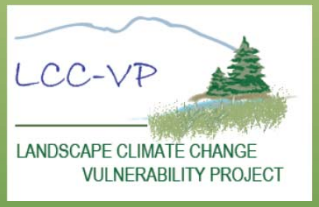
Using NASA Resources to Inform Climate and Land Use Adaptation:
Ecological Forecasting, Vulnerability Assessment, and Evaluation of Management Options Across Two USDOI Landscape Conservation Cooperatives

or

Landscape Climate Change Vulnerability Project (LCC_VP)



Colorado State University

Montana State University Bozeman

California State University Monterey Bay

Great Northern Landscape Conservation Cooperative

GRYN

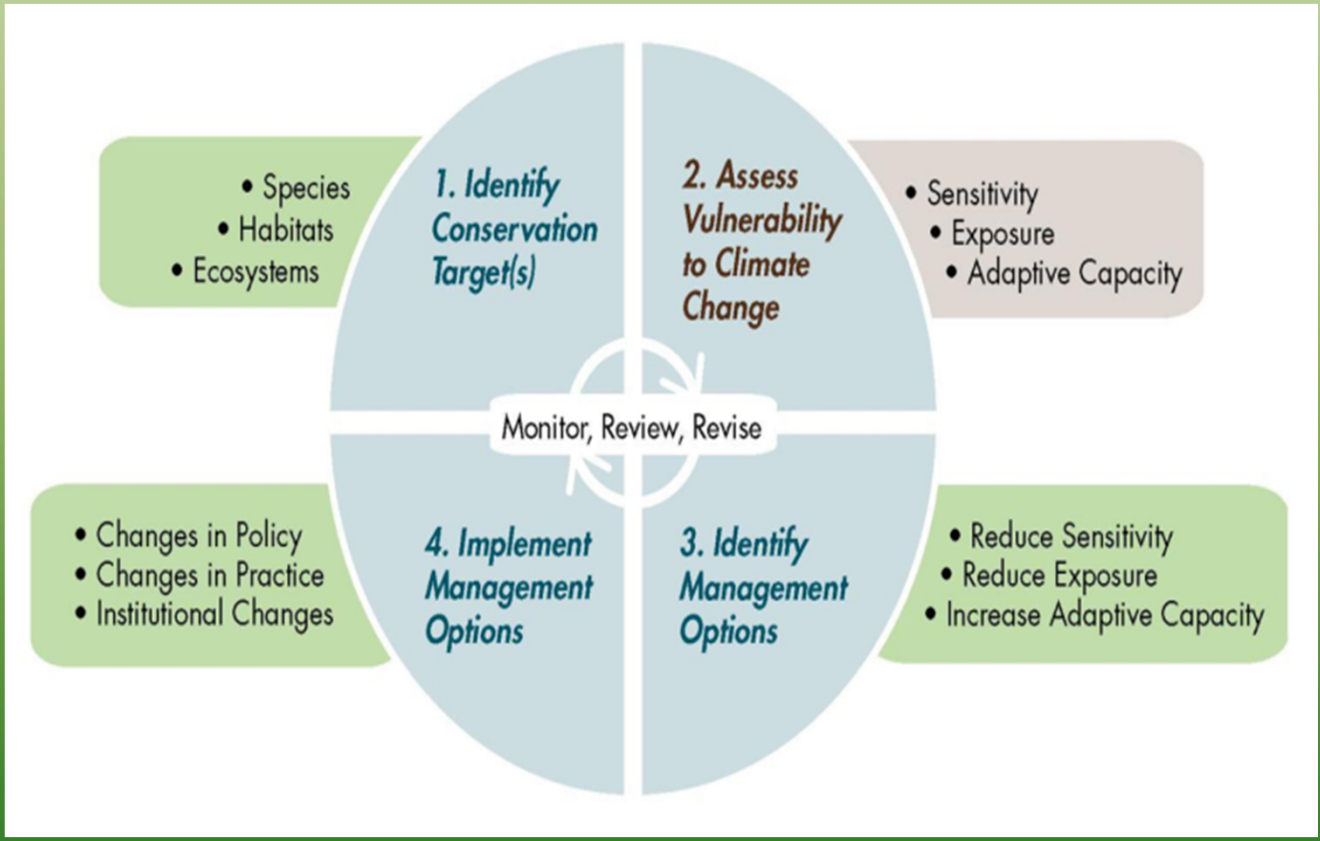
National Park Service

IMR Resources and Science

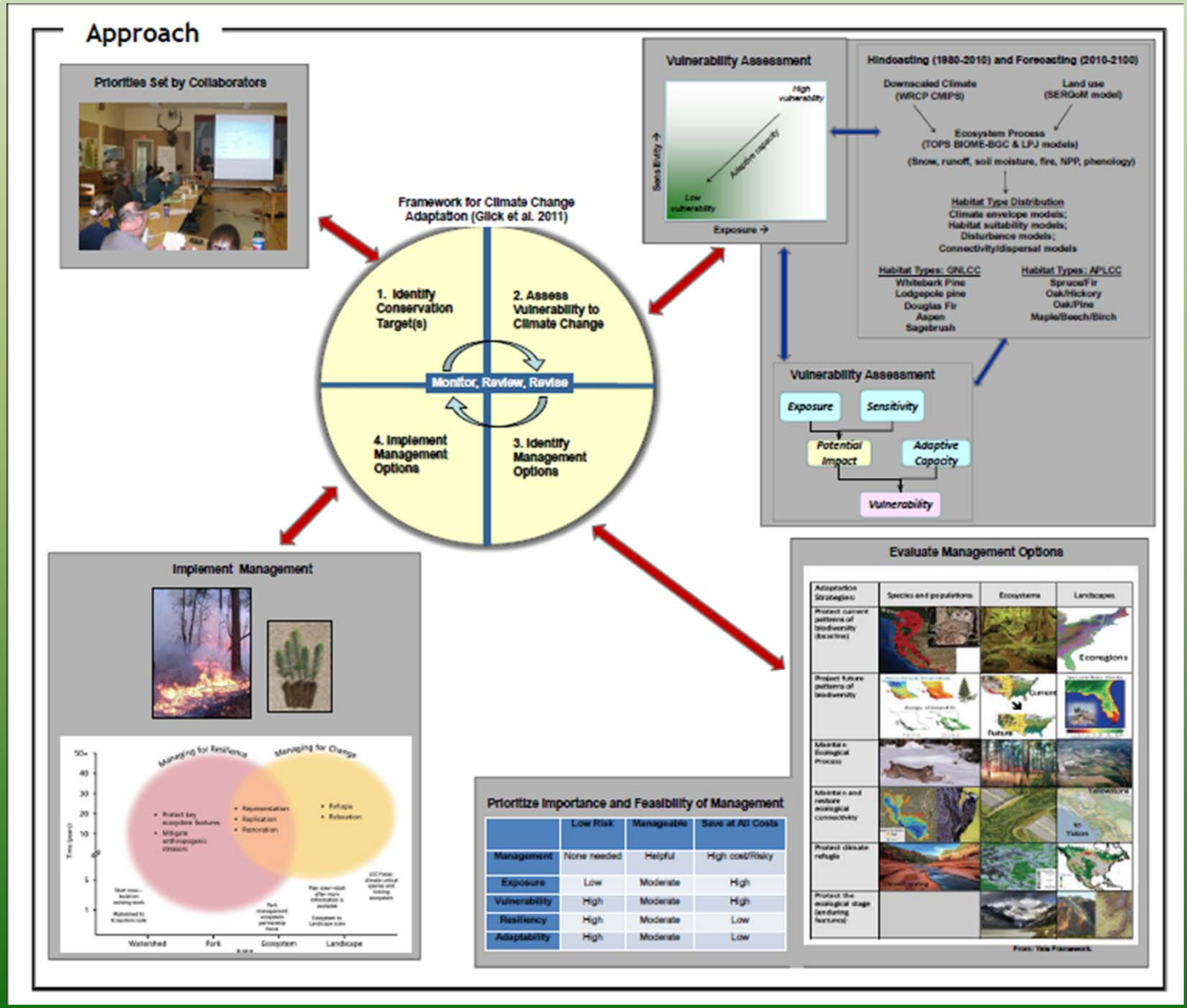
NASA

Approach

Glick et al. 2011. Scanning the Conservation Horizon: A guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D.C.



Approach


Approach
Priorities Set by Collaborators
Framework for Climate Change Adaptation (Glick et al. 2011)
1. Identify Conservation Target(s)
2. Assess Vulnerability to Climate Change
3. Identify Management Options
4. Implement Management Options
Monitor, Review, Revise
Vulnerability Assessment
High vulnerability
Low vulnerability
Sensitivity →
Exposure →
Hindcasting (1980-2010) and Forecasting (2010-2100)
Downscaled Climate (WRCP CMIP5)
Land use (SERGoM model)
Ecosystem Process (TOPS BIOME-BGC & LPJ models)
(Snow, runoff, soil moisture, fire, NPP, phenology)
Habitat Type Distribution
Climate envelope models;
Habitat suitability models;
Disturbance models;
Connectivity/dispersal models
Habitat Types: GNLCC
Whitebark Pine
Lodgepole pine
Douglas Fir
Aspen
Sagebrush
Habitat Types: APLCC
Spruce/Fir
Oak/Hickory
Oak/Pine
Maple/Beech/Birch
Vulnerability Assessment
Exposure
Sensitivity
Potential Impact
Adaptive Capacity
Vulnerability
Implement Management
Managing for Resilience
Managing for Change
Watershed
Park
Ecosystem
Landscape
Evaluate Management Options
Species and populations
Ecosystems
Landscapes
Ecoregions
Prioritize Importance and Feasibility of Management
Low Risk
Manageable
Save at All Costs
Management
None needed
Helpful
High cost/Risky
Exposure
Low
Moderate
High
Vulnerability
High
Moderate
High
Resiliency
High
Moderate
Low
Adaptability
High
Moderate
Low

Step 2. Assess Vulnerability: Hindcasting and Forecasting

Hindcasting (1980-2010) and Forecasting (2010-2100)

Downscaled Climate
(CMIP5 / AR5)

Land use
(SERGoM model)

Ecosystem Process
(TOPS BIOME-BGC & LPJ models)

(Snow, runoff, soil moisture, fire, NPP, phenology)

Habitat Type Distribution
Climate envelope models;
Habitat suitability models;
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Connectivity/dispersal models

Habitat Types: GNLCC
Whitebark Pine
Lodgepole pine
Douglas Fir
Aspen
Sagebrush

Habitat Types: APLCC
Spruce/Fir
Oak/Hickory
Oak/Pine
Maple/Beech/Birch

Step 2. Assess Vulnerability: Key Variables

Category	Indicator	Resolution	Source and reference	Delivery
Climate and Weather	Climate gridded daily	1 km; 2001-2010	TOPS, Nemani et al. 2008; Jolly et al. 2005	SOP; ArcGIS Server
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	Impervious cover	30 m; decadal; 1984-2100	SLEUTH; Goetz 2010b.	SOP; contract
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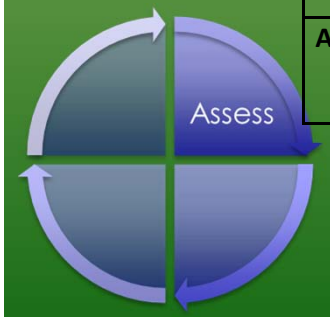
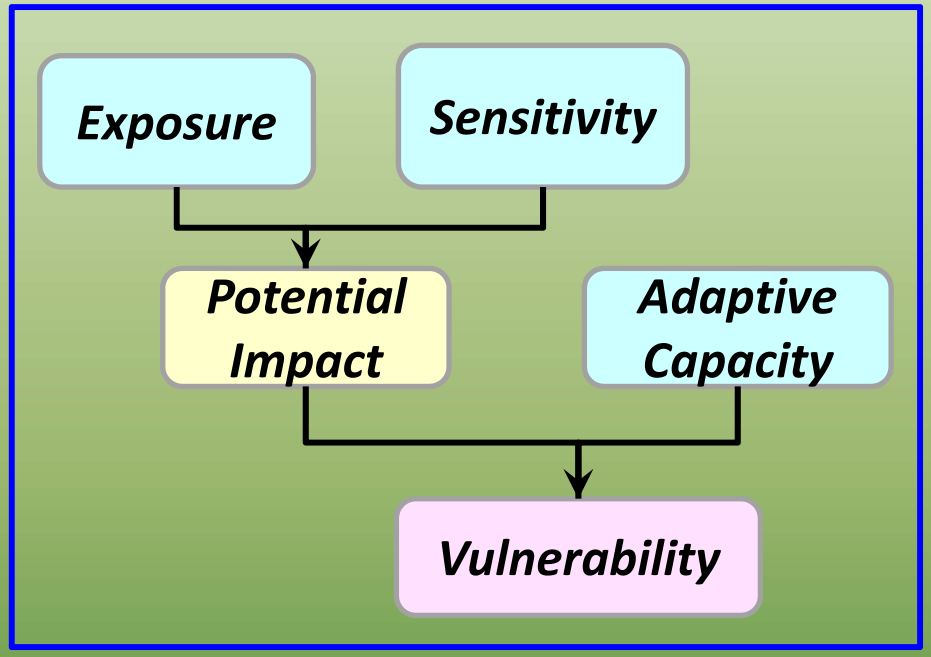
	Snow cover	1 km; decadal; 2000-2010 1 km; decadal; 2010-2100	TOPS SOP Nemani et al. 2008	SOP; ArcGIS Server
	Soil moisture / vegetation water stress	1 km; decadal; 2000-2010 1 km; decadal; 2010-2100	TOPS SOP Nemani et al. 2008	SOP; ArcGIS Server
	Primary productivity GPP/NPP	1 km; decadal; 2000-2010 1 km; decadal; 2010-2100	TOPS SOP Nemani et al. 2008	SOP; ArcGIS Server
	Vegetation Dynamics Lifeform	1 km; decadal; 2000-2010 1 km; decadal; 2010-2100	TOPS SOP Nemani et al. 2008	SOP; ArcGIS Server
Biodiversity	Land facets and connectivity	270 m; decadal;1940-2010	SERGoM; Theobald et al. 2012	SOP
	Ecosystem type and connectivity	1 km; decadal;1940-2100	Statistical modeling	SOP
	Dominant tree species and connectivity	1 km; decadal;1940-2100	Statistical modeling	SOP

Step 2. Assess Vulnerability: Key Variables - EST

Ecological System Type	Life History Stage					
	Presence and/or abundance	Establishment (seedling abundance)	Growth	Survival (mortality rates of adults)	Reproduction (cones and seeds)	Dispersal
Whitebark pine	GYCC FIA WLIS	FIA WLIS Tiers surveys	FIA	GYCC FIA WLIS	IGBP	
Lodgepole pine						
Douglas fir						
Sagebrush						
Aspen						



Step 2. Assess vulnerability



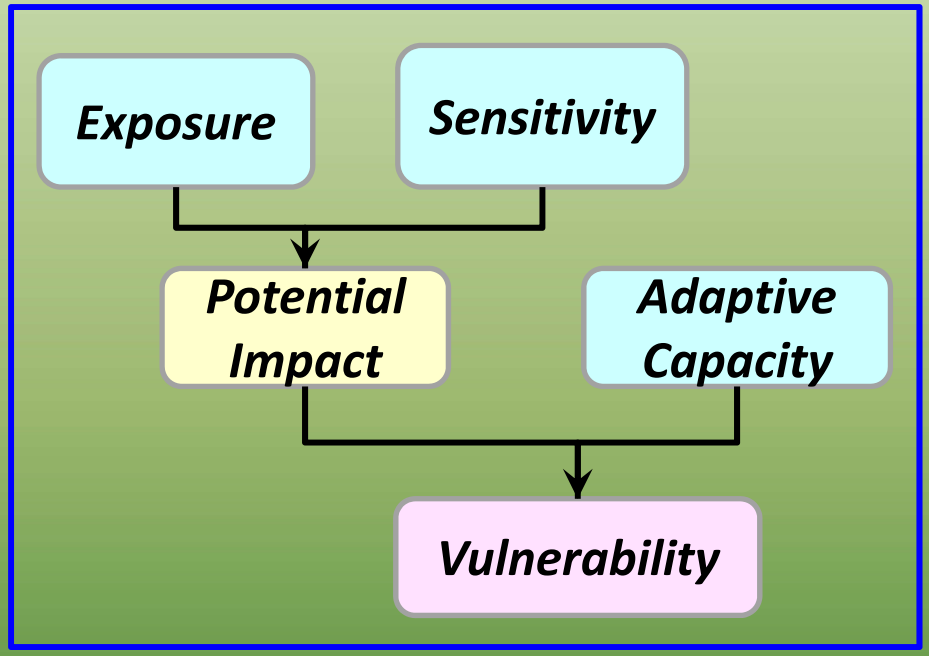
Exposure = magnitude & extent of change experienced

Sensitivity = degree to which fitness/process is affected

Adaptive capacity = coping responses of species/process

Step 2. Assess Vulnerability

At the level of ecological systems, variables and data sources that will be used to assess vulnerability to climate and non-climate stressors.



Exposure – climate, land use, ecosystem processes

Sensitivity – climate tolerances of EST by life history stage

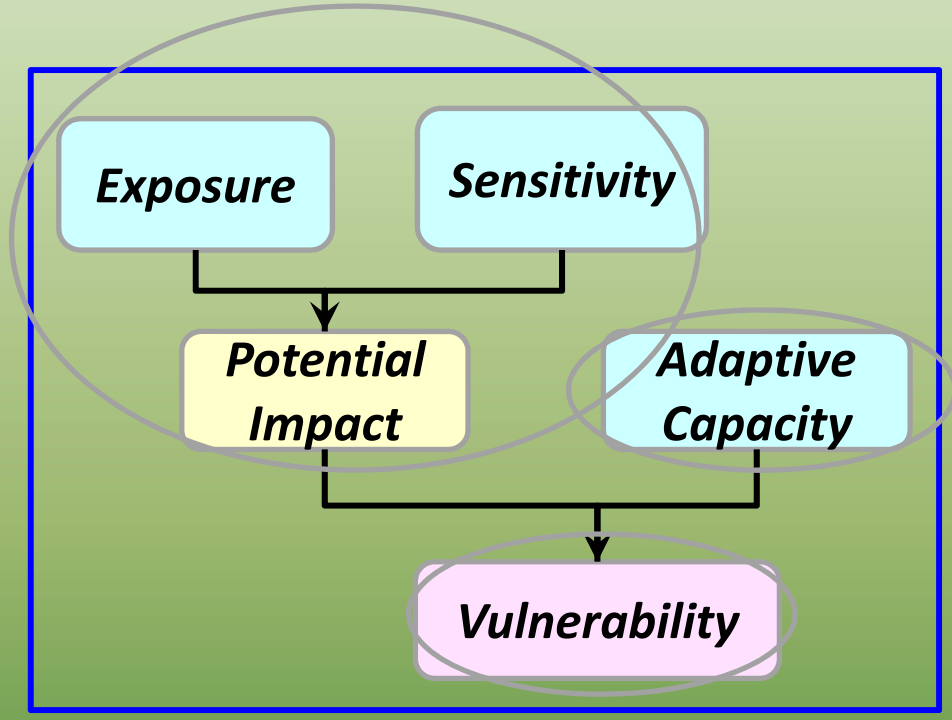
Potential Impact – modeled shifts in distribution of EST under future scenarios

Adaptive Capacity – e.g., connectivity, dispersal

Vulnerability – interaction of potental impact and adaptive capacity

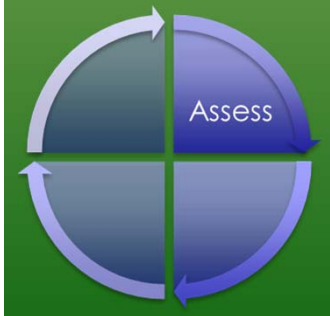
Step 2. Assess vulnerability: Expert Panels

Measured/modeled

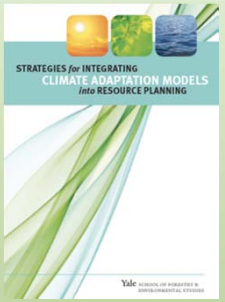


Literature and expert opinion

Expert evaluation of above

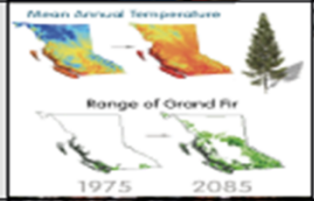
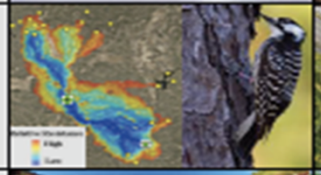
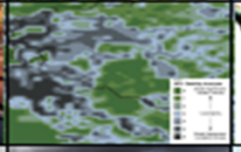
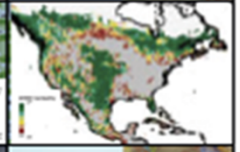


Step 3. Management Options



Identify Management Options

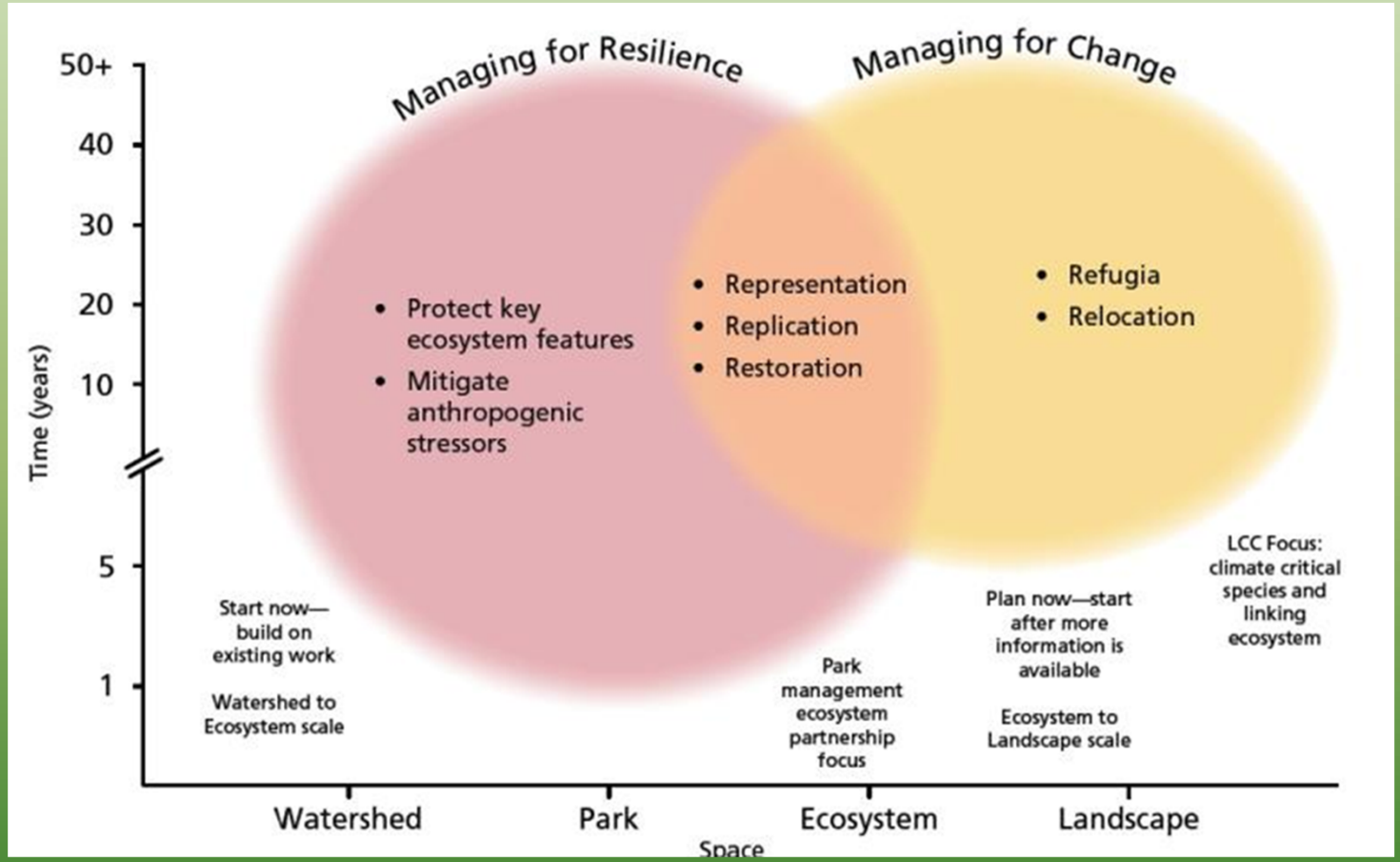
www.databasin.org/yale

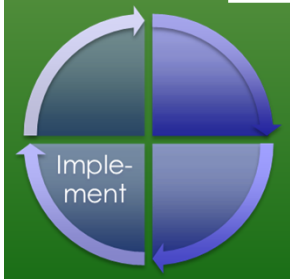
Adaptation Strategies:	Species and populations	Ecosystems	Landscapes
Protect current patterns of biodiversity (baseline)			
Project future patterns of biodiversity			
Maintain Ecological Process			
Maintain and restore ecological connectivity			
Protect climate refugia			
Protect the ecological stage (enduring features)			

Evaluate Management Options

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

Step 4. Deliver Management Strategies

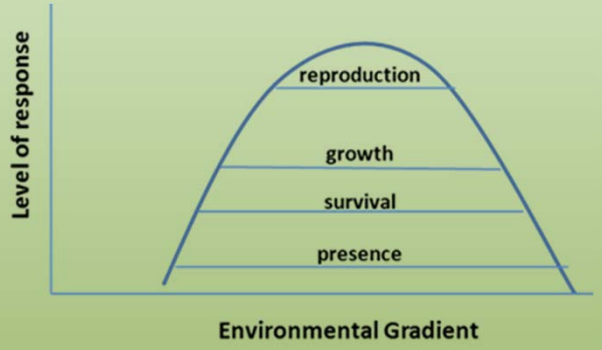




GYE Application: Whitebark Pine

Overview

- Keystone species
- Declining dramatically
- Listed as Candidate species
- Grizzly bear relisted



Management Questions

- Range change under future climate?
- Settings allowing reproduction?
- Where to focus treatment of competitors, translocation?

Collaborators

GYCC WBP Subcommittee

GYCC Whitebark Pine Management Strategies

PROTECTION	RESTORATION
• Apply verbenone and carbaryl to prevent mortality due to mountain pine beetle. • Prune to remove blister rust infection and/or improve fire resistance. • Prevent loss of high value whitebark pine trees from fire. • Natural regeneration.	• Whitebark pine seed orchard. • Participation in whitebark pine genetic conservation program. • Collect whitebark pine seeds and cones. • Plant whitebark pine seedlings and seeds. • Guidelines and limitations for fire in whitebark pine stands. • Creation of nutcracker openings. • Thinning. • Natural regeneration.

GYCC Whitebark Pine Management Strategies

The Whitebark Pine Strategy for the GYA: Three-year Action Plan			
Action	**Quantity**	**Description**	**Unit & Timeframe**
Protection: Reduce mountain pine beetle-caused mortality.	120 trees in blister-rust resistance trials.	Apply carbaryl and/or verbenone on annual basis.	All GYA units where rust trials occurs and high mountain pine beetle infestation persists (2011–2014).
Protection: Reduce mountain pine beetle-caused mortality.	300 acres additional cone-bearing trees total in several units, may increase in 2012.	Apply carbaryl and/or verbenone on annual basis.	Bridger-Teton National Forest, Gallatin National Forest, Shoshone National Forest, Grand Teton National Park, (2011–2013).
Protection of seed-bearing whitebark pine trees from fire.	Areas of remaining live whitebark pine throughout GYA.	Coordinate with fire managers to discourage fire in areas that act as seed reservoirs on a unit or watershed basis.	All units (2011–2014).
Pruning for fire protection.	25 acres.	Pruning.	Gallatin: Cooke City project 2011.
Thinning for fire protection.	120 acres.	Thinning.	Gallatin: Cooke City project 2011.
Restoration: Seed production on seed orchard.	Establish 5-acre orchard with 30–120 rust-resistant trees.	Provide rust resistant seedlings by 2025 for outplanting.	Gallatin National Forest "Little Bear": Site prep 2011. First planting 2012.
Restoration: Planting.	Within 40,000 acres designated for planting projects.	Plant seedlings.	2011–2013 projects currently in place for: Caribou-Targhee, Bridger-Teton, Shoshone, and Gallatin. Other units will plant as projects are developed.
Restoration: Scion collection.	Collect 25–30 scion from 30–60 trees based on blister rust screening results.	Collect scion from identified rust resistant trees to provide seed for orchard stock.	2011–2013 work to be conducted throughout GYA by Grand Teton and Gallatin climbers.

GYCC Whitebark Pine Management Strategies

THE WHITEBARK PINE STRATEGY FOR THE GYA: THREE-YEAR ACTION PLAN, CONT.

Action	Quantity	Description	Unit & Timeframe
Restoration: Cone collection.	20 trees per year.	Maintain reservoir of genetic diversity through operational cone collections, contract and unit tree climbers.	All units: emphasize collections from known resistance in Caribou-Targhee, Shoshone, and Bridger-Teton, and new sites on Gallatin for additional genetic diversity (2011–2013).
Restoration: Sow and grow seedlings.	30,000 per year.	Grow seedlings from collected seed for out-planting.	All units: coordinate funding and timing.
Restoration: Create nutcracker openings.	20 openings.	Remove overstory.	Gallatin: Cooke City project 2011.
Restoration: Daylight understory to release regeneration.	5 sites.	Remove overstory.	Gallatin: Cooke City project 2011.
Long-term monitoring.	176 transects across the GYA includes wilderness and non-wilderness sites.	Support continued implementation of the GYWPMWG monitoring protocol.	Greater Yellowstone Network in partnership with GYWPMWG, Whitebark Pine Sub-Committee and units, ongoing.
Monitoring.	All sites where management actions are taken.	Record treatments and outcomes for further refinement of management techniques.	Gallatin: Cooke City Rx burns/plantings. Caribou-Targhee sites planted in 2010. Bridger-Teton National Forest: Grouse Mountain.
GIS-based mapping.	GYA-wide whitebark pine distribution.	Update whitebark condition, keep track of project areas and acreage, refine site prioritization.	Ongoing by Whitebark Pine Subcommittee.
Develop database including spatial and monitoring data.	GYA-wide database to incorporate and maintain availability of multiple types of data.	Develop and maintain database and guide to available whitebark pine data.	Subcommittee/unit staff in collaboration with Grand Teton and possibly GRYN as repository, ongoing.
Ski area whitebark pine protection.	600 trees.	Collaborate with ski areas to protect remaining whitebark pine.	Ongoing at Jackson Hole Mountain Resort and Grand Targhee.

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Bioclimatic Niche Modeling
(ca 5 spcs/ecosystem types GYE)

WBP case-study (this year)

Methods:
- Stat. models 4 life-history stages

Accomplishments:
- Climate data acquired
- Response data sources identified

Upcoming:
- Acquire response data
- Build statistical models
- Forecast

Phenology
(GYE grasslands)

Patch dynamics of forage phenology

Methods:
- NDVI-based

Accomplishments:
- Current conditions described

Upcoming:
- Forecast under CC
- Expand to ROMN?
- Collaborations?