Informing Implementation of the Greater Yellowstone Coordinating Committee's Whitebark Pine Strategy based on Climate Sciences

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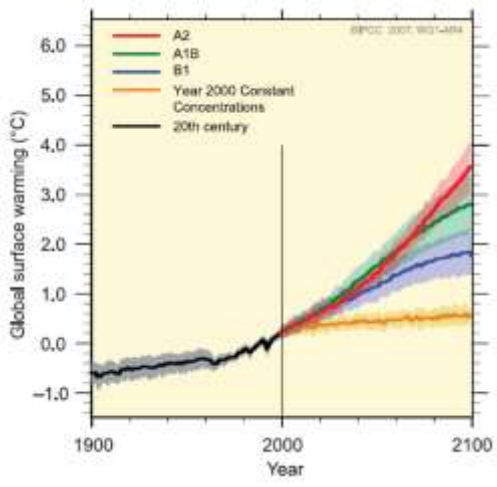
Challenges of Whitebark Pine Restoration Meeting
Bozeman, MT
Sept 20, 2013

Managing Natural Resources under Climate Change



Challenges

- Time horizon (decades to centuries) longer than planning and management horizons (1-5 yrs)
- Relevant spatial area (subcontinental) larger than management units
- High uncertainties on science (climate change, ecological response) and management effectiveness
- Requires coordination among multiple management units and jurisdictions
- Approach and methods are underdeveloped

MANAGING NATURAL RESOURCES UNDER CLIMATE CHANGE

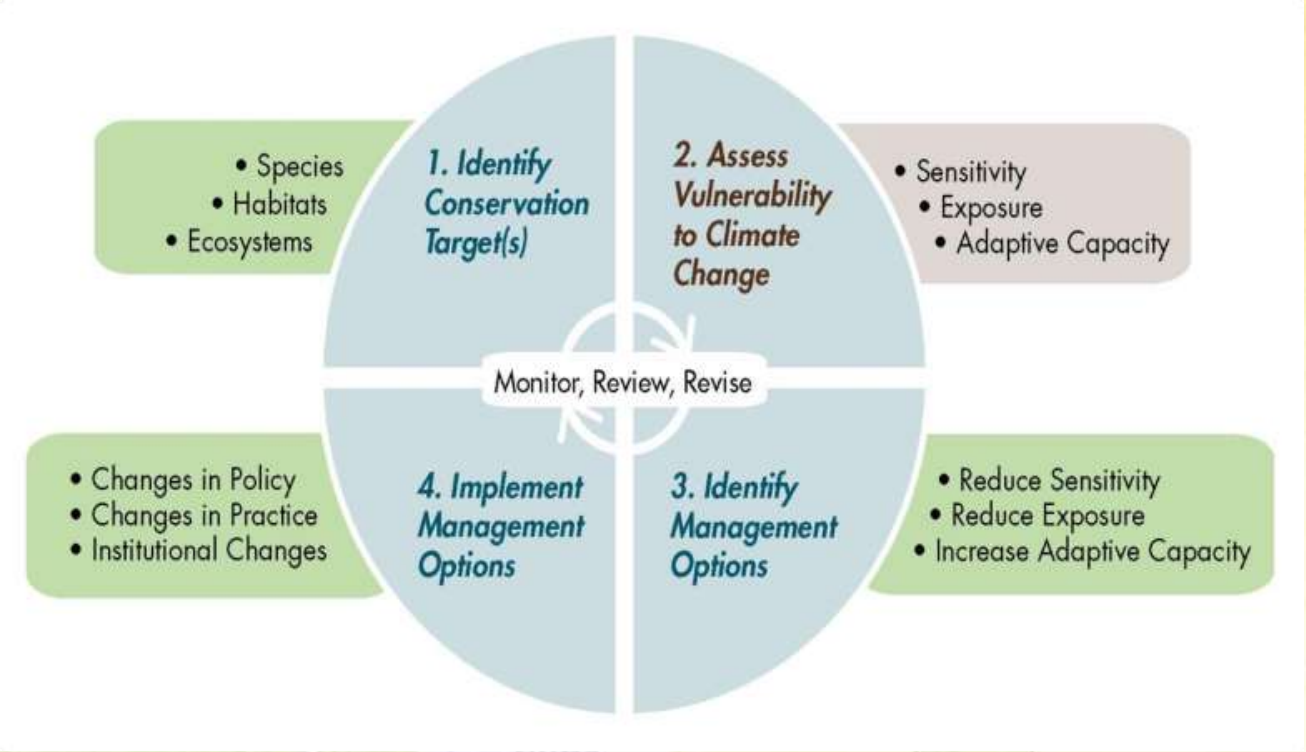
Consequently

North Central Climate Science Center – "the strongest need at this point is to demonstrate how climate science can be integrated into resource management decision---making".

NASA Applied Sciences - "We need to make progress connecting climate drivers to biological responses in order to improve our basic understanding of climate change impacts and to develop tools for managing species and ecosystems under climate change."

MANAGING NATURAL RESOURCES UNDER CLIMATE CHANGE

Approach

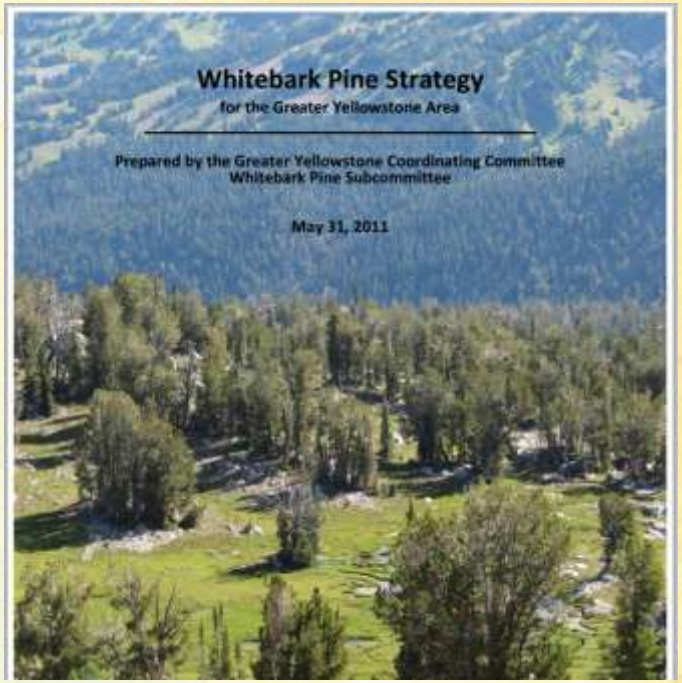


Glick et al. 2011. Scanning the Conservation Horizon: A guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D.C.

WHITEBARK PINE IN GYE

Overview

- Keystone species
- Early climate responder
- Listed as candidate species



GYCC WBP Strategy

- Interagency committee has worked since 1999 to develop a GYA-wide management strategy to protect and restore WBP under the threat of mountain pine beetles and blister rust.
- Little information on climate change available to committee.

Key Question

- What locations in GYE will have climates suitable for WBP and are candidates for restoration strategies under the GYCC WBP Strategy?

WHITEBARK PINE IN GYE

Objectives

1. Ecological forecasting under alternative IPCC climate and land use scenarios.

2. Analyzing WBP response to climate and extreme climate events over the past 15,000 years.

3. Develop spatially explicit WBP management alternatives.

4. Evaluate the management alternatives under future climate scenarios:
   - WBP goals
   - Ecosystem services derived from WBP
   - Cost of implementation.

5. Draw recommendations for implementation of the GYCC WBP strategy under climate change.

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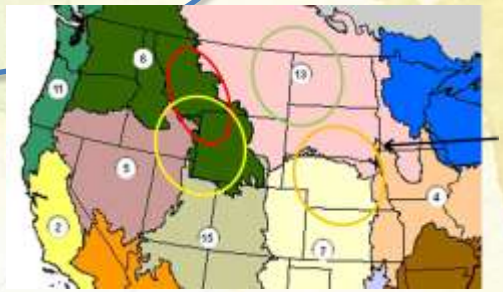
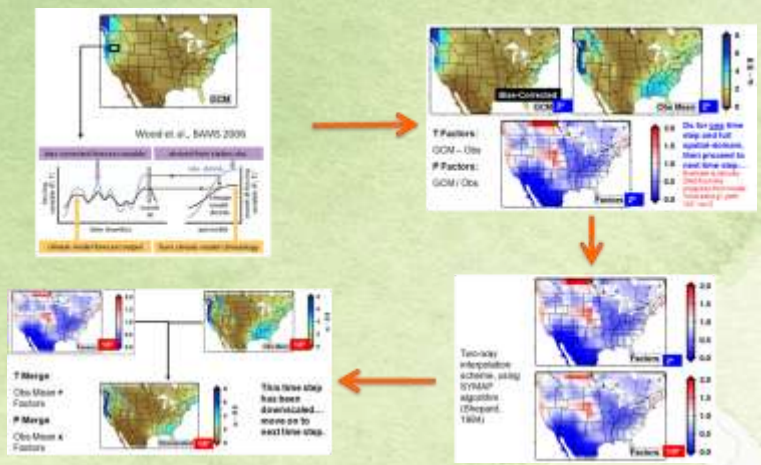


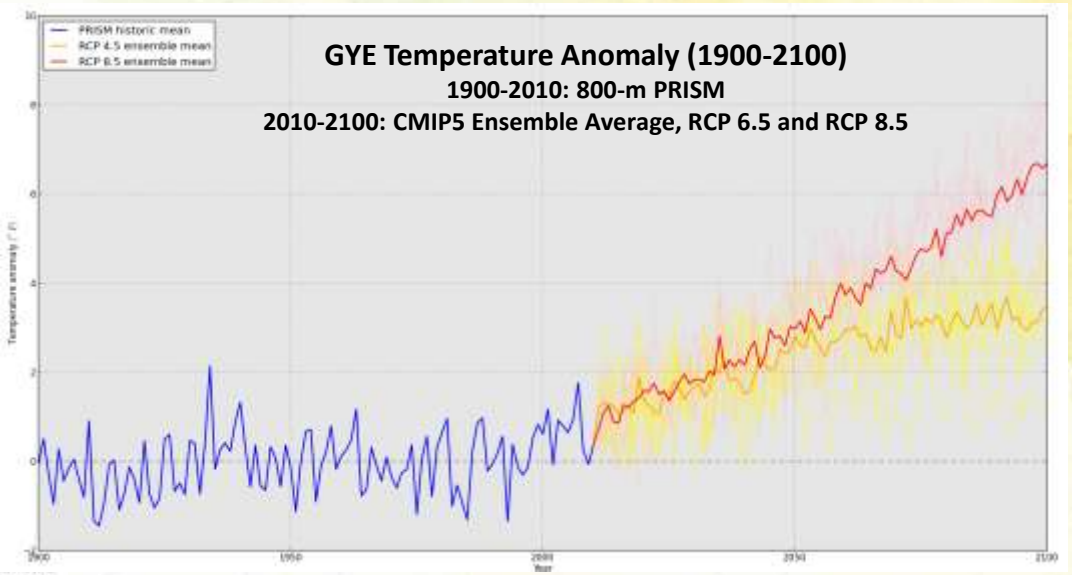
ECOLOGICAL FORECASTING

Downscaling Projected Climate



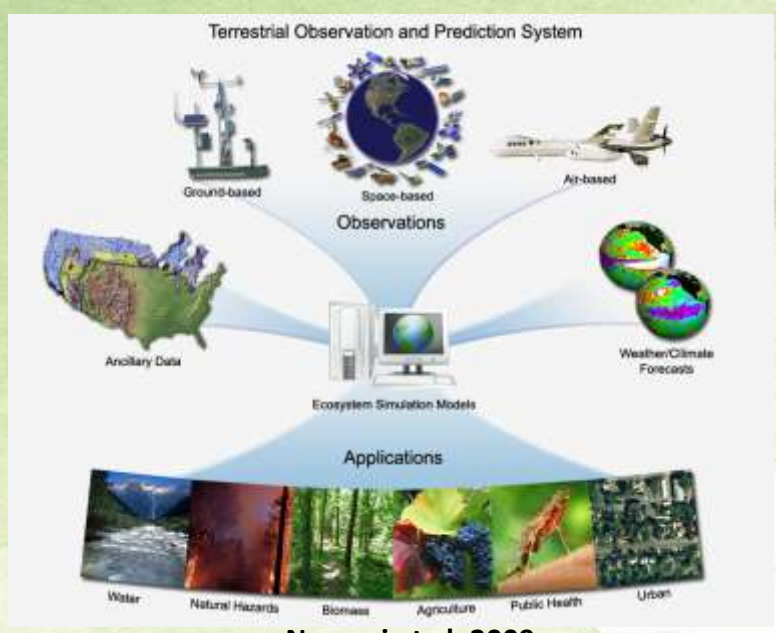
Bias-Correction Spatial Disaggregation
Thatcher et al. 2013. EOS.

	1900-2010	2030	2060	2090
Mean Temp	1.1 ^{0}F	1.7 – 2.0 ^{0}F	3.0-4.0 ^{0}F	3.0 – 6.0 ^{0}F



ECOLOGICAL FORECASTING

Ecosystem Processes

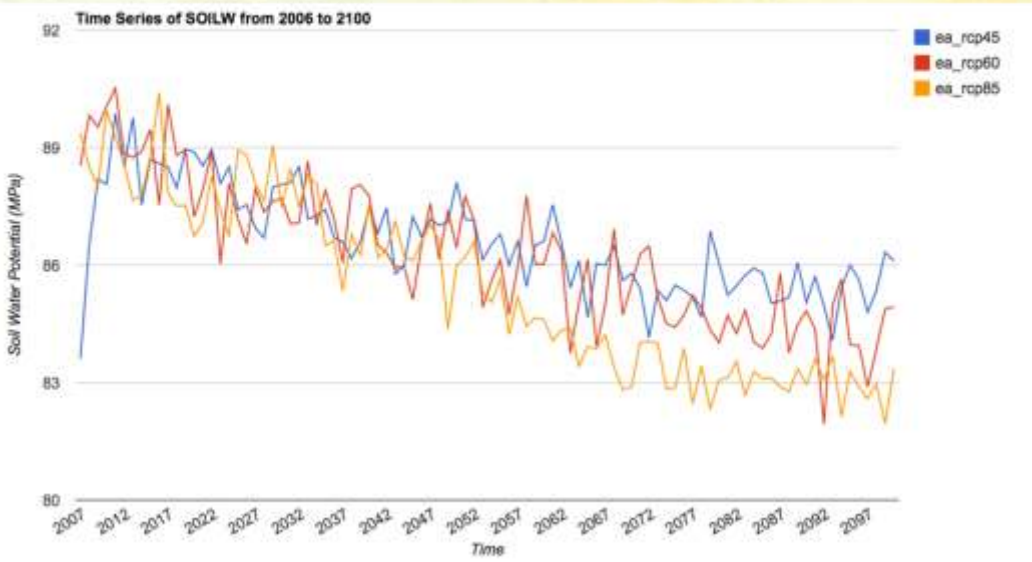


Nemani et al. 2009

TOPS Outputs

Hydrology	Vegetation
Evapotranspiration	Water Stress factor
Snow water equivalent	Gross primary productivity
Soil moisture	Net primary productivity
Runoff	Respiration

Yellowstone, Soil Water, Ensemble Average, Summer



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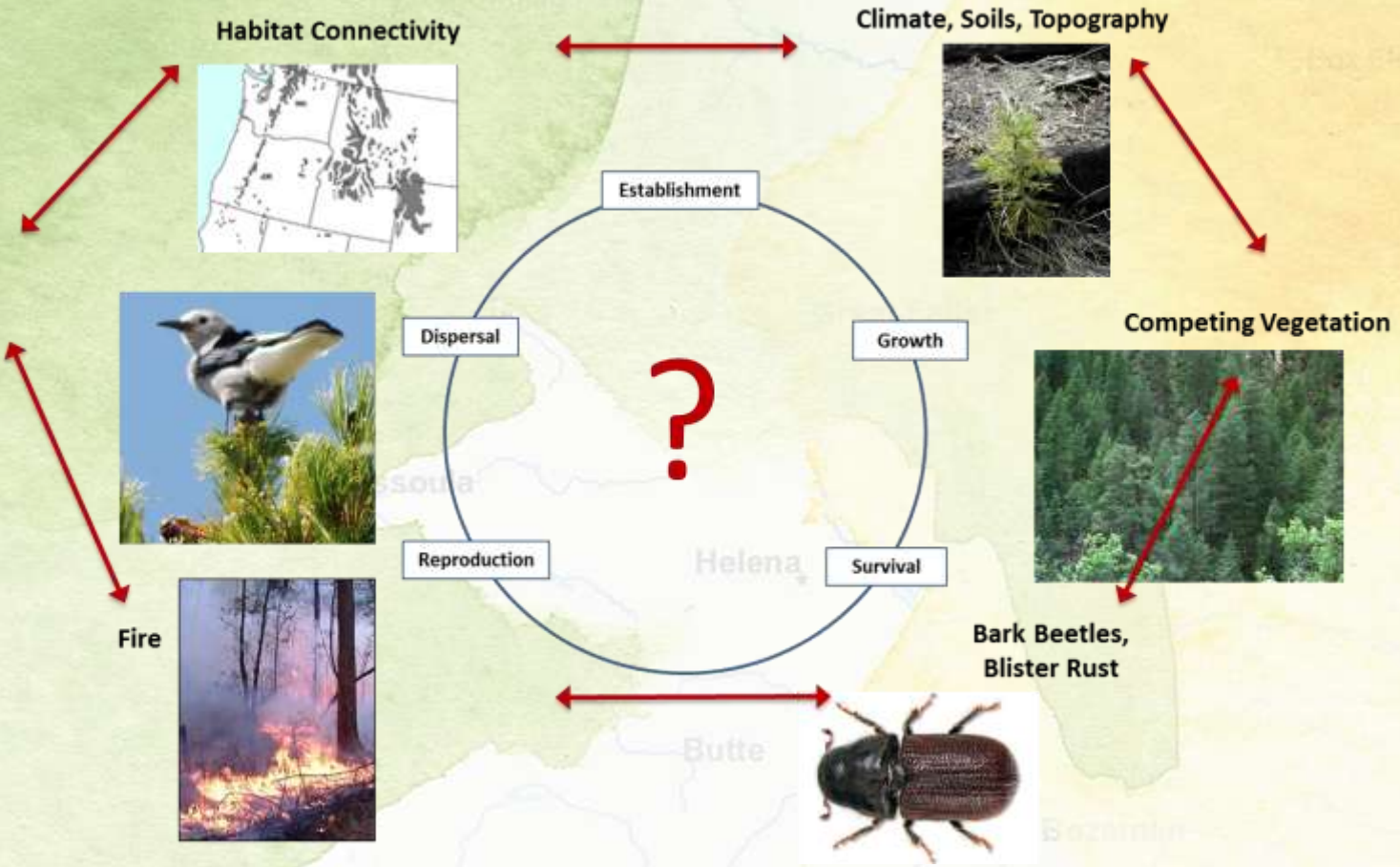
LANDSCAPE CLIMATE CHANGE VULNERABILITY PROJECT

ECOLOGICAL FORECASTING

Whitebark Pine Distribution Modeling



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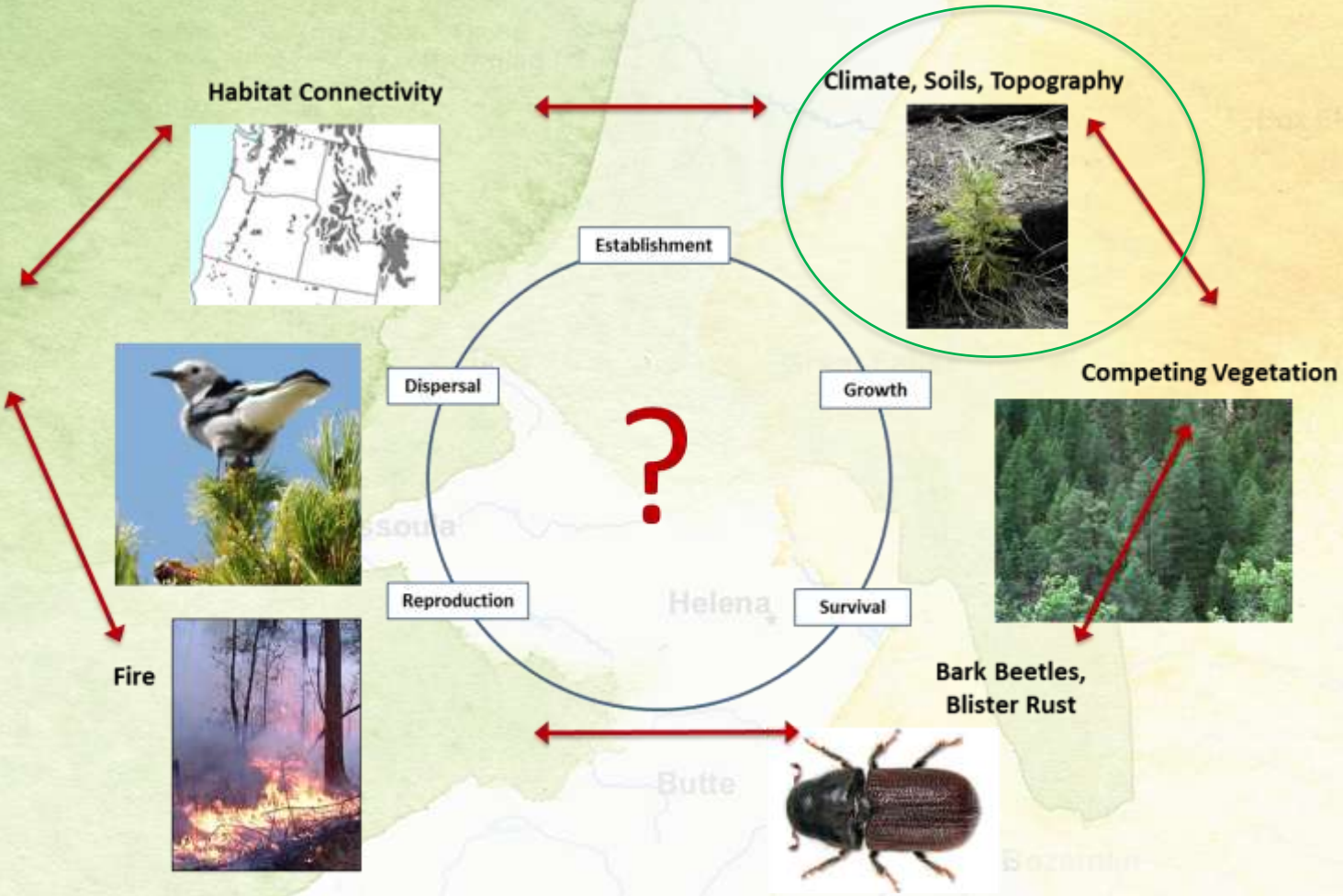

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ECOLOGICAL FORECASTING

Whitebark Pine Distribution Modeling

Study Area: GYE

Calibration

- Periods: 1950-1980; 1980-2010
- Climate Data: PRISM (800m, monthly)
  - Daley et al. 2010

Projection

- Period: 2040, 2070, 2100
- Climate Data: IPCC CMIP5 Downscaled (800m, monthly)
  - Thatcher et al. 2013

Global Circulation Models

- CCSM-1
- Ensemble average

Concentration Scenarios

- RCP 4.5
- RCP 8.5

Statistical Techniques

Multivariate adaptive regression splines, Random Forests, Boosted Random Forests, General Linear Models

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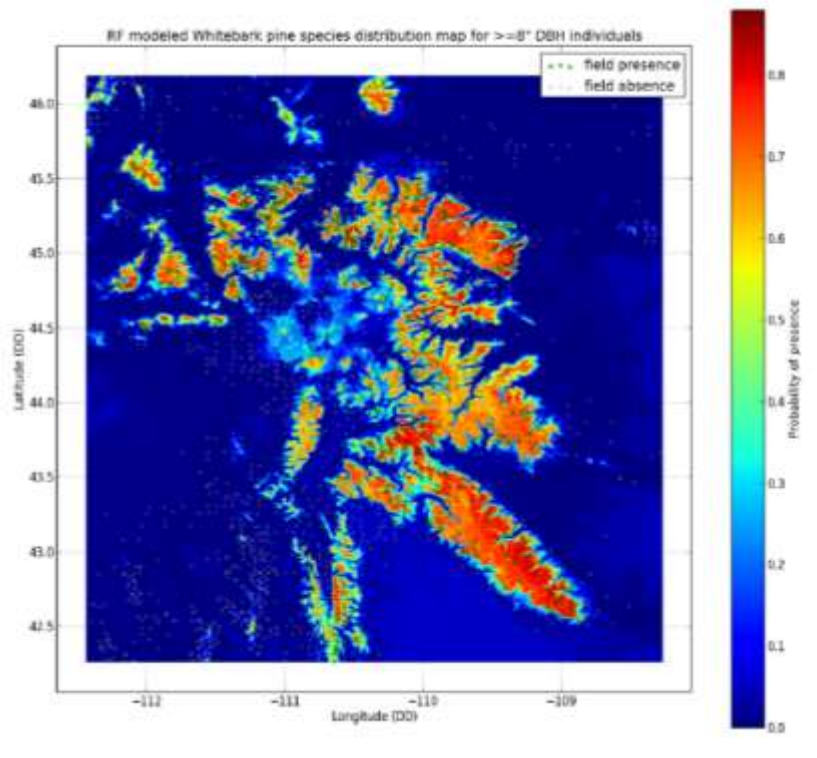
ECOLOGICAL FORECASTING

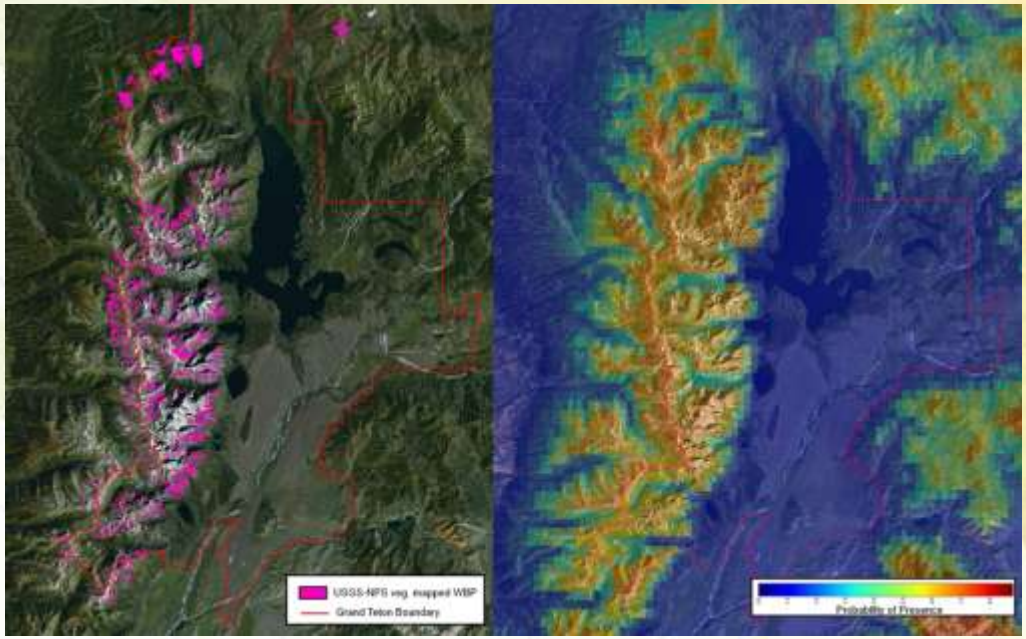
Whitebark Pine Distribution Modeling



Leading predictors:
Tmax8, VPD8, PET7, SWE5, Tmin1

USGS Mapped WBP

Predicted WBP



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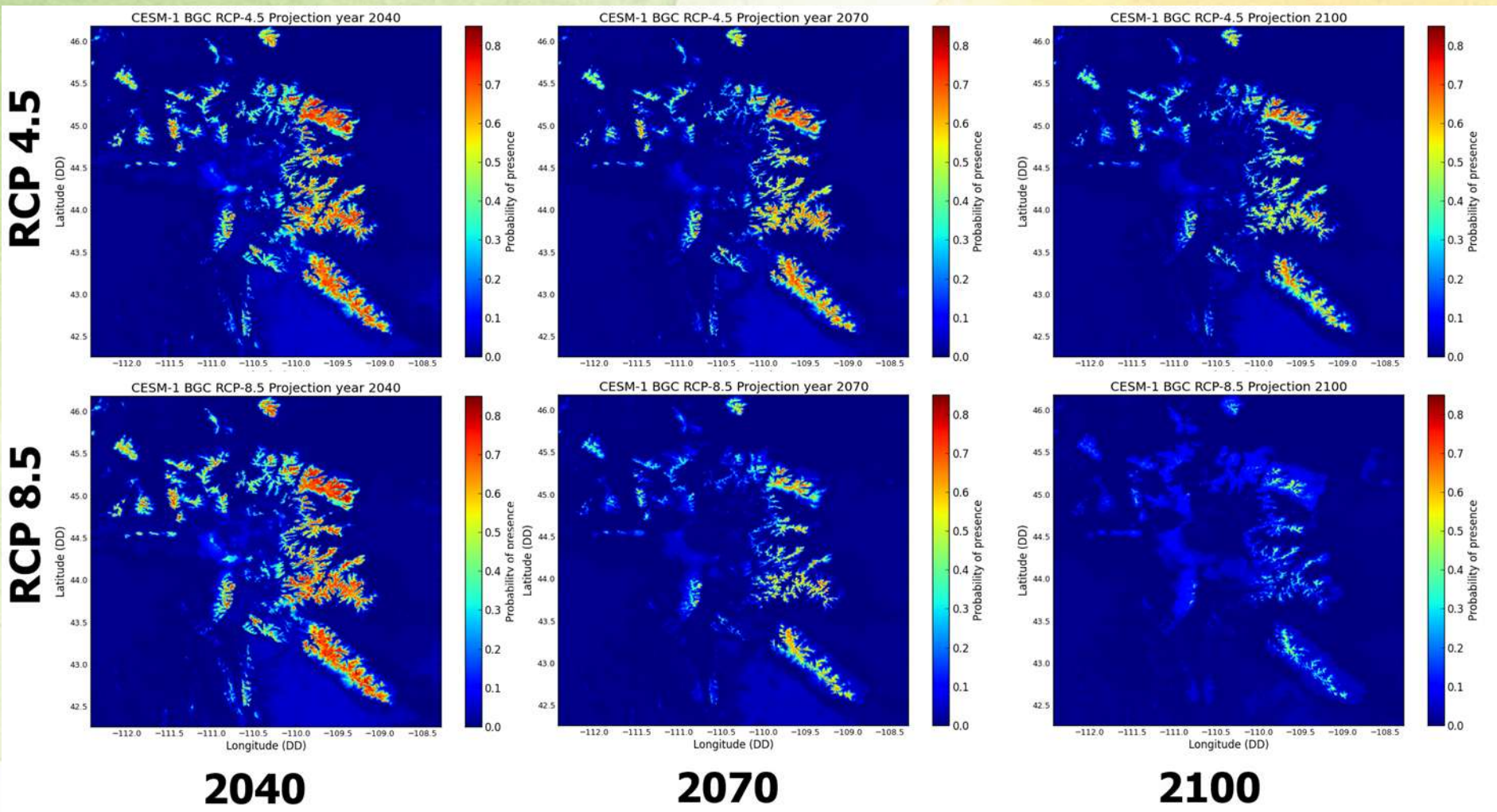
ECOLOGICAL FORECASTING

Whitebark Pine Distribution Modeling

WBP Adults (>8" dbh) Projected under averaged CMIP5 GCM Climate



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ECOLOGICAL FORECASTING

Whitebark Pine Distribution Modeling

Geographic Properties of Areas of Suitable Climate (RCP 8.5)

Prob. Presence > 50%	Current	2040	2070	2100
Area	28,732 km^2	10,227 km^2 (65% reduction)	6,160 km^2 (79% reduction)	3,949 km^2 (86% reduction)
Mean elevation	2,974 m (9,754 ft)	3,214 m (10,541 ft)	3,288 m (10,784 ft)	3,363 m (11,030 ft)
Elevation Range	2,226 – 4,101 m (7,301 – 11,030 ft)	2,478-4101 m (8,127 – 11,030 ft)	2,545-4,101 m (8,347 – 11,030 ft)	2,643-4,101 m (8,669 – 11,030 ft)

LONG-TERM CONTEXT

Has WBP persisted through unsuitable climate periods in the past?

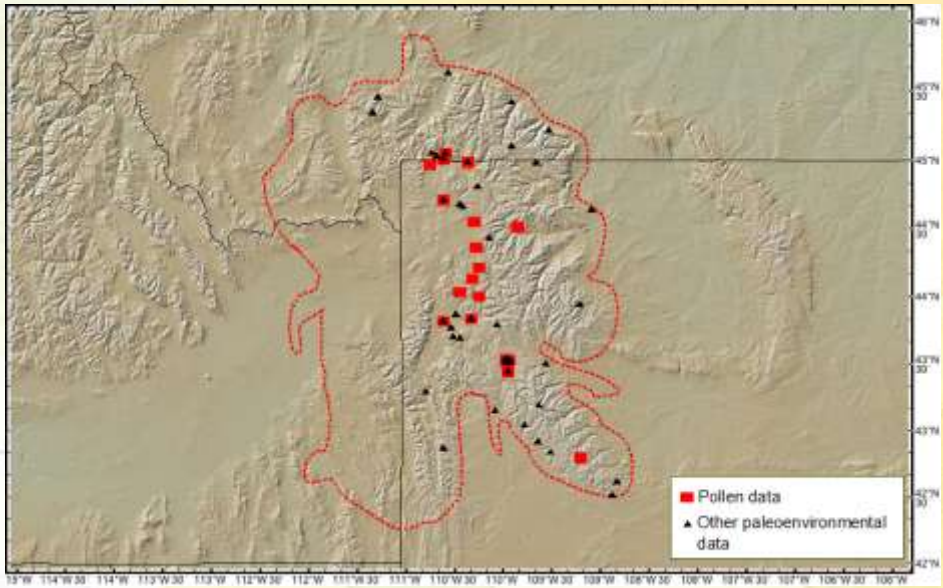
Goal: Understand WBP response to post-glacial (15 kyr) climate changes in GYE

Tasks:

- **Interpret fluctuations in WBP abundance in light of past climatic and environmental changes:**
  Medieval Climate Anomaly (800-1200 AD)
  Little Ice Age (1500-1900 AD)

- **Explore response of WBP during past periods of high and low fire activity**

- **Compare WBP growth rates in recent centuries with independent climate data**



Tree-ring and pollen records in the GYE

DEVELOP AND SIMULATE MANAGEMENT ALTERNATIVES

Approach

Simulate potential outcomes of alternative management options:

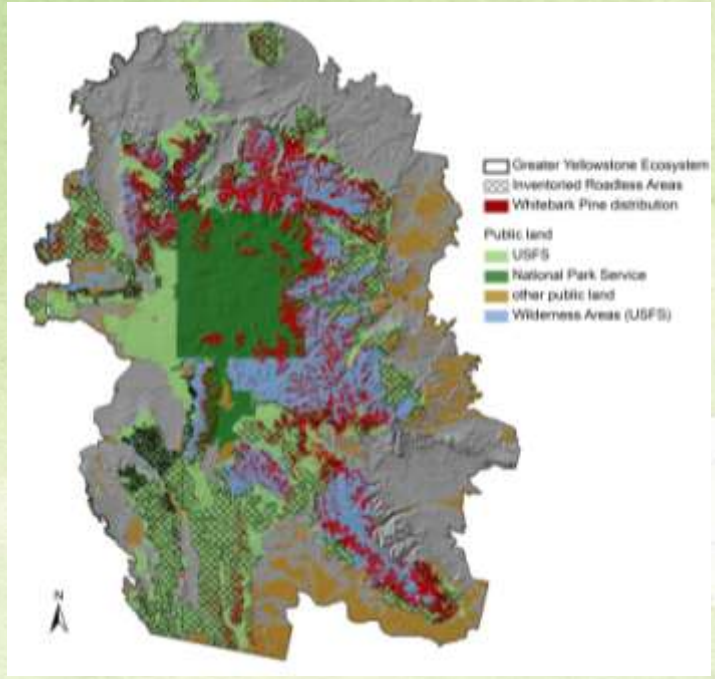
- **Evaluate current WBP Strategy against forecasts.**

- **Create two additional options that require new agency tolerances.**

Climate Scenarios	WBP Management Options			
	No Action	Low (GYCC 3-yr plan)	Medium	High
RCP 4.5				
RCP 6.0				
RCP 8.5				

DEVELOP AND SIMULATE MANAGEMENT ALTERNATIVES

Context



Challenge: Agencies / land allocation types differ in tolerance to management.

Greater Yellowstone Ecosystem			
Agency/Allocation	**Legal Direction/Mgt Philosophy**	**WBP Restoration Tools allowed or likely**	**% WBP**
National Forests	• Multiple use • Ecological integrity	All • Planting seedlings/sowing seeds • Pruning • Wildland and prescribed fire use • Targeted fire suppression • Mechanical thinning • Research/Monitoring	**5%**
NF – Wilderness Area	Most actions prohibited or discouraged	• Wildland fire use • Research/Monitoring	**54%**
NF – Inventoried Roadless Areas	Actions less restricted but remoteness an issue	• Planting seedlings/sowing seeds • Wildland fire use • Research/Monitoring • Mechanical thinning (but requires USDA Secretarial approval)	**27%**
Yellowstone National Park	Park Service Policy: "Take no action that would diminish the wilderness eligibility of an area" AND/BUT "Management actions…should be attempted only when knowledge and tools exist to accomplish clearly articulated goals."	• Wildland fire use • Research/Monitoring	**10%**
Grand Teton National Park		• Planting seedlings/sowing seeds • Pruning • Wildland fire use • Research/Monitoring	**3%**

EVALUATE MANAGEMENT ALTERNATIVES

WBP Goals, Cost of Implementation, Ecosystem Services

Ecosystem Service Valuation

Whitebark pine ecosystem services valued:

- **Hydrologic regulation**
- **Provisioning for other species**
- **Wilderness aesthetics and recreation**

Valuation methods:

- **Conjoint survey analysis to estimate total value (both use and non-use values including non-consumptive eco-system services)**
- **Market-based analysis for marketable ecosystem services (e.g., water replacement)**

Ecosystem values used for cost-benefit analysis

- **Costs of each management alternative will be compared with the benefit / value of the ecosystem services resulting from the alternative**
- **The management alternative with the largest net benefit (benefits – costs) would be recommended for adoption**

RECOMMENDATIONS FOR IMPLEMENTATION

Workshop with GYCC WBP Subcommittee and managers from WBP range to interpret results and make recommendations

TIME TABLE

Schedule	Year 1				Year 2				Year 3			
Task	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Study Design												
Pre-implementation Workshop		■										
Objective 1												
Ecological forecasting	■	■										
Objective 2												
Paleo analyses	■	■										
Objective 3:												
Management alternatives workshop			■									
Objective 4: Evaluate alternatives												
Analyze mgt alternatives on WBP status				■	■	■						
Conduct benefits surveys					■	■	■					
Analyze cost/benefits of alternatives						■	■	■				
Objective 5												
Workshop to define recommendations									■			
Data Transfer and Archive												
Targeted meetings to share results and science products										■	■	
GNLCC Science Webinar											■	
Finalize all data products											■	■
Archive all materials												■

Acknowledgements

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