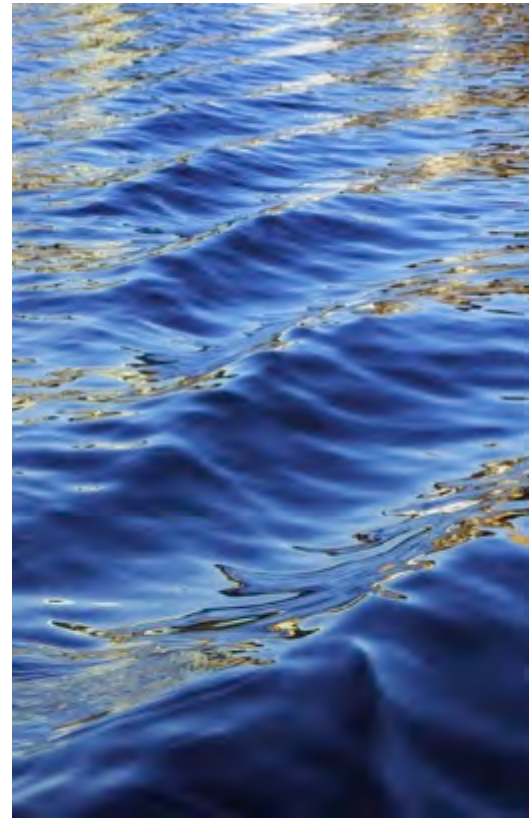


Yale Framework

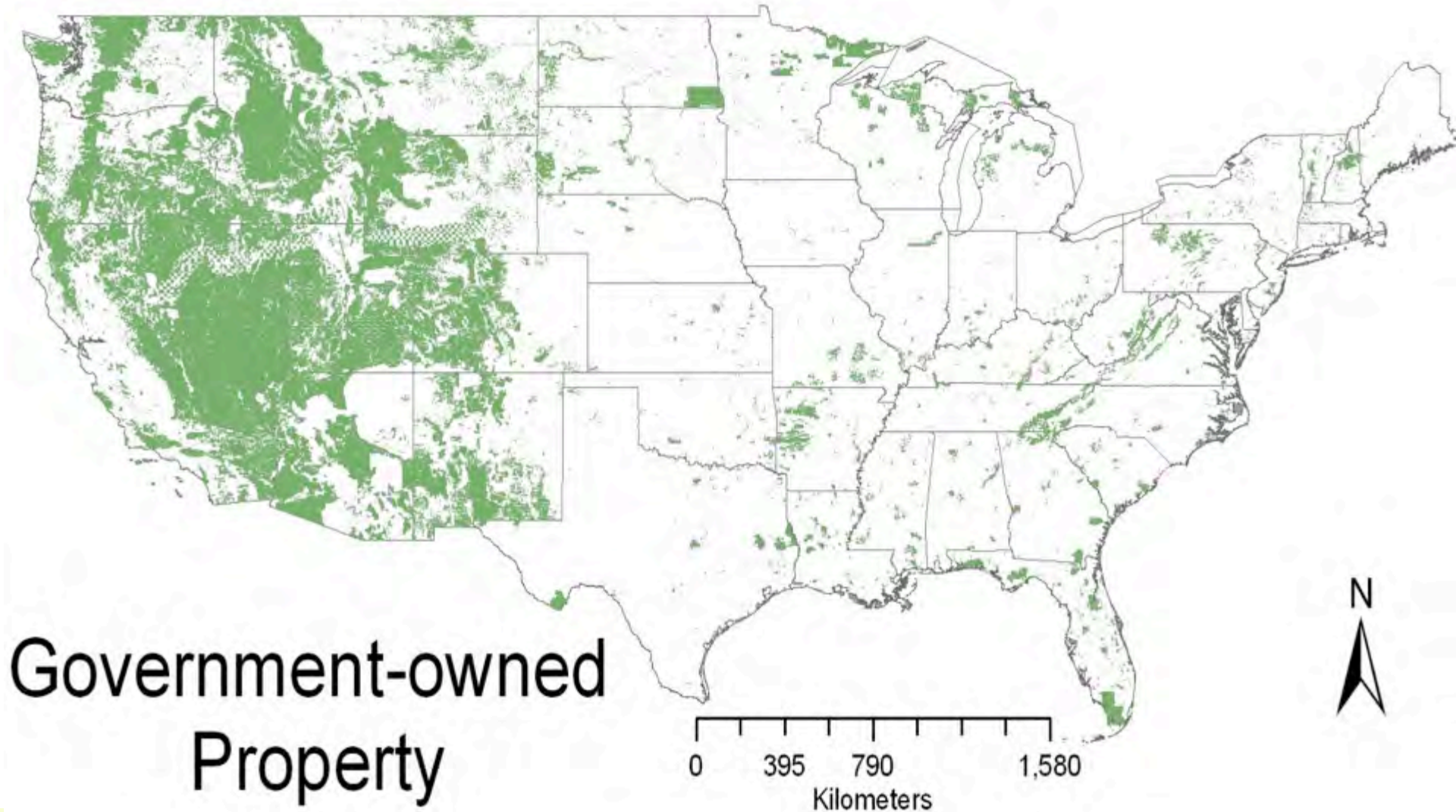
Strategies for Integrating
Climate Adaptation Models
Into Resource Planning

Anne M. Trainor
Yale University



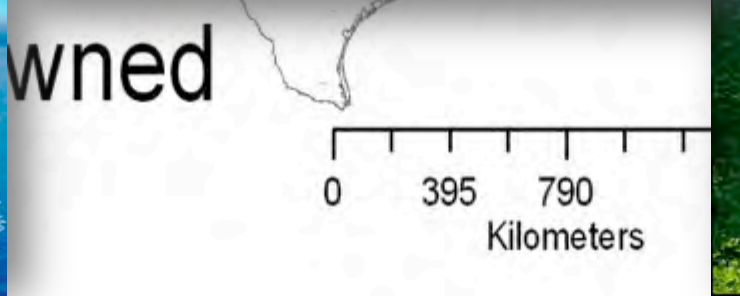
Classic conservation approach

Managing for the persistence of biodiversity and natural processes through restricting or excluding human activities within defined tracts of natural systems.



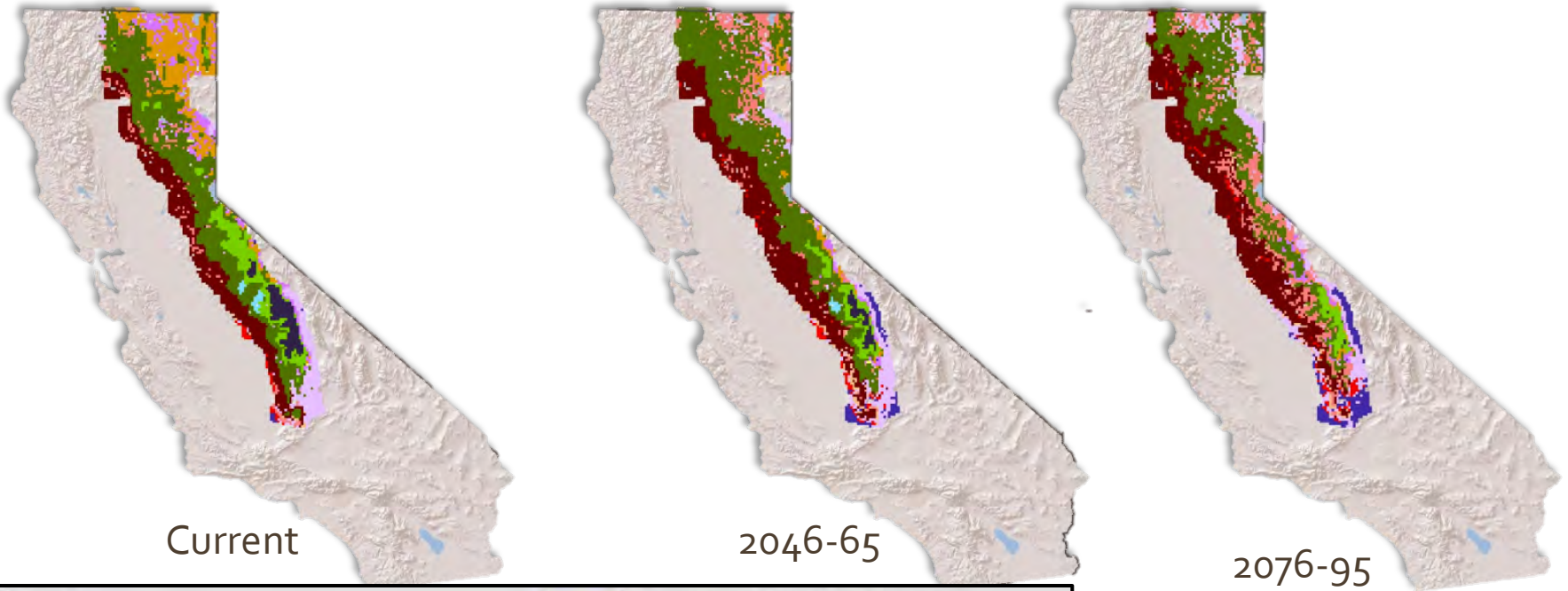
Classic conservation approach

Managing for the persistence of biodiversity and natural processes through restricting or excluding human activities within defined tracts of wilderness.



Climate change and dynamic landscapes

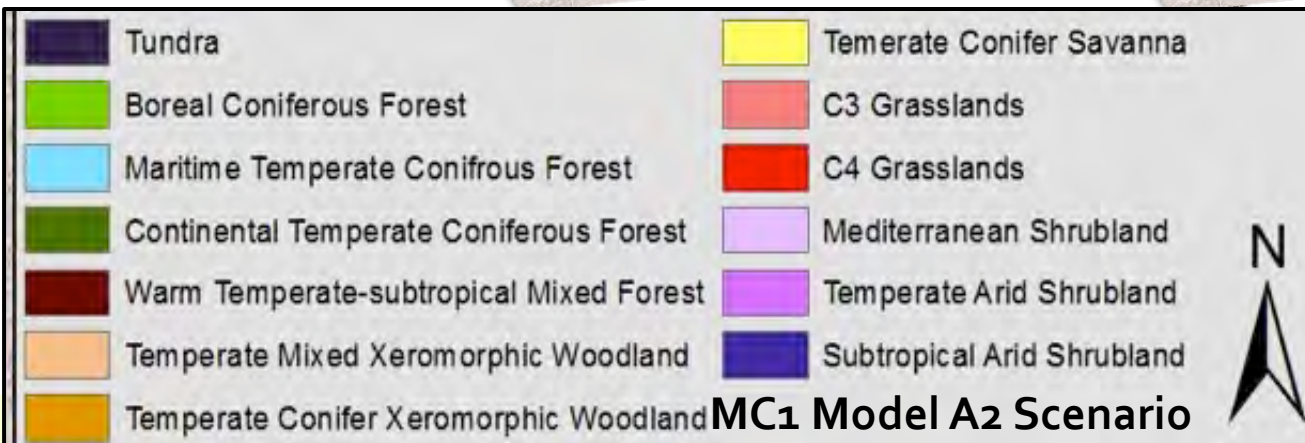
Shifting Major Ecosystem Types & Wildlife



Current

2046-65

2076-95



Global change is requiring conservation embrace a more dynamic view of landscapes

- Scientific assessment to evaluate spatial domains that natural systems require.
- Develop and implement adaptation approaches that will enable species and ecosystems to persist.



Credit: USGCRP & IPCC



available at www.sciencedirect.com



journal homepage: www.elsevier.com/locate/biocon



Review

Biodiversity management in the face of climate change: A review of 22 years of recommendations

Nicole E. Heller^{*}, Erika S. Zavaleta

Environmental Studies I

Conservation Biology

Review

A Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation

JONATHAN R. MAWDSLEY,^{*} ROBIN O'MALLEY, AND DENNIS S. OJIMA

The Heinz Center, 900 17th Street NW, Suite 700, Washington, D.C. 20006, U.S.A.

Global Change Biology

Global Change Biology (2011) 17, 3150–3160, doi: 10.1111/j.1365-2486.2011.02457.x

Incorporating climate change adaptation into national conservation assessments

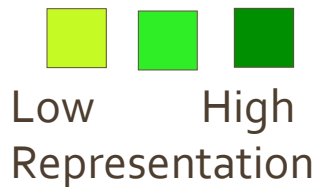
EDWARD T GAME^{*†}, GEOFFREY LIPSETT-MOORE^{*}, EARL SAXON[‡], NATE PETERSON^{*}
and STUART SHEPPARD[§]

^{*}The Nature Conservancy, South Brisbane, QLD 4101, Australia, [†]The School of Biological Sciences, University of Queensland, St Lucia, QLD 4072, Australia, [‡]Center for Environment, Energy and Enterprise, AED, Washington DC 20009, USA, [§]The Nature Conservancy, Sanur, Bali, Indonesia

Science Panel Representation

	Federal Govt.	State Govt.	NGO	Academia
Policy & Science	High	Low	Low	None
Technology & modeling	None	Low	High	Low
Conservation Biology	Low	Low	High	High

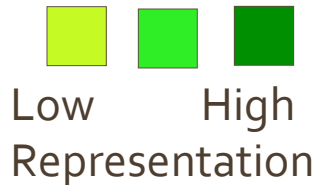
Science panel membership



Science Panel and Peer Review Representation

	Federal Govt.	State Govt.	NGO	Academia
Policy & Science	High Representation	Peer review contributions	Peer review contributions	
Technology & modeling		Low Representation	High Representation	Low Representation
Conservation Biology	Low Representation	Low Representation	Peer review contributions	High Representation

Science panel membership



Peer review contributions

	Ecological Level		
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			

Ecological Level			
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			
B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.			
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			

Adaptation Approach	Ecological Level		
	Species & Population	Ecosystem	Landscape
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Adaptation Approach	Ecological Level		
	Species & Population	Ecosystem	Landscape
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B. Anticipating and responding to future			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.			
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			

Assess population sizes, viability, conservation status, and map species occurrences

Ecological Level

Adaptation Approach

Species &
Population

Ecosystem

Landscape

A. Strengthen current conservation efforts

1) Protect current patterns of biodiversity

2) Protect large, intact, natural landscapes

3) Protect the geophysical setting

B. Anticipating and responding to future

4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.

5) Identify and protect climate refugia

6) Maintain and restore ecological connectivity

Map terrestrial and aquatic ecosystems and their associated services

Ecological Level

Adaptation Approach

Species &
Population

Ecosystem

Landscape

A. Strengthen current conservation efforts

1) Protect current patterns of biodiversity

2) Protect large, intact, natural landscapes

3) Protect the geophysical setting

B. Anticipating and responding to future conditions

4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.

5) Identify and protect climate refugia

6) Maintain and restore ecological connectivity

Map genetic pattern across the landscape
Map beta and gamma diversity,
Map biodiversity hotspots

Adaptation Approach	Ecological Level		
	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity	X	X	
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			
B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.			
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			

- Examine how the current distributions of martens and fishers are influenced by

- Vegetation characteristics (e.g., forest composition and structure),
- Climate (e.g., temperature, precipitation, snow depth and duration),
- Physical variables (e.g., elevation, % slope)
- Presence or absence of the other species.

Fisher



Marten



- Closely related forest carnivores of conservation concern in California
- Inform conservation efforts for these species



CONSERVATION
BIOLOGY
INSTITUTE

climate only.
vegetation only.
climate + vegetation.
climate + vegetation + physical.
climate + vegetation + presence/absence of the other *Martes* species.
climate + vegetation + physical + presence/absence of the other *Martes* species.

Fisher

Marten



- Examine how the current distributions of martens and fishers are influenced by

- vegetation characteristics (e.g., forest composition and structure),
- climate (e.g., temperature, precipitation, snow depth and duration),
- physical variables (e.g., elevation, % slope)
- presence or absence of the other species.

- Closely related forest carnivores of conservation concern in California
- Inform conservation efforts for these species

climate only.

vegetation only.

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climate + vegetation + physical.

climate + vegetation + presence/absence of the other *Martes* species.

climate + vegetation + physical +

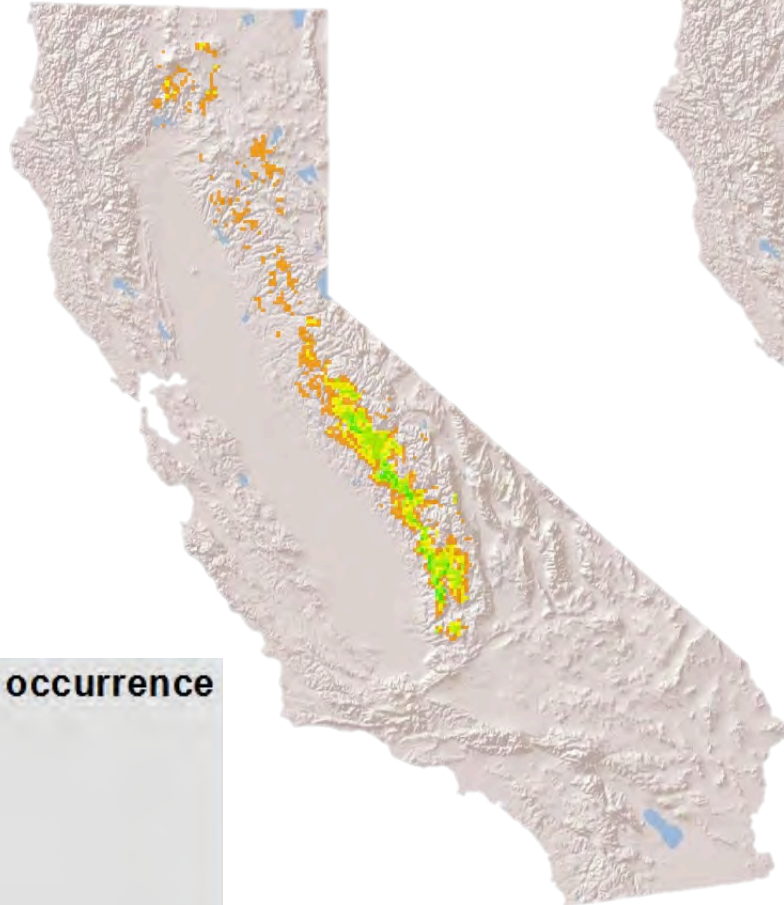
presence/absence of the other *Martes* species.



Fisher



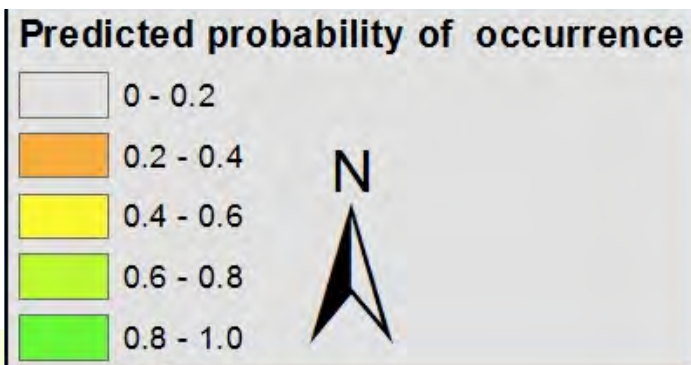
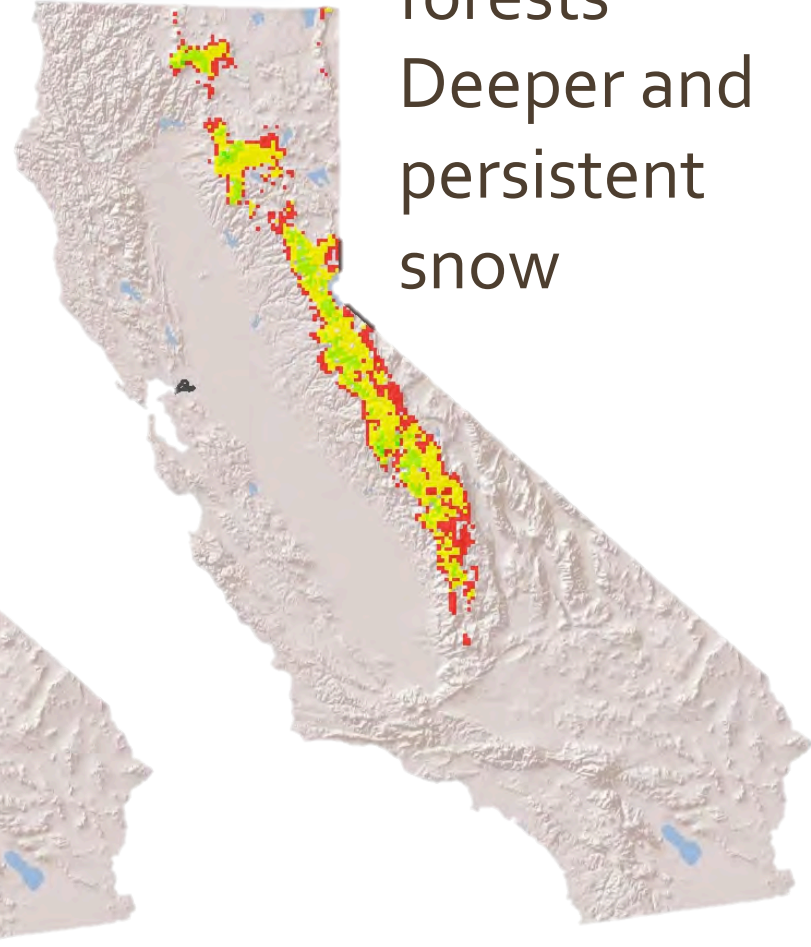
Mid-elevation
Yellow pine &
mixed conifer
forests
Less snow
Warmer Temp.



Marten



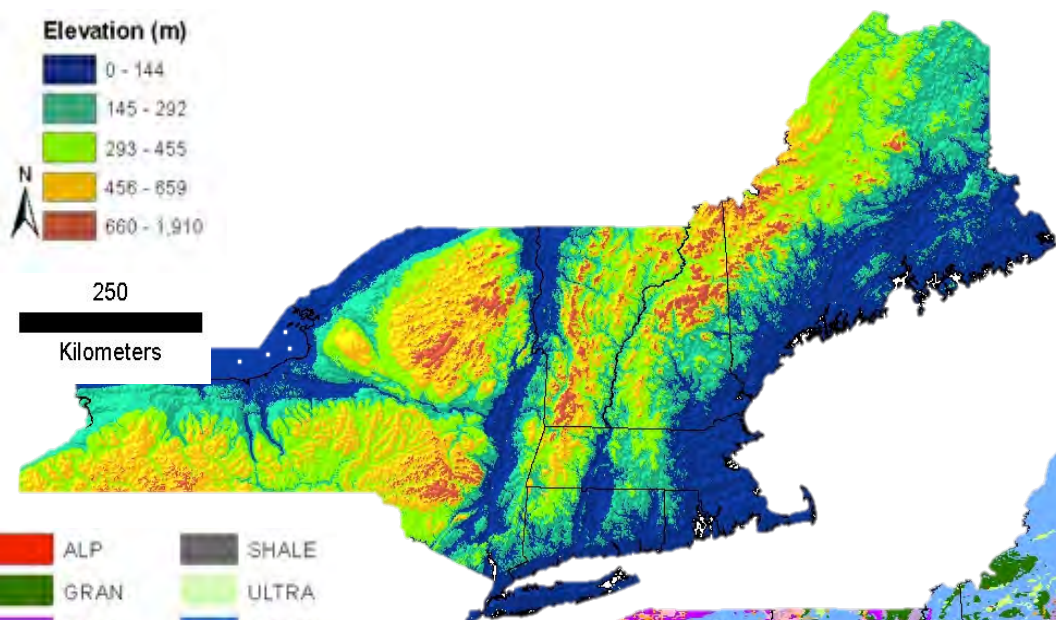
High
subalpine
forests
Deeper and
persistent
snow



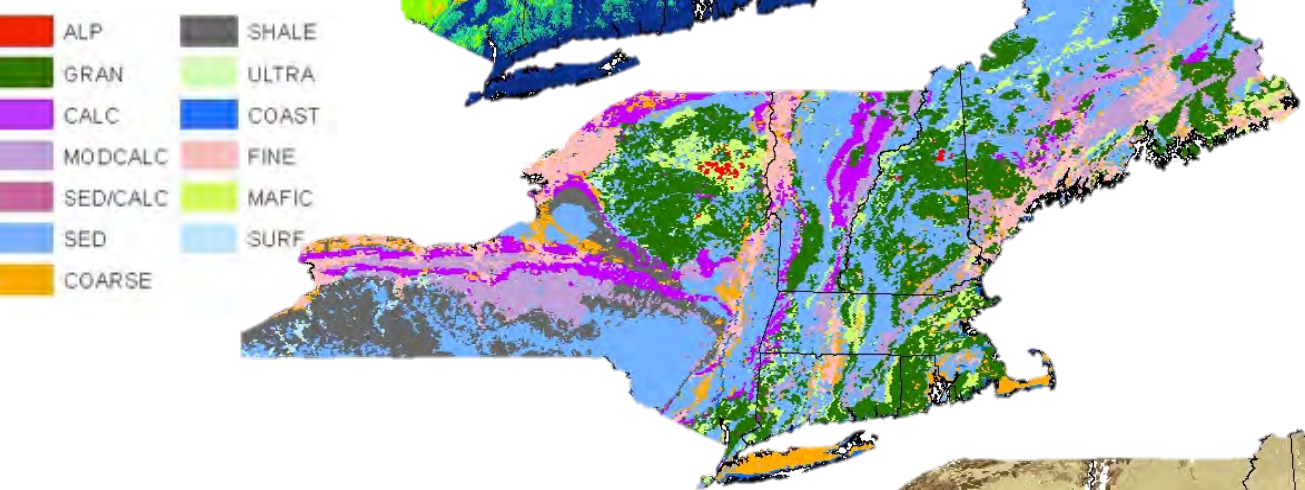
Adaptation Approach	Ecological Level		
	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
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B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.			
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			

Map areas of high ecological integrity
 Map areas of high topographic complexity

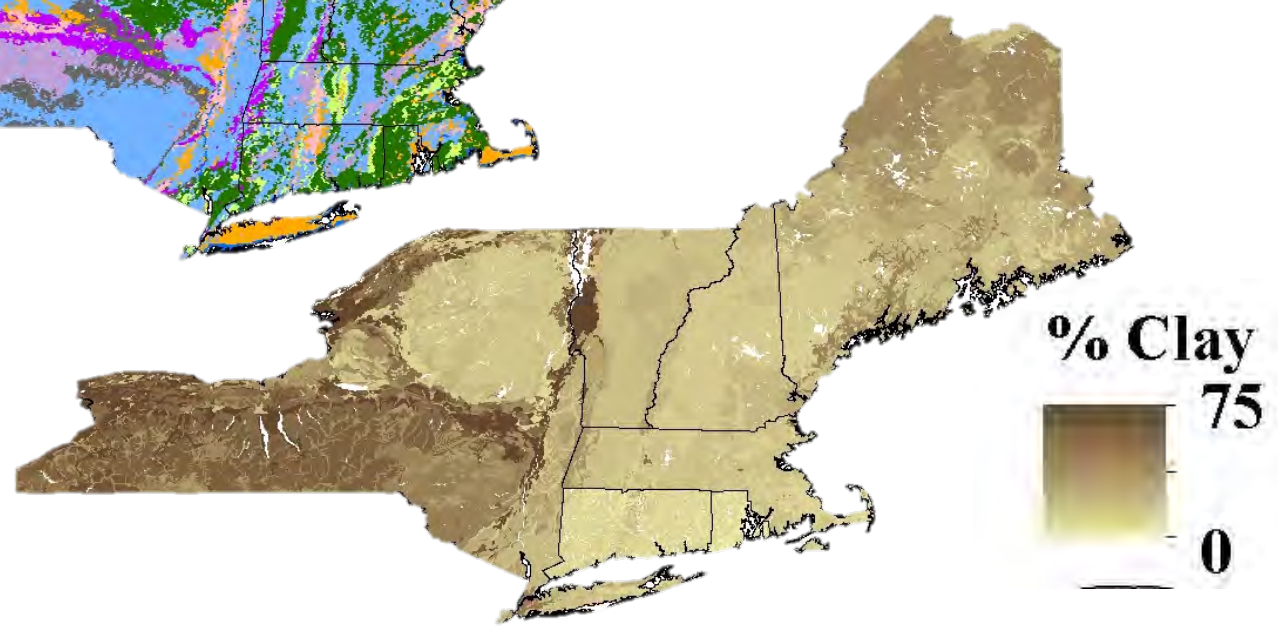
Ensure that conserved lands or lands under long-term stewardship cover a wide range of geophysical settings

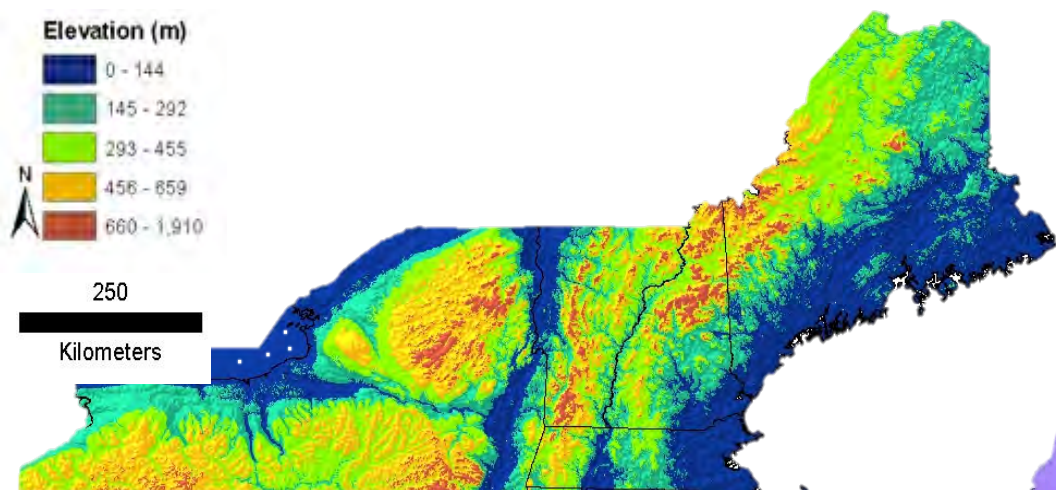


Protecting a wide variety of Geophysical settings that remain relatively constant as climate changes & plants and animals shift.

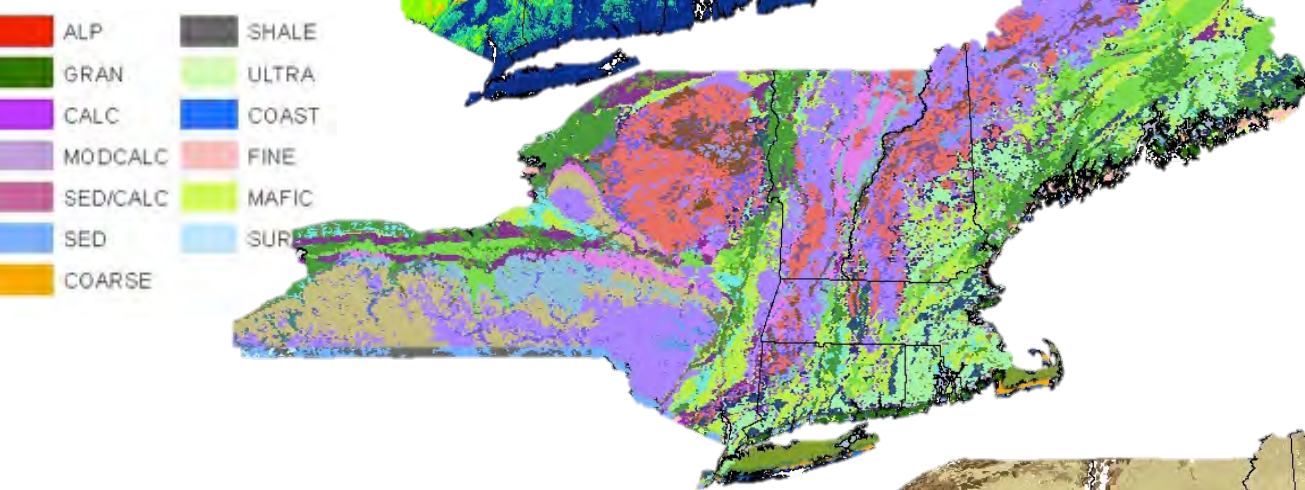


Topography, Bedrock, & Surface Material

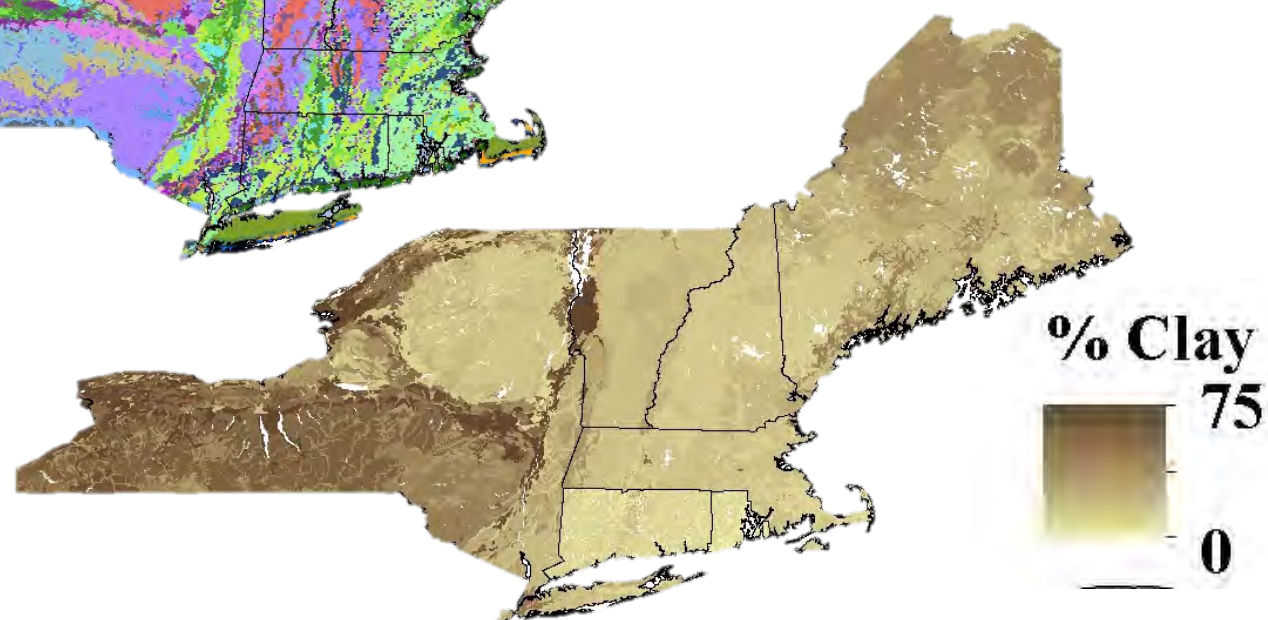




Protecting a wide variety of Geophysical settings that remain relatively constant as climate changes & plants and animals shift.

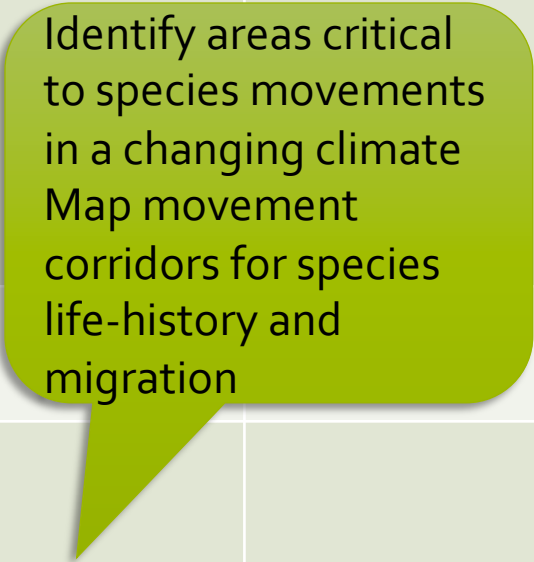


Topography, Bedrock, & Surface Material




Ecological Level			
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			
B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.			
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			

Ecological Level

Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			
B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.	 <p>Identify areas critical to species movements in a changing climate Map movement corridors for species life-history and migration</p>		
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			

Ecological Level

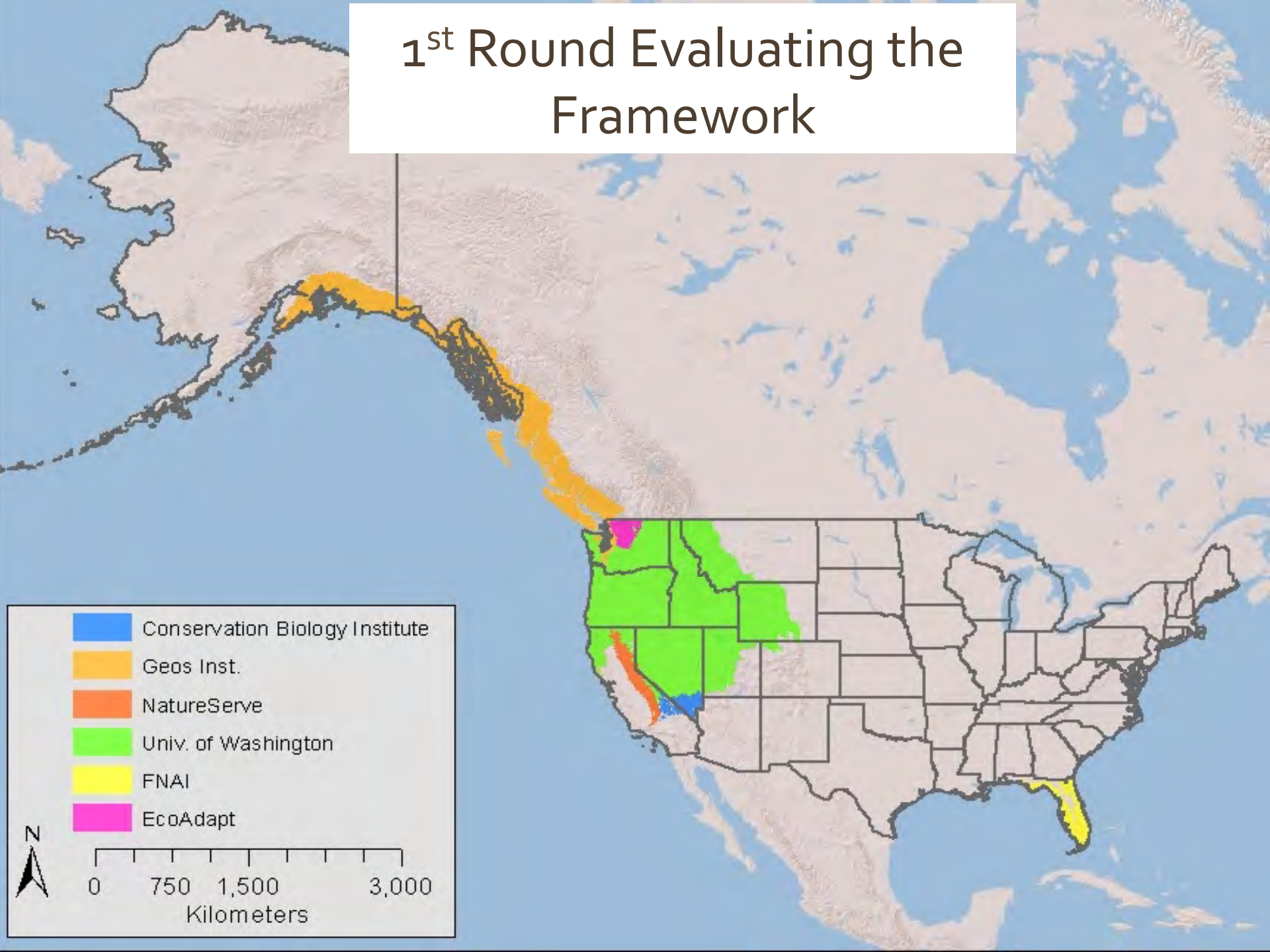
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			
B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.	 <p>Map connections between current and projected future locations Anticipate species invasions along planned corridors</p>		
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			

Ecological Level

Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity			
2) Protect large, intact, natural landscapes			
3) Protect the geophysical setting			
B. Anticipating and responding to future conditions			
4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change.			
5) Identify and protect climate refugia			
6) Maintain and restore ecological connectivity			

Map connections between land facets, ecological land units, refugia or areas of high ecological integrity

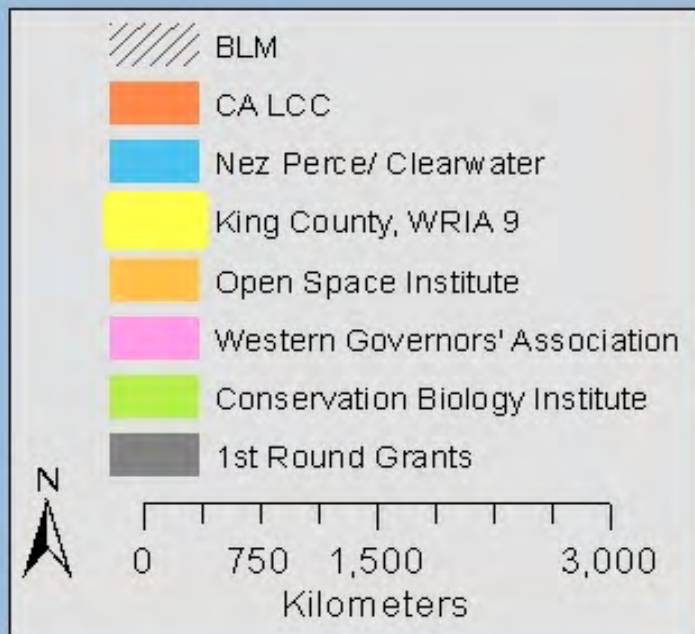
1st Round Evaluating the Framework



- Conservation Biology Institute
- Geos Inst.
- NatureServe
- Univ. of Washington
- FNAI
- EcoAdapt

0 750 1,500 3,000
Kilometers

2nd Round Evaluating the Framework



We are here

Using Yale Mapping Framework

yale.databasin.org

Hosted by



Get Started

Explore

Create

Community

My Workspace

What is the Yale Mapping Framework?

What is included?

What can I do?

The Yale Mapping Framework includes advice and tools to assist conservation planners in selecting the assessment and modeling strategies that fit their needs.



The Challenge



Debates about anthropogenic origins aside, scientific evidence demonstrates that the Earth's climate is changing. Many species are responding to this changing climate by shifting their geographic ranges. The differential rates at which species will shift their ranges will also result in a reshuffling of species relationships, ecological processes, and related ecosystem services.

As a result, conservation planners are now faced with the challenge of developing and implementing strategies that will support wildlife to adapt to climate change. The large number and diversity of models and data that can be applied to climate-impact analyses and adaptation strategies can often be confusing.

The Framework

Recognizing a need for clarity within this field, the Yale School of Forestry & Environmental Studies convened a working group of the nation's leading conservation biologists, modelers, and policymakers to develop guidance for integrating climate-change

adaptation strategies into the context of natural-resource planning and policymaking.

The product of this working group — The Yale Framework — assists conservation planners in selecting the assessment and modeling strategies that are most relevant to their specific needs. Rather than supplanting existing techniques, the Yale Framework provides simplified and flexible advice on models and data, and presents a list of commonly used datasets that can be helpful to planners. The Framework also provides a structured menu of options that assist resource managers in determining the best possible approach to conservation, as opposed to offering a prescriptive approach to natural resource management.

...assists in selecting the assessment and modeling strategies that are most relevant to specific needs...

Data Basin and the Framework

The Yale Mapping Framework has been built using the Data Basin platform. Data Basin makes it simple to find reliable data and make compelling visualizations. Planners can locate datasets, combine multiple layers together in a visualization session, and then share maps with their colleagues. With the Data Basin data and tools, planners have everything they need to make their assessments.

How the Framework Helps Planners

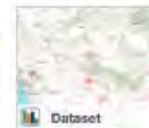
- It organizes the reasoning behind the use of specific assessment approaches.
- It helps build a better understanding of the types of questions a model can credibly address.
- It ensures greater transparency with a strong foundation of data.
- It focuses assessments on the appropriate scale and planning use.
- It can serve as a tool for policymakers to evaluate the models behind proposed land use plans.

Recent Datasets



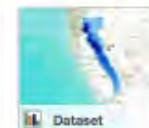
Dataset

National Land Cover Database, land cover - Alaska (north-central)



Dataset

National Land Cover Database, percent imperviousness - superzone five



Dataset

Mean annual precipitation, 2048-2085, Hadley CM3 A2, 4 km resolution



Dataset

Simulated vegetation carbon (g C m²), 2076-2095, Hadley CM3 A1f, 10 km ...

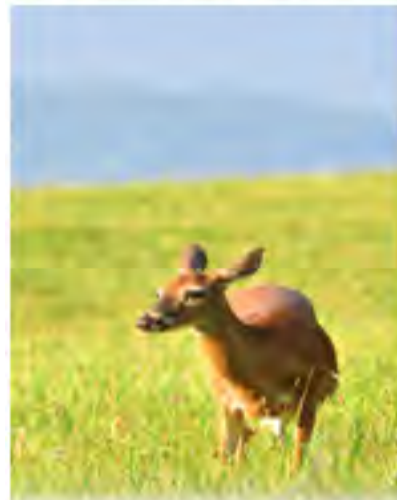
[see more](#)

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THE KRESGE FOUNDATION

The Framework Matrix



The Framework Matrix is built around the consideration of six major adaptation objectives for biodiversity conservation and climate adaptation and three levels of ecological analysis. The matrix is structured to provide a systematic way to arrive at an appropriate assessment approach and related tools:

1. Select the desired adaptation objectives (row)
2. Select the desired level of ecological analyses (column)
3. Use the links in each cell of the matrix to further investigate information about the appropriate approaches one would use to carry out an assessment.

Adaptation Objectives <i>How to choose adaptation objectives</i>	Levels of Ecological Analysis <i>How to choose levels of ecological analysis</i>		
	(A) Species and Populations	(B) Ecosystems	(C) Landscape
Strengthen current conservation efforts			
(1) Protect current patterns of biodiversity	1A Description Pilot projects: Conservation Biology Institute EcoAdapt Geos Institute NatureServe	1B Description Pilot projects: Conservation Biology Institute EcoAdapt Geos Institute NatureServe	1C Description Pilot projects: EcoAdapt Geos Institute
(2) Protect large, intact, natural landscapes and ecological processes	2A Description Pilot projects: Geos Institute NatureServe	2B Description Pilot projects: EcoAdapt Geos Institute NatureServe	2C Description Pilot projects: Geos Institute NatureServe
(3) Protect the geophysical setting		3B Description Pilot projects: Geos Institute University of Washington	3C Description Pilot projects: Geos Institute University of Washington
Anticipate and respond to future conditions			
(4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change	4A Description Pilot projects: Conservation Biology Institute EcoAdapt Geos Institute NatureServe	4B Description Pilot projects: Conservation Biology Institute EcoAdapt Florida Natural Areas Inventory Geos Institute NatureServe	4C Description Pilot projects: EcoAdapt Florida Natural Areas Inventory Geos Institute NatureServe
(5) Identify and protect climate refugia	5A Description Pilot projects: NatureServe	5B Description Pilot projects: EcoAdapt Florida Natural Areas Inventory Geos Institute NatureServe	5C Description Pilot projects: EcoAdapt Florida Natural Areas Inventory Geos Institute NatureServe
(6) Maintain and restore ecological connectivity	6A Description Pilot projects: NatureServe	6B Description Pilot projects: NatureServe	6C Description Pilot projects: Geos Institute NatureServe

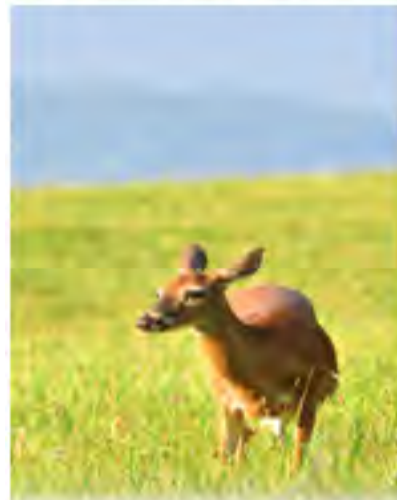
Using Yale Framework

yale.databasin.org/pages/matrix

Each cell links to :

- Description of Approaches
- Tool commonly used
- Pilot Projects

THE MAPPING FRAMEWORK | THE FRAMEWORK MATRIX
The Framework Matrix



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(1) Protect current patterns of biodiversity	1A Description Pilot projects: Conservation Biology Institute, EcoAdapt, Geos Institute, NatureServe	1B Description Pilot projects: Conservation Biology Institute, EcoAdapt, Geos Institute, NatureServe	1C Description Pilot projects: Geos Institute, EcoAdapt, Geos Institute
(2) Protect large, intact, natural landscapes and ecological processes	2A Description Pilot projects: Geos Institute, NatureServe	2B Description Pilot projects: EcoAdapt, Geos Institute, NatureServe	2C Description Pilot projects: Geos Institute, NatureServe
(3) Protect the geophysical setting		3B Description Pilot projects: Geos Institute, University of Washington	3C Description Pilot projects: Geos Institute, University of Washington
Anticipate and respond to future conditions			
(4) Identify and appropriately manage areas that will provide future climate space for species expected to be displaced by climate change	4A Description Pilot projects: Conservation Biology Institute, EcoAdapt, Geos Institute, NatureServe	4B Description Pilot projects: Conservation Biology Institute, EcoAdapt, Florida Natural Areas Inventory, Geos Institute, NatureServe	4C Description Pilot projects: EcoAdapt, Florida Natural Areas Inventory, Geos Institute, NatureServe
(5) Identify and protect climate refugia	5A Description Pilot projects: NatureServe	5B Description Pilot projects: EcoAdapt, Florida Natural Areas Inventory, Geos Institute, NatureServe	5C Description Pilot projects: EcoAdapt, Florida Natural Areas Inventory, Geos Institute, NatureServe
(6) Maintain and restore ecological connectivity	6A Description Pilot projects: NatureServe	6B Description Pilot projects: NatureServe	6C Description Pilot projects: Geos Institute, NatureServe

Using Yale Framework

Selecting and developing adaptation approaches

Choose the:

1. Adaptation strategy(ies) goals.
2. Level(s) of ecological organization.
3. Analysis tool(s).
4. Data sets.
5. Assessment time horizon

Evaluating the Guidance

Project Overview

Study Area/Ecosystem

Objectives

Adaptation Strategies

Full Project Analysis

Methods

Outcomes

Interpretation

Related Data

Yale *Mapping Framework*

INTEGRATING CLIMATE ADAPTATION AND LANDSCAPE CONSERVATION PLANNING

Get Started

Explore

Create

Commu



Pilot Projects *Practical experience with the Yale Mapping Framework*

The Yale Framework will be evaluated through a process of grants to regional mapping and analysis teams that reflect the wide diversity of planning needs and challenges across the United States. These teams will use the Framework guidelines to implement geospatial analysis approaches pertinent to their respective regional planning contexts and objectives. After implementing and evaluating the Yale Framework, these teams will then provide feedback on the utility of its guidelines and the strengths and weaknesses in relation to each team's specific approach, objectives, scales, and planning timeframe. Teams will also identify improvements to the guidelines that are delineated in the Yale Framework. During this time the Science Panel will continue to refine the Framework as input from outside experts and policy makers is sought through a peer review process. Below are the guides and case studies developed by these teams.



Guide/Study

Climate Change
Adaptation Strategies
for BLM Resource
Management in ...



Guide/Study

Effects of climate and
vegetation on martens
and fishers in the Sierra
...



Guide/Study

From the Mountains to
the Sea: Applying the
Yale Framework in
Puget ...



Guide/Study

Land Facets for
Conservation Planning



Guide/Study

Rapid Assessment of
the Yale Framework and
Adaptation Blueprint for
the ...

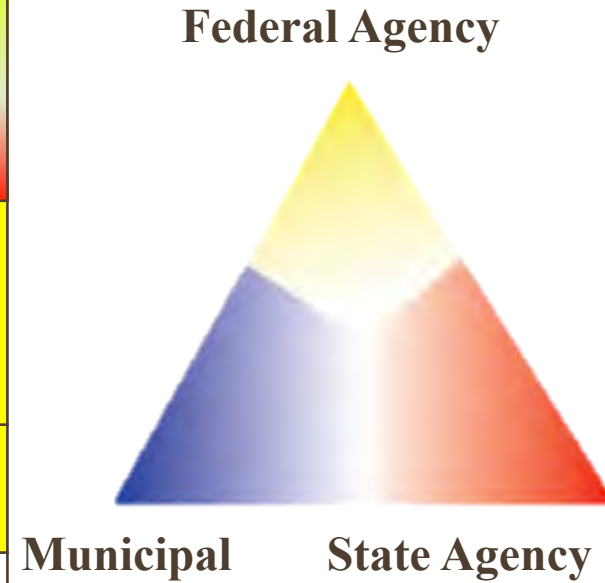


Guide/Study

Re-evaluating Florida's
ecological conservation
priorities in the face ...



Ecological Level			
Adaptation Approach	Species & Population	Ecosystem	Landscape
A. Strengthen current conservation efforts			
1) Protect current patterns of biodiversity	USFWS, State Wildlife and Local Agencies	BLM, USFS	USFWS, Regional State Assoc.
2) Protect large, intact, natural landscapes	State Wildlife and Local Agencies	USGS	NOAA
3) Protect the geophysical setting		NPS	NPS
B. Anticipating and responding to future conditions			
4) Protect future patterns of biodiversity	BLM	BLM, USGS	USFS
5) Identify and protect climate refugia	NPS, USFS	NPS, USFS	NPS, USFS
6) Maintain and restore ecological connectivity	USFWS, State Wildlife Agencies	Regional State Assoc.	BOR



Acknowledgements



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foundation

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Questions?



STRATEGIES *for* **INTEGRATING**
CLIMATE ADAPTATION MODELS
into **RESOURCE PLANNING**