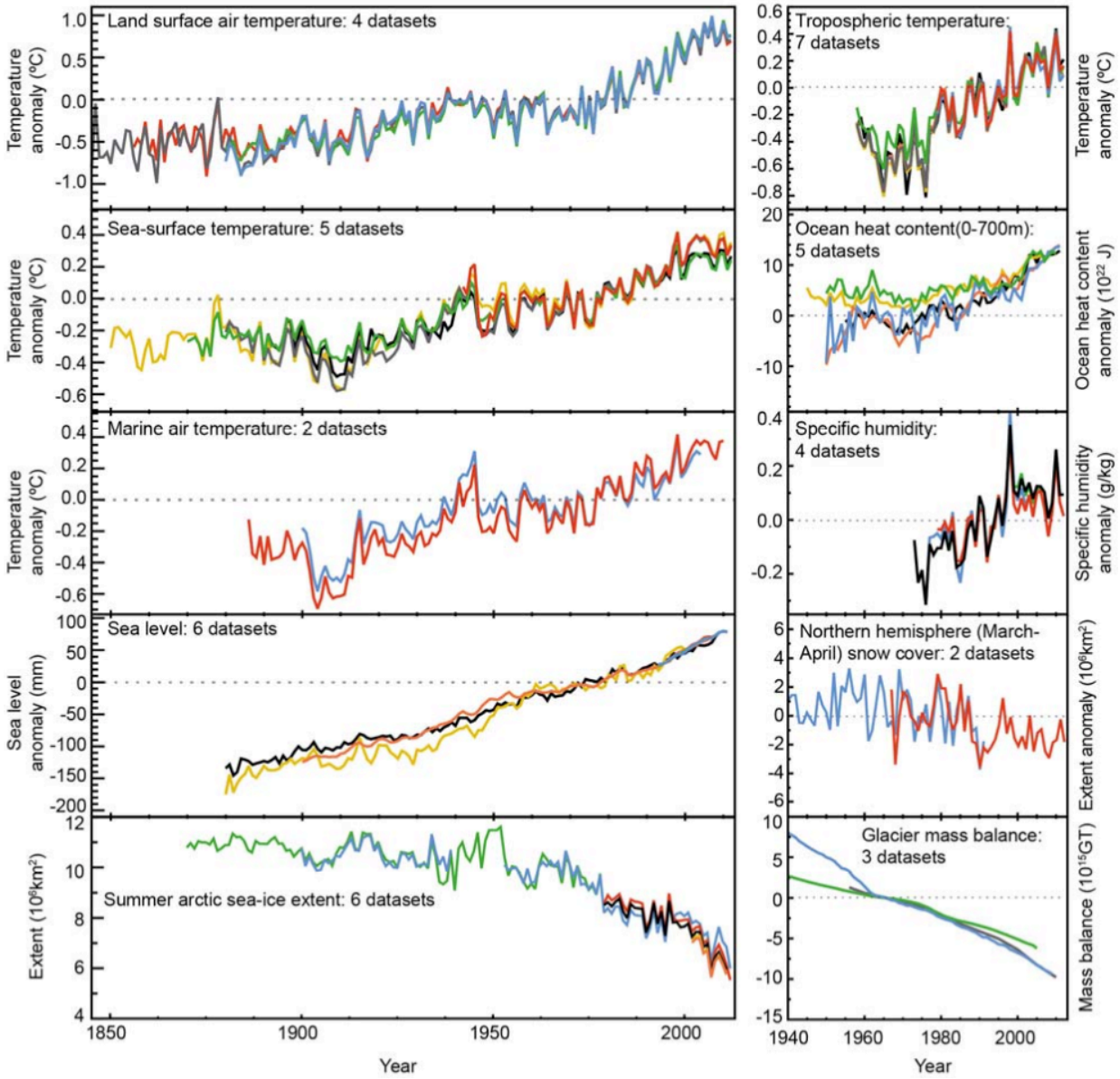

Figure TS.1: Multiple complementary indicators of a changing global climate. Each line represents an independently-derived estimate of change in the climate element. The times series presented are assessed in chapters 2, 3, and 4. In each panel all datasets have been normalized to a common period of record. A full detailing of which source datasets go into which panel is given in Chapter 2, Supplementary Material 2.SM.5 and in the respective chapters (See also FAQ 2.1, Figure 1). {2.4, 2.5, 3.2, 3.7, 4.5.2, 4.5.3}

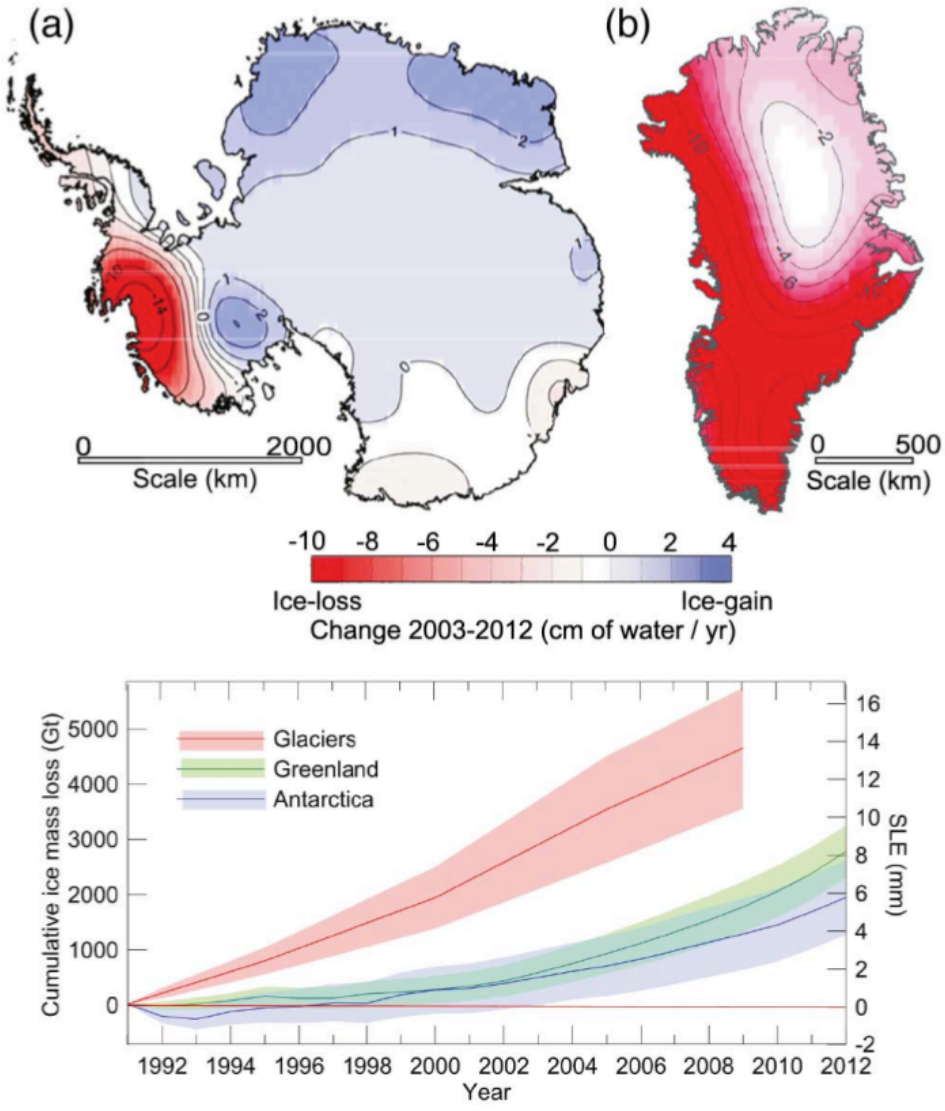

Figure TS.3: Upper panels: distribution of ice loss determined from GRACE time-variable gravity for (a) Antarctica and (b) Greenland, shown in centimetres of water per year (cm of water yr^{-1}) for the period 2003 to 2012. Lower panel: the assessment of the total loss of ice from glaciers and ice sheets in terms of sea level equivalent (in mm). The contribution from glaciers excludes those on the periphery of the ice sheets. {4.3.4; Figures 4.12, 4.13, 4.14, 4.16, 4.17}

Climate Change and Wildlife

- Pattern of warming recognized as major threat to wildlife populations worldwide
  - loss of habitat, range reduction, local extirpation, extinction

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- Pattern of warming recognized as major threat to wildlife populations worldwide
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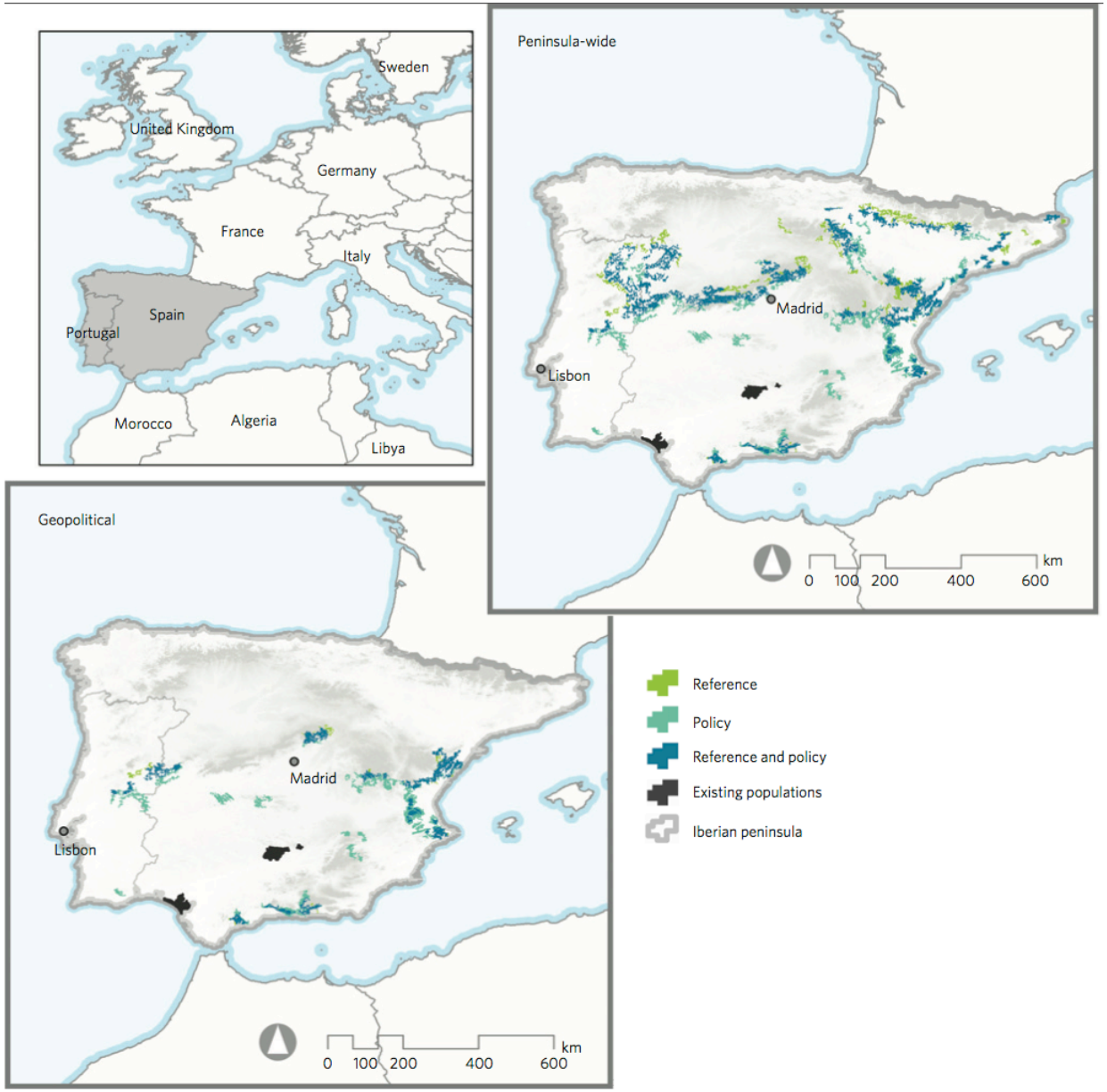
- Primary conservation concern: mitigation
  - reduce emissions of green house gases
- Secondary concern: adaptation
  - how do we lessen ongoing impacts of climate change on wildlife?
- Main tool for adaptation: projection
  - predict where wildlife **habitats** will be in future
  - protect these areas
  - facilitate animal movement to, and between, these areas (corridors)

Fordham et al. (2013) *Nature Climate Change*



Iberian lynx (*Lynx pardinus*)
Up to 30 kg!

Figure 3 | Forecast location of lynx populations in the Iberian Peninsula in 2090. Occupied habitats are shown for the Peninsula-wide and Geopolitical reintroduction scenarios and two climate change scenarios: a high-CO_2 concentration stabilizing Reference scenario (WRE750) and an alternative Policy scenario that assumes strong mitigation (LEV1). Maps capture lynx demographic responses to spatial patterns of rabbit abundance (conditioned by disease, climate and environmental variation) and changes in climate suitability and landscape modification. Only grid cells where lynx were present in 90% of stochastic iterations of the demographic model were treated as populated. See Supplementary Information and Methods for further details.

Is Projection Enough?

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- No, because some animals may not be able to respond adaptively to climate change
  - e.g., keep pace
- & because climate change also alters biotic interactions
  - when climate changes, so can interactions among competitors, predators, parasites
  - modified interactions can determine whether areas projected as future habitat are actually *usable*
- To forecast how species will fare as climate warms, we need to better understand
  - shifts in future habitat, *and*
  - species' movement (dispersal) capabilities, *and*
  - changes to current biotic relationships

Case study: Can Wildlife Keep Up With the Pace of Climate Change?

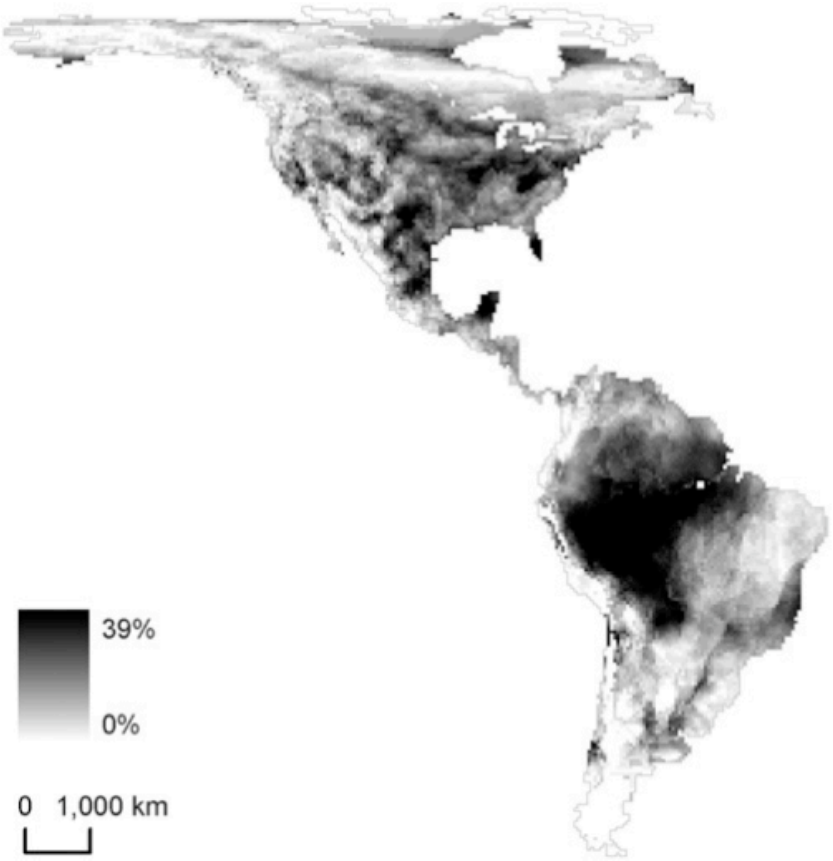


Fig. 1. Percentage of mammalian species that are projected to be unable to keep pace with climate change. Results are average percentages across projections that incorporate the output from 10 climate models run for a midhigh (SRES A2) emissions scenario.

Emporer tamarin (*Saguinus imperator*)

Schloss et al. (2012) *PNAS*

Climate Change and Biotic Interactions: Lynx vs. Coyotes

Canada lynx (*Lynx canadensis*)

Coyote (*Canis latrans*)

Lynx

- Snowshoe hare specialist
- Adapted for hunting in deep, soft snow
  - Long legs (esp. hind legs)
  - Huge feet
  - Coat sheds moisture

Coyote

- Typically 20-30 lbs as adults
- Generalist
  - broad diet (small mammals to deer)
  - but, an effective snowshoe hare predator
  - ambushes hares
- Competes with lynx
  - **exploitation**: competes for hares
  - **interference**: will kill lynx

Coyote foot area = 77cm^2
Footload (FL) = 136g / cm^2

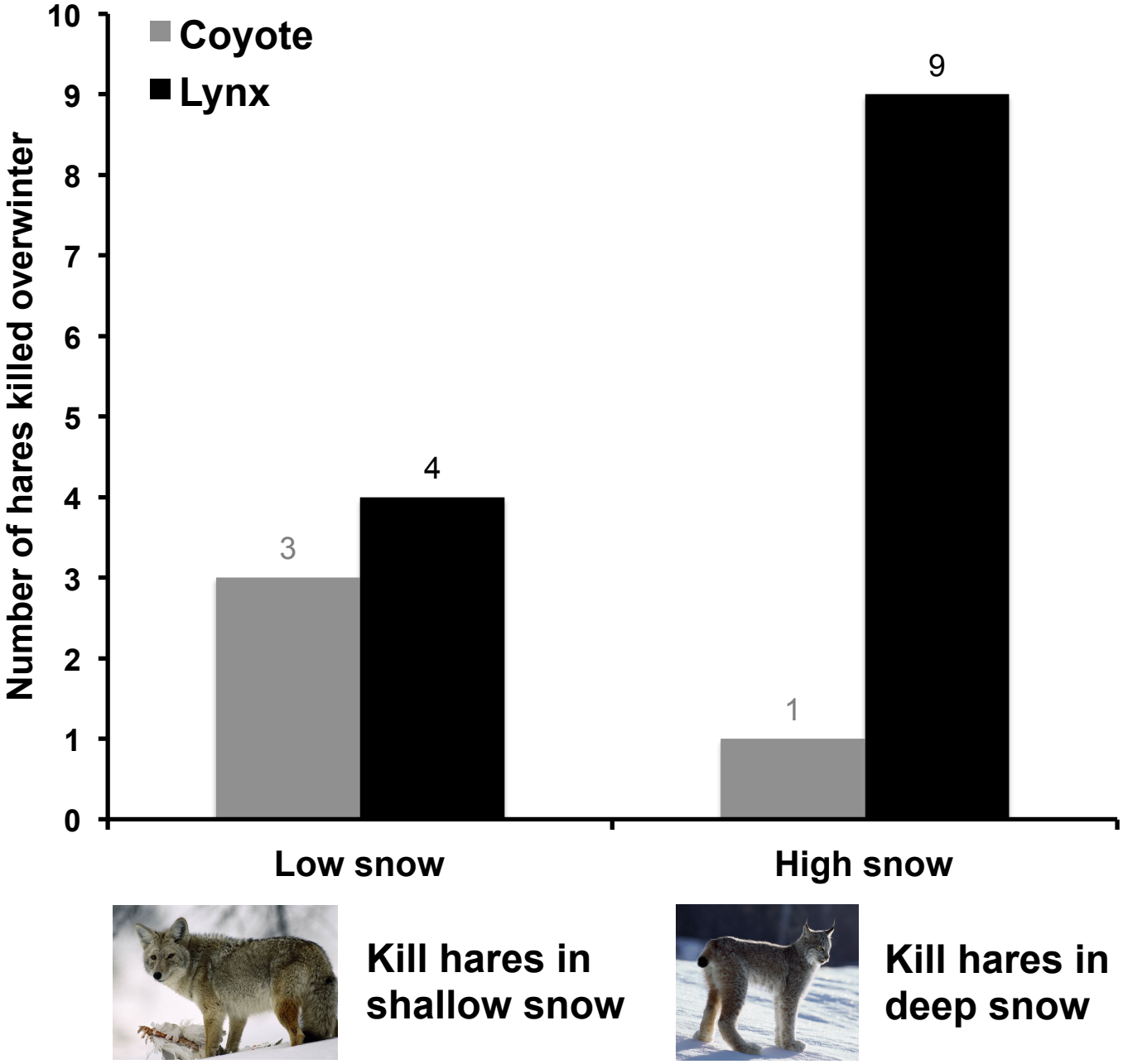
Lynx foot area = 280 cm^2
FL = 31g / cm^2

Predictions

- During winter
  - Lynx should hunt hares where snow is deep
  - Coyotes should hunt hares where snow is shallow

- Climate change in WA should favor coyotes
  - Reduced snowpack
  - Snow crusting
  - Greater access to snowy, high-elevation forests where hares abound

Peelle et al. *Unpublished data*



Preliminary Conclusions

- High elevation forest - winter hunting refuge for lynx
- Coyotes (higher footload) more reliant on lower elevation sites with reduced snowpack
- Climate warming could spell trouble for lynx
  - more winter competition with coyotes
- **Upshot**: climate change could alter distribution of lynx habitat *and* trigger harmful biotic interactions