Responding to Climate Change in the NPS Intermountain Region:

A Guide to Developing Park-based Adaptation Strategies

Great Northern LANDSCAPE CONSERVATION COOPERATIVE

NASA

LCC-VP LANDSCAPE CLIMATE CHANGE VULNERABILITY PROJECT

NATIONAL PARK SERVICE IMR Resources and Science

GRYN

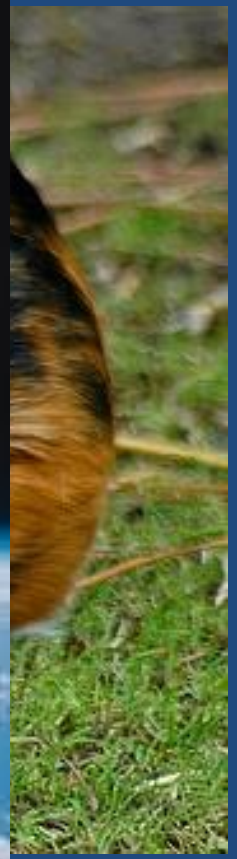
GOAL

Provide guidance for park managers to use the science and tools of climate change adaptation to develop climate change adaptation strategies that support science-based park management:

- Scenario planning
- Climate data, models, and projections
- Ecological and cultural resource response models
- Vulnerability assessments
- Adaptation options guidance
- Landscape partnerships

DRAFT

RESPONDING TO CLIMATE CHA
DEVELOPING



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  Science is available from a variety of s
  as the USGS, NOAA, the Bureau of R
  Management, and the National Forest
  Federation, the Wildlife Conservation

- ***Collaborate with partners to develop, test, and appropriately apply climate change models to NPS activities.*** New partnerships are developing to enhance climate change adaptation. The DOI is actively developing both Landscape Conservation Cooperatives (Millard et al. 2012) and Climate Science Centers to increase our opportunities to work across agency boundaries and to support climate change science. The NPS Climate

Guiding Principles

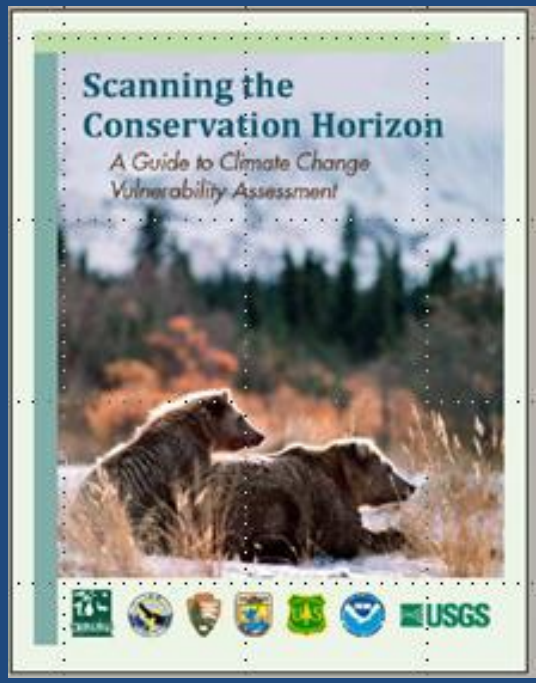
- Use the best available scientific data and knowledge to inform decision making
- Collaborate with partners to develop, test, and apply climate models
- Incorporate climate change considerations and responses in all levels of planning
- Implement adaptation strategies that promote ecosystem resilience and enhance park resources
- Develop, prioritize, and implement strategies to preserve climate-sensitive cultural resources

Assumptions

- Most of these concepts and science are new—many NPS managers are not familiar with them
- Most park managers simply don't have time to track this stuff down, learn to use it, and incorporate it into management—this process must add value without adding (too much) work
- The science we need is or mostly will be available—we do not have to conduct most of it ourselves
- The future of managing resources in parks will depend on a larger part on working with partners at the ecosystem and landscape scale—the scale of the impacts
- This first iteration won't be perfect—we will continue to monitor, review, revise

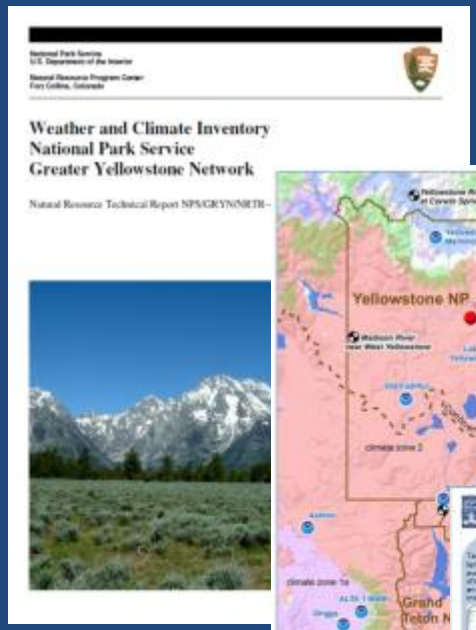
Steps to Develop Park-based Adaptation Strategies

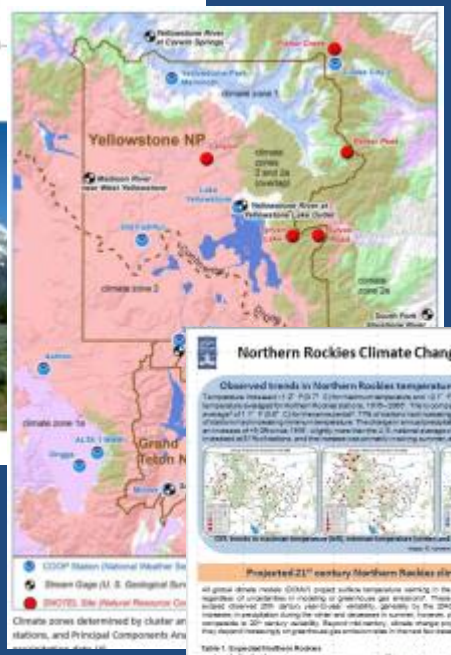
1. Designate a Climate Adaptation Network (a group of parks with similar climates and some overlap of Conservation Targets)

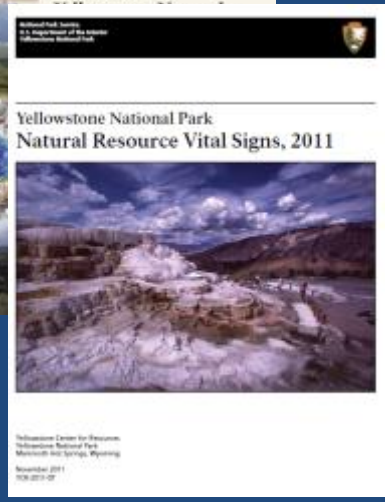


Adapted from Glick et al, NASA LCC-VP

1. Develop a climate adaptation network



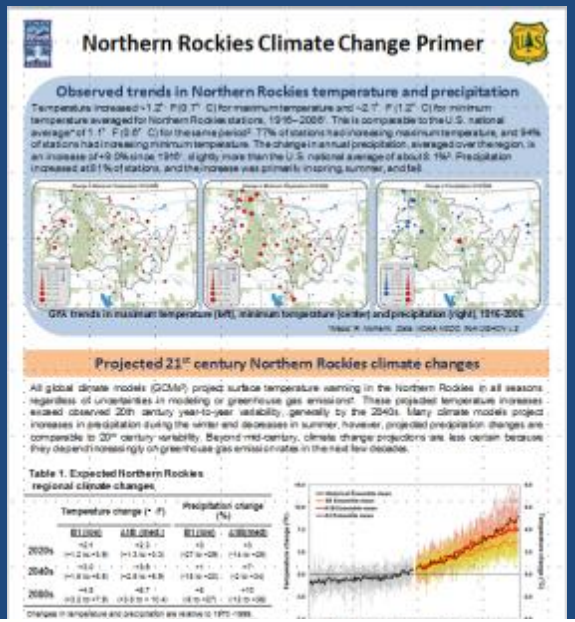




Overlapping Conservation Targets

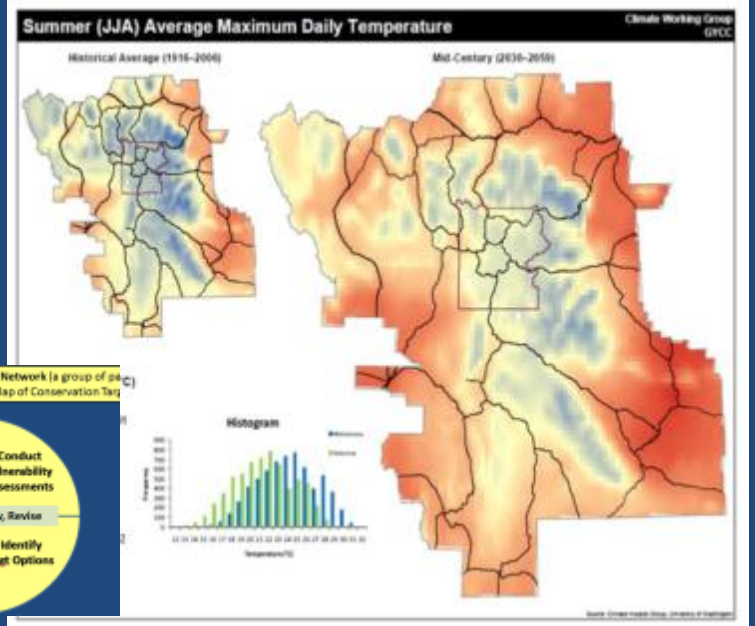
Similar climates and climate futures

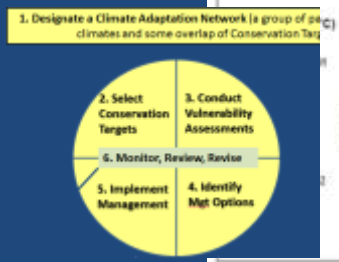
1b. Develop a climate scenario for the CAN for drivers and impacts



Greater Yellowstone Area Summary of Climate Change Projections to 2050

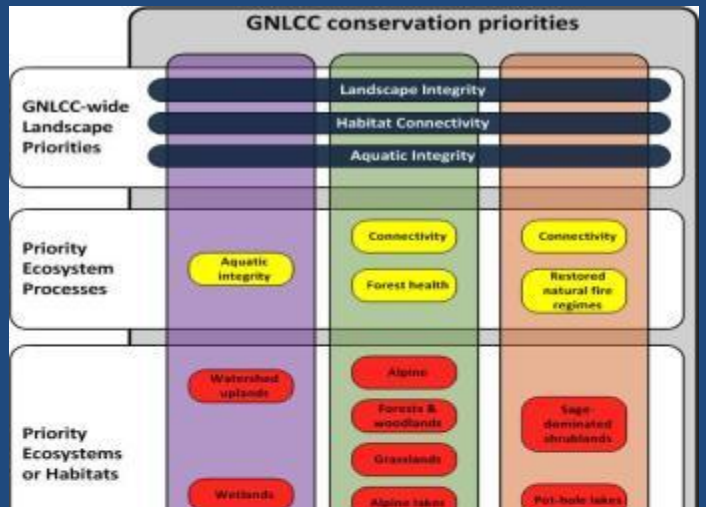
Climate Variable	Trend	Change since 1900	Projections for 2040s[1]	Projections for 2080s[1]	Source[3]
Temperature (Average annual, C^0)	↑	1.1 C^0/100 yrs	+3.9[2] (+2.5 to +5.9)	+6.7[2] (+3.8 to +10.4)	Haas 2010; UW Climate Impacts Group
Precipitation (Average annual, mm)	↔	0 mm /100 yrs	+7[2] (-2 to +34)	+10[2] (-12 to +36)	Haas 2010; UW Climate Impacts Group
Moisture Index (PPT/PET); Soil Moisture (mm)	↓	-0.4 mm /100 yrs	-17mm		Haas 2010; UW Climate Impacts Group
Snow Pack (April 1 snow water equiv.)	↓	~20% lower than 500-year average	-34%		Peterson et al. 2011; UW Climate Impacts Group





Impacts of Climate Change on Greater Yellowstone Resources

Category	Topic	Trend	Comments
Air Quality	N Deposition	↔	Ammonium in wet deposition is elevated. This nitrogen species is of concern due to possible impacts on high elevation lakes and streams, and possible nutrient enrichment in soils, leading vegetation changes in alpine and arid shrublands areas
	Ozone	↔	Ozone concentrations are low. There are ozone sensitive plants in YELL and GRTE, including sagebrush, spreading dogbane, aspen and Scouler's willow. However risk of foliar injury is low at this time.
Biota	Amphibians	↓	The effects of climate change on amphibians are expected to be multi-faceted and include direct physiological impacts as well as indirect impacts to the species' habitat, competitors, predators, and pathogens. Boreal toads appear to have experienced a population decline across the Rocky Mountains from north to south, a pattern potentially associated with the distribution of chytrid fungus. (summarized in Ashton 2010)
	Aspen Trees	↓	There has been some expansion of aspen into higher elevations, and aspen may be positively affected by global changes such as increasing fire frequency, beetle outbreaks, and rising CO2, however, aspen is expected to continue to decline at the landscape scale as a result of fire suppression and a recently-described phenomenon known as sudden aspen decline that may be associated with disease and other pathogens (Strand et al. 2009; Worrall et al. 2008). Aspen recruitment has been very limited since 1975 in areas of Rocky Mountain National Park, and heavy browsing by elk has reduced regeneration by up to 90%, although aspens have remained stable in areas with fewer elk, suggesting that herbivory plays a larger role than climate change in aspen decline (Binkley 2008).
	Birds	↔	Avian responses to climate change can be broadly categorized as changes in range and distribution, phenology, behavior, and morphology (Fiedler 2009; Van Buskirk et al. 2010). American Robins in the Colorado rocky Mountains are arriving earlier in spring than in previous decades (14 days earlier in 1999 than in 1981).
	Elk	↑	Reduced precipitation, especially less snow, has created more favorable conditions for elk population growth in Montana (Creel and Creel 2009) and is predicted to improve conditions for elk in Colorado, including a potential increase in the size of the equilibrium population (Wang et al. 2002).



2. Select conservation targets

- Species
- Ecosystems
- Ecological Processes
- Cultural Resources

DRAFT criteria for selecting the conservation targets:

(1) They are priority resources or issues for NPS management (e.g., part park's enabling legislation; iconic resources);

(2) They are resources that can be impac d actions; (i.e., Managers can "turn the knobs")

(3) We are required by law to report on the status of the resource (e.g., cies; air quality; National Historic Landmarks)

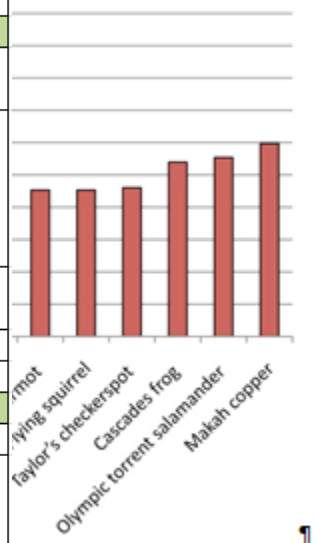
(4) Species, ecosystems, or processes that have a multiplier effect on other resources (e.g., ecological systems, keystone species, ecological engineers, umbrella species, link species)

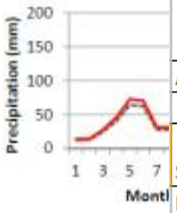
(5) Resources that might be particularly sensitive to climate change

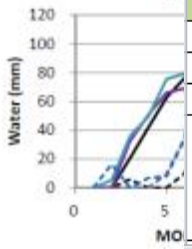
WORKSHOP ALERT!

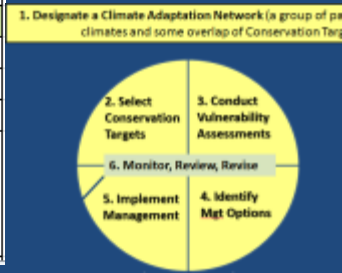
Beg… …nts

Potential Climate Change Conservation Targets					
Workshop/Process to Identify Conservation Targets					
Science Agenda (Nov 2009)[1]	High Elevation Climate Workshop (May 2010)[2]	YELL Natural Resource Vital Signs (2011)[3]	GRNY Vital Signs (Phase III Report)[4]	Great Northern LCC DRAFT Strategic Framework (June 2011)[5]	Potential Vulnerability Assessment that can inform Adaptation Options for this Conservation Target
Ecological Processes					
	Hydrology/Ground water		Hydrology		>>Middle Rockies REA;
				Connectivity	BLM Middle Rockies REA; Western Governors' Association Landscape Integrity and Connectivity Team assessment (including impacts of climate on connectivity);
Fire	Fire	Fire	Fire	Natural Fire Regimes	>>BLM Middle Rockies REA; >>Westerling et al. 2011
Drought					CIG data; Hostetler model
Flood					CIG data; Hostetler model
Ecological System					
	Aspen		Aspen		NASA LCC-VP;
Aquatic Systems			Riparian/Riverine	Rivers and Riparian Areas	Middle Rockies REA; Regional Stream Temperature Model (Isaak, GNLCC funded)
	Grassland/Shrubland		Shrub-steppe	Grasslands	NASA LCC-VP
Alpine	Alpine tundra		Alpine	Alpine	NASA LCC-VP
			Cushion Plants		
Sub-Alpine Forests				Sub-Alpine Forests	
Douglas Fir	Woodland			Woodland	NASA LCC-VP
				Alpine Lakes	
Lodgepole Pine					NASA LCC-VP
	Limber Pine				
Native Species					
		Amphibians	Amphibians		
		Arctic Grayling	Arctic Grayling		
		Bald Eagles	Bald Eagles		
		Bighorn Sheep	Bighorn Sheep		>>Middle Rockies REA; >> Mountain Ungulate Research Initiative; >>Northwest Climate Vulnerability Assessment (Lawler--GNLCC funded)



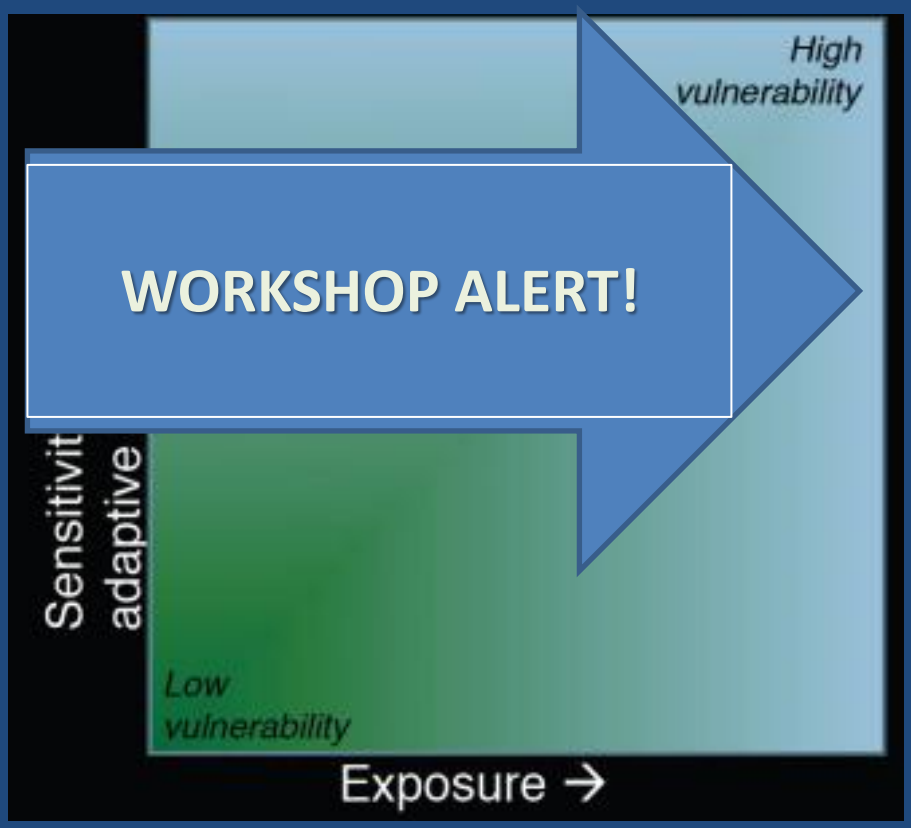






4. Identify management options

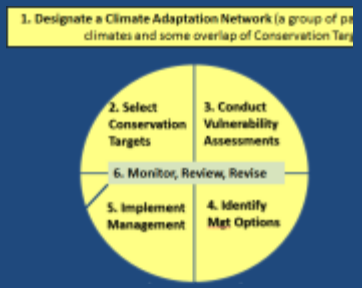
- Can management reduce the vulnerability of the conservation target?



4. Identify management options

- How feasible is it to manage for this conservation target?

¤	Low·Risk¤	Manageable¤	Save·at·High·Cost¤
Management¤	None· needed¤	Helpful¤	High·cost/Risky¤
Exposure¤	Low¤	Moderate¤	High¤
Vulnerability¤	LOW	Moderate¤	High¤
Resiliency¤	High¤	Moderate¤	Low¤
Adaptability¤	High¤	Moderate¤	Low¤



4. Identify management options

- How uncertain are we in the projections and vulnerability assessment?

Table 1. Expected Northern Rockies regional climate changes

	Temperature change (° F)		Precipitation change (%)	
	B1 (low)	A1B (med.)	B1 (low)	A1B(med)
2020s	+2.1 (+1.2 to +3.9)	+2.3 (+1.3 to +3.3)	+3 (-27 to +29)	+3 (-14 to +25)
2040s	+3.0 (+1.5 to +5.5)	+3.9 (+2.5 to +5.9)	+1 (-18 to +20)	+7 (-2 to +34)
2080s	+4.8 (+3.2 to +7.9)	+6.7 (+3.8 to + 10.4)	+8 (-8 to +27)	+10 (-12 to +36)

Changes in temperature and precipitation are relative to 1970 -1999, averaged over 117W-105W and 42N-49N. 2020s = 2010- 2039; 2040s = 2030 – 2059; 2080s = 2070 – 2099. B1 is a low greenhouse gas emissions scenario; A1B is higher until about the 2040s, then is moderate (see right). Data: CMIP3 (IPCC AR4 GCMs)[3]

4. Identify management options

- What is the time frame for the projections?

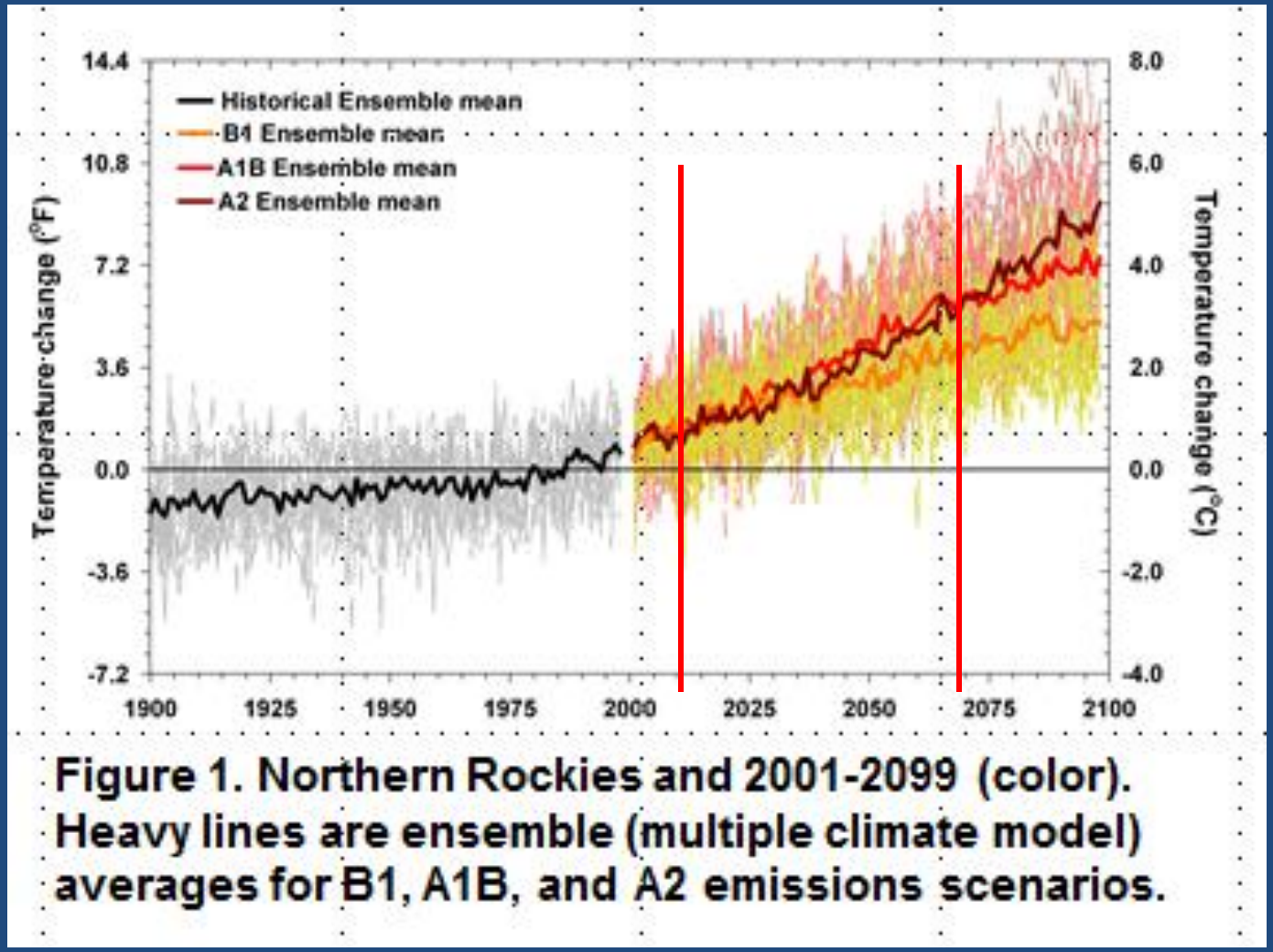
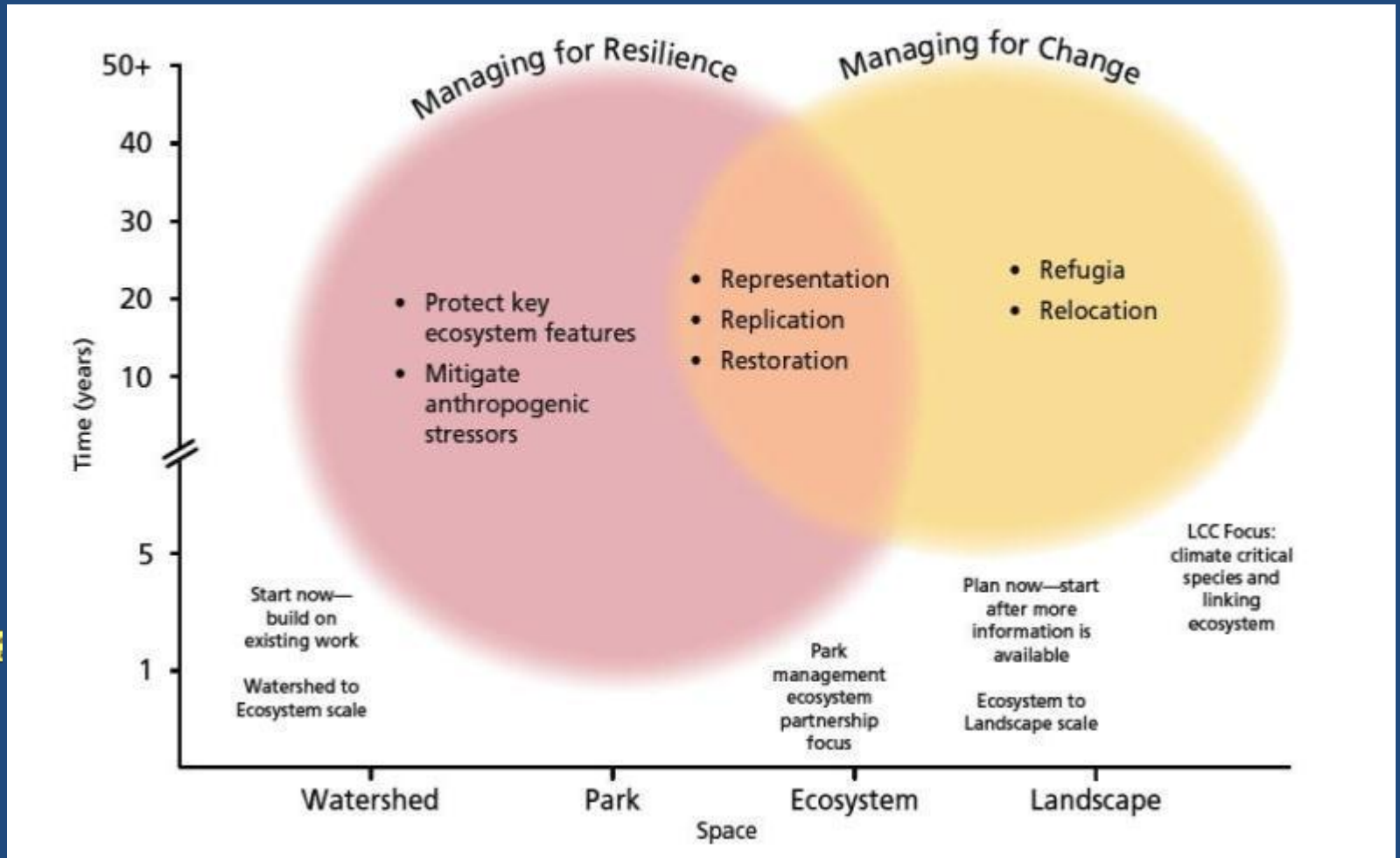


Figure 1. Northern Rockies and 2001-2099 (color). Heavy lines are ensemble (multiple climate model) averages for B1, A1B, and A2 emissions scenarios.

4. Identify management options

- Management/Adaptation Option Guidelines

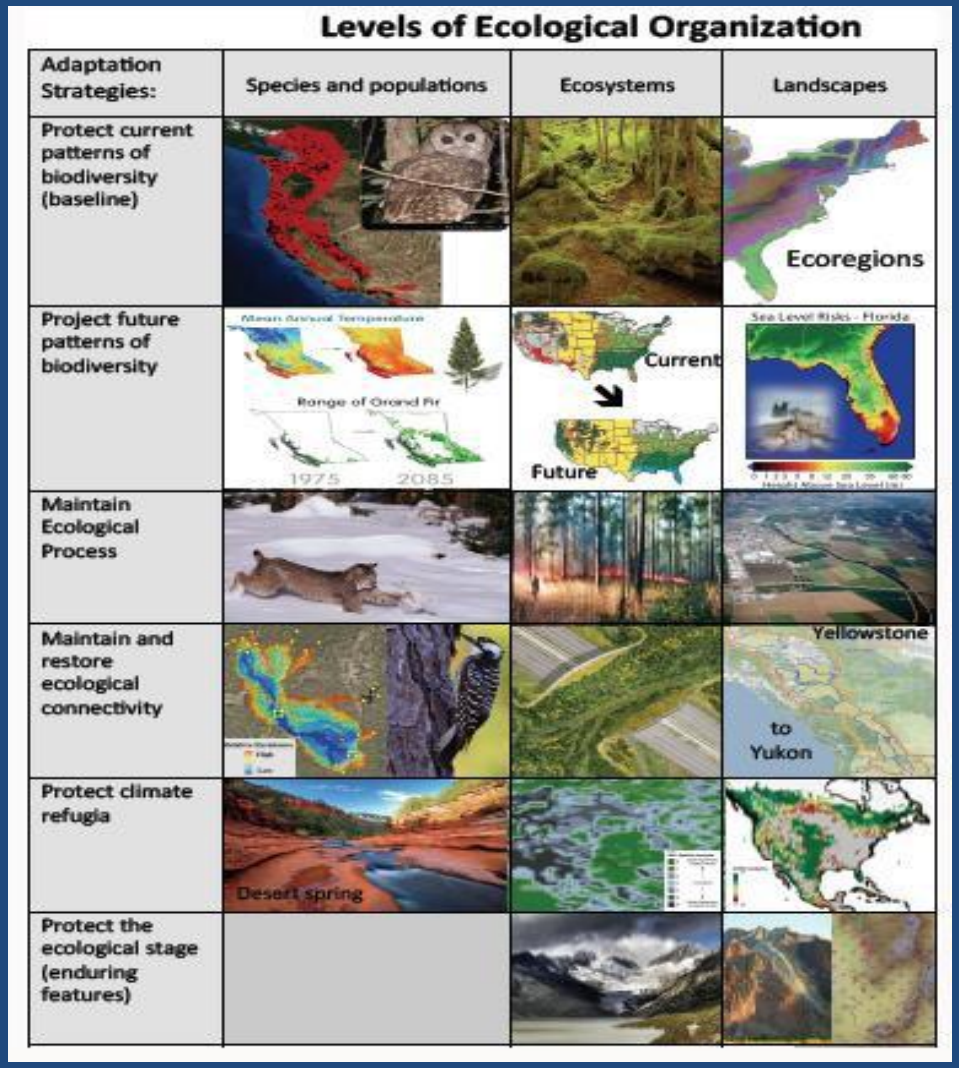
SAP 4.4



4. Identify management options

- Management/Adaptation Option Guidelines

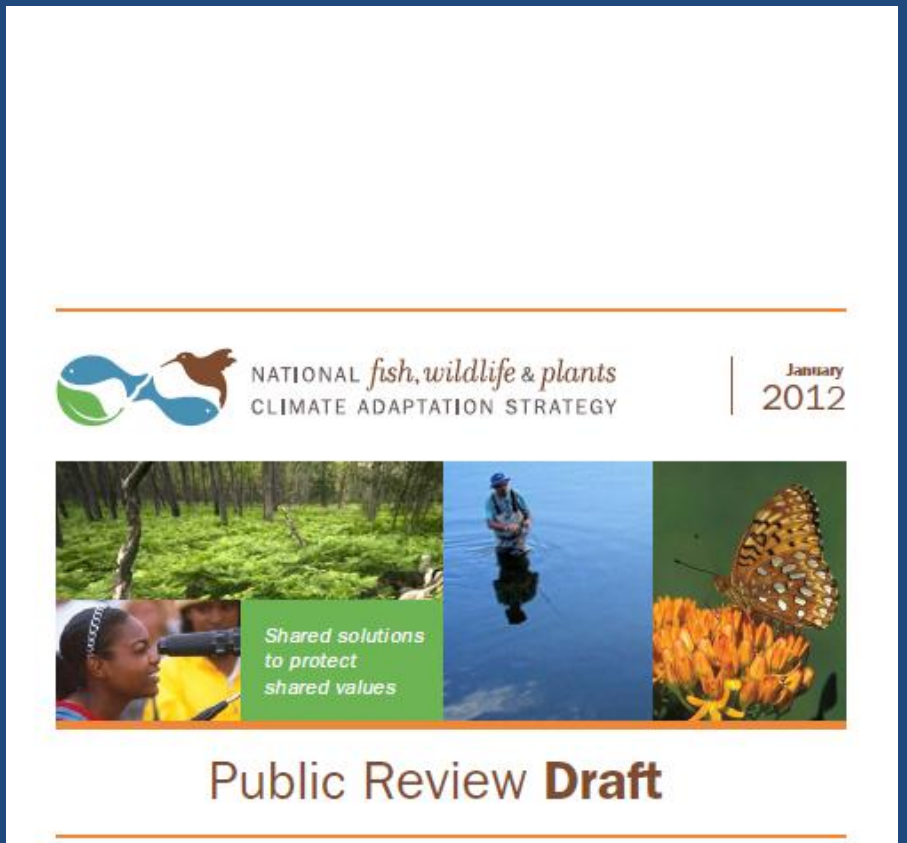
Yale Framework



4. Identify management options

- Management/Adaptation Option Guidelines

DRAFT National Fish, Wildlife, and Plant Adaptation Strategy



4. Identify management options

- What are the best management options (guidance in YALE Framework, SAP4.4, National FWP Strategy)?

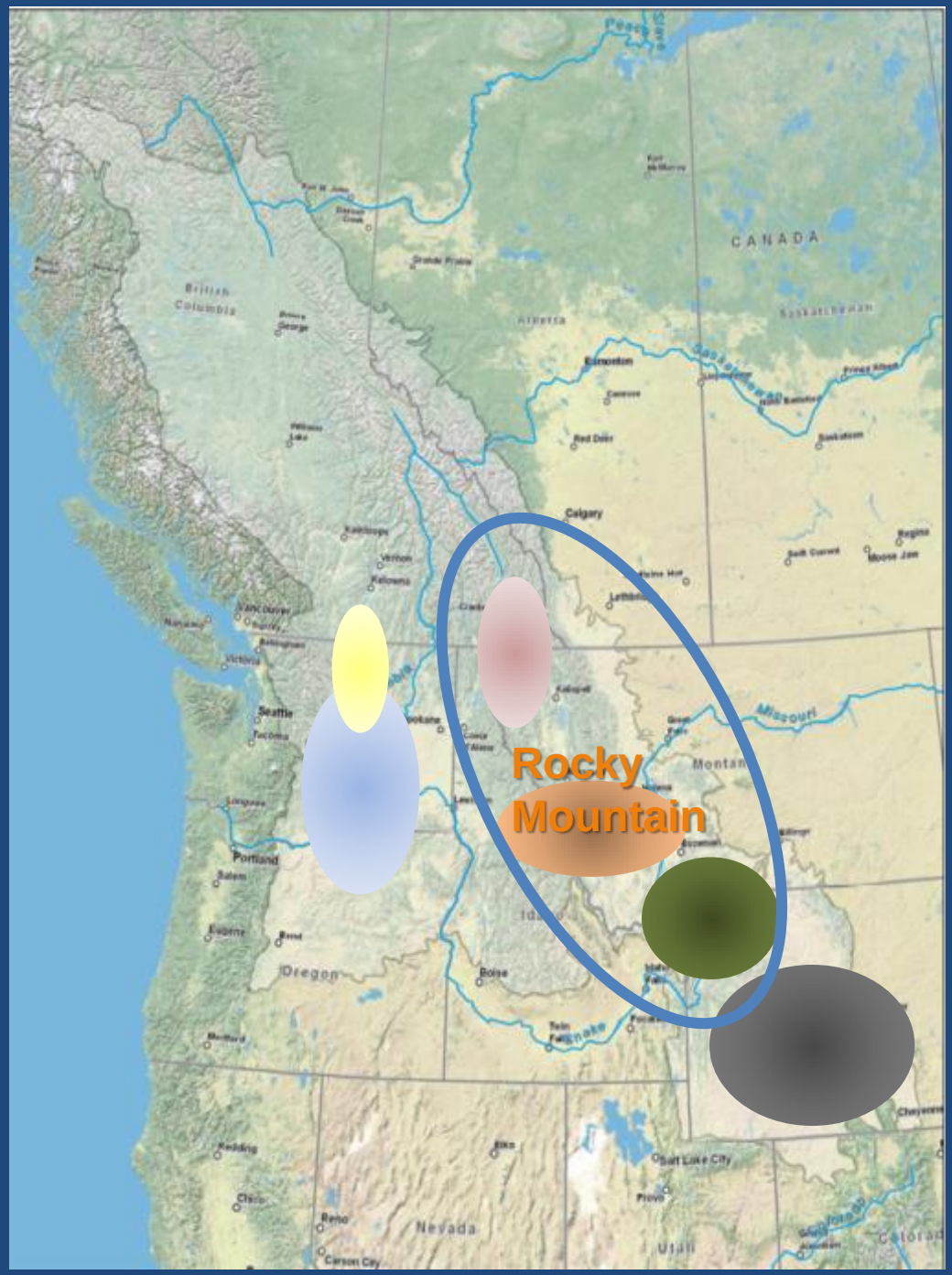
Yale Framework Adaptation Strategies compared to the Adaptation Options in US Climate Change Science Program SAP 4.4 and the National Fish, Wildlife, and Plant Adaptation Strategy

Yale Framework		US Climate Change Science Program: Synthesis and Assessment Product 4.4		National Fish, Wildlife, and Plant Adaptation Strategy	
Adaptation Strategies	Defined	Adaptation Options	Defined	Goals	Defined
1. Protect current patterns of biodiversity	Identify current patterns of biodiversity across landscapes and reduce stressors as a way to increase the probability that key components of biodiversity (e.g., vulnerable species, habitat cores, and high value ecological processes) persist or improve into the future.	1. Protect Key Ecosystem Features	Focus mgt protections on structural characteristics, organisms, or areas that represent important "underpinnings" or "keystones" of the overall system	1. Conserve habitat to support healthy fish, wildlife, and plant populations and ecosystem functions in a changing climate.	• Conserve a sufficient variety and amount of habitat and build a well-connected network of conservation areas to allow the movement of species in response to climate change.
		2. Reduce anthropogenic stresses	Minimize localized human stressors (e.g., pollution, fragmentation) that hinder the ability of species or ecosystems to withstand climatic events	2. Manage species and habitats to protect ecosystem functions and provide sustainable cultural, subsistence, and recreational, and commercial use in a changing climate.	• Integrate climate adaptation strategies and actions into existing species and conservation area management plans; • Consider species abilities to adapt to climate change, including a full range of genetic diversity; Some species may need direct management, such as captive breeding; In some cases, species may need human interventions such as translocation or assisted migration; • Continued development and application of ecosystem based approaches is a key step in the process.
		3. Representation	Protect a portfolio of variant forms of a species or ecosystem so that, regardless of the climatic change that occurs, there will be areas that survive and provide a source for recovery	3. Enhance capacity for effective management in a changing climate.	• CC adaptation requires altering existing or developing new ways of assessing information, new management tools, and new professional skills • Successful adaptation to CC demands a strong collaboration among all jurisdictions charged with fish, wildlife, and plant conservation, both domestic and international, because the impacts are occurring as scales much larger than the organizational scope of individual agencies or organizations • Many fish, wildlife, and plant conservation laws, regulations, and policies will have to be reviewed to improve their ability to address climate change considerations.
		4. Replication	Maintain more than one example of each ecosystem or population such that if one area is affected by a disturbance, replicates in another area provide insurance against extinction and a source for recolonization of affected areas	4. Support adaptive management in a changing climate through integrated observation and monitoring and use of decision support tools.	• Develop coordinated I&M systems to enable resources managers to identify changed in ecological baselines from the species to the ecosystem level • Conduct Vulnerability Assessments to inform adaptation planning • Develop Decision Support Tools to inform and enable management planning and decision making under uncertainty
		5. Restoration	Rehabilitate ecosystems that have been lost or compromised	6. Reduce non-climate stressors to help fish, wildlife, plants and ecosystems adapt to a changing climate	• Reduce the negative impacts of existing stressors, especially those that interact with climate change to magnify impacts to fish, wildlife, and plants (e.g., habitat loss and fragmentation; invasive species, disease, pollution, over-harvest, and illegal trade).

Comment [DT1]: Tom, I modified to try to organize the UCCSP and NFWPAS columns to be arranged or comparable to the YSP strategies… Not sure this is too clear or that I've got them arranged correctly as there are a lot of fuzzy areas, but I wanted to try to compare/evaluate them a bit more…

4. Identify management options

- At what scales should management occur? With which partners?



A Landscape Case Study:

Whitebark Pine

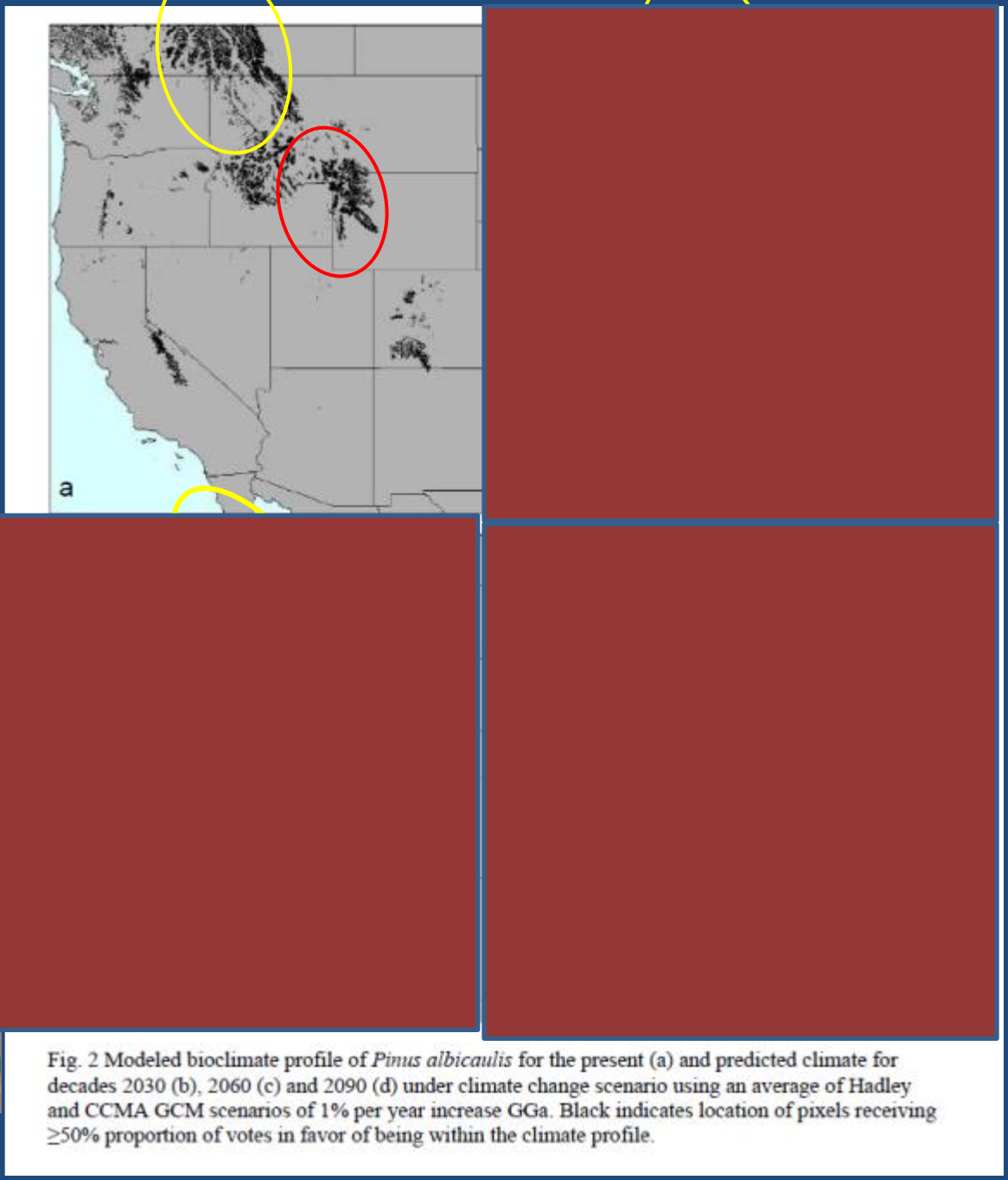
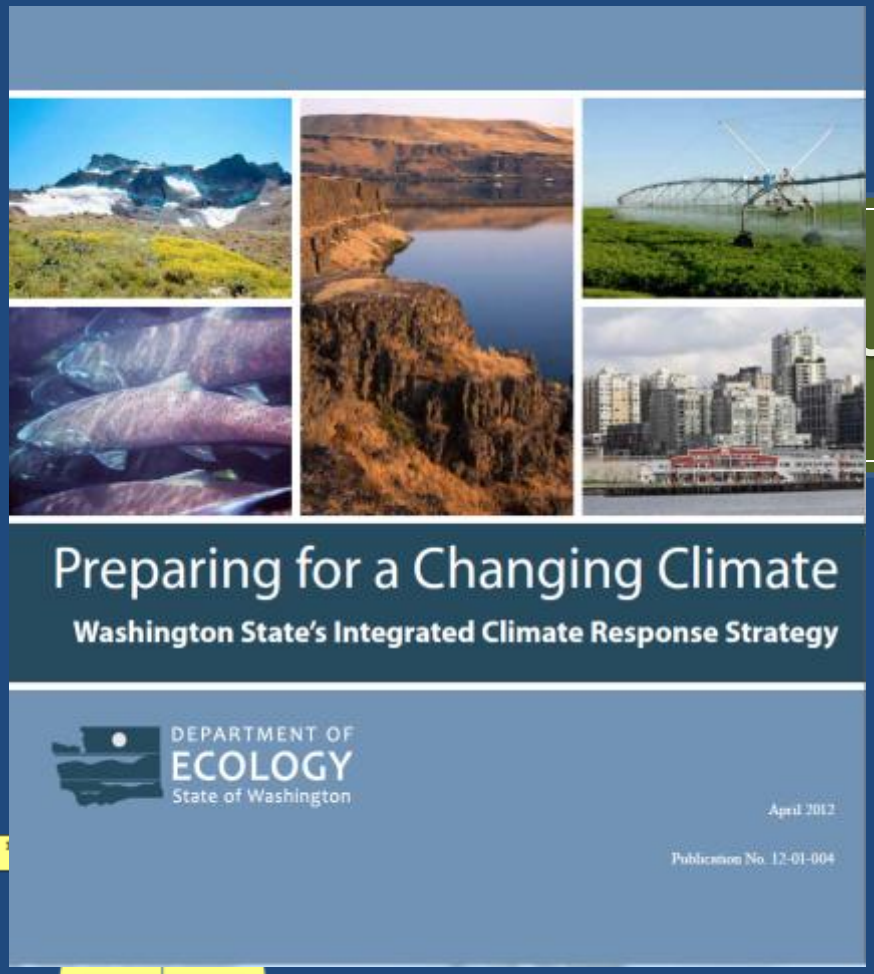


Fig. 2 Modeled bioclimate profile of *Pinus albicaulis* for the present (a) and predicted climate for decades 2030 (b), 2060 (c) and 2090 (d) under climate change scenario using an average of Hadley and CCMA GCM scenarios of 1% per year increase GGa. Black indicates location of pixels receiving ≥50% proportion of votes in favor of being within the climate profile.

4. Identify management options (Develop Adaptation Strategy)



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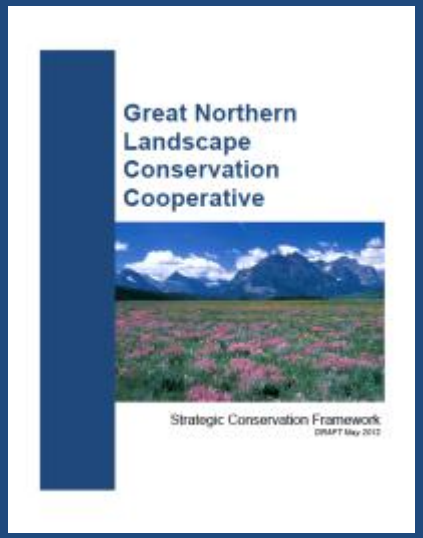
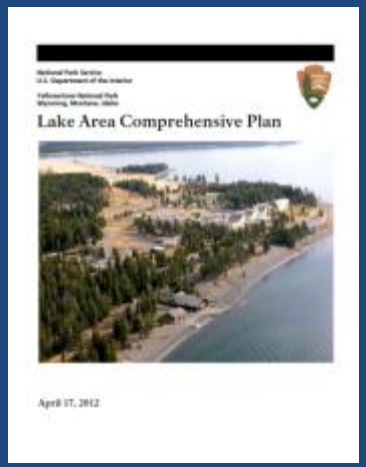
Figures and Tables

5. Implement management options



Landscape Frameworks

Ecosystem Strategies



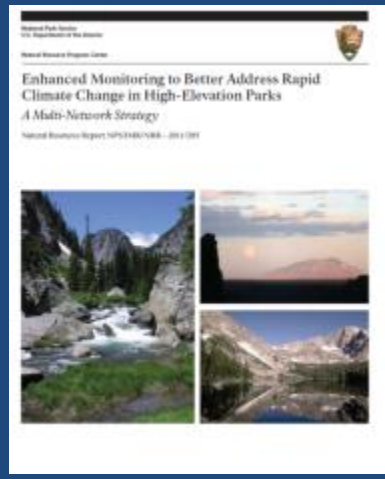
Foundation and Comprehensive Planning

Compliance and Project Planning/Implementation

6. Monitor, review, and revise (examples from High Elevation I&M)

- **Monitoring Sagebrush Steppe and Grasslands**

  Objective: Expand monitoring across all three networks to included sagebrush steppe (GRYN), grassland/woodlands (ROMN) and ecotones for conifer encroachment (UCBN, GRYN, ROMN)

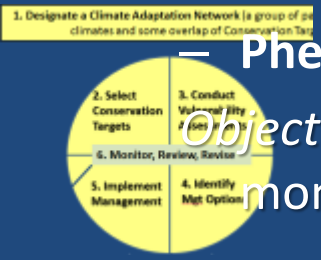


- **Monitoring Alpine Vegetation and Soil**

  Objective: Establish new GLORIA sites (GRYN and ROMN)

- **Monitoring Five-Needle Pines**

  Objective: Expand monitoring of five-needle pines (White-bark, Limber) across all three networks (disease and regeneration)



- **Phenology and Snowpack**

  Objective: Evaluate MODIS and similar technologies for broad-scale monitoring of phenology, snowpack, and productivity

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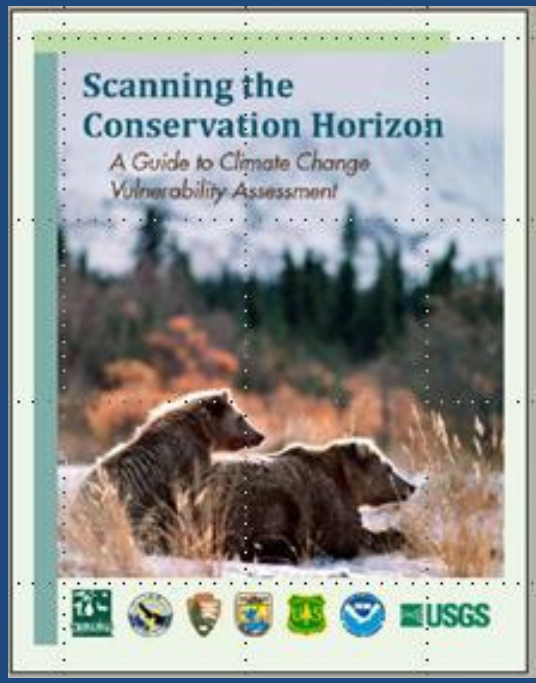

Adapted from Glick et al, NASA LCC-VP

Next Steps

- **GRTE-JODR-YELL Pilot**
  - Select Conservation Targets
  - Assess Vulnerability Assessments
  - ID Management (Adaptation) Options
  - Develop Adaptation Strategy
  - Develop Implementation Workplan
  - Monitor, Review Revise

- **IMR Regional Guidance**
  - Feedback from RSAT
  - Feedback from GRTE-JODR-YELL Pilot
  - Re-Write Document with feedback, experience, editing
  - Review and Approval from IMR
  - Establish CANs (talk with Patrick Gonzales)
  - Develop workplan to assist parks

THANKS!

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Great Northern LCC

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