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

Using NASA Resources to Inform Climate and Land Use Adaptation

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Matt Marshall, NPS I&M Eastern Rivers and Mountains Network

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GYCC Whitebark Pine Subcommittee

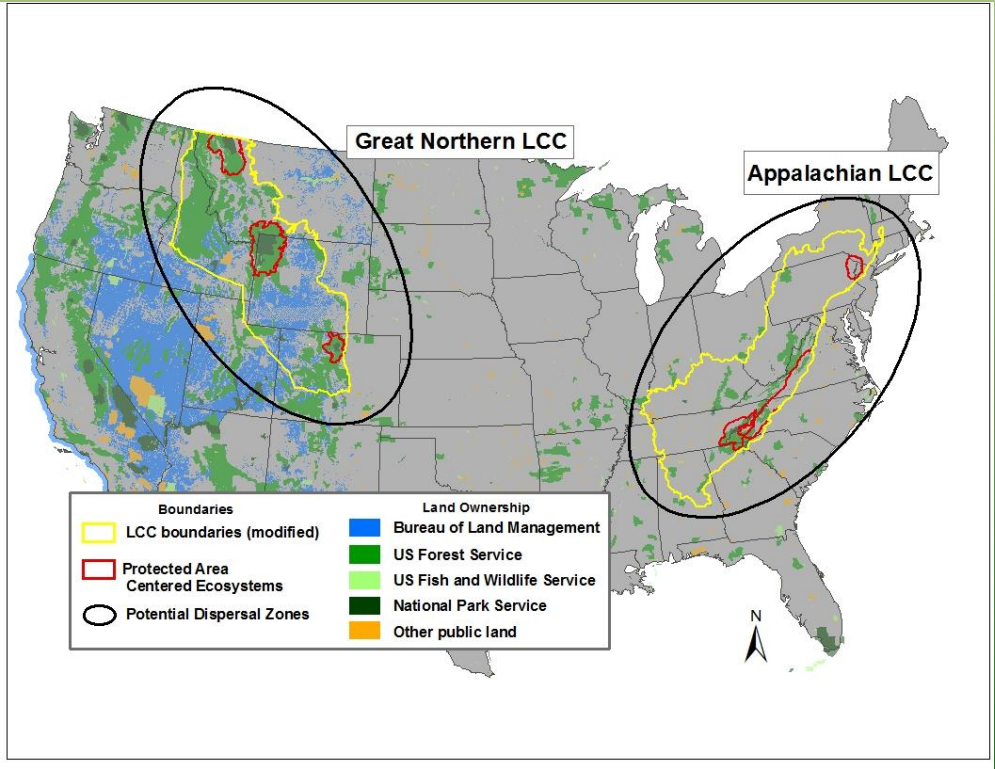
Supported by

NASA Applied Sciences Program, NPS Inventory & Monitoring Program, Great Northern Landscape Conservation Cooperative

Goals and Objectives

Goal

Demonstrate the four steps of a climate adaptation planning strategy in two LCCs using NASA and other data and models.

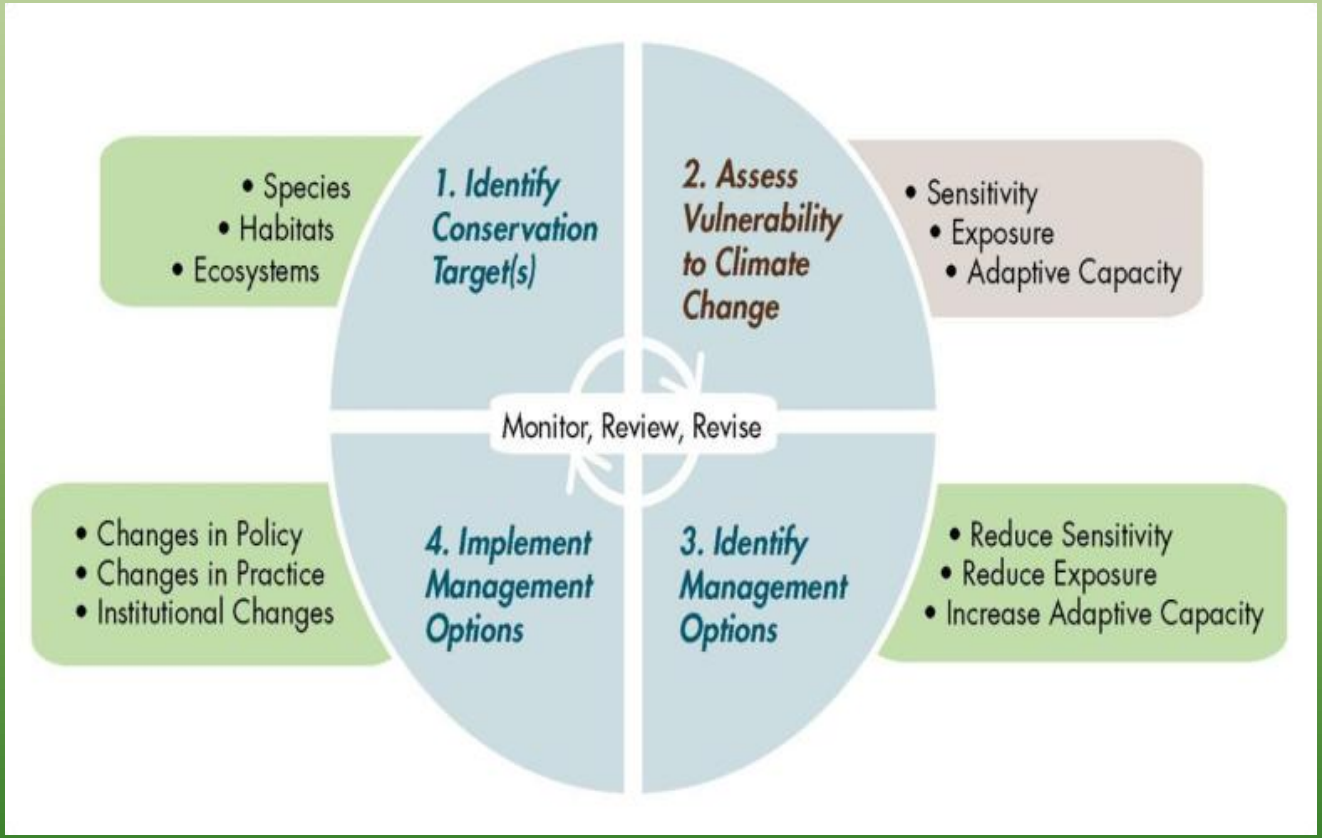


Objectives

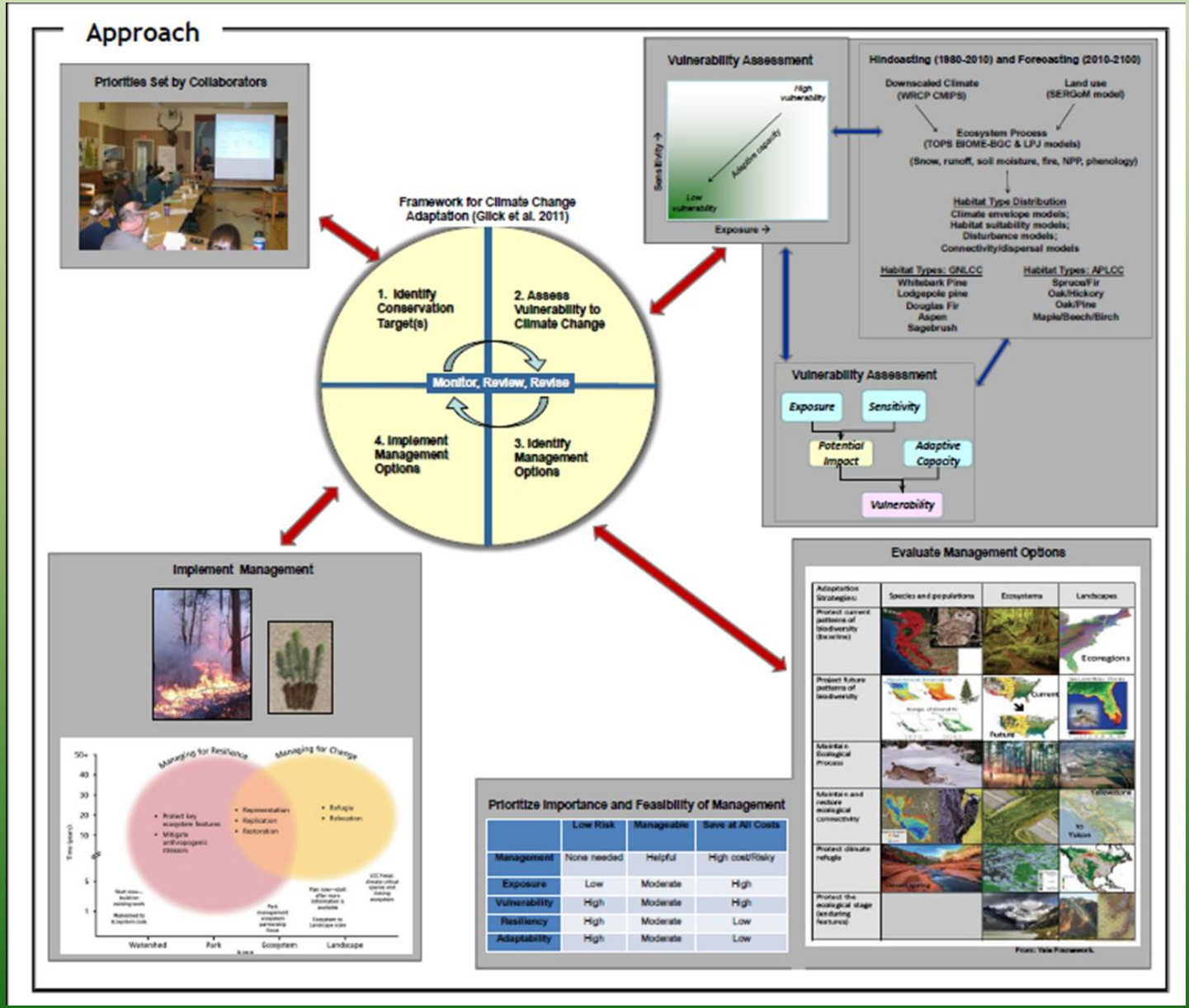
1. **Hindcast and forecast future climate and land use scenarios.**
2. **Assess the vulnerability of ecological processes and key habitat types.**
3. **Evaluate management options.**
4. **Design and deliver management adaptation strategies.**
5. **Inform decision support.**

Approach

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



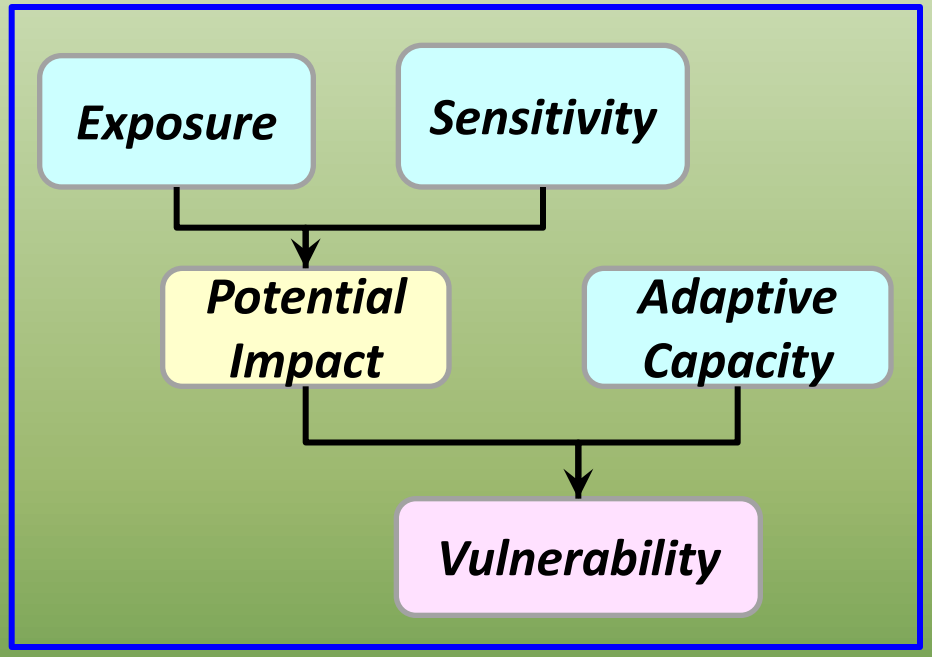
Approach


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
Adaptive capacity
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
Protect key ecosystem features
Mitigate anthropogenic stressors
Representation
Replication
Restoration
Refugia
Relocation
Watershed
Park
Ecosystem
Landscape
Evaluate Management Options
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)
Ecoregions
Current
Future
Yellowstone
to Yukon
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 1. Identify Management Targets

STEPS	*Purpose*	*Outputs*	*Tools*
1. Select Specific Conservation Targets	• Conservation Targets are species, ecosystems, ecological processes, and cultural resources that are climate sensitive, iconic, keystone, or umbrella • This again reduces complexity by focusing on the priority resources that need to be analyzed as Conservation Targets for this exercise	Define 5-10 Conservation Targets	• Enabling Legislation; • Existing Priorities from Mgt Documents I&M Networks; • Exiting research on Climate Sensitive Resources or workshops to define Science needs • Scenario Planning Workshops • Natural Resource Condition Assessments

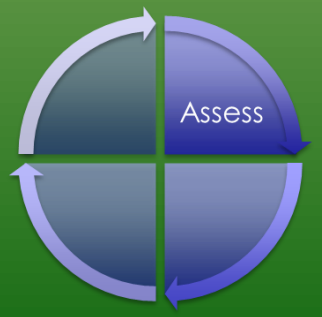
Step 2. Assess vulnerability



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

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;
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Disturbance models;
Connectivity/dispersal models

Habitat Types: GNLCC
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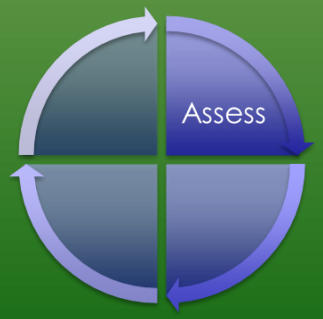
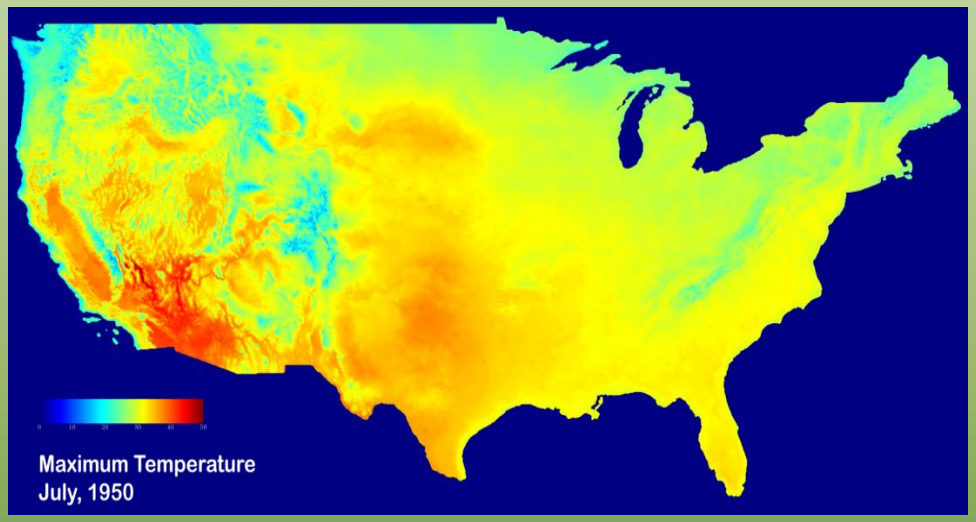


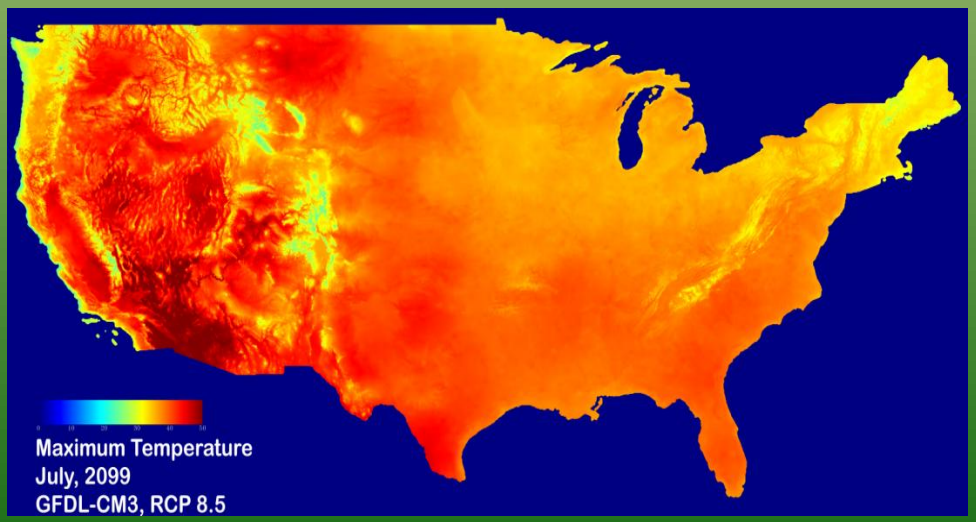
Step 2. Assess Vulnerability

Downscaled Climate Scenarios

Max temp, PRISM, July, 1950

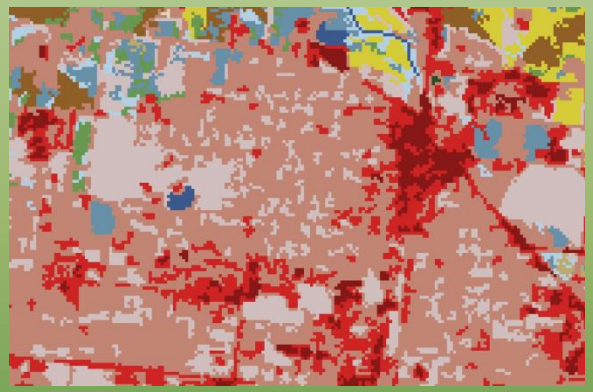


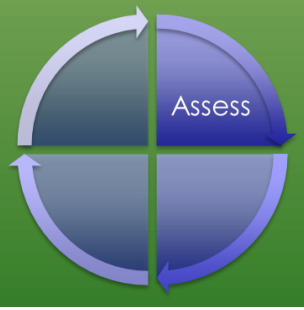
Max temp, Downscaled 800m CMIP5 GFDL-CM3, RCP 8.5, July, 2099 (Bridget Thrasher)



Step 2. Assess Vulnerability

SERGoM Land Use Change Model



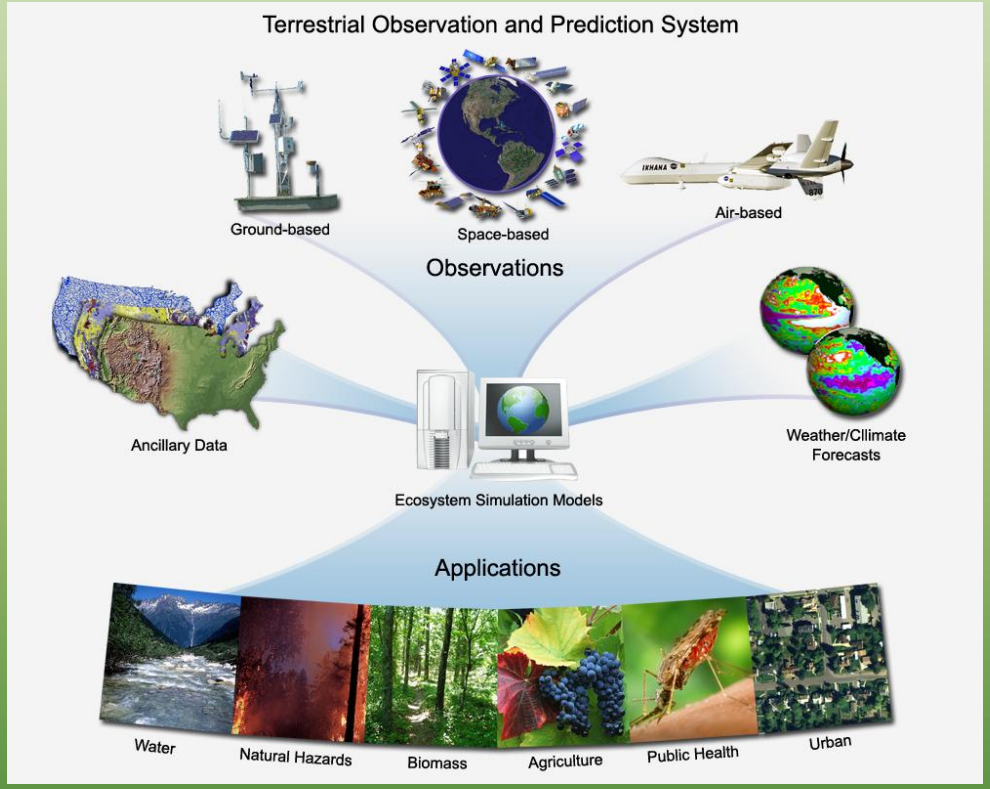


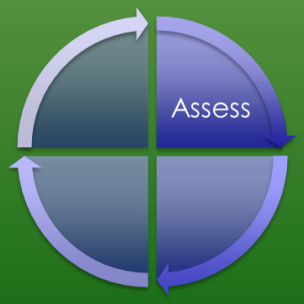
Classes have been expanded to better represent land use

Code	Group	Class Name	Description
0	Water	Lake	Natural "standing" waters
1	Water	Reservoir	"Standing" water with dam or other human structure controlling flow
2	Water	Wetlands	Wetlands
3	Protected	Recreation	National parks, natural areas, wilderness, multi-use lands, etc. (includes barren areas on public lands)
4	Working/ production	Timber	Timber production
5	Working/ production	Agriculture grazing	Grazing (and other resource extraction e.g. oil & gas)
6	Working/ production	Agriculture pastureland	Pasture
7	Working/ production	Agriculture cropland	Cropland
8	Working/ production	Mining/barren	Mineral resources (barren on private)
9	Built	Parks/open space	Parks with structures (fields, courts, golf courses, cemeteries). 0 DUA
10	Built	Residential (exurban low)	Exurban housing density 1 per 10-40 ac)
11	Built	Residential (exurban)	Exurban housing density 1 per 2.5-10 ac)
12	Built	Residential (suburban)	Housing density 1 per 0.6-2.5 ac
13	Built	Residential (medium)	Housing density 1 per 0.1-0.6 ac
14	Built	Residential (high)	Housing density 1 per >0.1 ac
15	Built	Mixed residential and commercial	Residential housing medium or higher and density of employees > xx
16	Built	Commercial	Commercial complexes, office buildings
17	Built	Industrial and utility	Industrial parks, factories, power plants, military, airports
18	Built	Institutional	Schools, churches, government complexes
19	Built	Transportation	Interstates, highways, railways

Step 2. Assess Vulnerability

TOPS Ecosystem Process Model





Vegetation Outputs
Water stress factor
Gross primary productivity
Net primary productivity

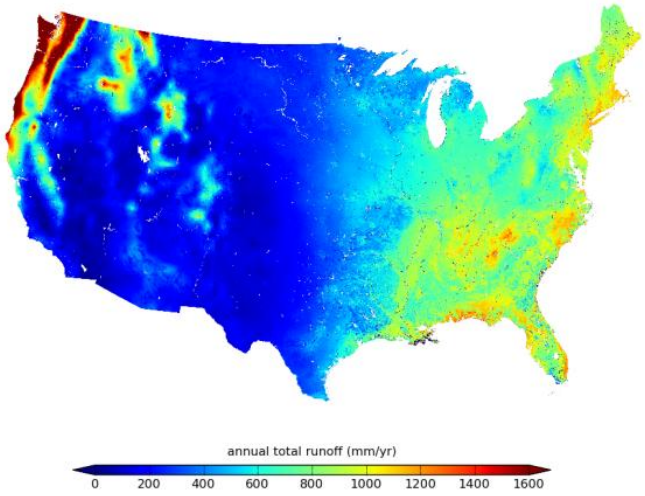
Hydrology Outputs
Outflow
Evapotranspiration
Soil water potential
Snow water equivalent
Soil moisture (VWC)

Input Parameter	United States (1km)
Impervious surface area	SERGoM (Theobald et al., 2009)
Climate (baseline run)	TopoMet Meteorological Surfaces (NTSG)
Climate (forecast)	Downscaled AR5 Scenarios, 1km resolution ensemble averages (Maurer et al., 2007) RCPs 4.5, 6.0, 8.5
Elevation	National Elevation Dataset (resampled)
Leaf Area Index (baseline run)	MODIS MOD15A2 LAI (Myneni et al., 2000)
Leaf Area Index (forecast)	Simulated by BIOME-BGC
Soils	U.S. STATSGO2 database
Land Cover	MODIS MOD12Q1 Land cover (Friedl et al., 2002)

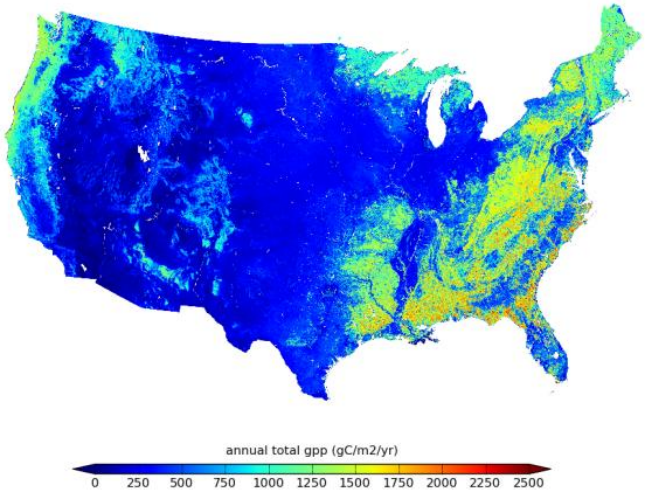
Step 2. Assess Vulnerability

TOPS Results

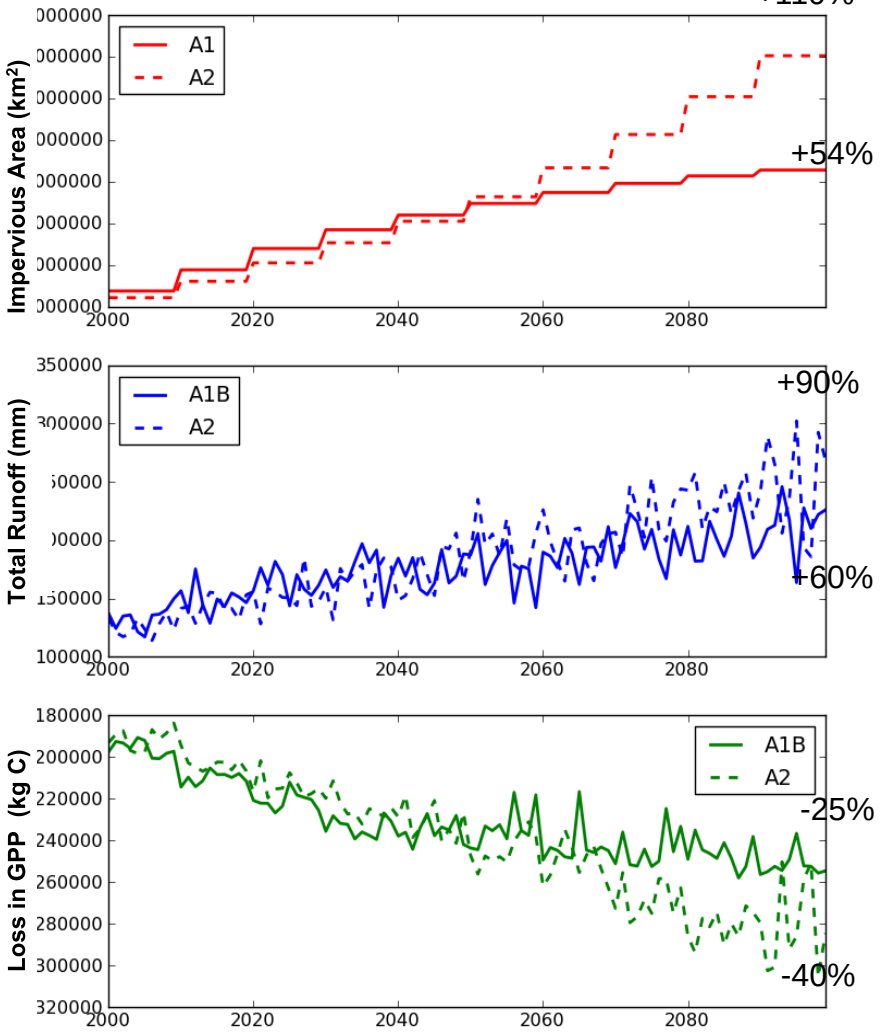
2100 Runoff



2100 GPP

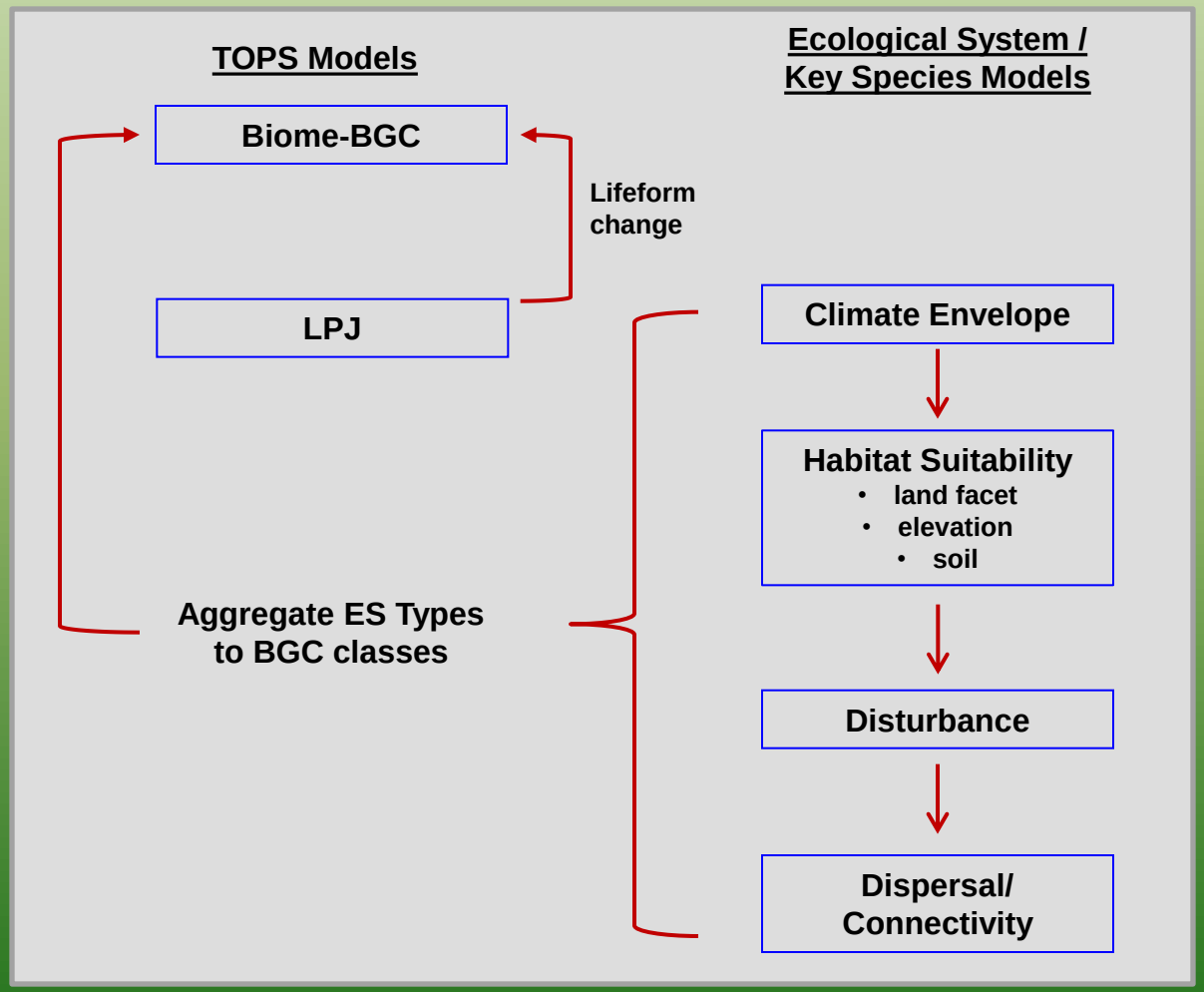


Coupled climate and land use change impacts over urban areas



Step 2. Assess vulnerability

Linking Vegetation and Process Models



Step 2. Assess vulnerability

Linking Vegetation and Process Models

TOPS Models

Biome-BGC

Lifeform change

LPJ

Aggregate ES Types to BGC classes

Ecological System / Key Species Models

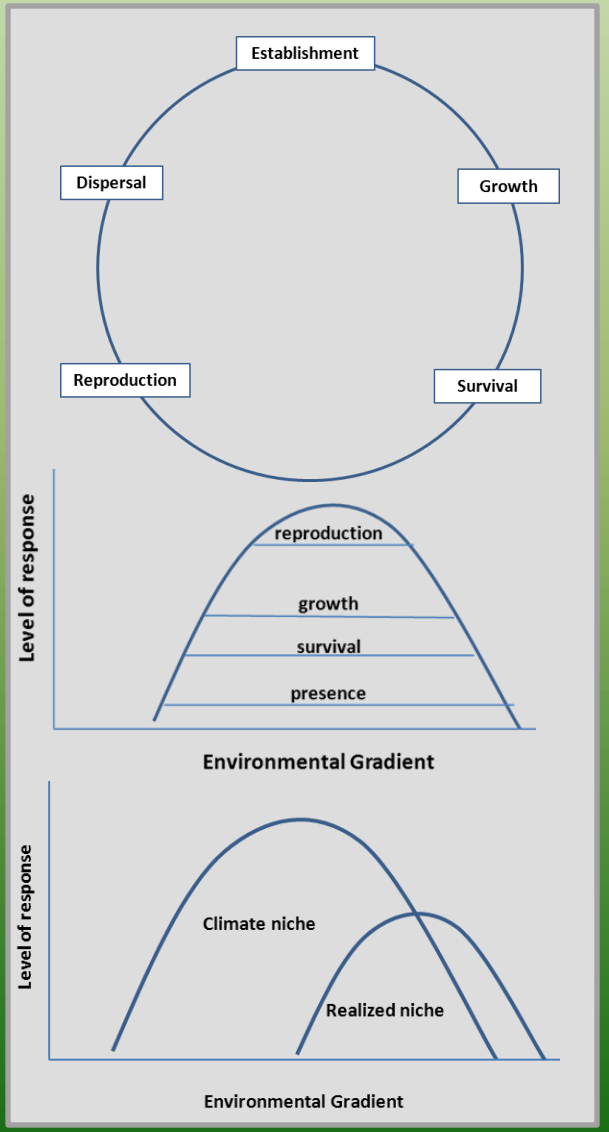
Climate Envelope

Habitat Suitability
- land facet
- elevation
- soil

Disturbance

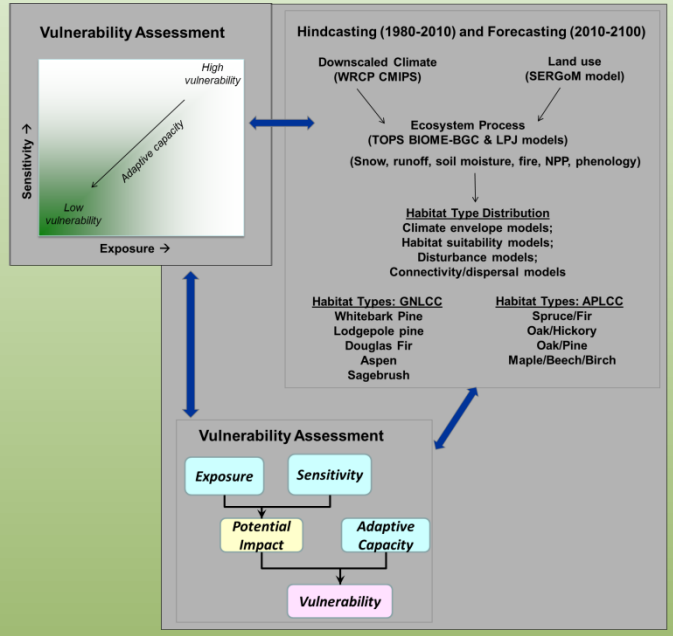
Dispersal/ Connectivity

Niche-based Approach

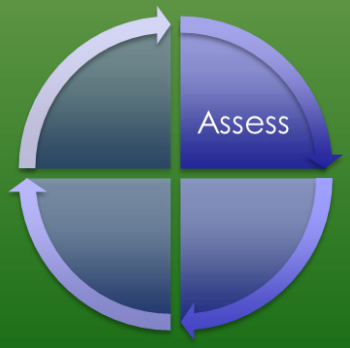


Step 2. Assess Vulnerability

Crosswalk Forecasting Results in Vulnerability Assessment

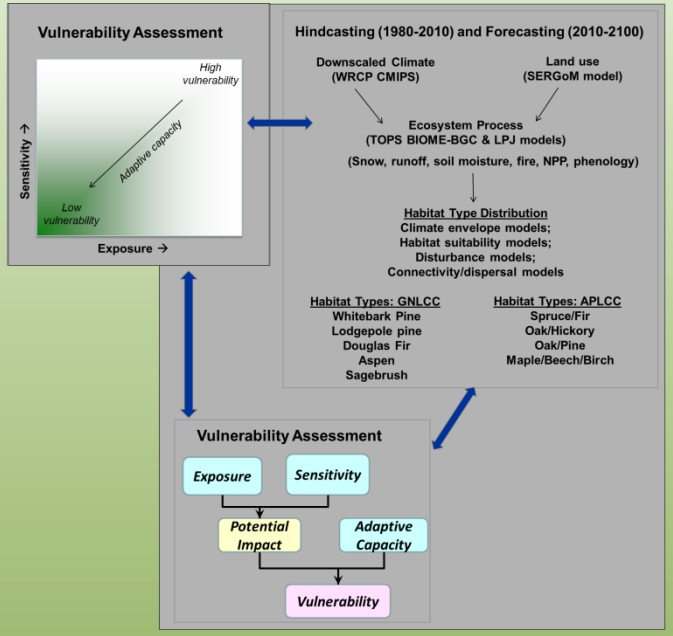


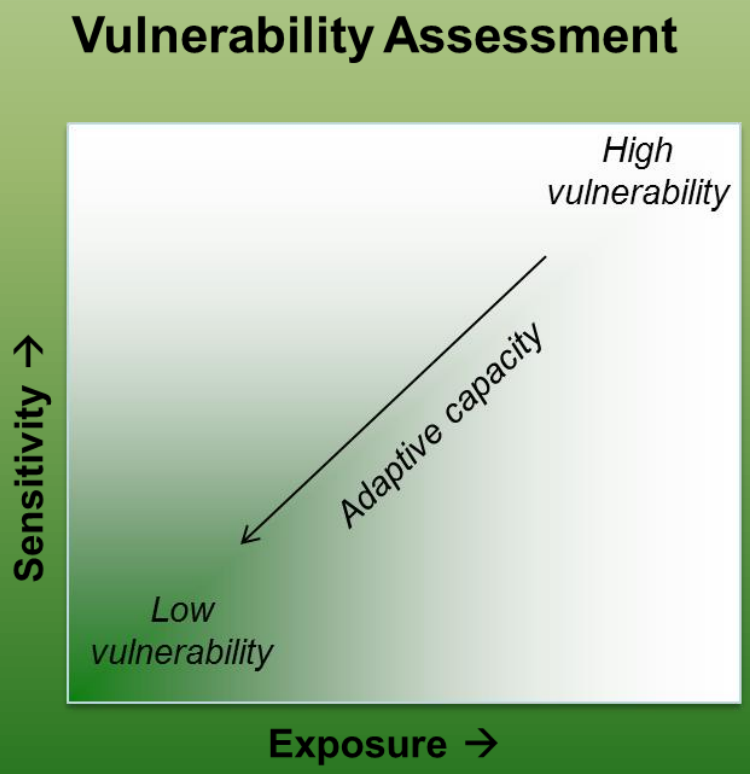
Component of Vulnerability	Species / Communities	Ecological System (ES)	Biomes
Exposure	Climate (TOPS) and land use (SERGoM) projections	Climate (TOPS) and land use (SERGoM) projections	Climate (TOPS) and land use (SERGoM) projections
Sensitivity	Bioclimate modeling; Dynamic vegetation modelling	Climate space modeling; TOPS projections	Biome BGC projections; controls of NPP; ecosystem model responsiveness
Adaptive Capacity	Species & habitat traits	Landscape facets; ecosystem modifications; connectivity; protection	Diversity at Ecological System level; conservation context

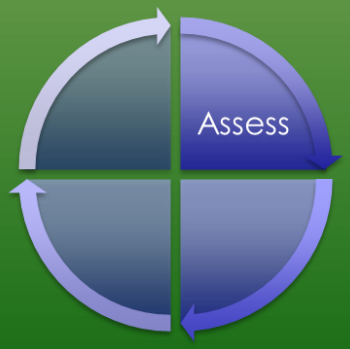


Step 2. Assess vulnerability

Adaptive Capacity

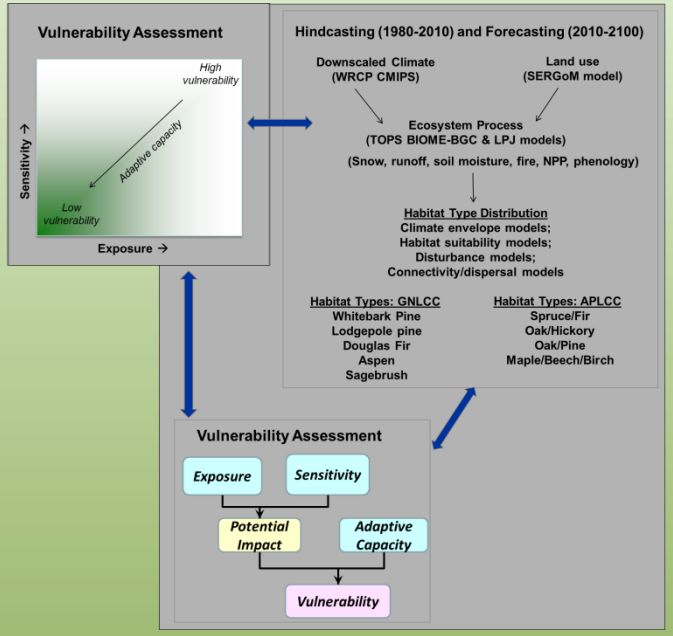


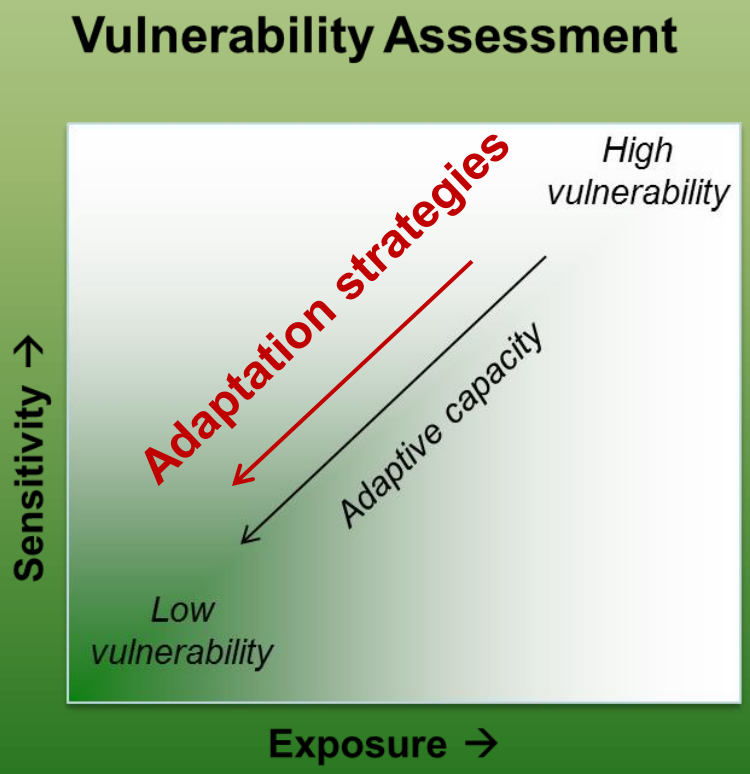


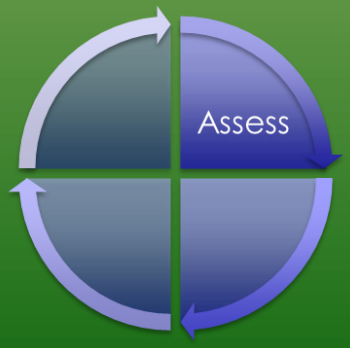


Step 2. Assess vulnerability

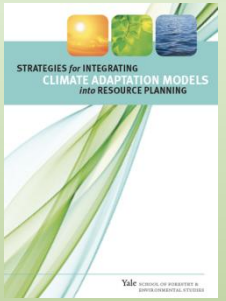
Adaptive Capacity







Step 3. Management Options



Identify Management Options

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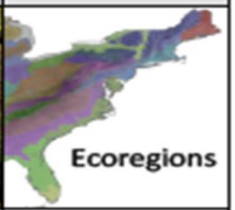
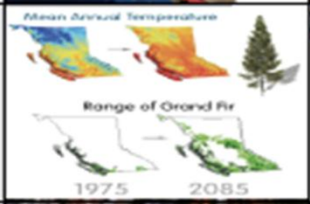
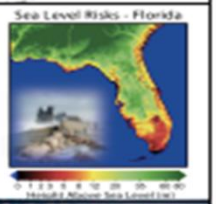
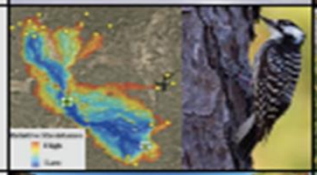
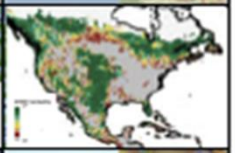
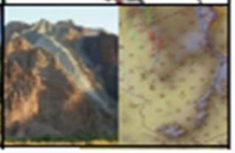
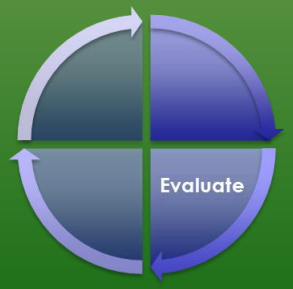
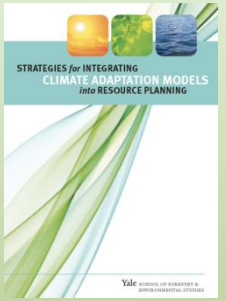
Adaptation Strategies:	Species and populations	Ecosystems	Landscapes
Protect current patterns of biodiversity (baseline)			
Project future patterns of biodiversity			
Maintain Ecological Process			
Maintain and restore ecological connectivity			
Protect climate refugia			
Protect the ecological stage (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 3. Management Options



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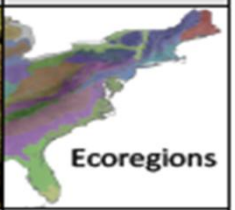
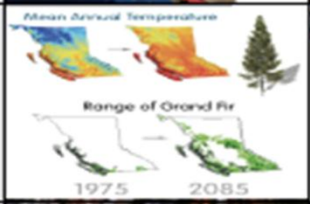
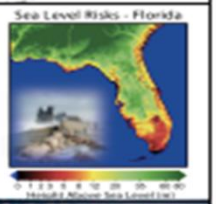
Protect current patterns of biodiversity (baseline)			
Project future patterns of biodiversity			
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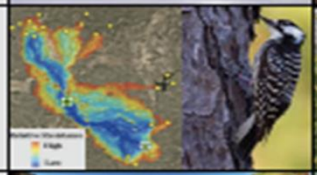
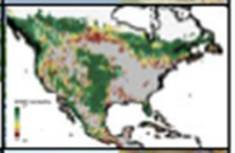
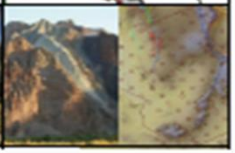
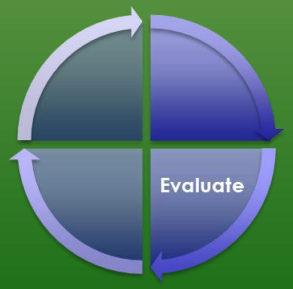
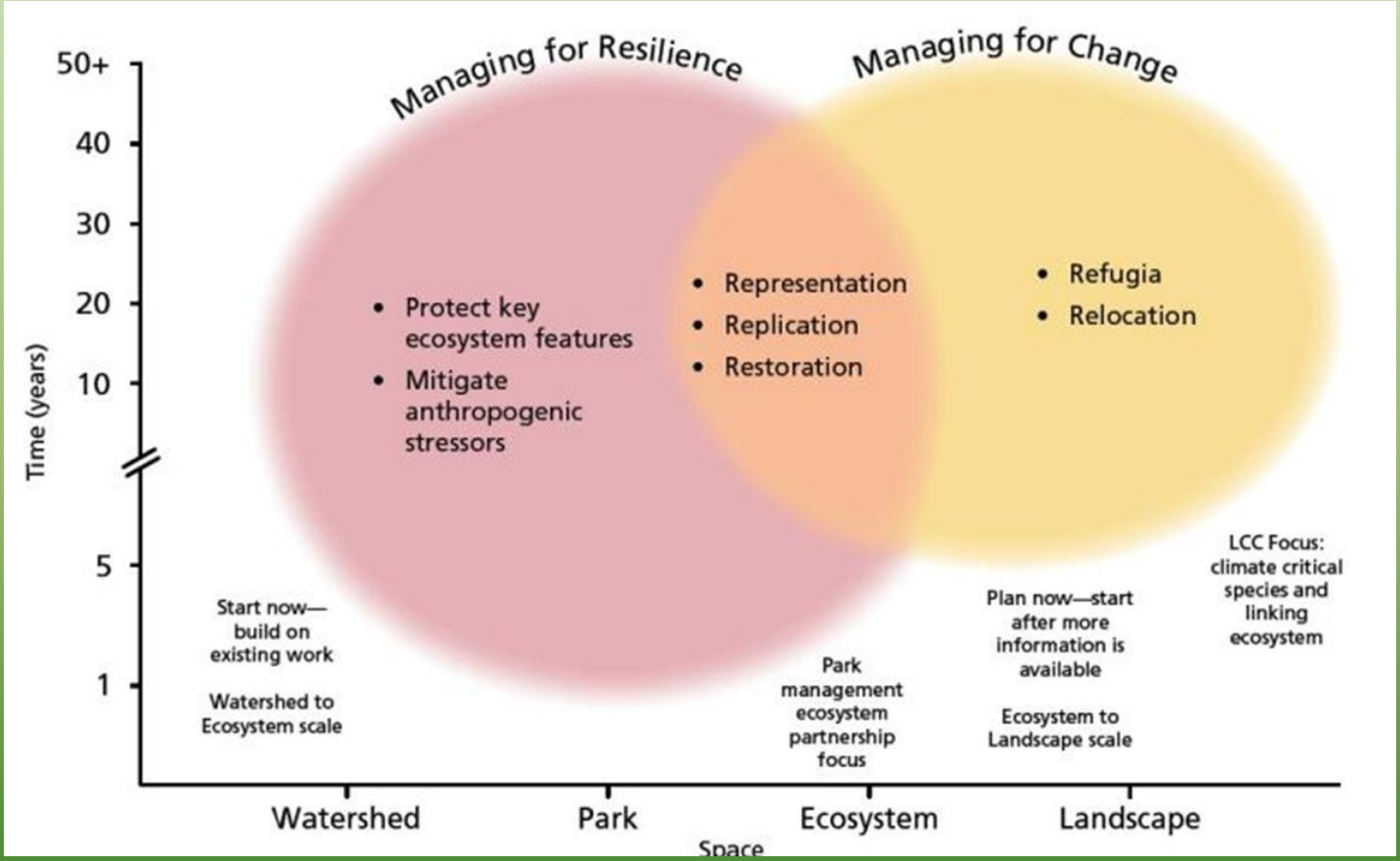
Maintain and restore ecological connectivity			
Protect climate refugia			
Protect the ecological stage (enduring features)			

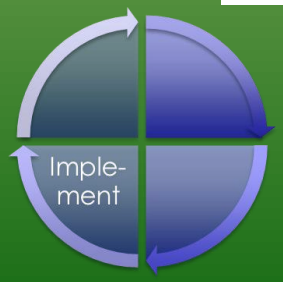
Evaluate Management Options

	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





Decision Support

Decision Support Product	Spatial Scale		
	LCC	Greater Ecosystem	Mgt. Unit
Data layers (e.g.): • downscaled climate SERGoM projections, • TOPS and biodiversity outputs	X	X	X
Development of metrics for conservation targets (e.g.): • permeability • biodiversity index	X		
Syntheses reports (e.g.): • downscaled climate • land use change • Vegetation response	X	X	
Test theory of V.A. at scales relevant to management		X	X
Development of climate adaptation options		X	X
Implementation of strategies			X
Demonstration of full four-step vulnerability assessment.	X		
Training on overall approach	X	X	X

Current Status

Current Status

The project is the first year of the four-year funding period.

Year 1: Refine study approach; engage key collaborators; compile data sets; validate models

Year 2: Do ecological hindcasts and forecasts; model habitat types; assess vulnerability in GNLCC with cooperators.

Year 3: Do management evaluation and implementation in GNLCC; assess vulnerability in APLCC with cooperators.

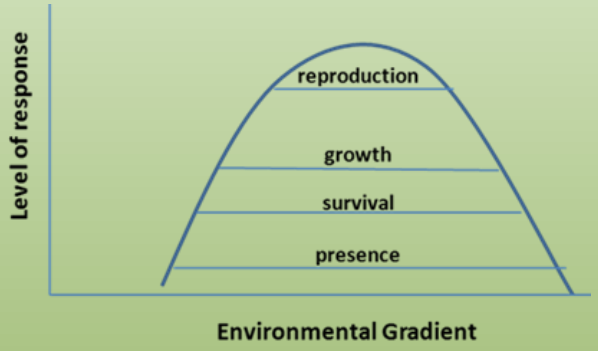
Year 4: Do management evaluation and implementation in APLCC; technology and data transfer; final reporting.

http://www.montana.edu/lccvp/index.html

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

GYE Application:

Draft Ecological System Types and Data Sources

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	Stand maps FIA Phil Farnes Landenburger et al. 2008	FIA Dan Tiers surveys GRYN I&M surveys	FIA Weaver 2000	Mcfarlane et al. 2010 Jewett et al. 2011 Hatala et al. 2010	GRYN I&M surveys Larson and Kipfmueller 2010	
Lodgepole pine	Stand maps FIA Hansen et al. 2000 Monica Turner?	FIA Dan Tiers surveys Monica Turner?	FIA Hansen et al. 2000 Monica Turner?	Monica Turner?	Monica Turner?	
Douglas fir	Stand maps FIA Hansen et al. 2000	FIA	FIA Hansen et al. 2000			
Sagebrush	Stand maps FIA Hansen et al. 2000	FIA	FIA			
Aspen	Stand Maps Brown et al. 2006	FIA	FIA Brown et al. 2006			

GYE Application:
Draft Questionnaire for LCC-VP Collaborators

1. Describe your level of knowledge about past change climate and land use from 1900 to present and about projected future climate and land use to 2100.

2. What is your current approach to managing natural resources under climate and land use change? List 3-5 of the key steps you use to go from identifying potential conservation concerns to implementing management to alleviate concerns for high priority issues?

3. Do you currently have the data and decision support tools necessary to execute these steps?

4. What are the major conceptual challenges you face in executing these steps?

5. What additional resources (concepts, data, and/or tools) would improve your ability to manage under climate and land use change?

6. Which of the landscape metrics listed in Table 1 do you currently have access to? What time periods and spatial extents do your data sets cover? How relevant is each metric to management of natural resources in your unit under climate and land use change?

GYE Application: Schedule

4-Year Development Plan	Leads	2012		2013				2014				2015	
		FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2
Step 1. Id Conservation Targets													
Whitebark Pine Subcom workshop Apr 4, 2012 NPS workshop July 30, 2012	Olliff Hansen												
Step 2. Hindcasting and Forecasting													
Select IPCC scenarios, downscale climate	Melton												
Summarize climate and land use exposure	Chang Hansen Gross Monihan												
SERGoM and TOPS parameters, runs, validation	Theobald Melton												
Summarize ecological process outputs	Hansen Phillips												
Quantify land facets and soils	Theobald Reed												
Obtain/develop ecological system type data sets (presence, growth, reproduction)	Phillips Chang Nelson												
Develop, validate EST models and forecast change	MonihanC hang Nelson												
Quantify connectivity for project suitable habitats	Theobald Reed												

LCC-VP
LANDSCAPE CLIMATE CHANGE VULNERABILITY PROJECT

GYE Application: Schedule

4-Year Development Plan	Leads	2012		2013				2014				2015	
		FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2
Step 3. Vulnerability Assessment													
Summarize sensitivity of ecological processes and biodiversity	Hansen Chang Nelson												
Convene Expert Vulnerability Assessment and Management Panel	Gross Monihan												
Assess vulnerability based on exposure, sensitivity, and adaptive capacity	Gross Monihan												
Step 4. Management Options and Implementation													
Prioritize manageability of key responses	Olliff Monihan												
Design management strategies	Olliff Monihan												
Implement management strategies	Collab-orators												
Step 5. Decision Support													
Document methods	All												
Distribute data and summary reports	All												
Training workshops	All												

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