Elements of success for climate adaptation planning: Perspectives from the NASA Landscape Climate Change Vulnerability Project

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Landscape Climate Change Vulnerability Project (LCC-VP)

Clingman's Dome, Great Smoky Mountain NP

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NPS I&M Program

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NPS / Great Northern LCC

Tom Olliff

CSU Monterey Bay / NASA Ames

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Conservation Science Partners

Dave Theobald

NASA Applied Sciences Program (NNH10ZDA001N - BIOCLIM)

NPS I&M Program

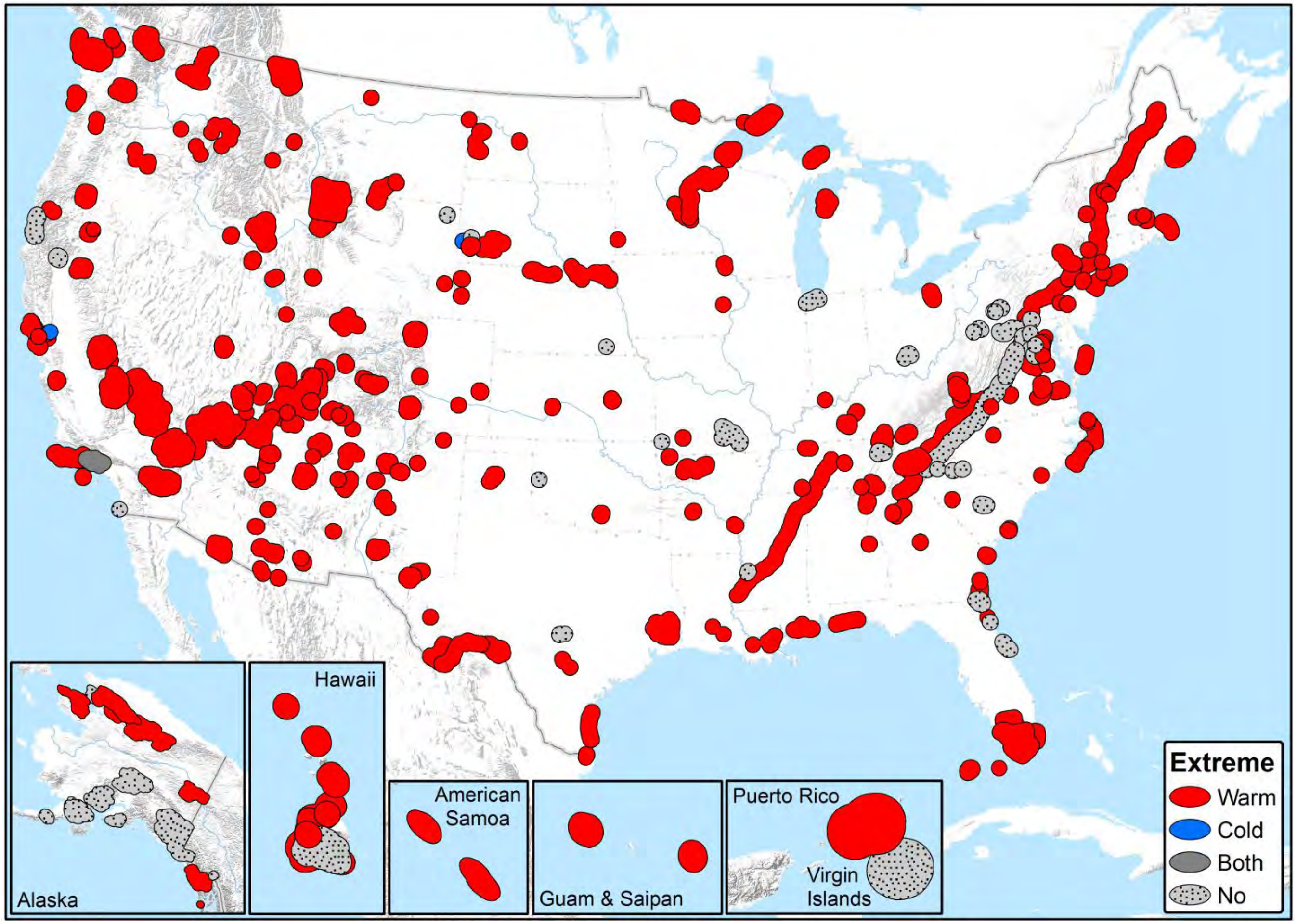
Outline

- Climate change and protected areas
- Challenges to adaptation
- Emerging solutions
- Putting it all together

Bering Land Bridge N Pres

Climate is Already Changing

<u>Pushing the envelope of HRV</u>: 81% of parks (235/289) are already "**extreme warm**" (i.e. most recent 10-30 years warmer than 95% of historical conditions going back to 1901)

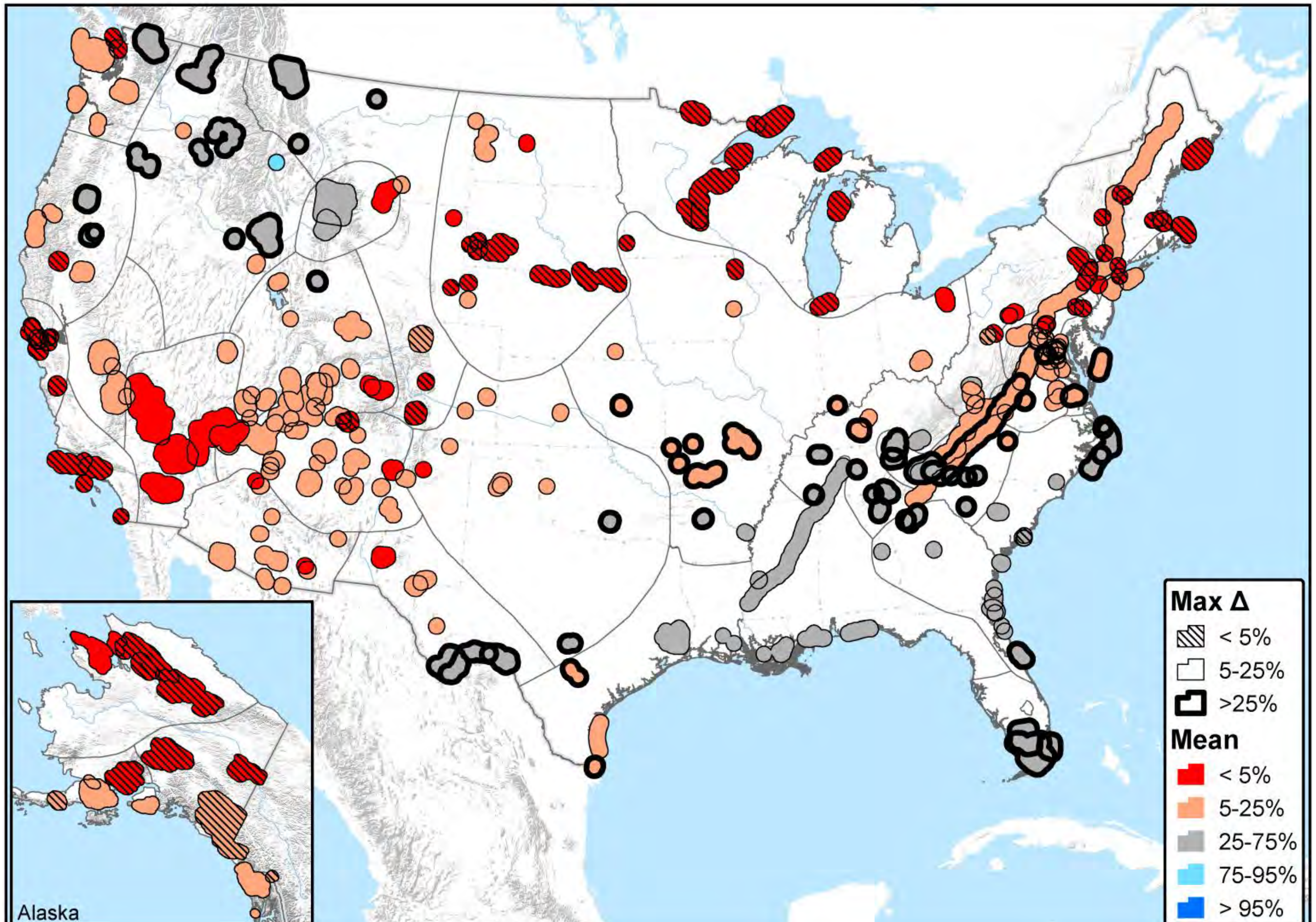


"Extreme" for any one of 7 temperature variables

Monahan & Fisichelli (2014)

Resources are Responding

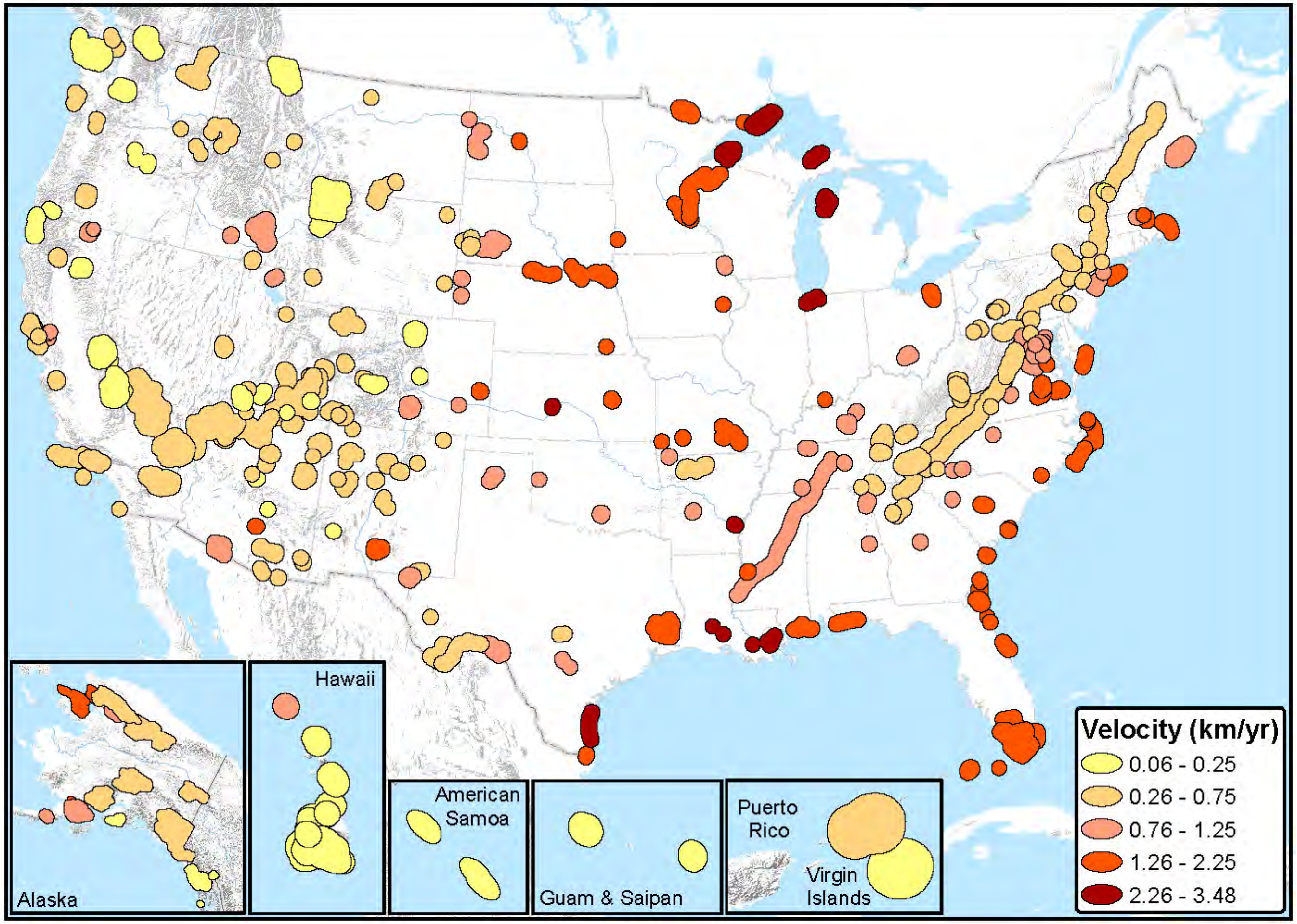
<u>Pushing the envelope of HRV</u>: 75% of parks (*n* = 276) are seeing an advance in the timing of spring onset (~ 0.8 days/decade)



Monahan et al. (2016)

Climate Change will Continue

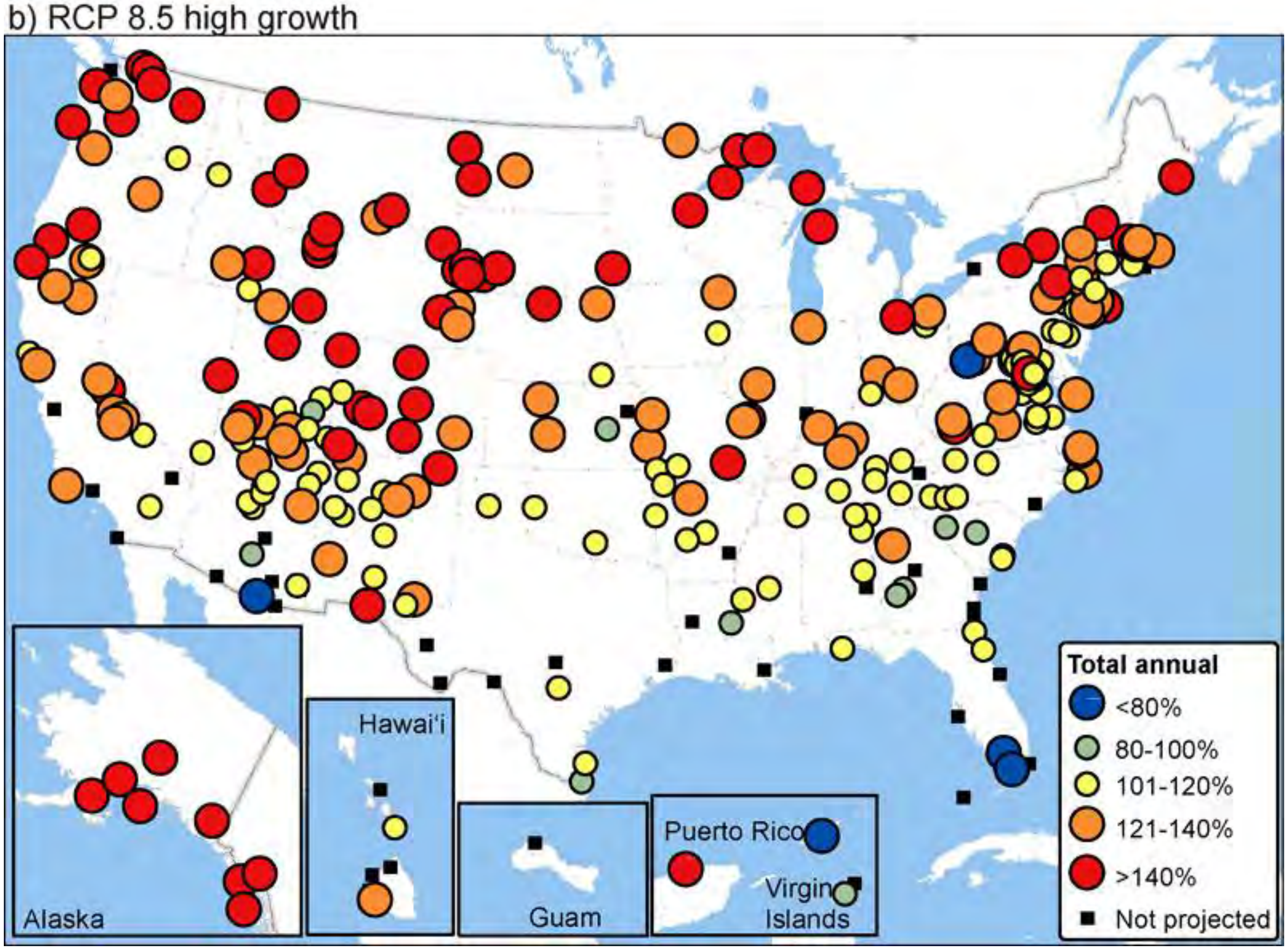
<u>Pushing beyond HRV</u>: By 2100 under RCP 8.5 W/m[2], parks would need to move 6-348 km to maintain their current climates



Rodhouse et al. (in press)

Resources & Values will Impacted

<u>Pushing beyond HRV</u>: 8-23% increase in annual visitation
13-31 day expansion of visitation season



Fisichelli et al. (2015)

Climate Change Adaptation

- Climate change is recognized as a major issue
- Agency policies lay foundation for climate adaptation planning
- Action plans and adaptation frameworks are helping translate policies into practice
- ***But…site-level implementation within protected areas is still challenging***

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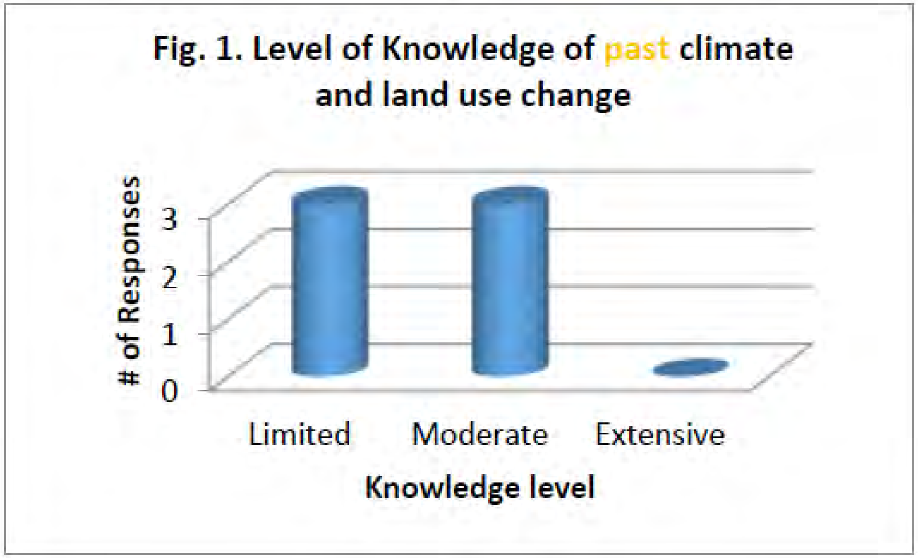
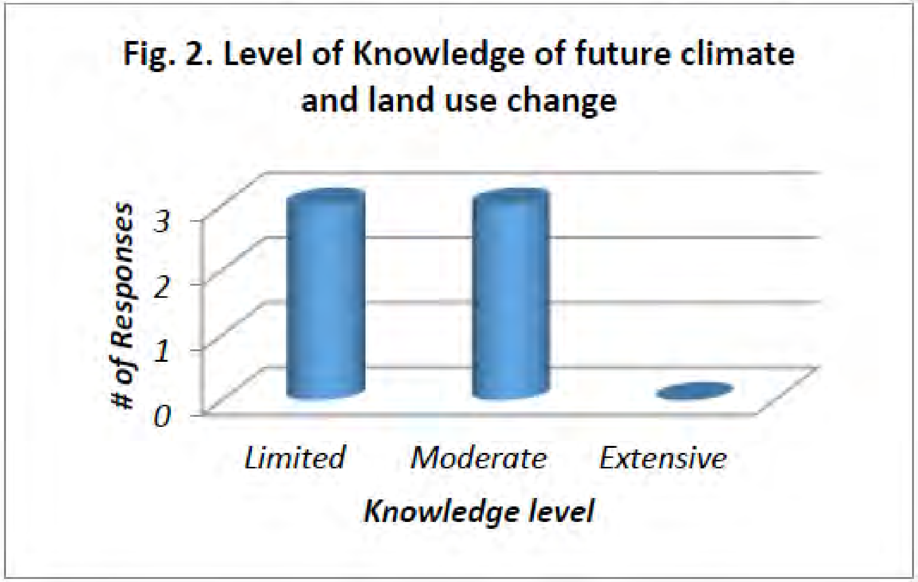
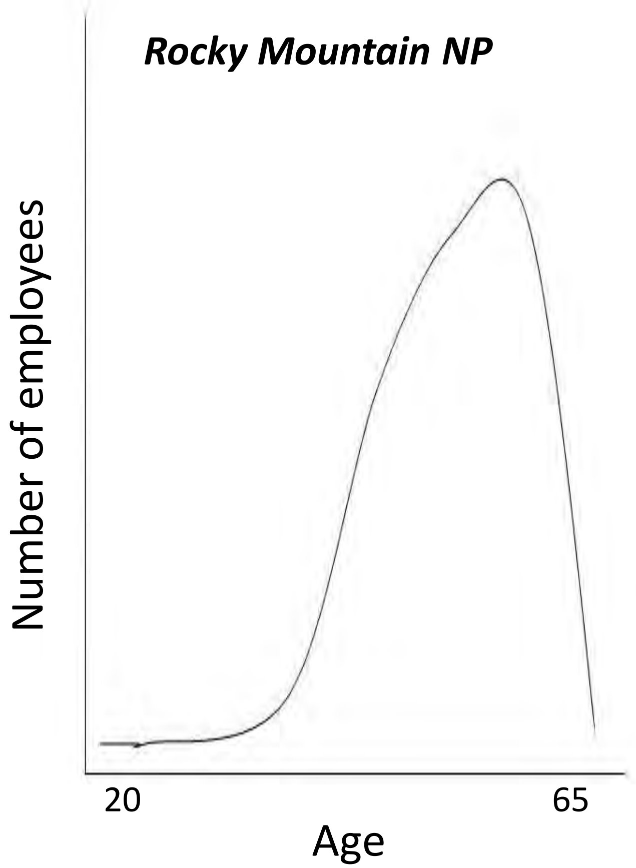
New Concepts, Language & Science

LCC-VP Survey



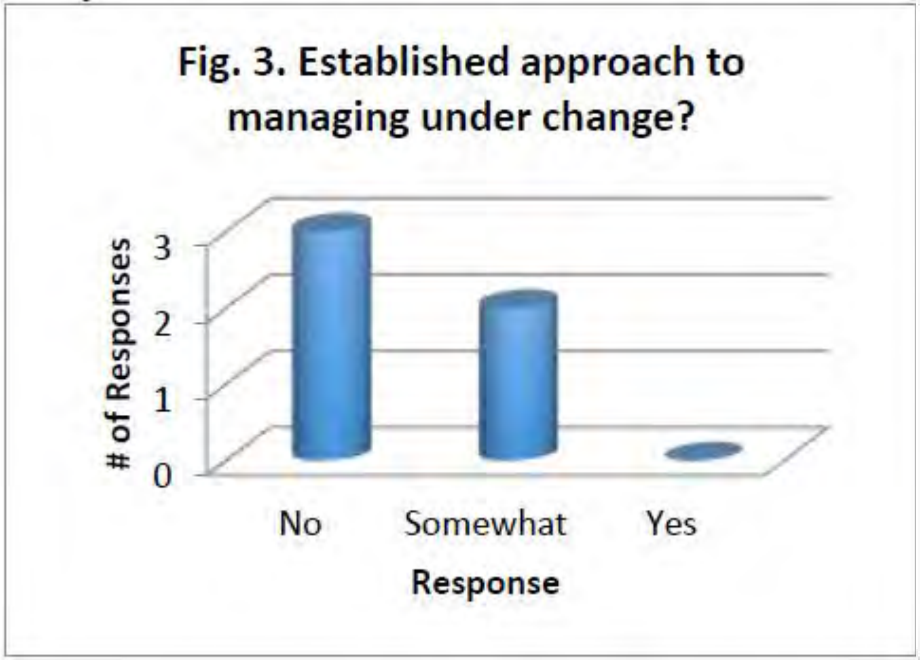


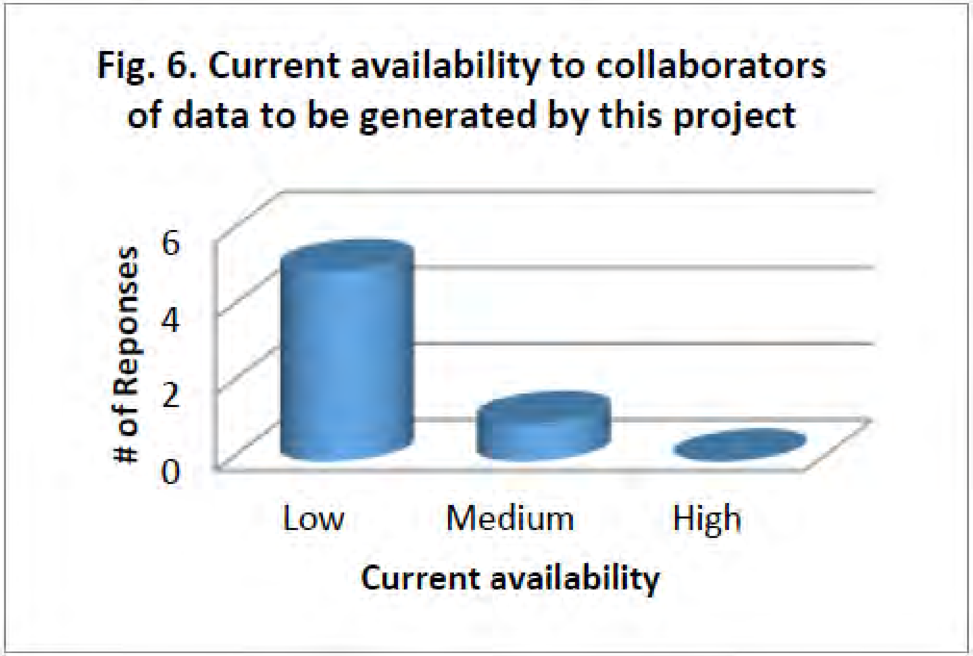
Most staff educated before climate change became a major issue



High Uncertainty -> Indecision

LCC-VP Survey





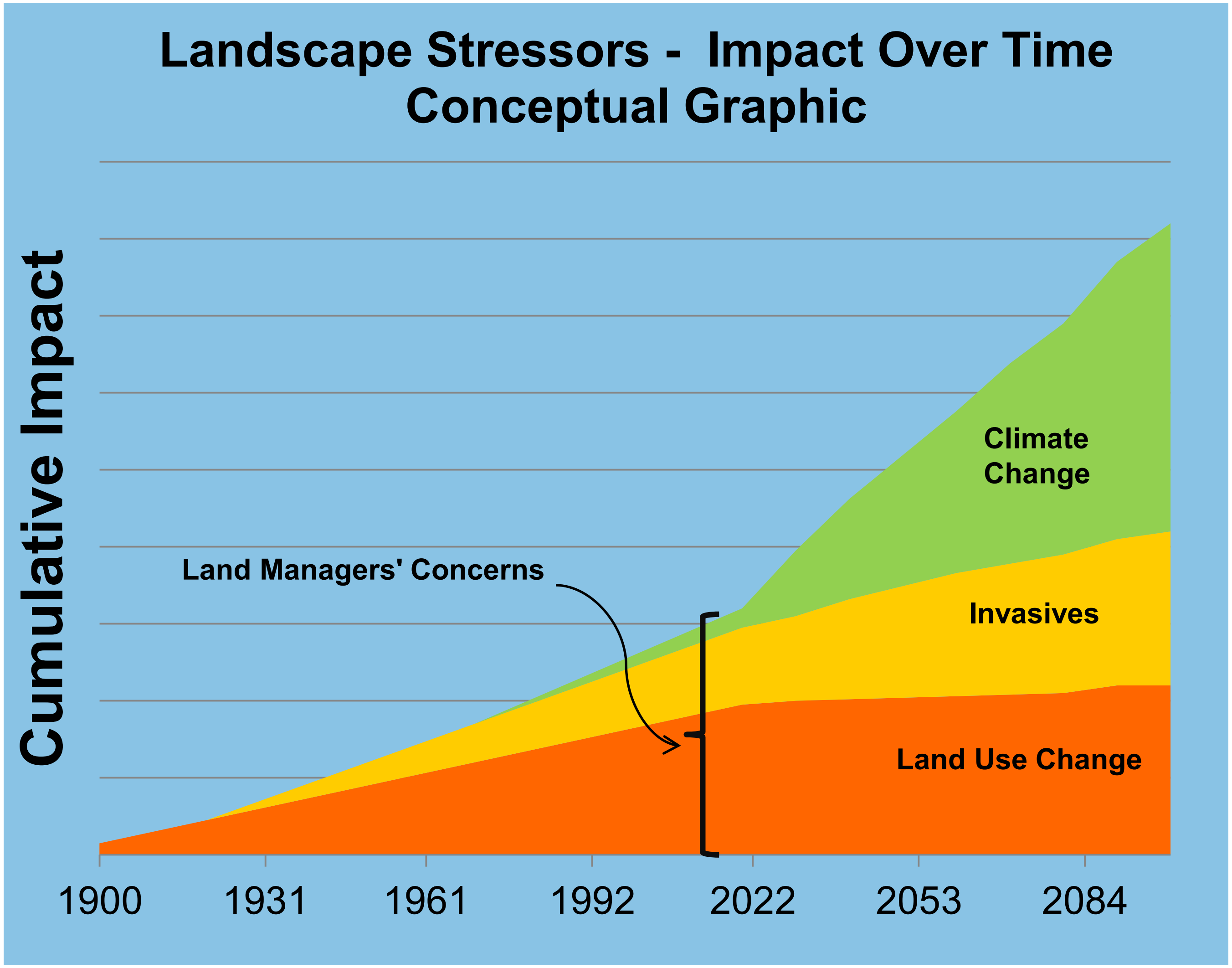
>30 GCMs and 4 emissions scenarios (RCPs)

>> 100 climate variables

Climate per se is several steps removed from

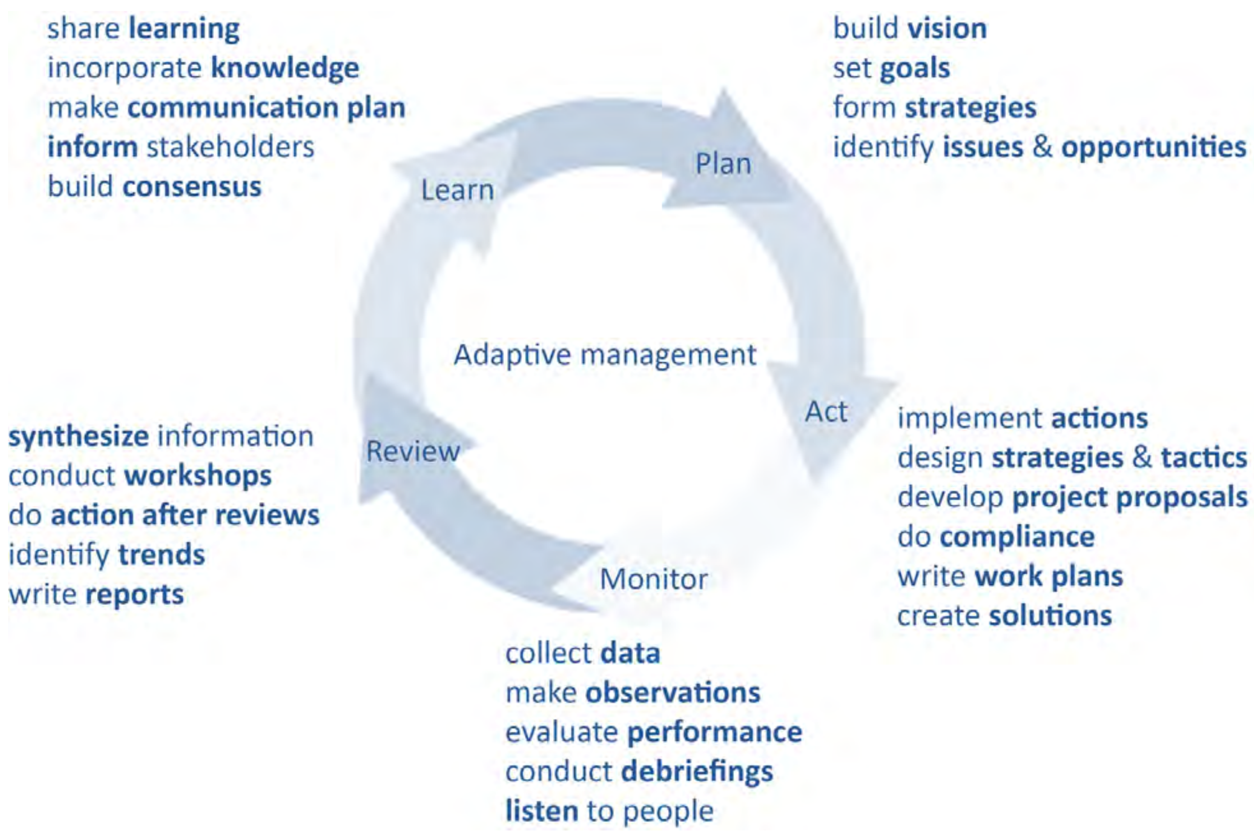
protected area resources and values

Management Urgency



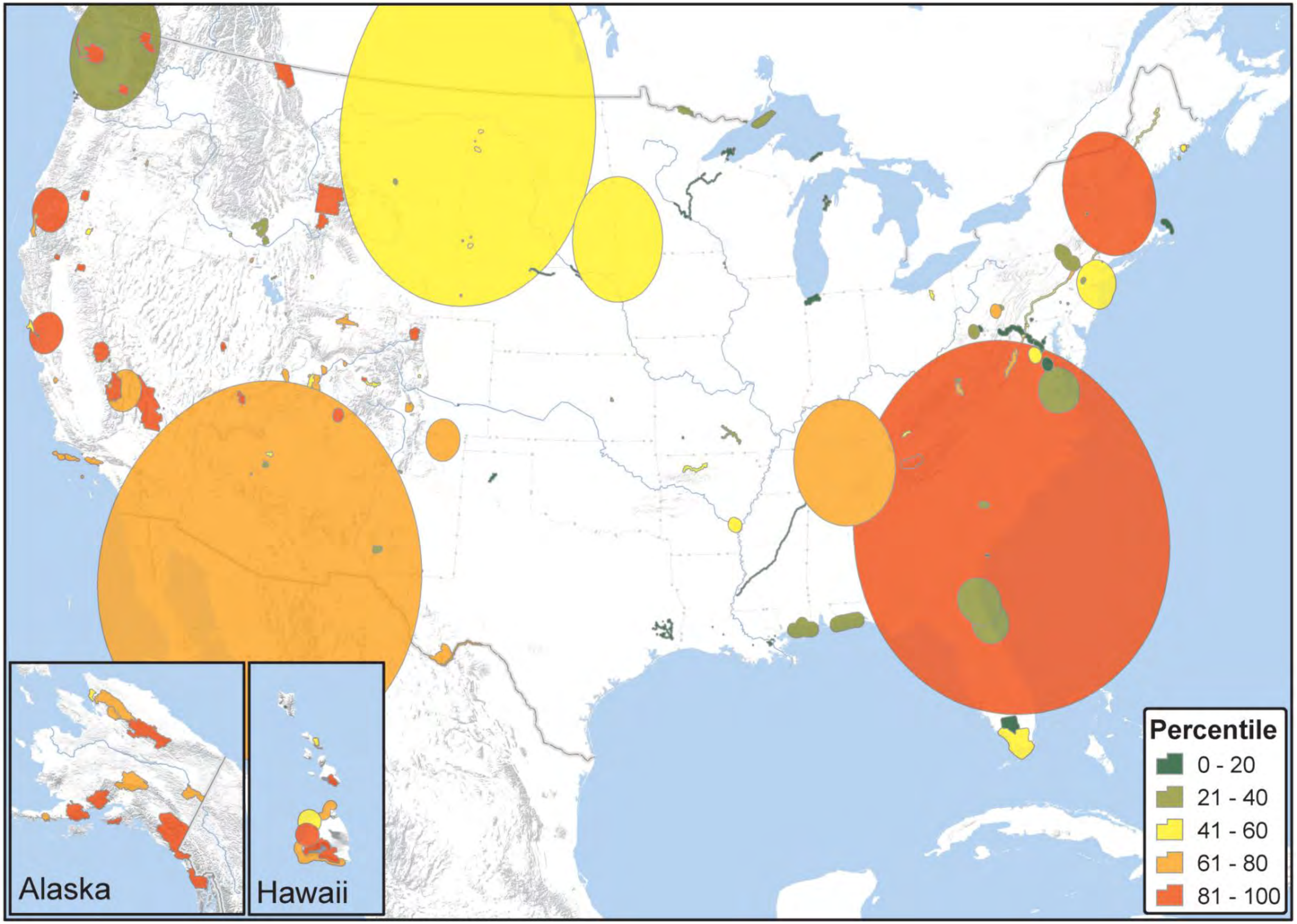
Need for Organizing Frameworks

Adaptive management framework at Rocky Mountain National Park



Bobowski et al. (Island Press, 2016)

Large Scale -> Cross Boundary



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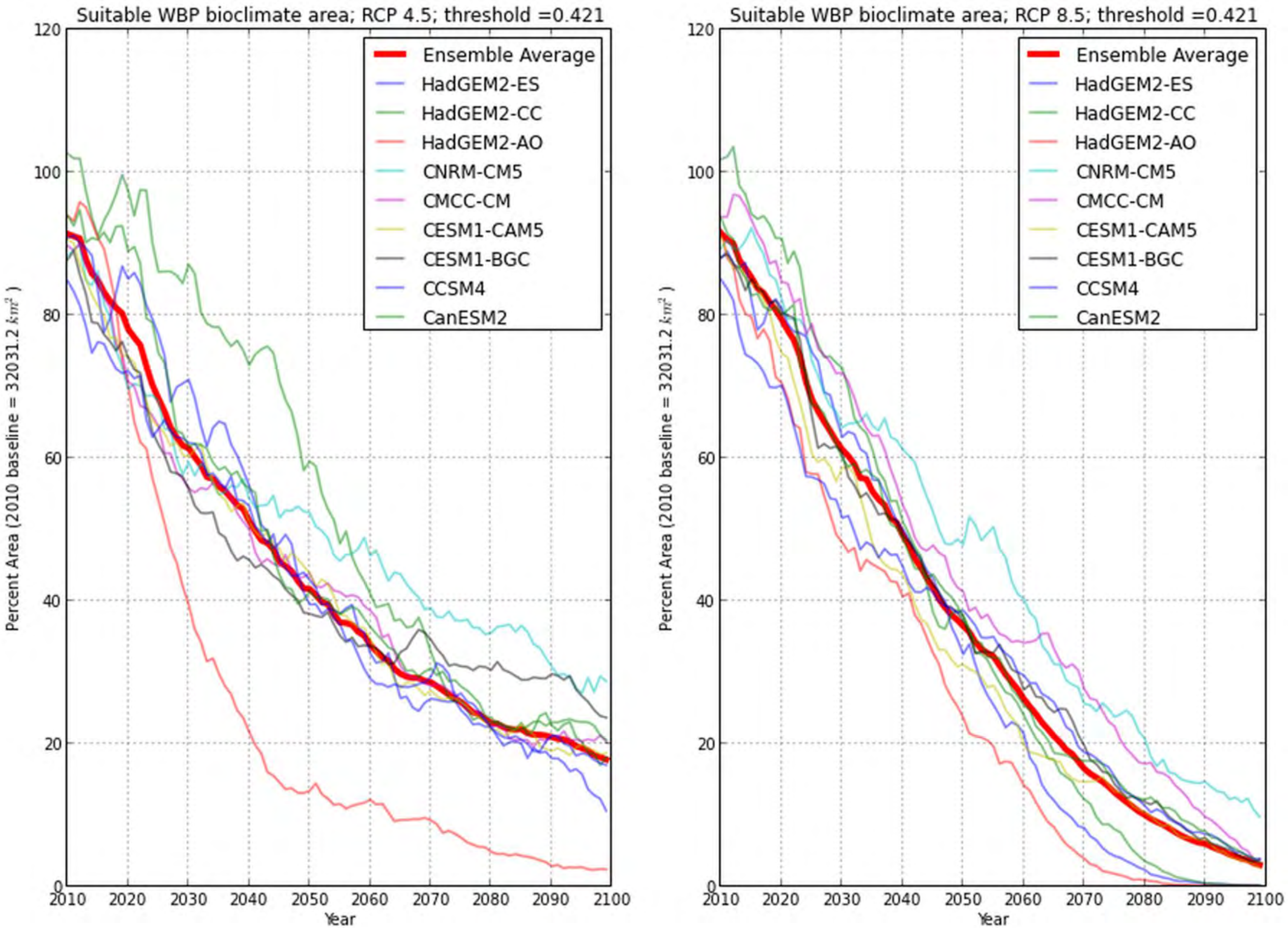
Access to Relevant Science

- Landscape Conservation Cooperatives (LCCs)
- Climate Science Centers (CSCs)
- NOAA Regional Integrated Sciences and Assessments (RISAs)
- USDA Climate Hubs
- Cooperative Ecosystem Studies Units (CESUs)
- Climate Registry for the Assessment of Vulnerability (CRAVe)
- Science and Research Learning Centers (SLCs and RLCs)
- NPS Inventory and Monitoring Program
- NPS projects like LCC-VP

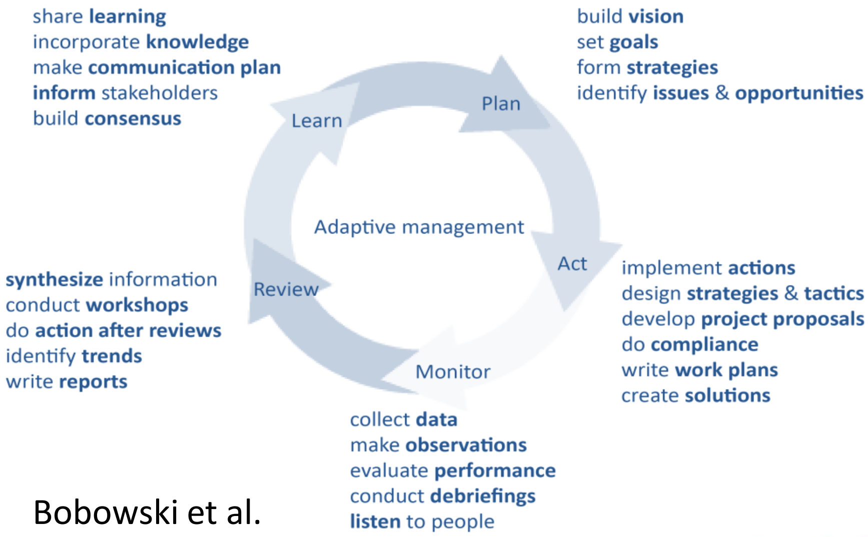
Embracing Uncertainty

Future Whitebark Pine distribution in the Greater Yellowstone Ecosystem

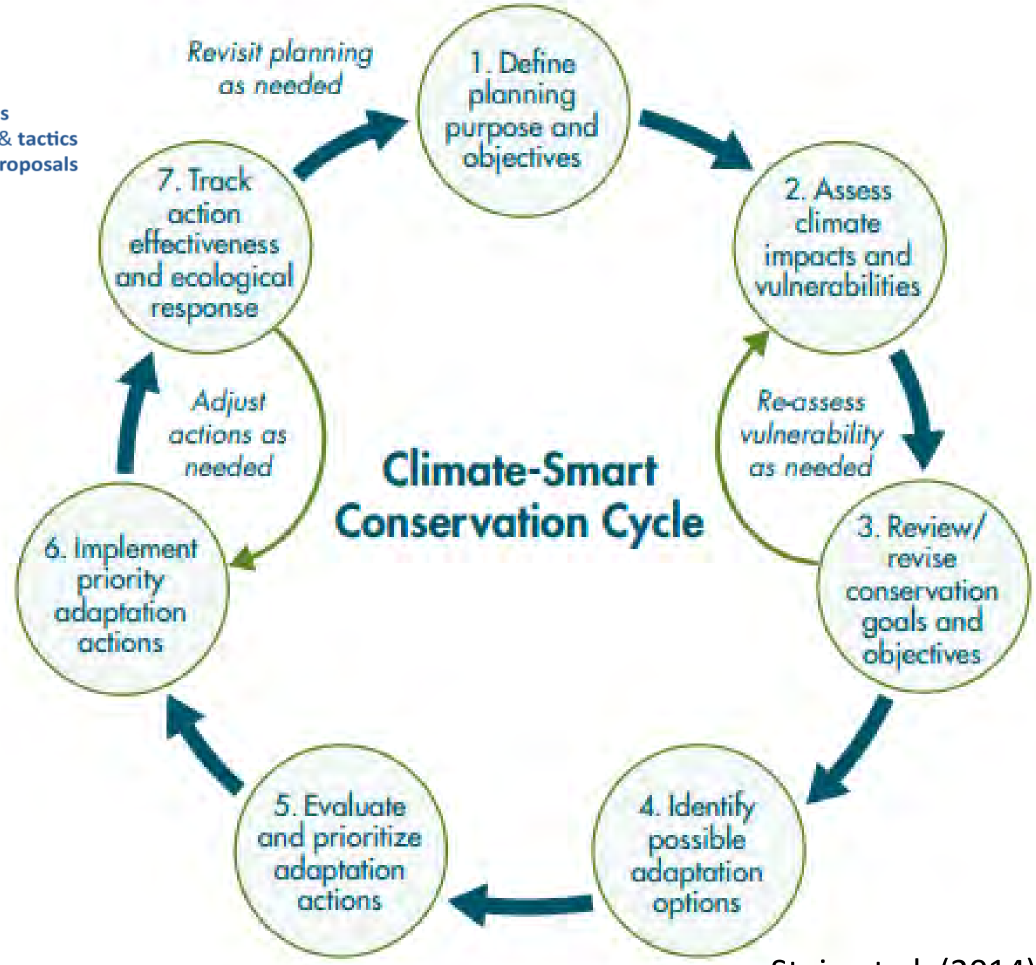


Chang et al. (2014)

Organizing Frameworks

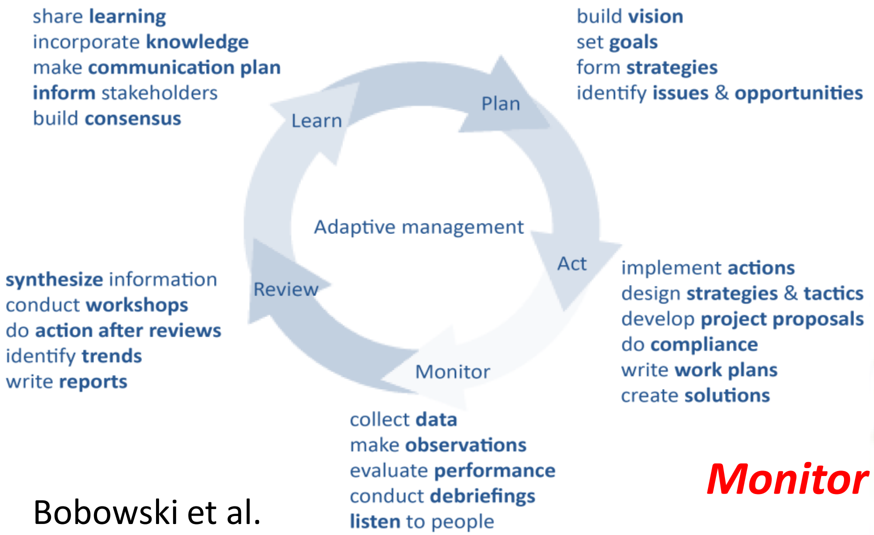


Bobowski et al.
(Island Press)



Stein et al. (2014)

Organizing Frameworks



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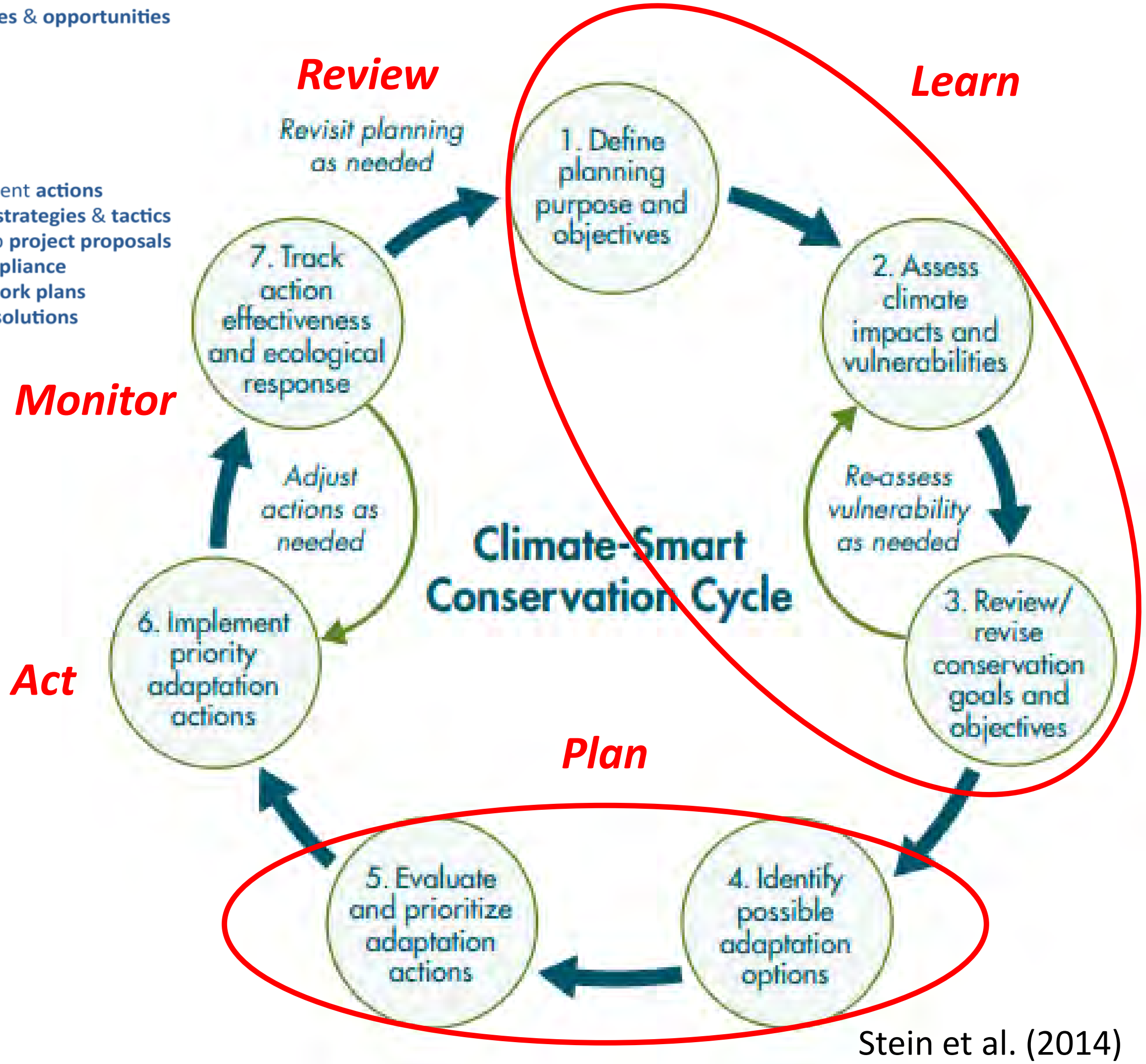
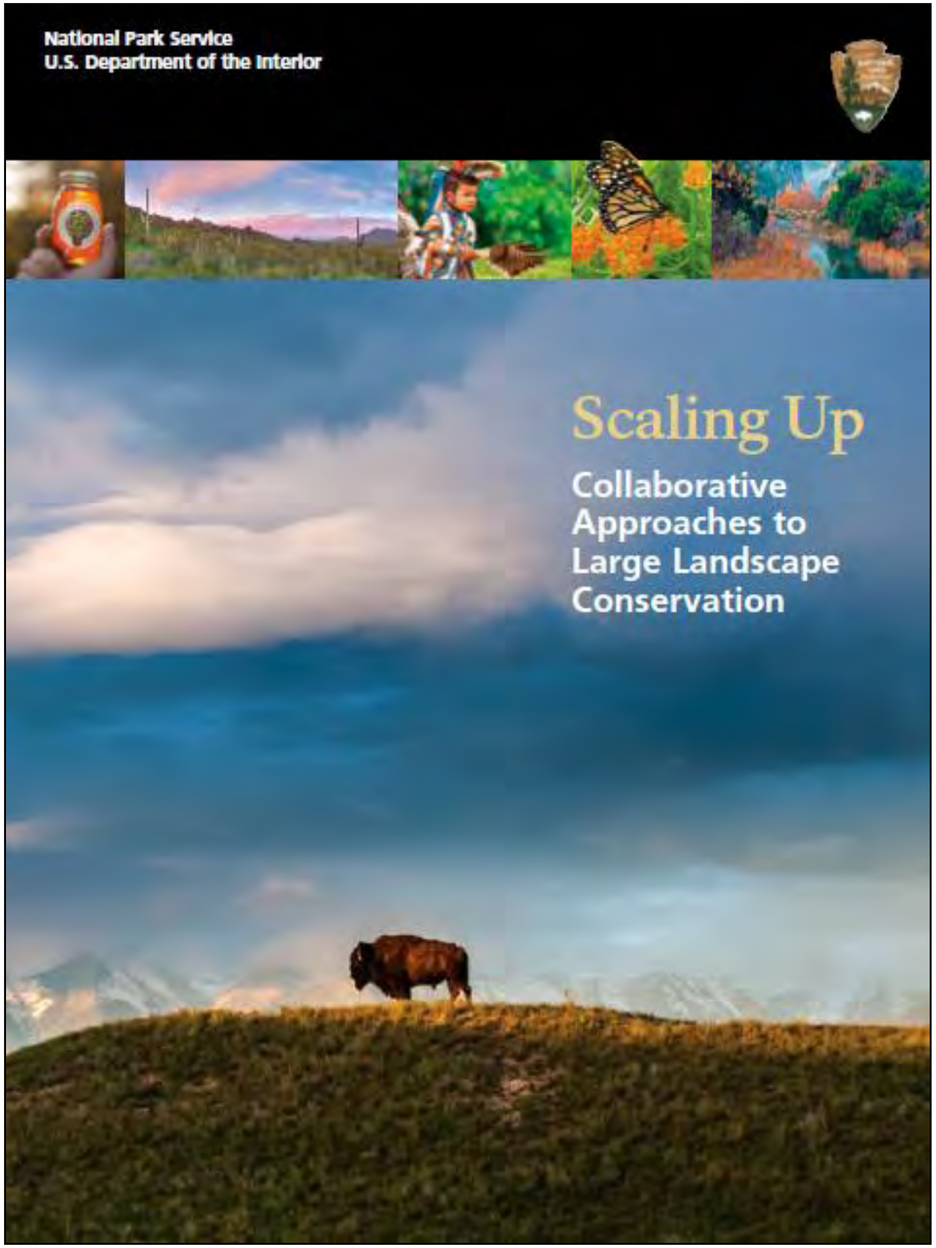
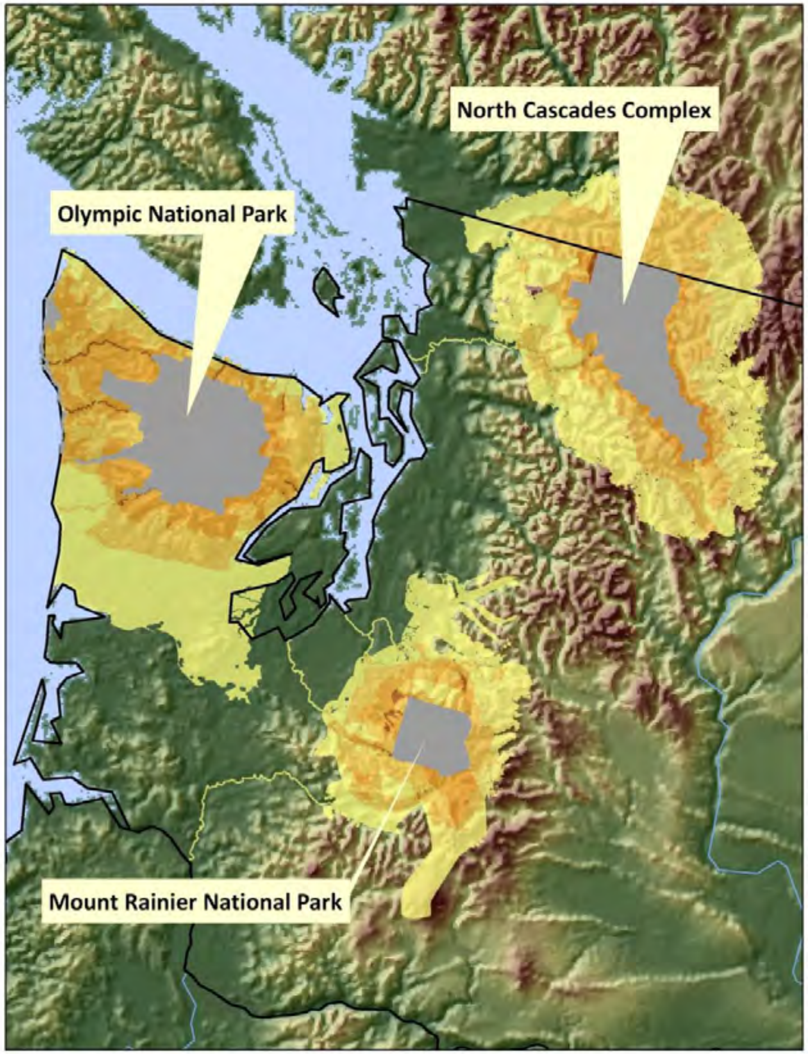


Stein et al. (2014)

Scaling Up



Protected Area Centered Ecosystem (PACE)



Hansen et al. (2011)

Communication

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Climate Exposure of US National Parks in a New Era of Change

William B. Monahan ✉, Nicholas A. Fisichelli

Published: July 02, 2014 • DOI: 10.1371/journal.pone.0101302 • Featured in PLOS Collections

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Abstract

US national parks are challenged by climate and other forms of broad-scale environmental change that operate beyond administrative boundaries and in some instances are occurring at especially rapid rates. Here, we evaluate the climate change exposure of 289 natural resource parks administered by the US National Park Service (NPS), and ask which are presently (past 10 to 30 years) experiencing extreme (<5th percentile or >95th percentile) climates relative to their 1901–2012 historical range of variability (HRV). We consider parks in a landscape context (including surrounding 30 km) and evaluate both mean and inter-annual variation in 25 biologically relevant climate variables related to temperature, precipitation, frost and wet day frequencies, vapor pressure, cloud cover, and seasonality. We also consider sensitivity of findings to the moving time window of analysis (10, 20, and 30 year windows). Results show that parks are overwhelmingly at the extreme warm end of historical temperature distributions and this is true for several variables (e.g., annual mean temperature, minimum temperature of the coldest month, mean temperature of the warmest quarter). Precipitation and other moisture patterns are geographically more heterogeneous across parks and show greater variation among variables. Across climate variables, recent inter-annual variation is generally well within the range of variability observed since 1901. Moving window size has a measureable effect on these estimates, but parks with extreme climates also tend to exhibit low sensitivity to the time window of analysis. We highlight particular parks that illustrate different extremes and may facilitate understanding responses of park resources to ongoing climate change. We conclude with discussion of how results relate to anticipated future changes in climate, as well as how they can inform NPS and neighboring land management and planning in a new era of change.

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Climate Change
Resource Brief

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship & Science

Recent Climate Change Exposure of Rocky Mountain National Park

Climate change is occurring at especially rapid rates in some areas of the U.S. In national parks, climate change challenges the ability of park managers to preserve natural and cultural resources. To understand the "climate change exposure" of national parks—that is, the magnitude and direction of ongoing changes in climate—we investigated how recent climates compare to historical conditions. This recently published research (Monahan & Fisichelli 2014) updates the basic climate inventories for 289 national park units. Here, we summarize results for Rocky Mountain National Park, including areas within 30-km (18.6-mi) of the park's boundary.

We evaluated climate-change exposure by asking which of 25 biologically relevant climate variables recently (past 10–30 years) experienced "extreme" values relative to the 1901–2012 historical range of variability. We define "extreme" conditions (e.g., extreme warm, extreme wet) as exceeding 95% of the historical range of conditions.

Methods

To evaluate recent climate values within the context of historical conditions, we used the following methods (also illustrated in Figure 1):

- **For each temperature and precipitation variable, we analyzed data within three progressive time intervals, or "moving windows," of 10, 20, and 30 years to calculate a series of averages over the entire period of analysis (1901–2012). For example, in progressive 10-year intervals, we calculated averages of temperature and precipitation for** 103 blocks of time (1901–1910, 1902–1911 . . . 2003–2012), and repeated this approach for the 20 and 30-year "windows." This type of analysis helps to smooth year-to-year fluctuations in order to identify longer-term trends that characterize the park's historical range of variability (HRV). The three windows encompass both near- and long-term management and planning horizons, as well as important climatic periods and cycles.
- **We compared the average temperature and precipitation values for each of the *most recent* 10, 20, and 30 year intervals (2003–2012; 1993–2012; and 1983–2012) to those of all corresponding intervals across the entire period of 1901–2012. These results (expressed as percentiles) describe "recent" conditions relative to historical conditions. For example, a 90th percentile for annual average temperature over the most recent 10-year interval (2003–2012) means that the annual average temperature during this time exceeded 90% of annual average temperatures for all 10-year periods from 1901 to 2012.**
- **We then averaged the percentiles of the most recent 10, 20, and 30-year time periods and computed the maximum difference in recent percentile. For each park and climate variable, this resulted in both an overall measure of recent climate change exposure with respect to HRV (dots in Figure 2), and an estimate of sensitivity to moving-window size (length of bars in Figure 2).**

See Monahan & Fisichelli (2014) for a detailed explanation of methods, and Figure 1 for an example analysis applied to annual mean temperature.

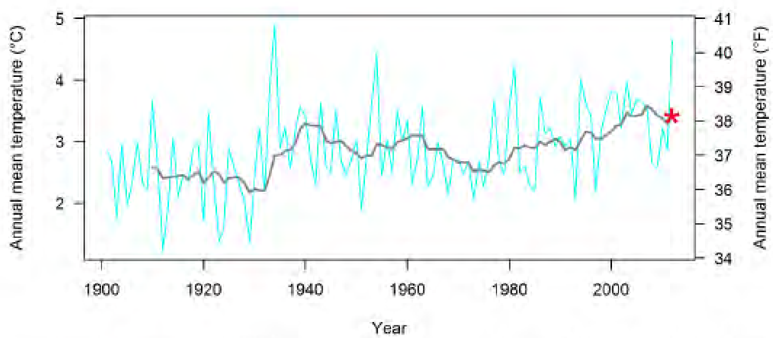

Figure 1. Time series used to characterize the historical range of variability and most recent percentile for annual mean temperature at Rocky Mountain National Park (including areas within 30-km [18.6-mi] of the park's boundary). The blue line shows temperature for each year, the gray line shows temperature averaged over progressive 10-year intervals (10-year moving windows), and the red asterisk shows the average temperature of the most recent 10-year moving window (2003–2012). The most recent percentile is calculated as the percentage of values on the gray line that fall below the red asterisk (see results of most recent percentiles for all temperature and precipitation variables in Figure 2).

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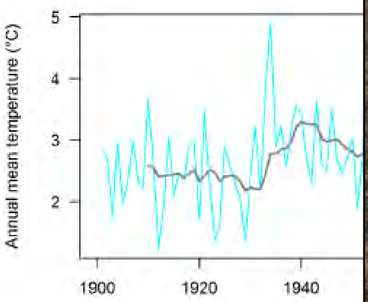

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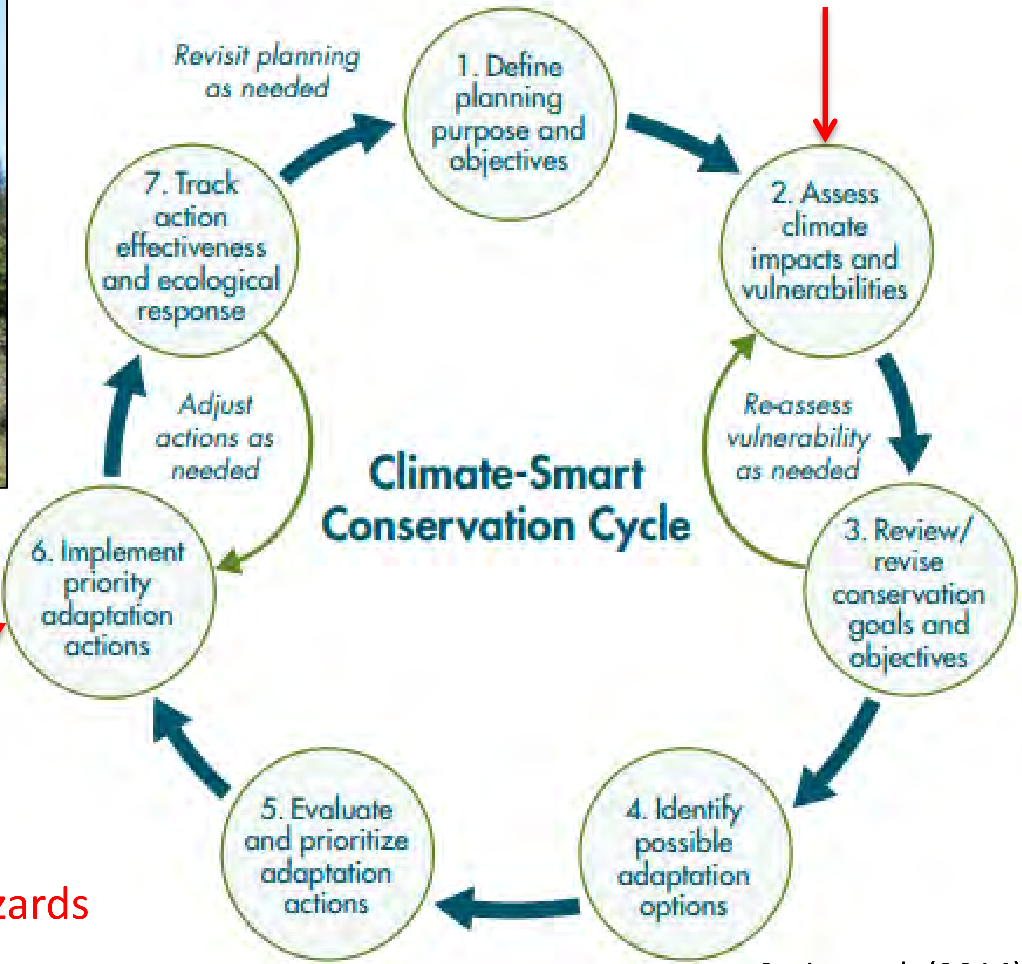
Putting it All Together

Mountain pine beetle epidemic – Rocky Mountain NP

Epidemic not unprecedented



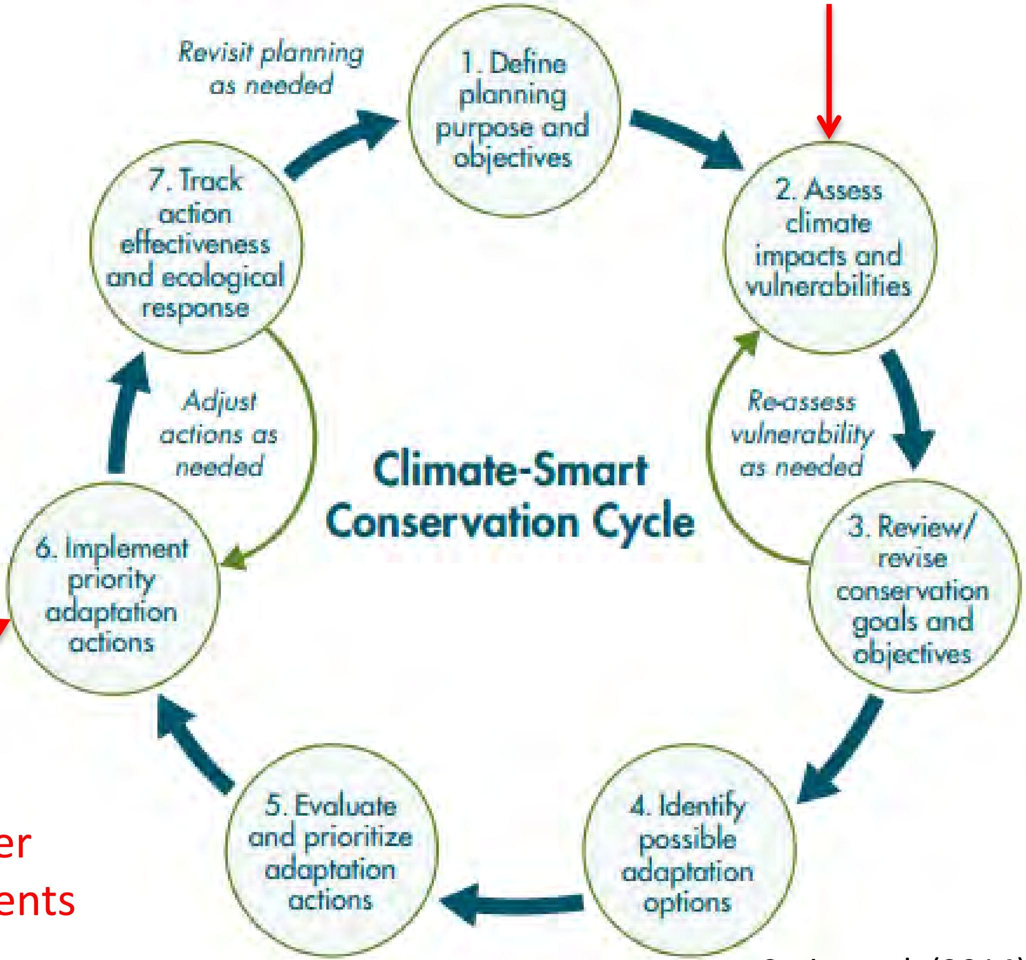
Already increased fire frequency
Active management = removing tree hazards

Stein et al. (2014)

Putting it All Together

Floods – Rocky Mountain NP

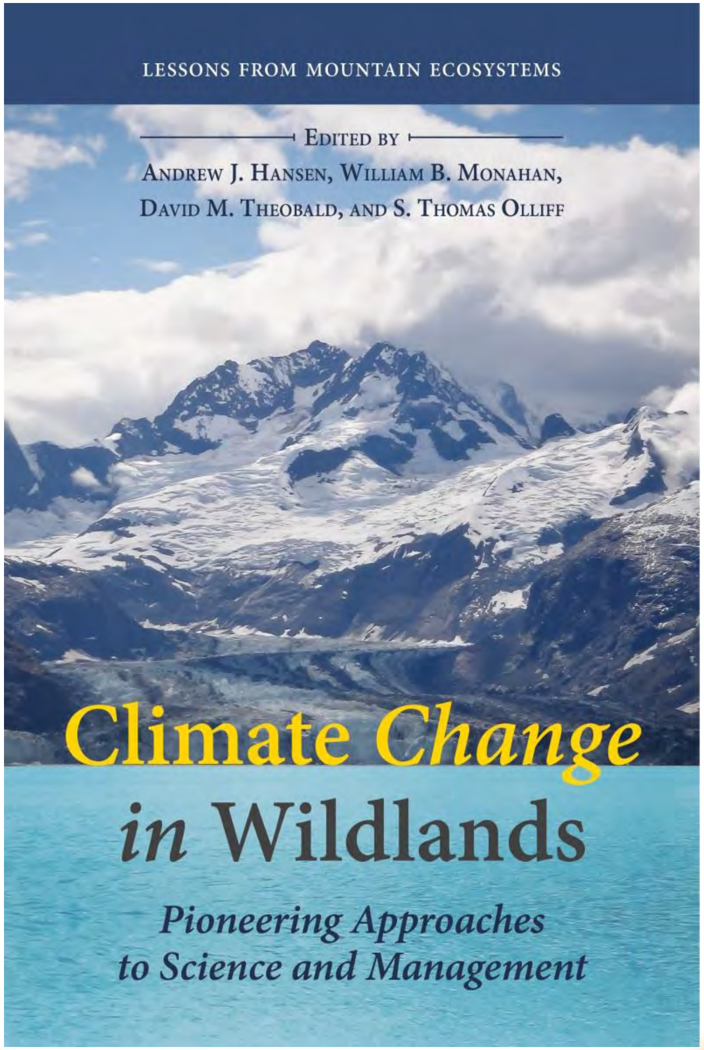
Increasing precip & runoff



Large culverts being installed to better accommodate future extreme flood events

Stein et al. (2014)

LCC-VP Findings and Lessons-Learned



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