2015 Invasive Species Webinar Series

Invasive Species and Climate Change: Addressing the Intersecting Drivers of Ecosystem Transformation

Thursday, February 26, 2015
1:00pm-3:00pm Eastern Time
(speaking will begin at 1:03)

Co-hosted by the Environmental Law Institute &
The National Invasive Species Council

This webinar is made possible by the generous support of the Turner Foundation.

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2015 Invasive Species Webinar Series

ENVIRONMENTAL LAW • INSTITUTE®

Invasive Species and Climate Change: Addressing the Intersecting Drivers of Ecosystem Transformation

Thursday, February 26, 2015 • 1:00pm-3:00pm ET

NOW SPEAKING:

Read Porter

Director, Invasive Species Program, Environmental Law Institute

Read Porter is Director of the Invasive Species Program and a senior attorney with the Environmental Law Institute. Mr. Porter has published widely on a range of invasive species topics, including state law, federalism, and bioenergy; as well as on fisheries, aquaculture, natural resources law enforcement, third-party certification, and regulation of emerging technologies. Prior to joining ELI in 2006, Mr. Porter served as a law clerk for the Honorable Julia Smith Gibbons on the United States Court of Appeals for the Sixth Circuit and was Editor-in-Chief of the Harvard Environmental Law Review. Mr. Porter holds a J.D. from Harvard Law School and a B.A. in geology from Amherst College.

ENVIRONMENTAL LAW • INSTITUTE®

2015 Invasive Species Webinar Series

Invasive Species and Climate Change: Addressing the Intersecting Drivers of Ecosystem Transformation

Thursday, February 26, 2015 • 1:00pm-3:00pm ET

INTRODUCING:

Stas Burgiel

Assistant Director for Prevention and Budgetary Coordination, National Invasive Species Council (NISC)

Stas Burgiel serves as the NISC policy lead on issues related to preventing the introduction and spread of invasive species with a focus on the pathways for their movement. He coordinates a prevention committee convened jointly with the Aquatic Nuisance Species Task Force and also oversees the collation of information on NISC member agency budgets related to invasive species issues. Key areas of interest and activity include the role of trade agreements, links to climate change and multi-level stakeholder coordination.

Stas received his Ph.D. in international service from the American University and a B.A. in political science from Swarthmore College. He has worked and consulted for a range of nongovernmental, governmental and intergovernmental organizations, including the Global Invasive Species Programme, the Nature Conservancy, the UNEP/World Conservation Monitoring Centre and the New Zealand government, on invasive species and other environmental policy issues.




Bioinvasions in a Changing World:
A Resource on Invasive Species-Climate Change Interactions for Conservation and Natural Resource Management

Report of the ANSTF/NISC *Ad Hoc* Working Group on Invasive Species and Climate Change
(ELI-NISC Webinar Series, 26 February 2015)

THE NATIONAL INVASIVE SPECIES COUNCIL (NISC)

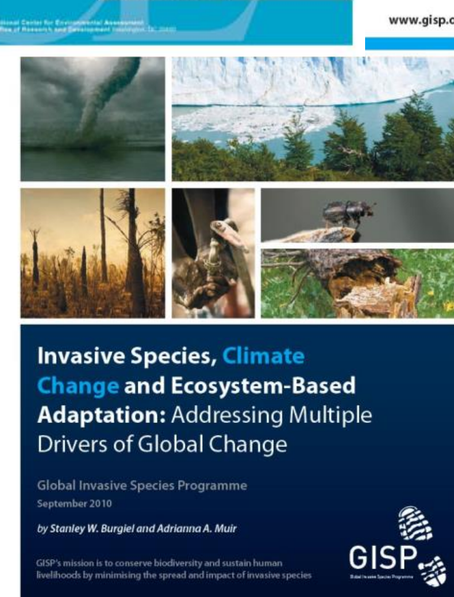
Meet the Invasive Species Challenge. Know the NISC Plan, Manage the Problem. PREPARE, PREVENT, PROTECT.

Aquatic Nuisance Species Task Force (ANSTF)

Fall 2011 Meeting

- Special session on invasive species and climate change
- Recommendation: establish an *ad hoc* working group to
  - Identify knowledge gaps and provide recommendations for future research needs.
  - Identify and provide a platform for disseminating existing management strategies, tools and resources.
- Audience: resource managers and decision-makers

Shift from the realm of scientific research and the hypothetical to management applications.



ANSTF/NISC *Ad Hoc* Working Group

Co-chairs:
Stanley W. Burgiel (NISC)
Thomas Hall (USDA Animal and Plant Health Inspection Service)

Working group members:

Noah Adams (U.S. Geological Survey)
Kevin Anderson (Puget Sound Partnership)
Elizabeth Bella (U.S. Fish and Wildlife Service)
Britta Bierwagen (Environmental Protection Agency)
Maria Boroja (U.S. Fish and Wildlife Service)*
Elizabeth Brusati (California Invasive Plant Council)
Jeff Burgett (U.S. Fish and Wildlife Service)
LaDonna Carlisle (Bureau of Indian Affairs)
Ruark Cleary (Florida Fish and Wildlife Conservation Commission)
Dave Cleland (U.S. Forest Service)
John Darling (Environmental Protection Agency)
Robyn Draheim (U.S. Fish and Wildlife Service)
Darryl Forest (Department of Defense)
Sara Grise-Stahlman (Pennsylvania Sea Grant)
Sean Hart (Bureau of Indian Affairs)
Keith Hatch (Bureau of Indian Affairs)
Paul Heimowitz (U.S. Fish and Wildlife Service)
Jennie Hoffman (independent)
Tracy Holcombe (U.S. Geological Survey)
Doug Johnson (California Invasive Plant Council)
Denny Lassuy (North Slope Science Initiative)
Louanne McMartin (U.S. Fish and Wildlife Service)
Phil Moy (University of Wisconsin Sea Grant Institute)
Adrianna Muir (Department of Interior)*
Richard Nelson (U.S. Fish and Wildlife Service)
Judith Pederson (MIT Sea Grant College Program)
Glenn Plumb (National Park Service)
Jim Quinn (University of California-Davis)
Jennifer Resnick (National Park Service)
Dolores Savignano (U.S. Fish and Wildlife Service)
Nick Schmal (U.S. Forest Service)
Linda Shaw (National Oceanic and Atmospheric Administration)
Bruce Stein (National Wildlife Federation)
Genelle Winter (Metlakatla Indian Community)
David Woodson (U.S. Geological Survey)
David Wooten (Bureau of Indian Affairs)
John Wullschleger (National Park Service)

Report Structure

I. Overview
   A. Basic Interactions
II. Context for Management
   A. Climate Change Adaptation and Conservation Planning
   B. Framework of Invasive Species Management
III. Tools and Methods
   A. Prevention
   B. Early Detection and Rapid Response (EDRR)
   C. Management and Control
IV. Institutional Coordination and Outreach
V. Recommendations and Resources

Bioinvasions in a Changing World:
A Resource on Invasive Species-Climate Change Interactions for Conservation and Natural Resource Management

December 2014

Prepared for
The Aquatic Nuisance Species Task Force (ANSTF) and
The National Invasive Species Council (NISC)

By the *Ad Hoc* Working Group on Invasive Species and Climate Change

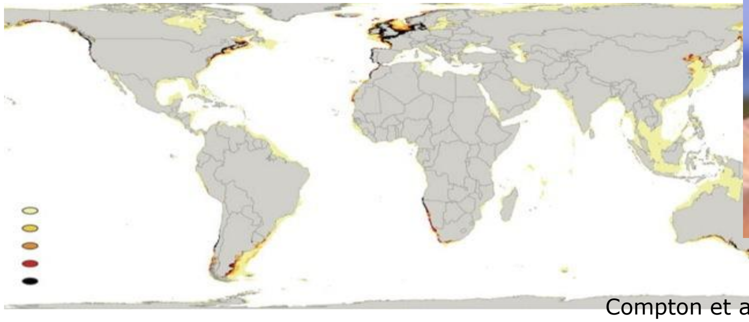
Overarching Themes

- Climate change will have ***direct and indirect impacts*** that facilitate the introduction, establishment and/or spread of invasive species.
- Invasive species can ***increase the vulnerability of ecosystems*** to other climate-related stressors and ***reduce their potential to sequester greenhouse gasses***.
- These species and impacts need to be ***assessed on a case-by-case basis***.
- Management of invasive species (prevention, eradication and control) can be a ***critical component in enhancing the "resilience" of natural areas*** to other climate-related stressors.

Influence of Climate Change on Invasive Species

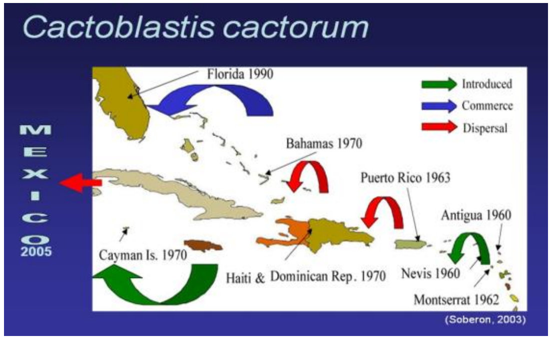
- **Range Shift**: changing climatic variables (temperature, precipitation, water salinity, CO_2 concentrations) can alter the range of invasive species or be the trigger that causes previously benign alien species to become invasive.
- **Ecosystem transformation**: broader changes in relations between species and ecosystem functions due to climate variability may provide advantages or new niches for invasive species.


TNC


Compton et al. 2010

WA Dept of Fish & Wildlife

Influence of Climate Change on Invasive Species

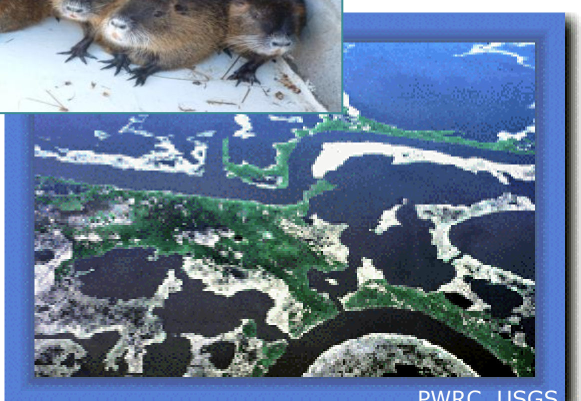


- **Weather-related movements and ecosystem disturbance**: severe weather events, such as storms and floods, can introduce and spread invasive species, particularly insects and plants. They can also increase disturbance in ecosystems, making them more vulnerable to biological invasion.
- **Pathways of introduction**: climate change may shift the risks associated with existing pathways of introduction and may create new pathways based on human responses.

Influence of Invasive Species on Climate Change

- **Sequestration Ability:** invasive species can degrade the ability of ecosystems to sequester carbon or lead to release of greenhouse gasses (e.g., through forest dieback, changing fire cycles, shifts in soil chemistry).

K.Greer, Natl Interagency Fire Center

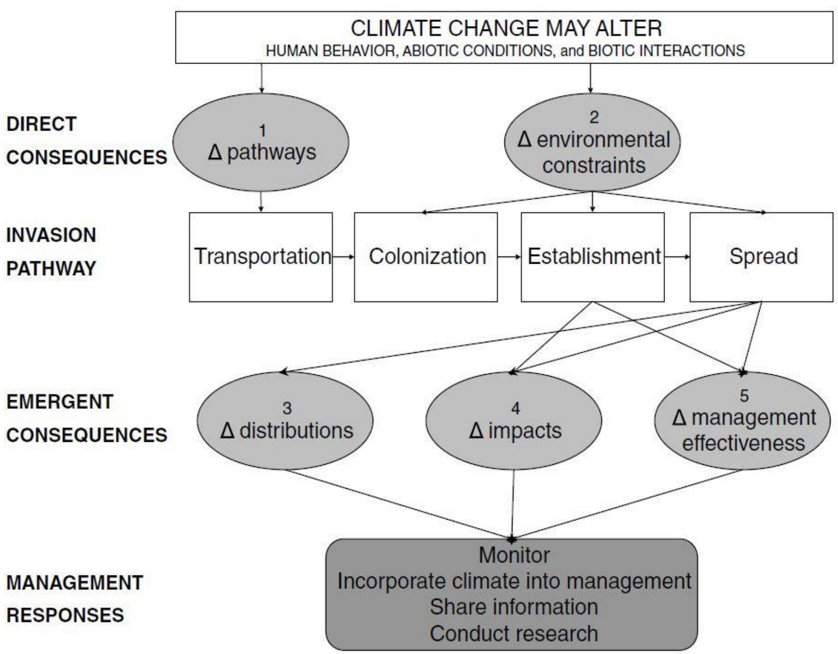


PWRC, USGS

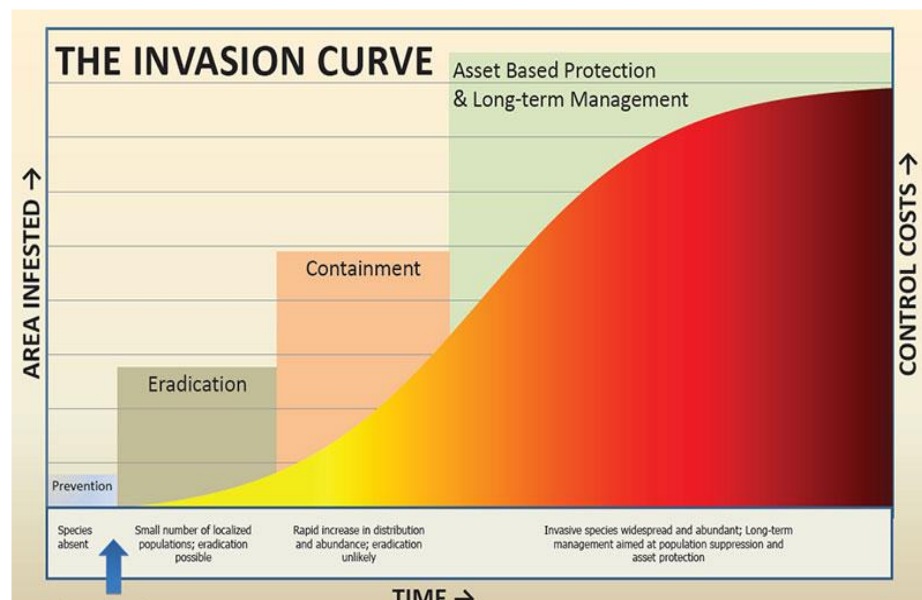
THE NATIONAL INVASIVE SPECIES COUNCIL (NISC)
Meet the Invasive Species Challenge. Know the NISC Plan, Manage the Problem. PREPARE, PREVENT, PROTECT.

Management Frameworks

- **Invasive Species**: prevention, early detection/rapid response, eradication, control.
- **Climate Change**: adaptation, mitigation, resilience, vulnerability



Hellman et al. 2008



Rodgers

Tools, Methods and Other Resources

Prevention

- Risk assessment models
- Climate matching models
- Habitat suitability models

Early Detection & Rapid Response

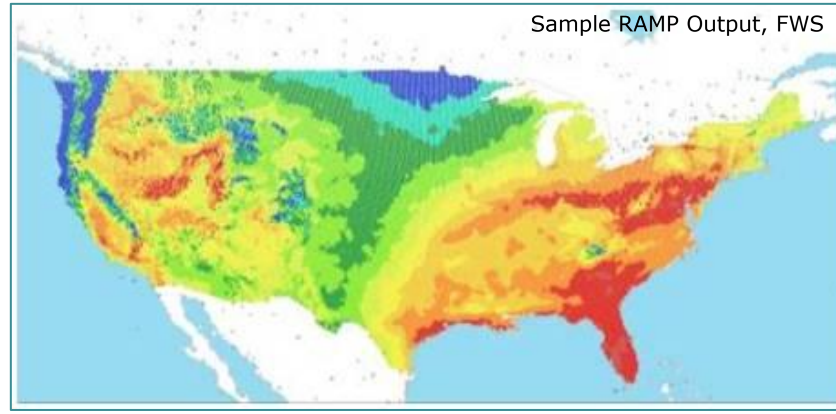
- Mapping tools
- Rapid Response tools

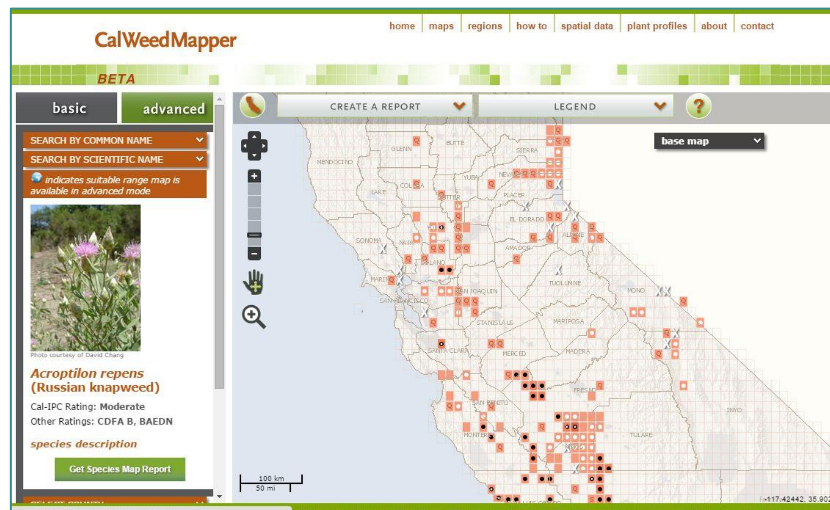
Control

- Control prioritization tools

Coordination and outreach

- Data and supporting information
- Potential resources

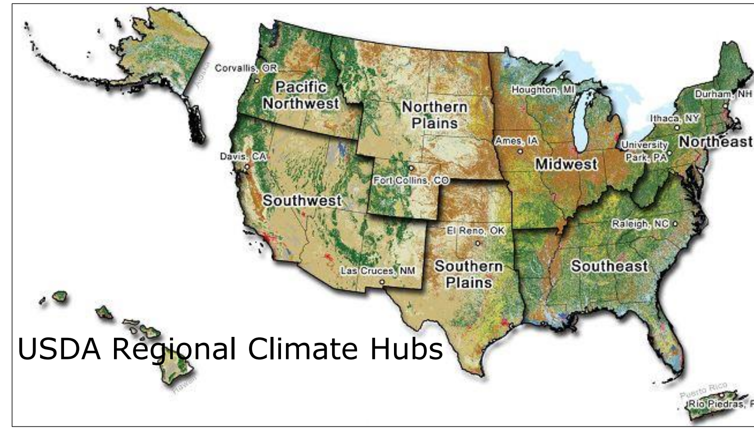


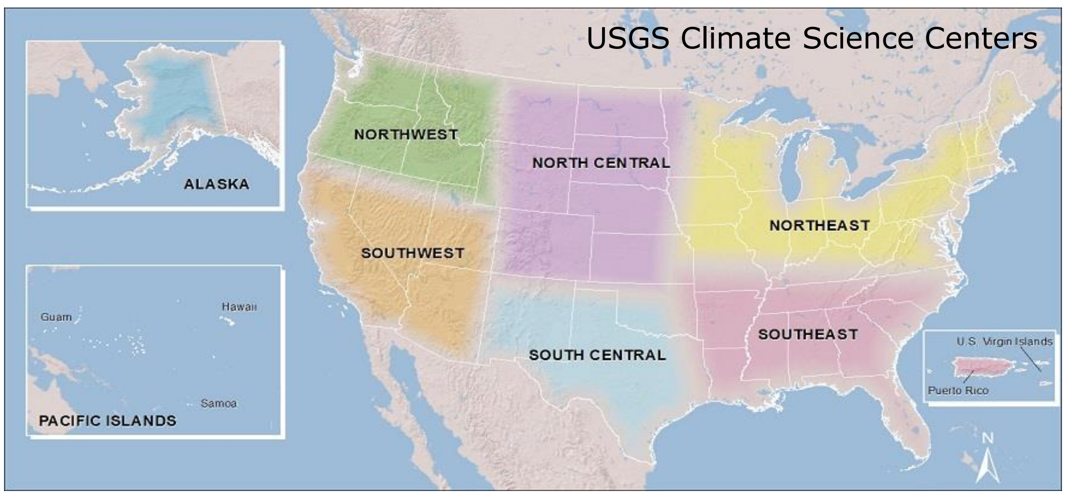


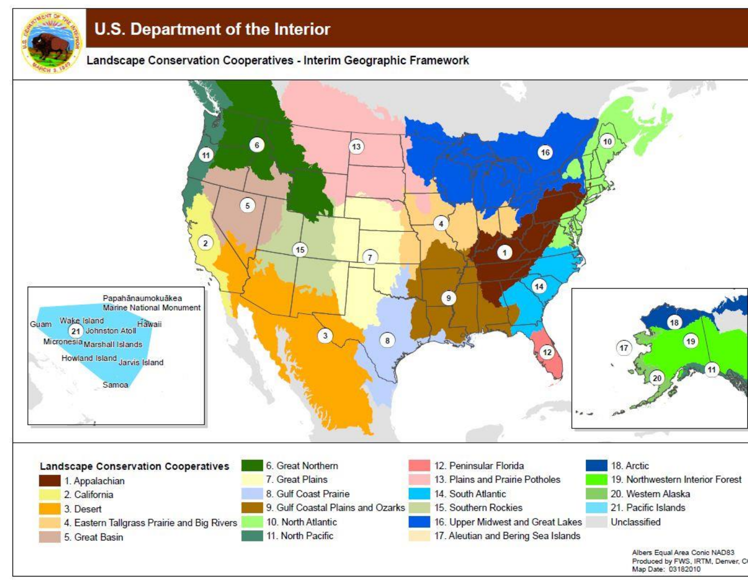
The Evolving Institutional and Policy Context

Coordination

- Landscape Conservation Cooperatives
- USGS Climate Science Centers
- USDA Regional Climate Hubs
- Interagency coordinating groups



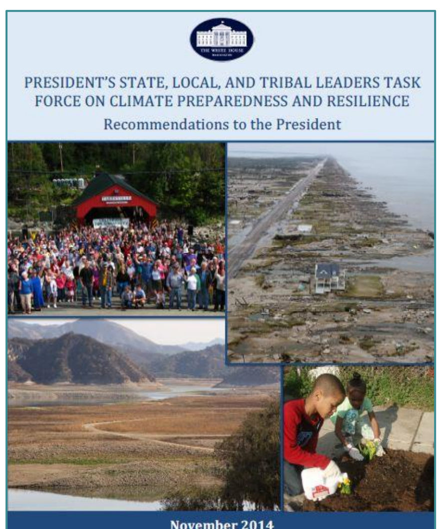




The Evolving Institutional and Policy Context

Guidance

- Priority Agenda: Enhancing the Climate Resilience of America's Natural Resources (October 2014)
- President's State, Local and Tribal Leaders Task Force on Climate Preparedness and Resilience (November 2014)
- National Fish, Wildlife and Plants Climate Adaptation Strategy (2012)



Take Home Messages

1. Target invasive species that increase vulnerability to climate change; and
2. Prioritize adaptation options that decrease the risk and impact of invasion.

Recommendations for Prevention, Eradication, EDRR, Control, Institutional Coordination and Outreach, Research and Data

Special considerations

- assisted migration
- Connectivity
- native vs. non-native invasive species
- “benefits” of invasive species
- unintended consequences of adaptation and mitigation measures

Next Steps

- Platform for collecting additional information
- Early Detection and Rapid Response Framework
- Economic costs of invasive species control under climate change

Uncertainty is a given, but we can use our constantly improving knowledge and tools to inform decision-making and resource allocation for natural resource management.

Stas Burgiel, Ph.D., National Invasive Species Council
Tel: 202.208.4163; Eml: stanley_burgiel@ios.doi.gov

Invasive Species and Climate Change: Addressing the Intersecting Drivers of Ecosystem Transformation

Thursday, February 26, 2015 • 1:00pm-3:00pm ET

INTRODUCING:

Catherine Jarnevich

Research Ecologist, U.S. Geological Survey Fort Collins Science Center

Catherine Jarnevich is a research ecologist with the U.S. Geological Survey Fort Collins Science Center. She has developed a research program through the USGS Resource for Advanced Modeling to assist multiple agencies and groups with species distribution modeling, focusing on invasive species. Her current research involves development of the software to assist habitat suitability modeling and the application of species distribution models to answer applied research and management questions for species across a range of taxa and spatial scales.

science for a changing world

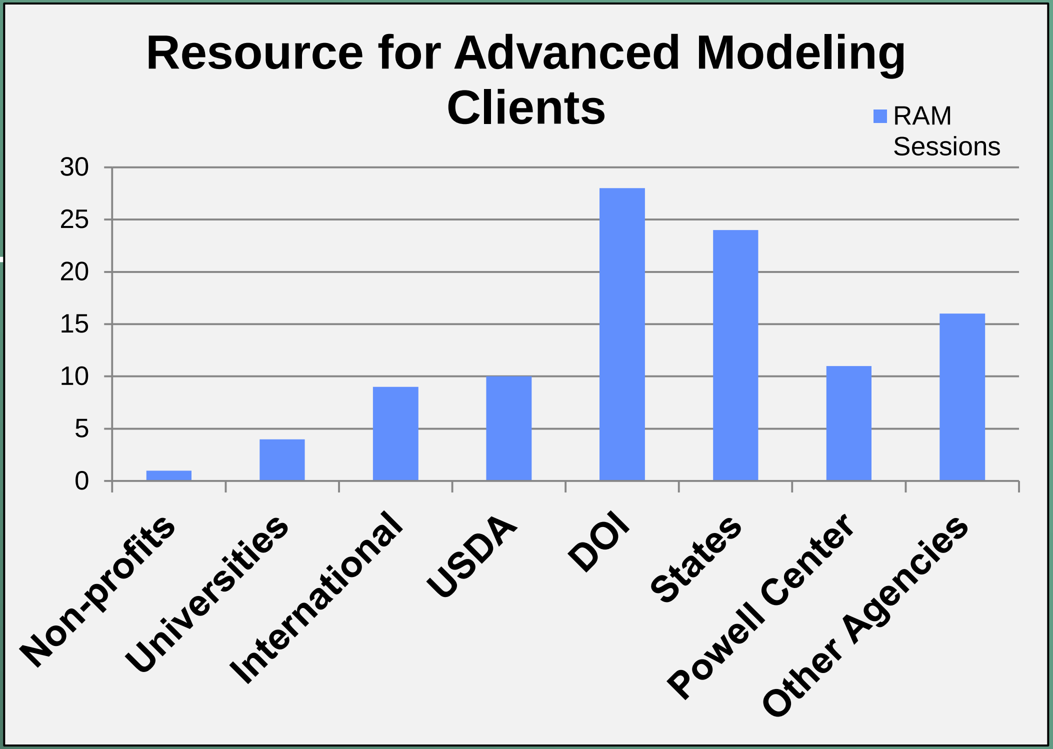
Invasive species distribution modeling and climate

Catherine Jarnevich – with help from Colin Talbert, Marian Talbert, Jeff Morisette, Nick Young, and others

U.S. Department of the Interior
U.S. Geological Survey

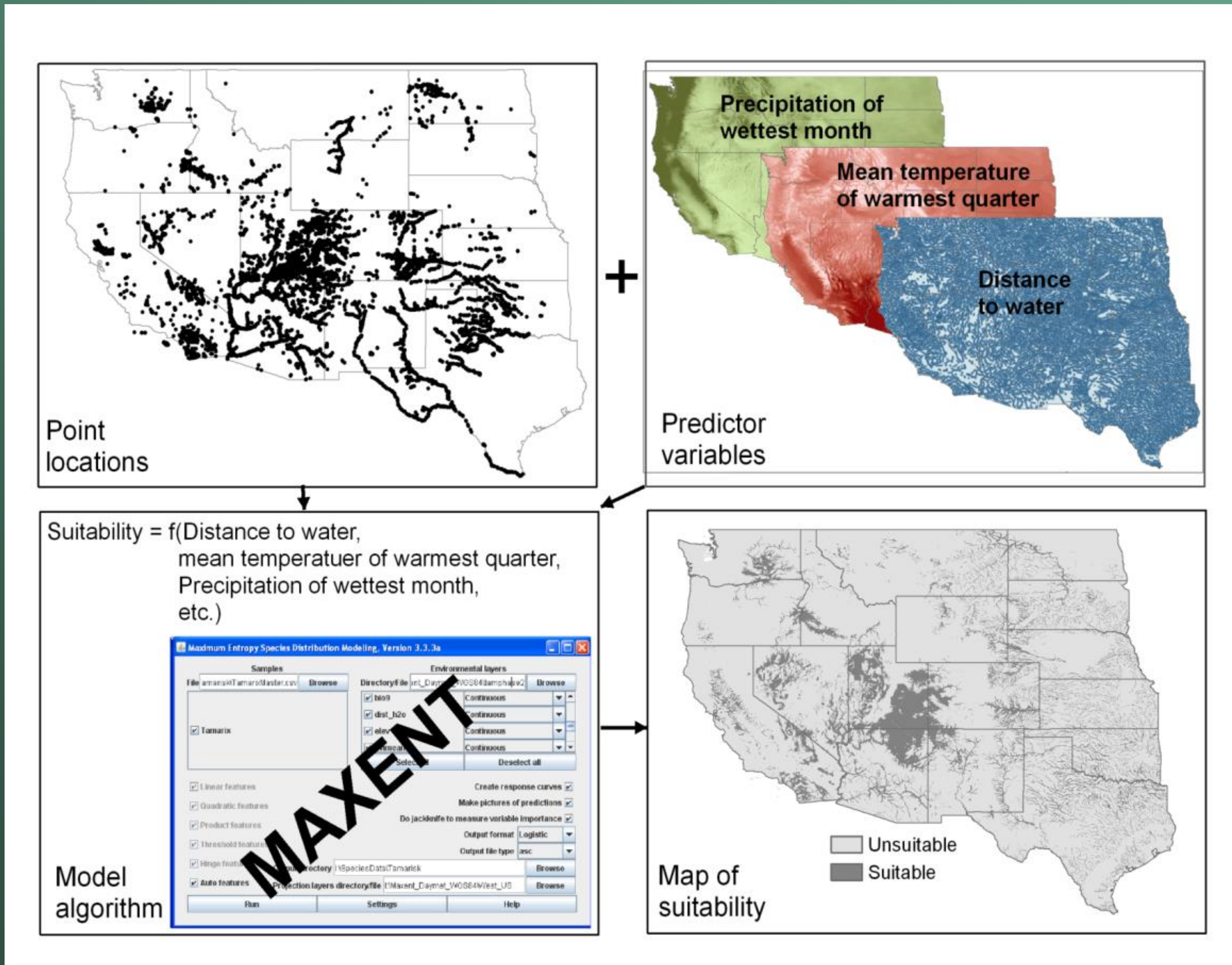
The RAM

Resource for Advanced Modeling



USGS

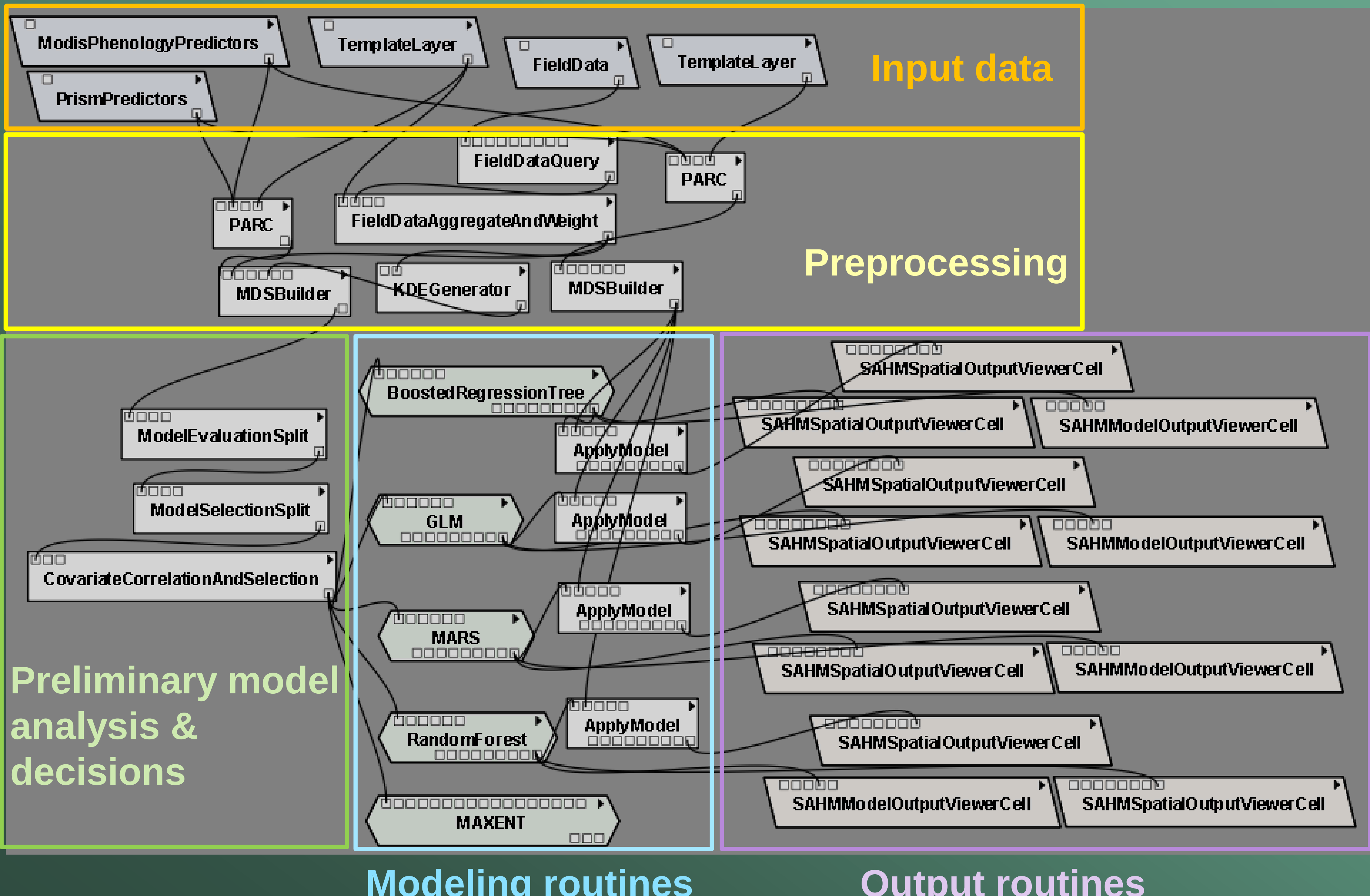
Species Distribution Modeling



VisTrails:SAHM Software

- VisTrails
  - Open-source scientific workflow and provenance management system
  - Supports simulation, data analysis, visualization
- Software for Assisted Habitat Modeling (SAHM)
  - Module within VisTrails to facilitate modeling

VisTrails:SAHM standard workflow

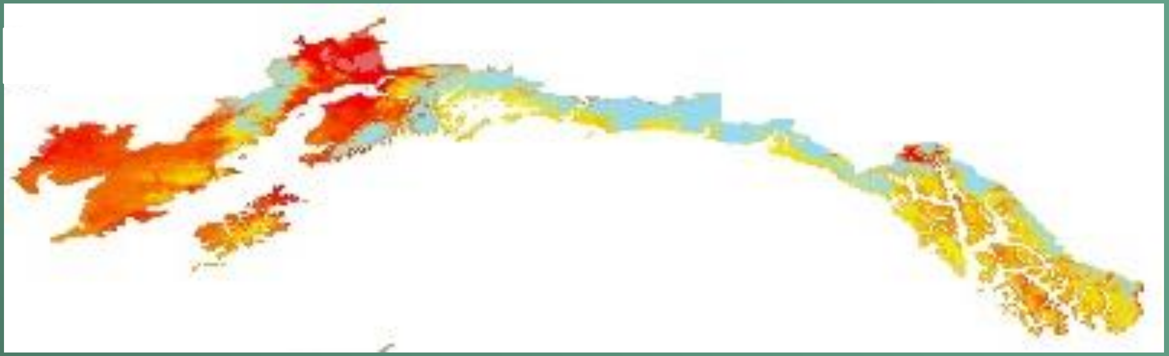


VisTrails:SAHM provides:

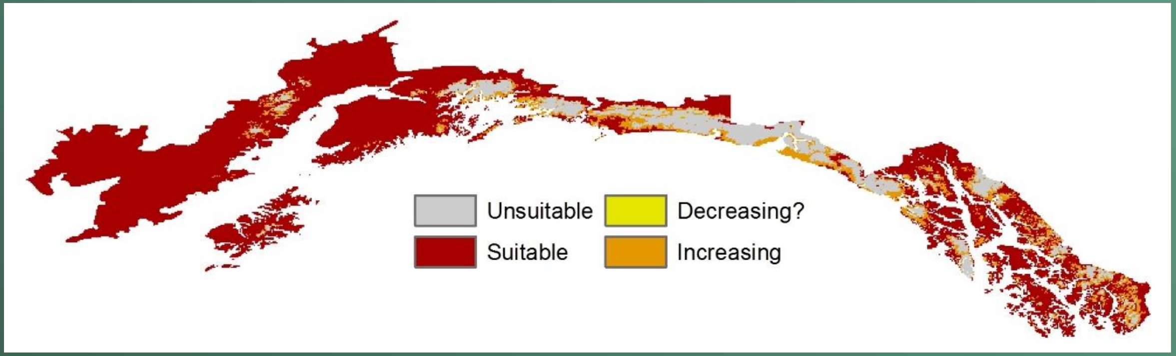
- Efficiency
  - User-friendly interface in single program
  - Manages files and metadata for you
- Reproducibility
  - Formalization and tractable recording of modeling process
- Collaboration facilitation
  - Single file allows others to see entire process
  - Model configuration changes explicit and tractable
- Extensibility
  - Modular setting to allow incorporation of future and additional modeling routines

Forecast habitat suitability:
Weeds in Alaska

- **Current habitat suitability**



- **Forecasted match of climate**



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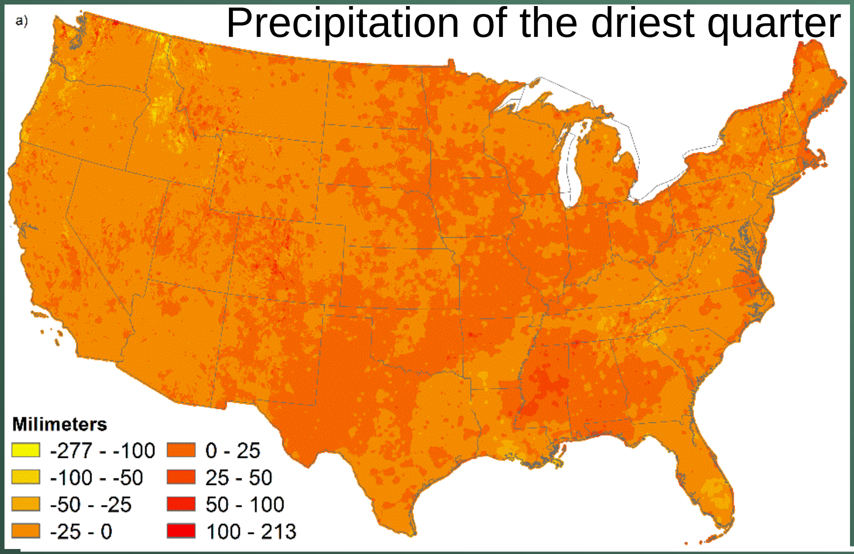
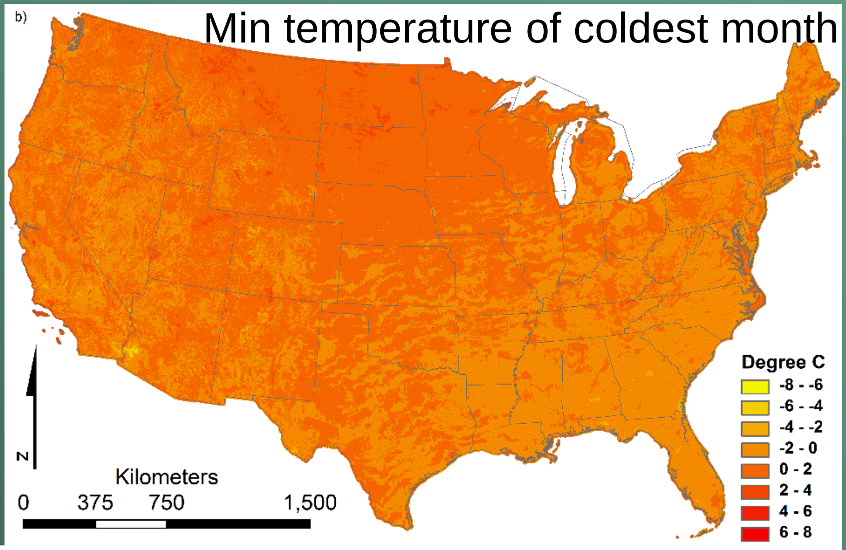
Jarnevich et al. 2014 Invasive Plant Sci Manag

Baseline climate

- **What difference does baseline climate make?**
  - **Compare predictions from average climate 1971-2000 to 1981-2010 (from PRISM 800m normals)**





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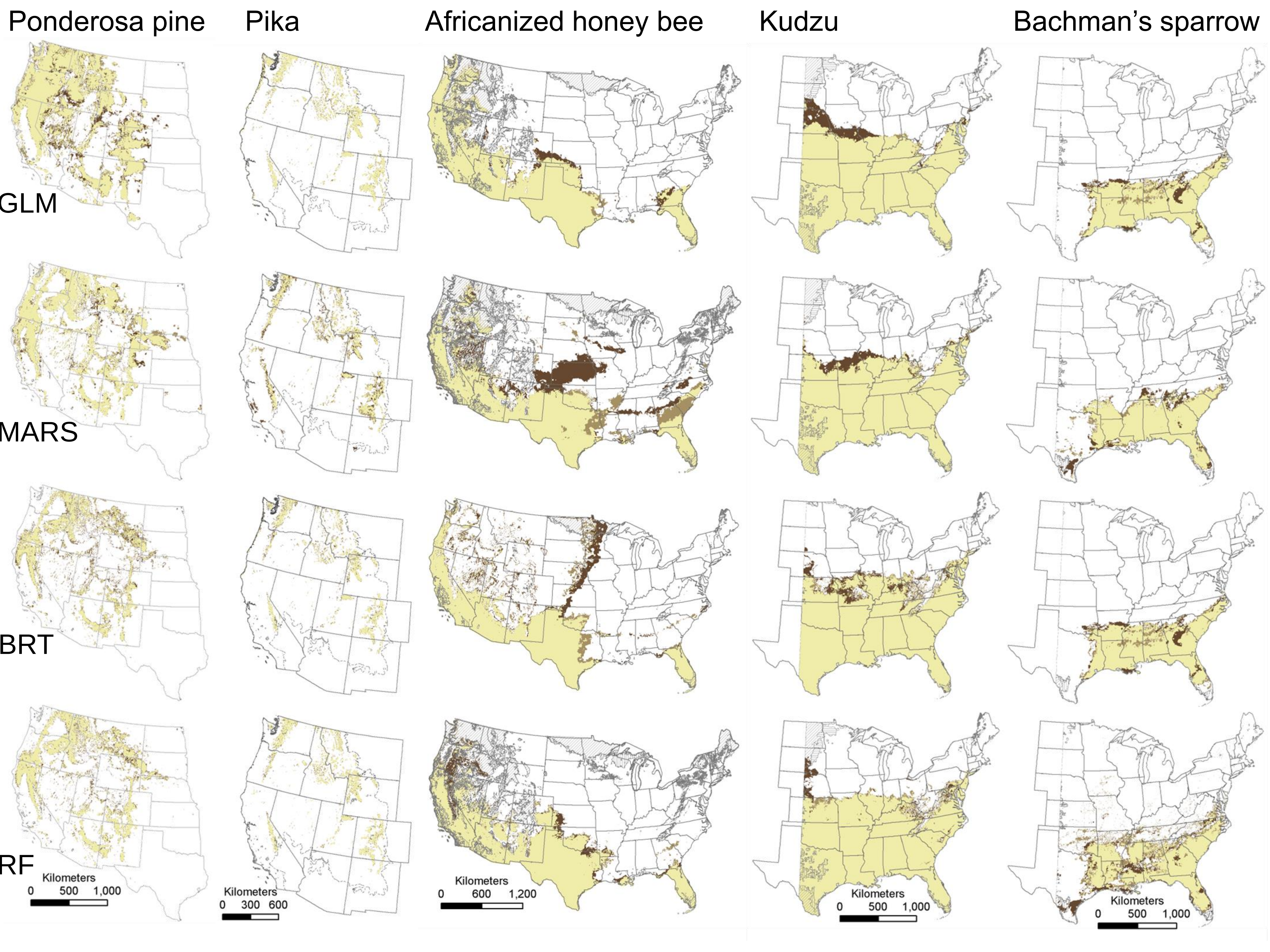
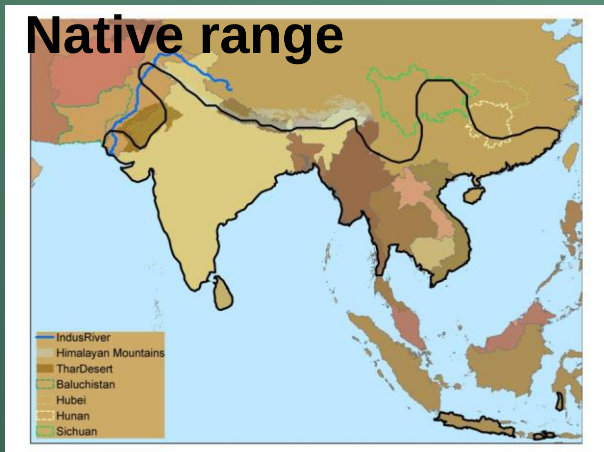


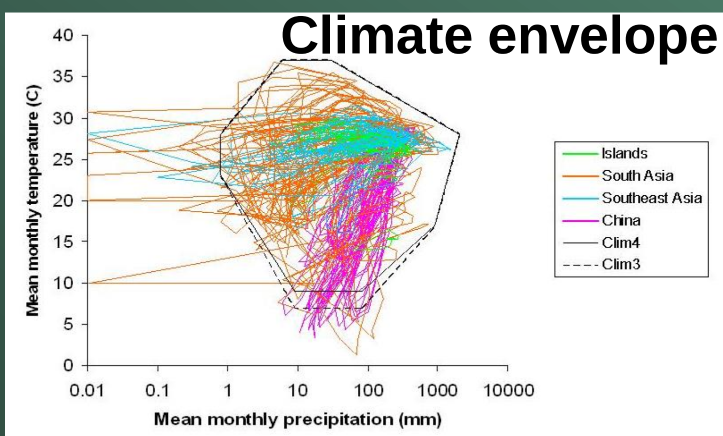
Ponderosa pine
Pika
Africanized honey bee
Kudzu
Bachman's sparrow
GLM
MARS
BRT
RF
Kilometers
0 500 1,000
Kilometers
0 300 600
Kilometers
0 600 1,200
Kilometers
0 500 1,000
Kilometers
0 500 1,000

Burmese python

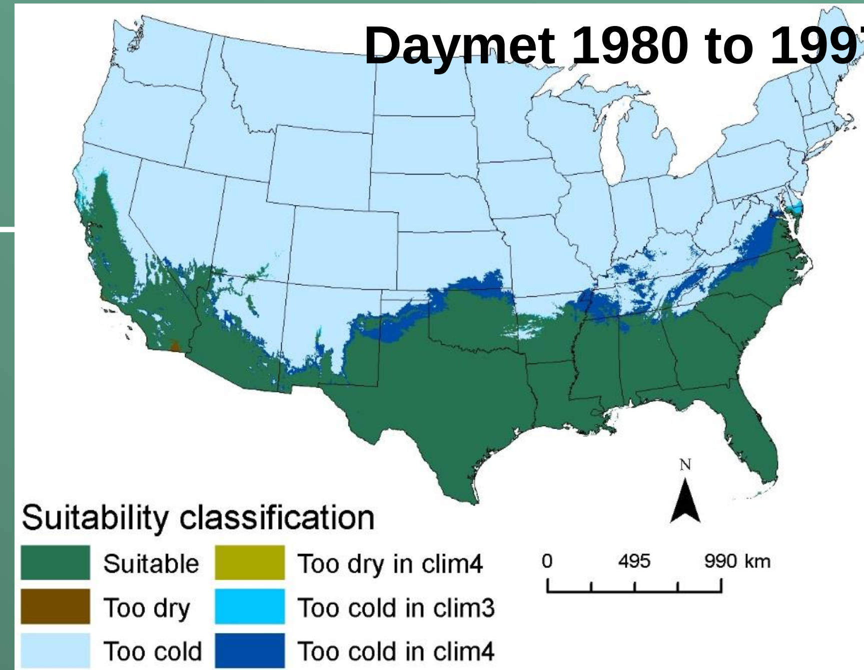
Native range



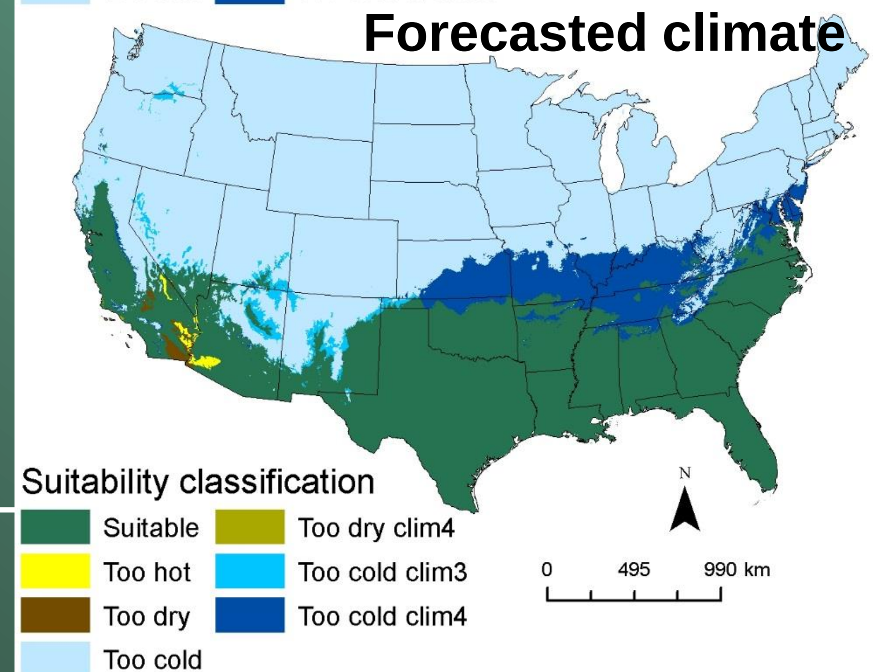
Climate envelope



Daymet 1980 to 1997



Forecasted climate

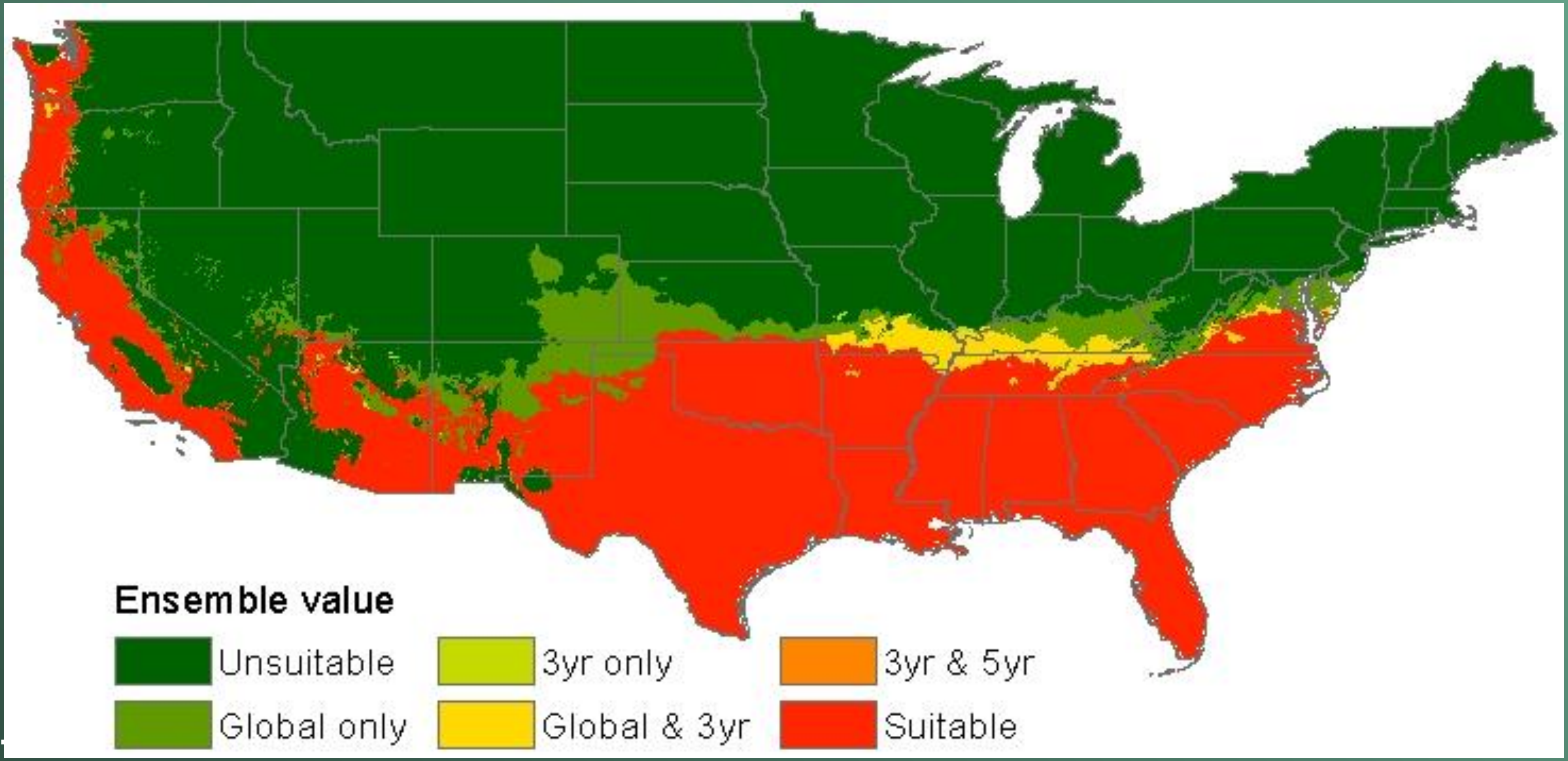


USGS

Rodda et al. 2009 Biol Invasions

Nutria: physiologically based model

Months where min temp < 0^0C & max temp < 5^0C



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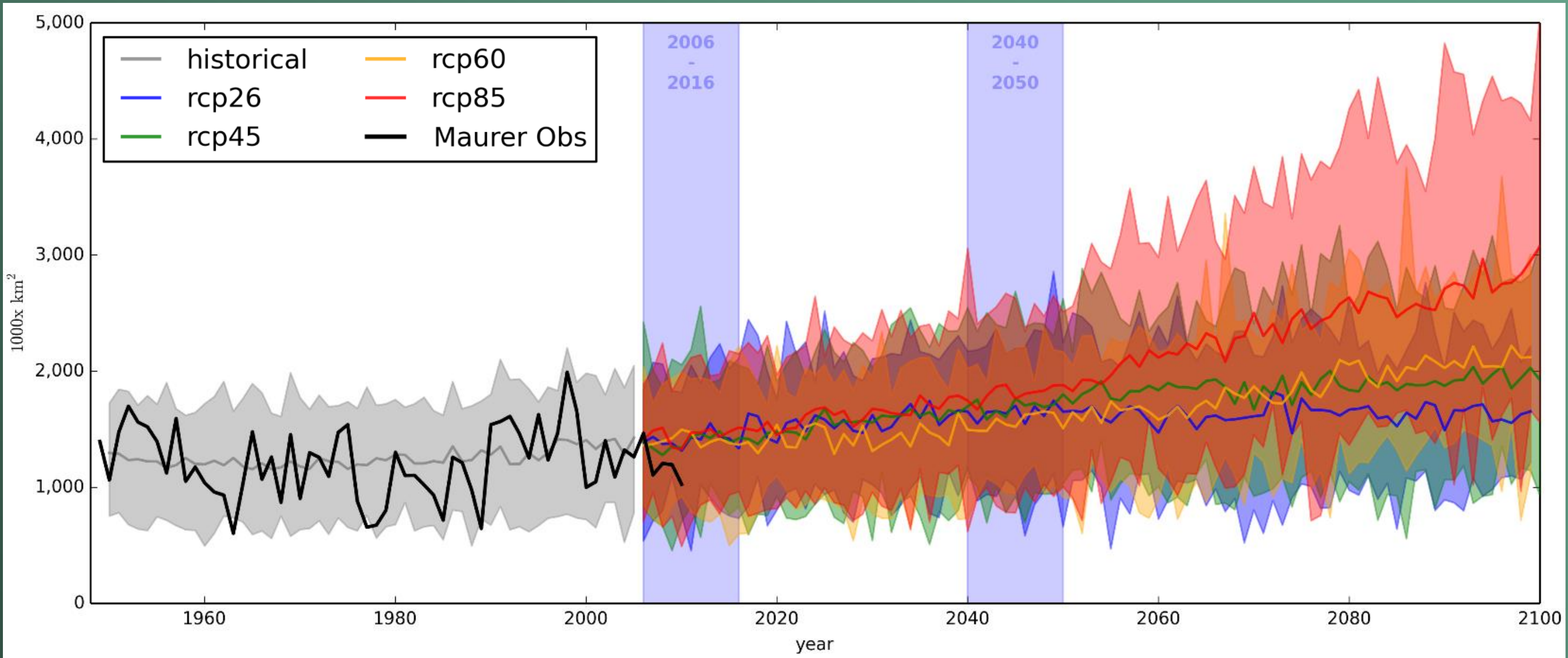
Climatic uncertainty

- **Land area within cold tolerance criteria**



USGS


THANKS!
USGS
Advanced Invasive Species Modeling Room
USGS
RAM
Resource for Advanced Modeling
EXIT

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ENVIRONMENTAL LAW • INSTITUTE®

Invasive Species and Climate Change: Addressing the Intersecting Drivers of Ecosystem Transformation

Thursday, February 26, 2015 • 1:00pm-3:00pm ET

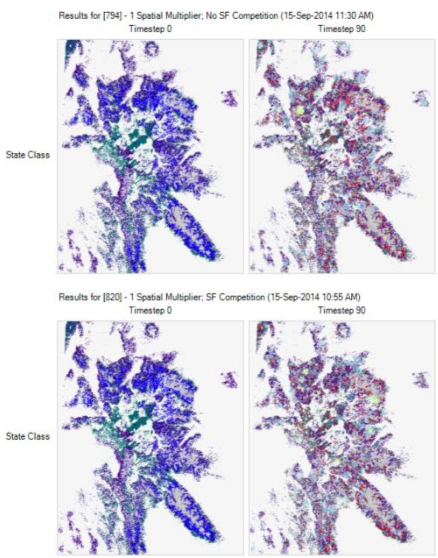
INTRODUCING:

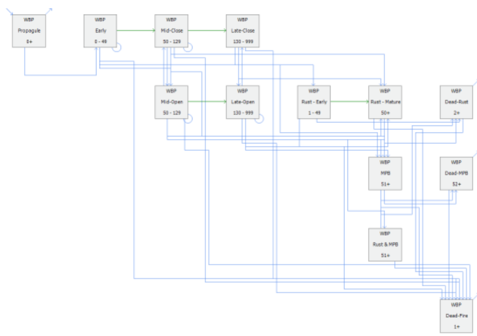
Brian Miller

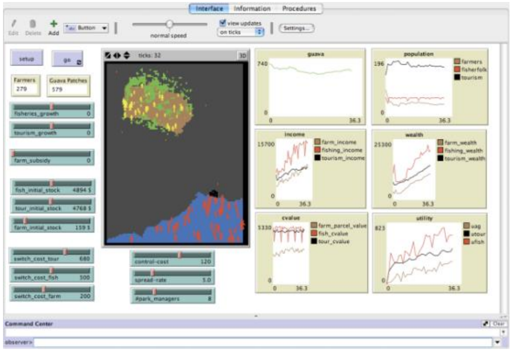
Staff Member & Research Scientist, DOI North Central Climate Science Center & Colorado State University

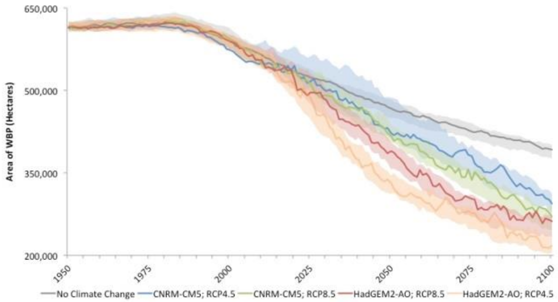
Dr. Brian Miller is a Research Scientist at the Natural Resource Ecology Laboratory at Colorado State University, and is a staff member of the Department of Interior North Central Climate Science Center (NC CSC). He is working with other NC CSC staff and partners to develop simulation and scenario planning tools that can support resource management under climate change, and is also helping to manage capacity building projects in the north central domain. He draws on a variety of research methods, including remote sensing, surveys, interviews, state-and-transition simulations, and agent-based models. He has applied these methods to questions of resource management in East Africa, the Galápagos Islands, and the western U.S.

Using Simulation Models to Assess Climate Change Impacts and Responses

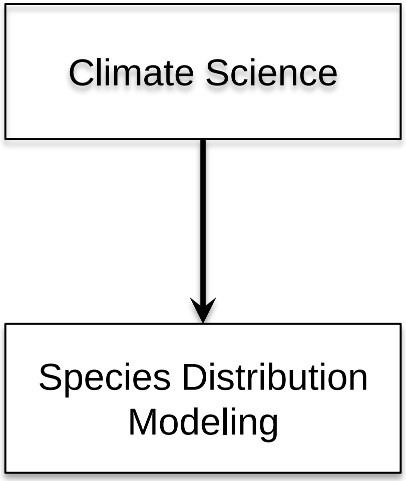


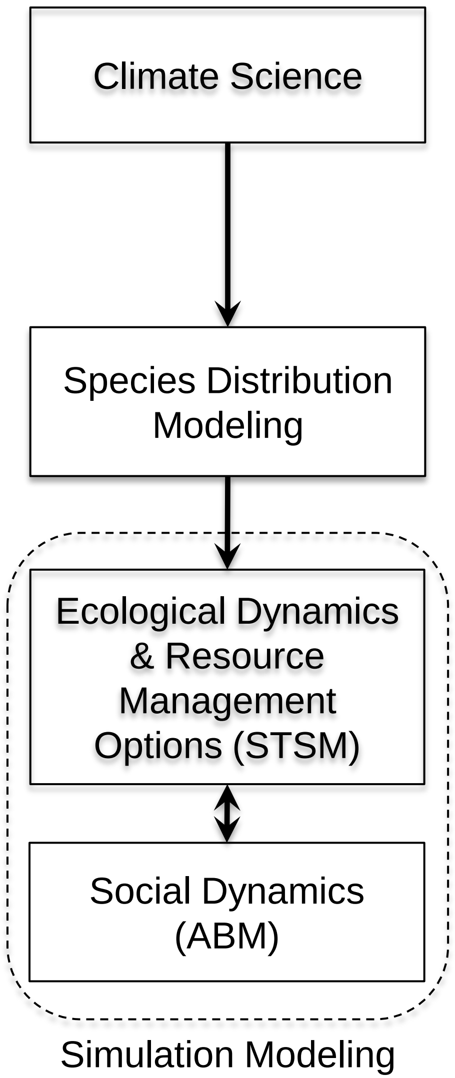


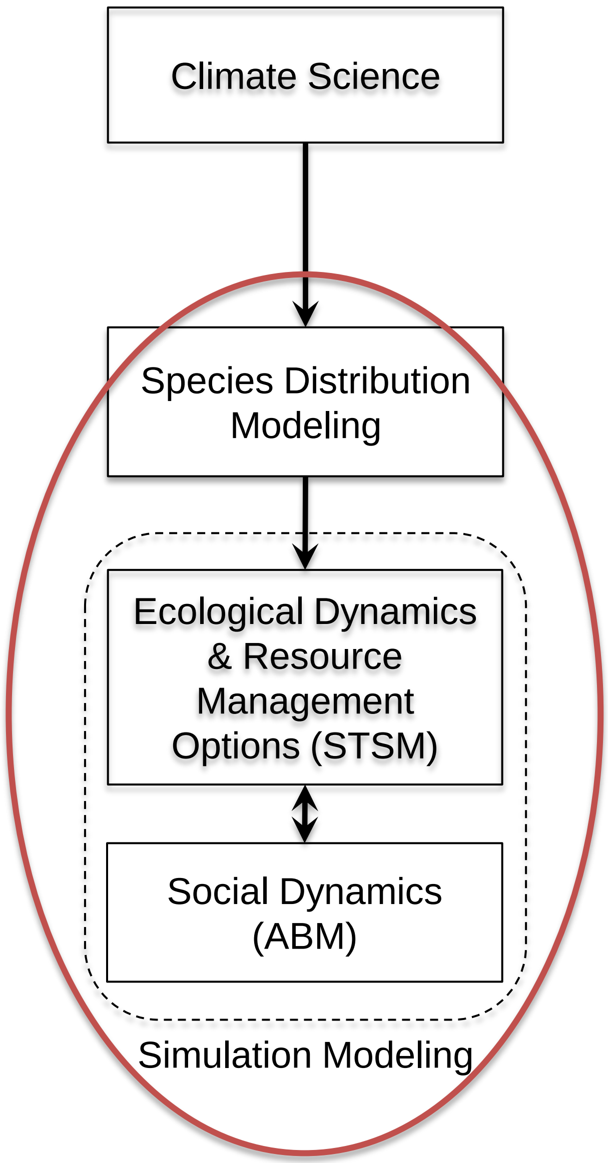




Brian W. Miller
Research Scientist
North Central Climate Science Center
Natural Resource Ecology Lab, Colorado State University


Climate Science
Species Distribution Modeling


Climate Science
Species Distribution Modeling
Ecological Dynamics & Resource Management Options (STSM)
Social Dynamics (ABM)
Simulation Modeling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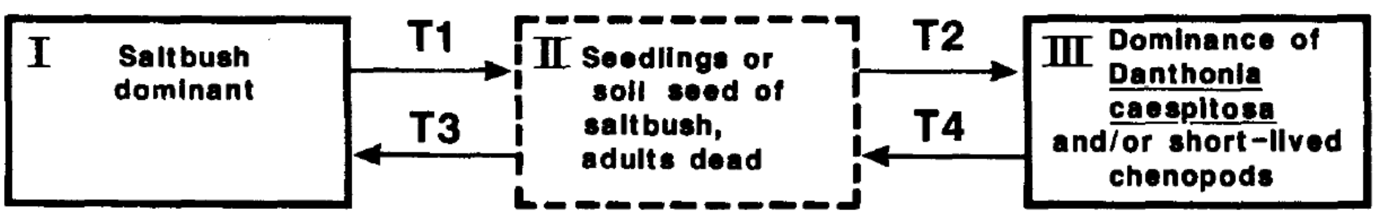
Simulation Modeling

State-and-Transition Models

- Conceptual
  - Groups of vegetation communities and shifts between them (Westoby et al. 1989)
- Simulation
  - Computer-based prototype of real world
  - Temporally dynamic, spatially explicit
  - Disturbance, climate, and management scenarios



Source: Example from Westoby et al. (1989)

Whitebark Pine (*Pinus albicaulis*)

Photo: http://en.wikipedia.org/

- Keystone species
- Listed candidate species

Photo: Jesse Logan

Slide: modified from Tony Chang

Whitebark Pine (*Pinus albicaulis*)

Photo: www.fs.fed.us/

Photo: Wilson Kern (nrdc.org/)

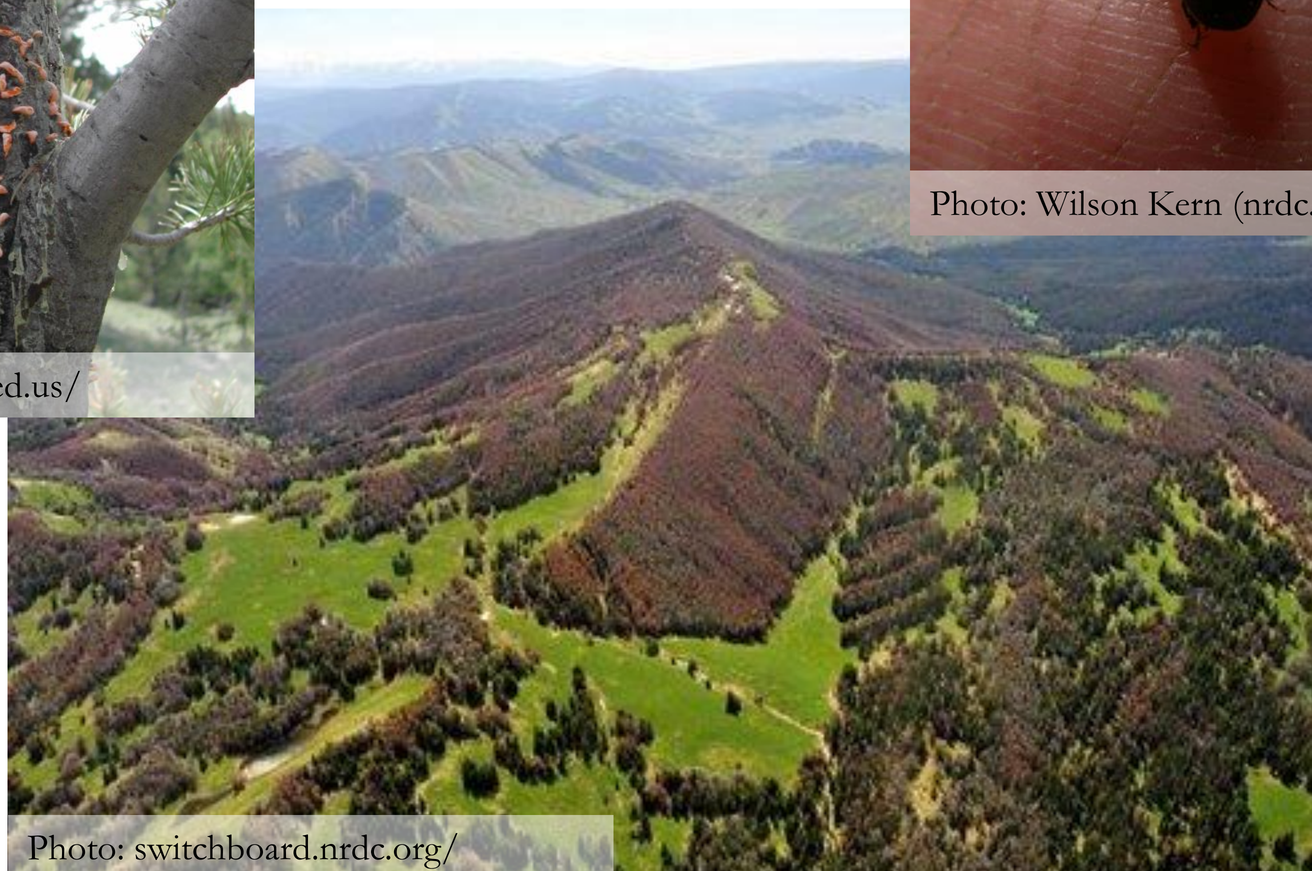
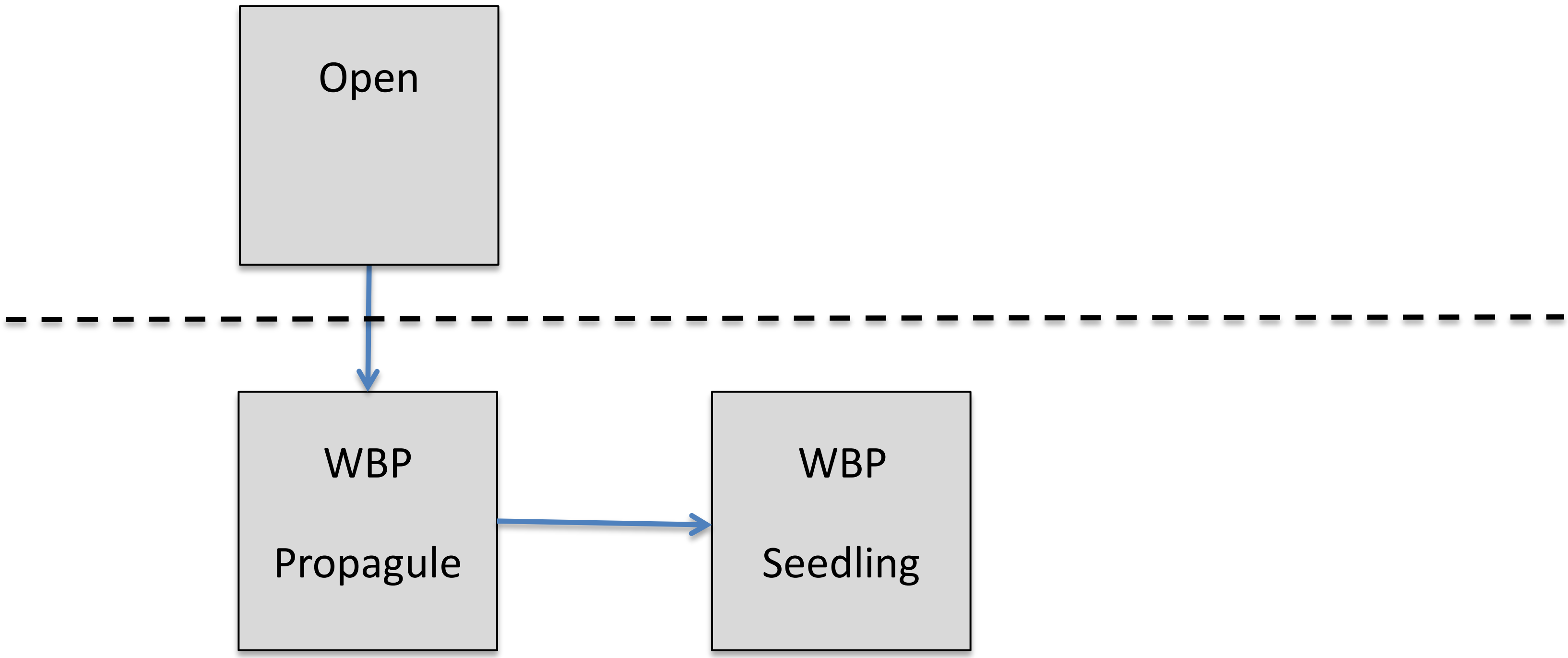
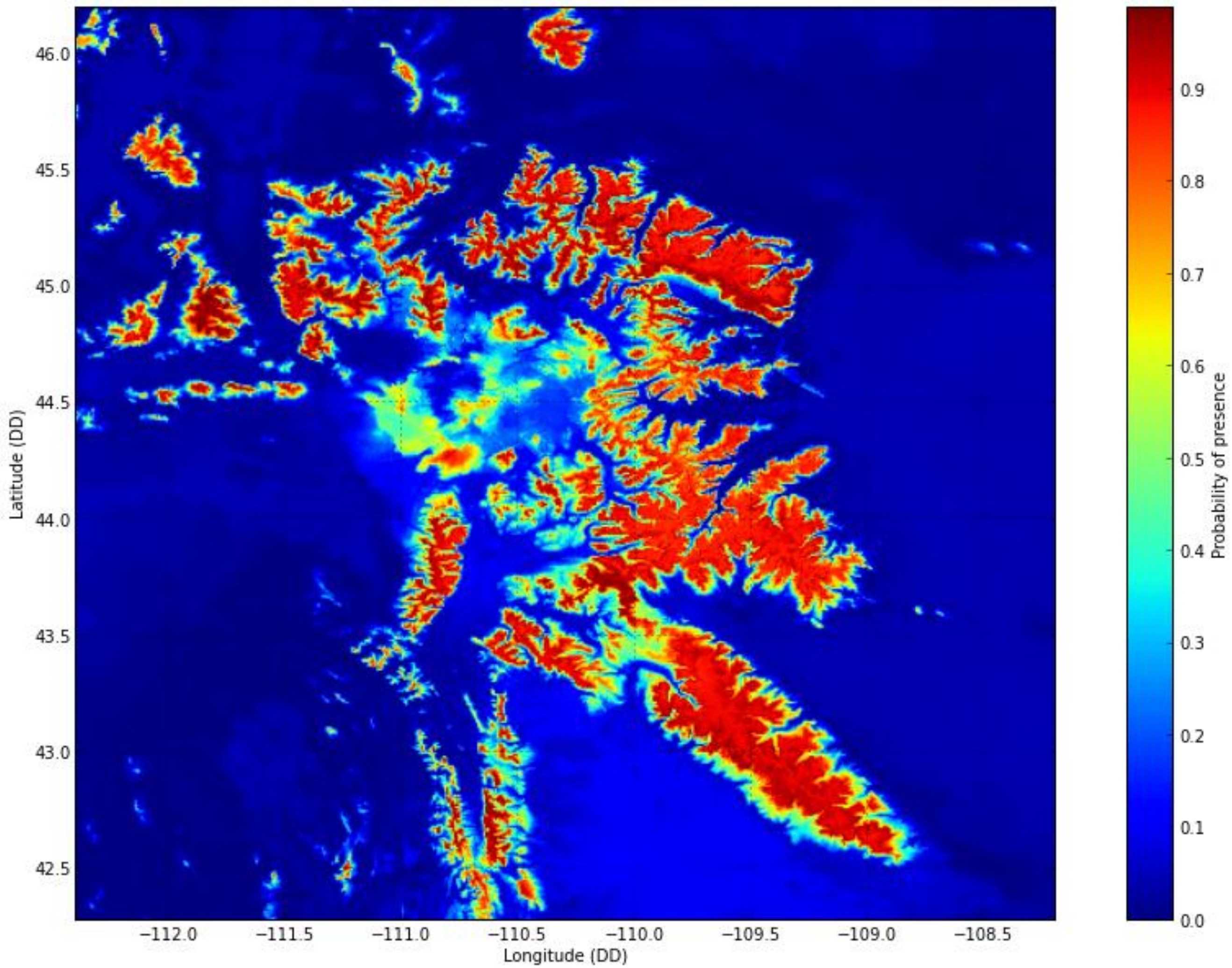


Photo: switchboard.nrdc.org/

Basic Structure of State-and-Transition Simulation

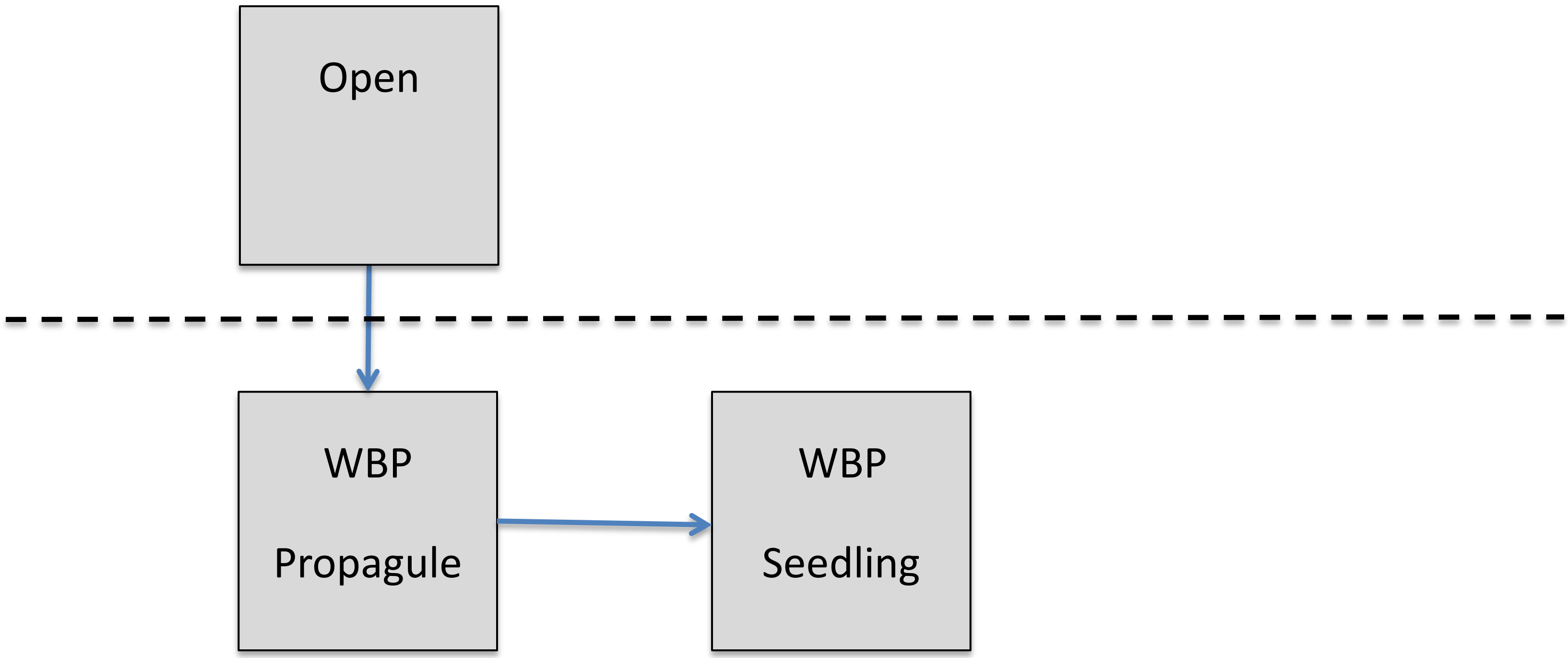


Species Distribution Model Results

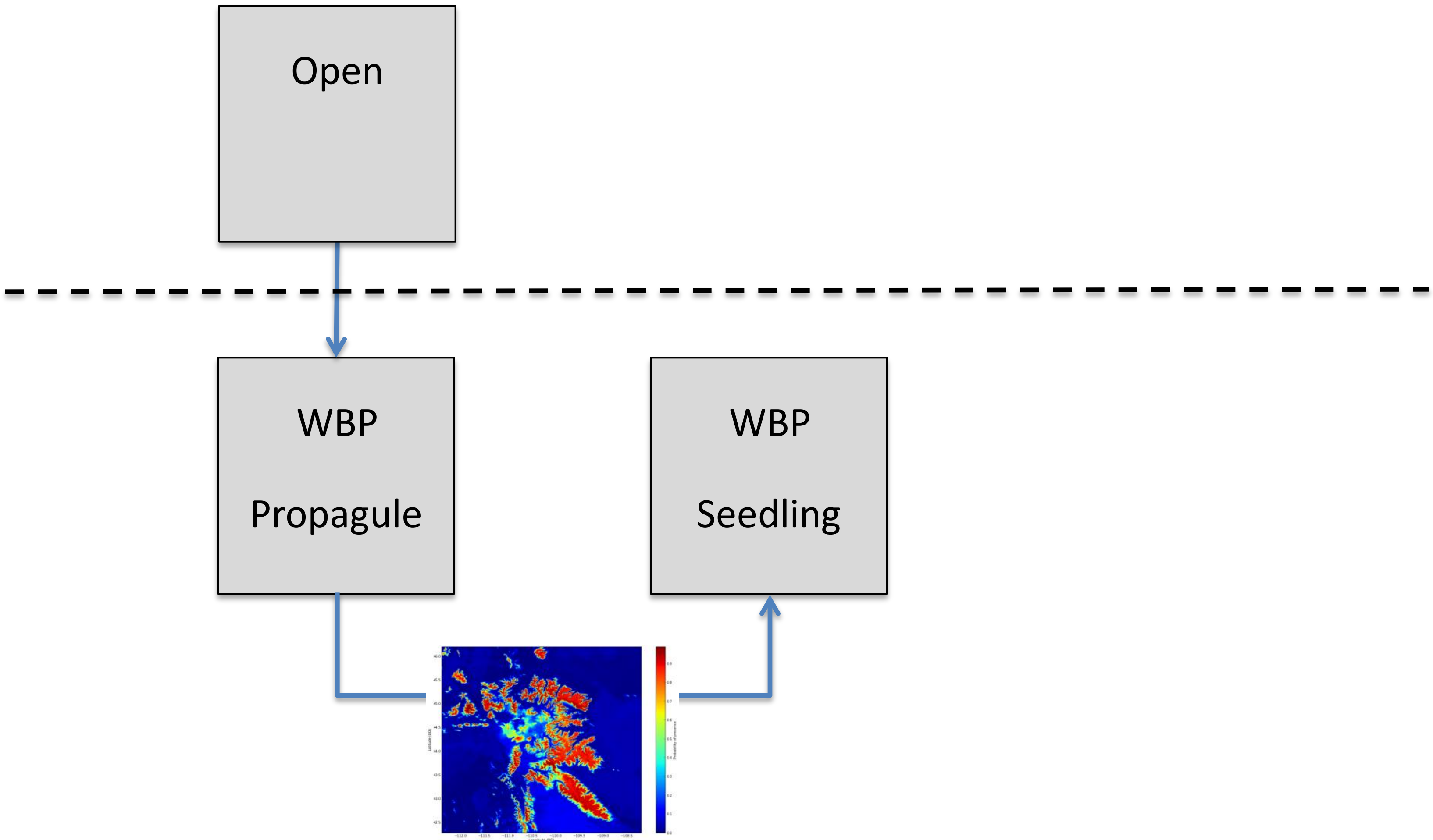


Slide: Tony Chang

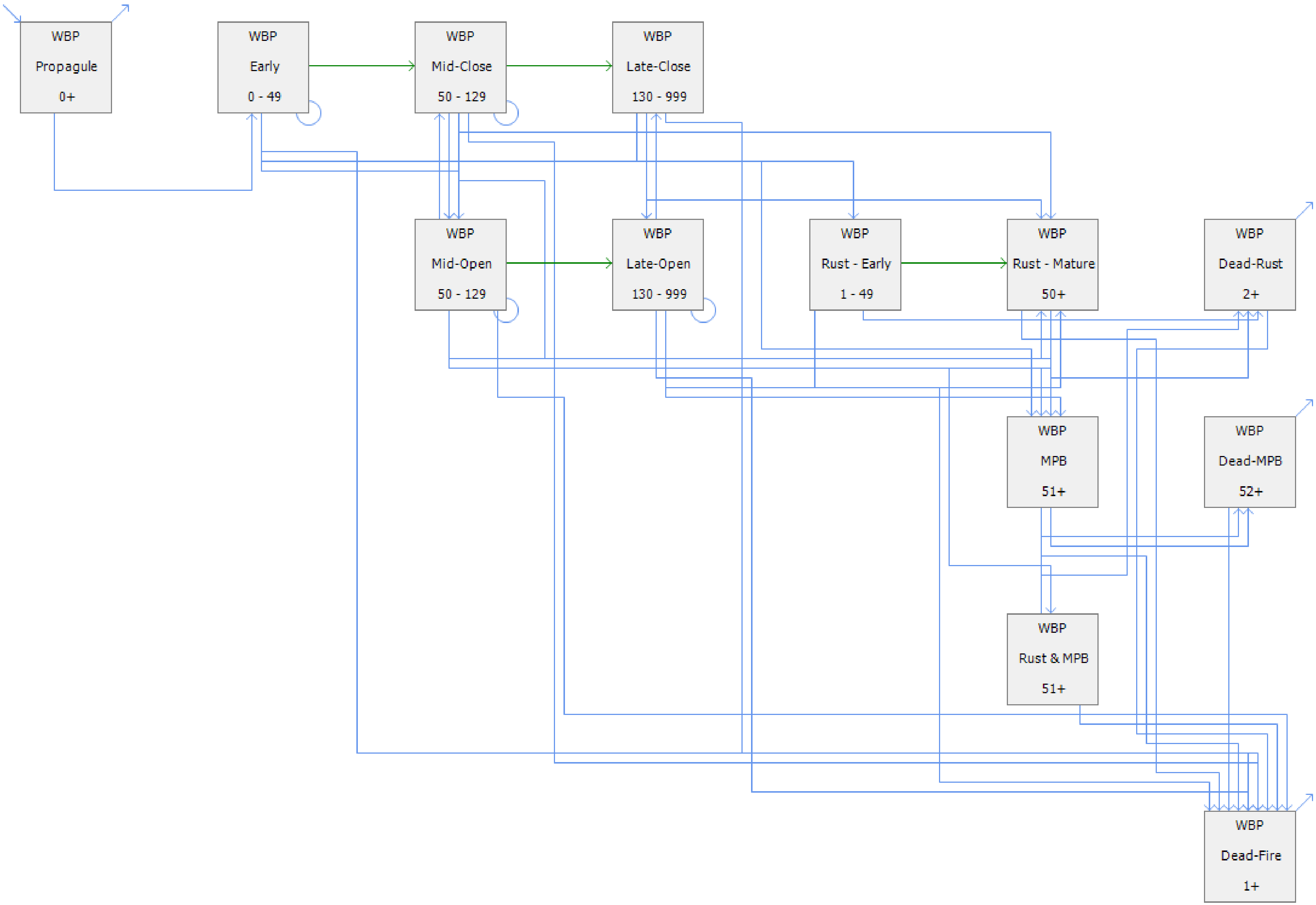
Basic Structure of State-and-Transition Simulation

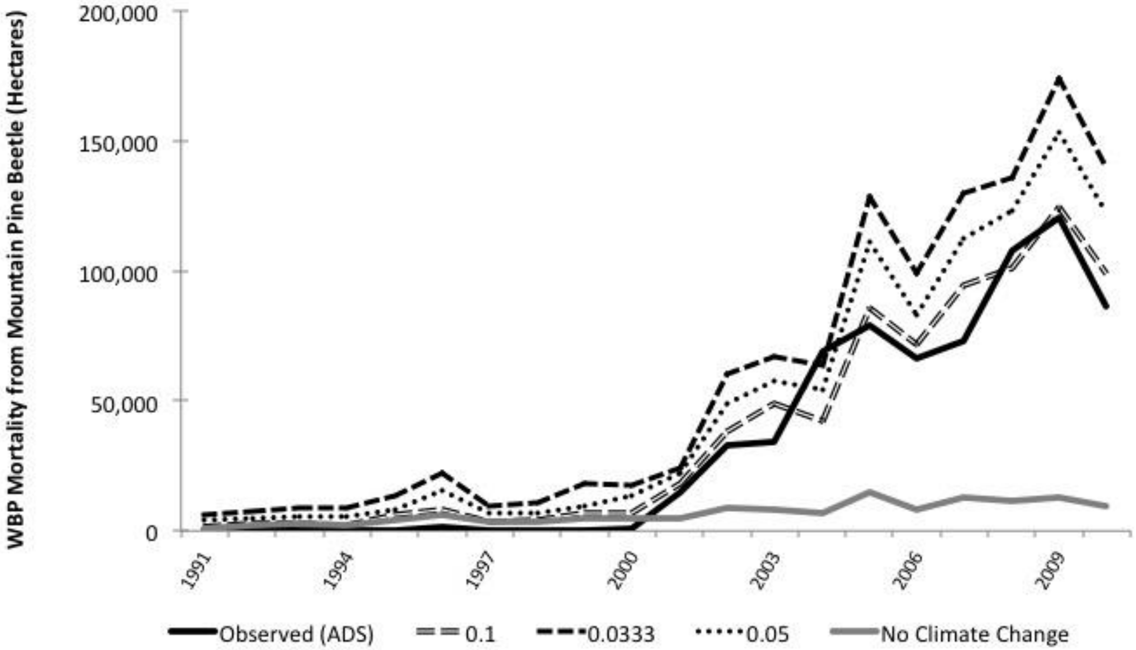


Basic Structure of State-and-Transition Simulation

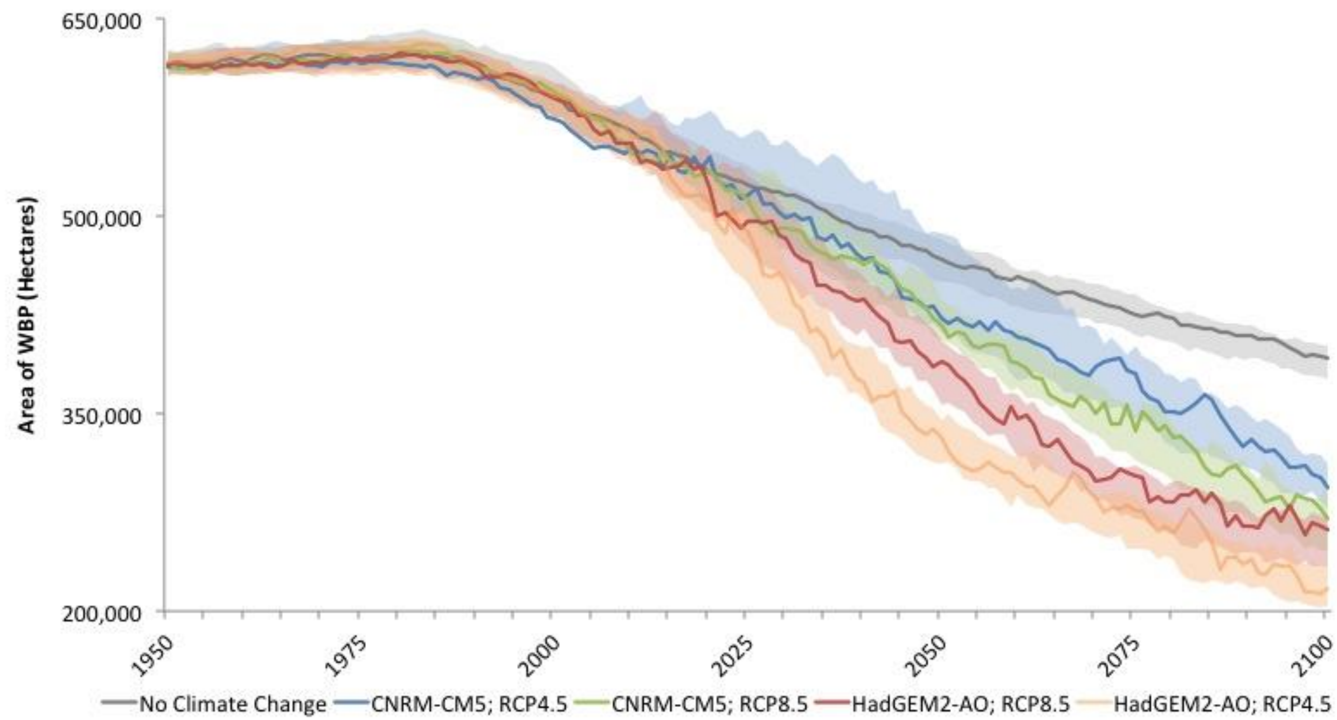


Spatial Multiplier = Habitat Suitability

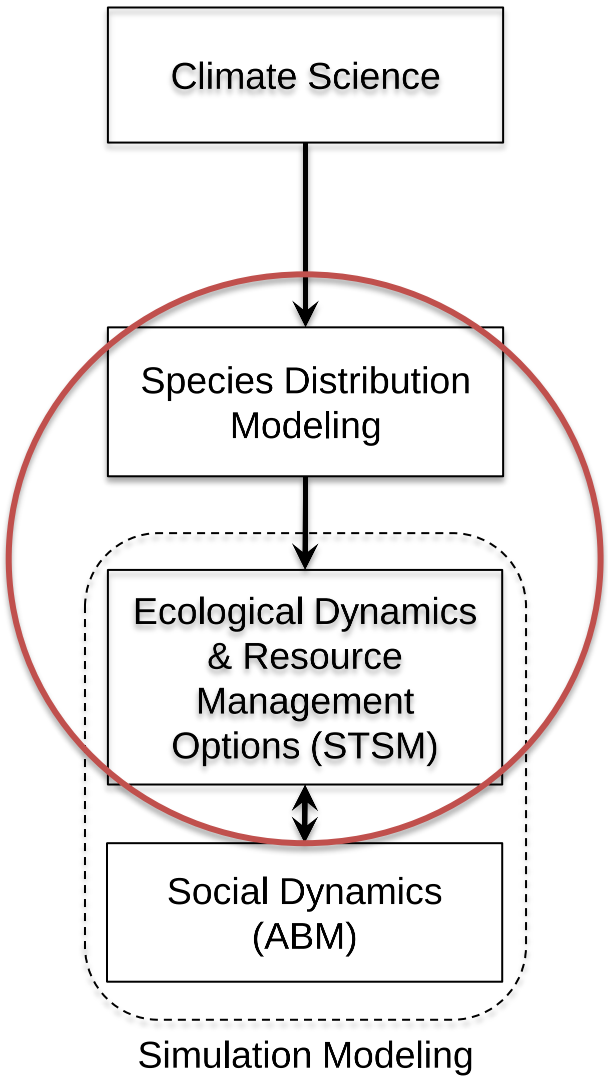

WBP
Propagule
0+
WBP
Early
0 - 49
WBP
Mid-Close
50 - 129
WBP
Late-Close
130 - 999
WBP
Mid-Open
50 - 129
WBP
Late-Open
130 - 999
WBP
Rust - Early
1 - 49
WBP
Rust - Mature
50+
WBP
Dead-Rust
2+
WBP
MPB
51+
WBP
Dead-MPB
52+
WBP
Rust & MPB
51+
WBP
Dead-Fire
1+

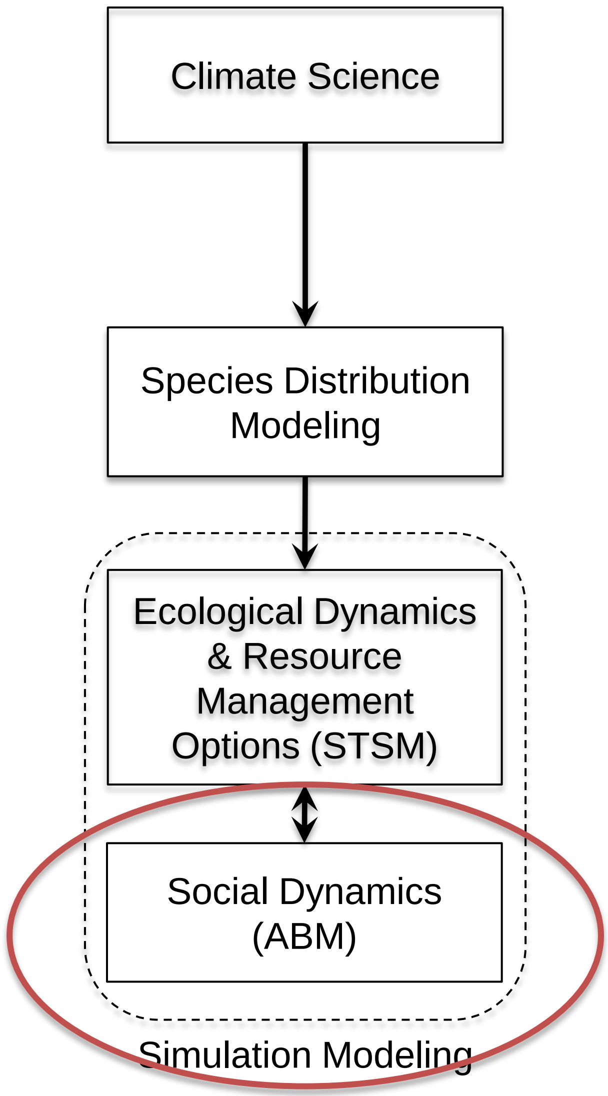


WBP Mortality from Mountain Pine Beetle (Hectares)
200,000
150,000
100,000
50,000
0
1991
1994
1997
2000
2003
2006
2009
Observed (ADS)
0.1
0.0333
0.05
No Climate Change



Area of WBP (Hectares)
650,000
500,000
350,000
200,000
1950
1975
2000
2025
2050
2075
2100
No Climate Change
CNRM-CM5; RCP4.5
CNRM-CM5; RCP8.5
HadGEM2-AO; RCP8.5
HadGEM2-AO; RCP4.5


Climate Science
Species Distribution Modeling
Ecological Dynamics & Resource Management Options (STSM)
Social Dynamics (ABM)
Simulation Modeling


Climate Science
Species Distribution Modeling
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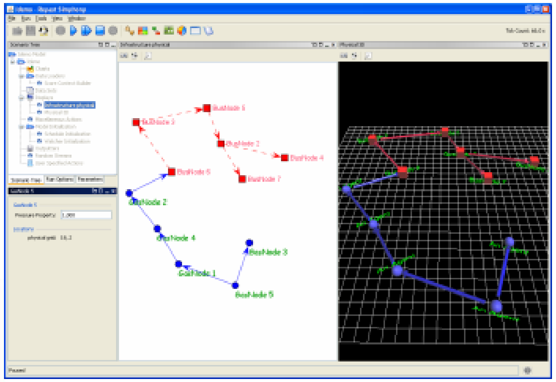
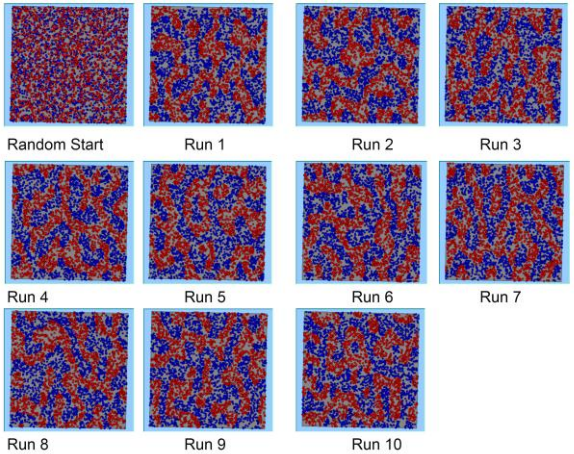
Simulation Modeling

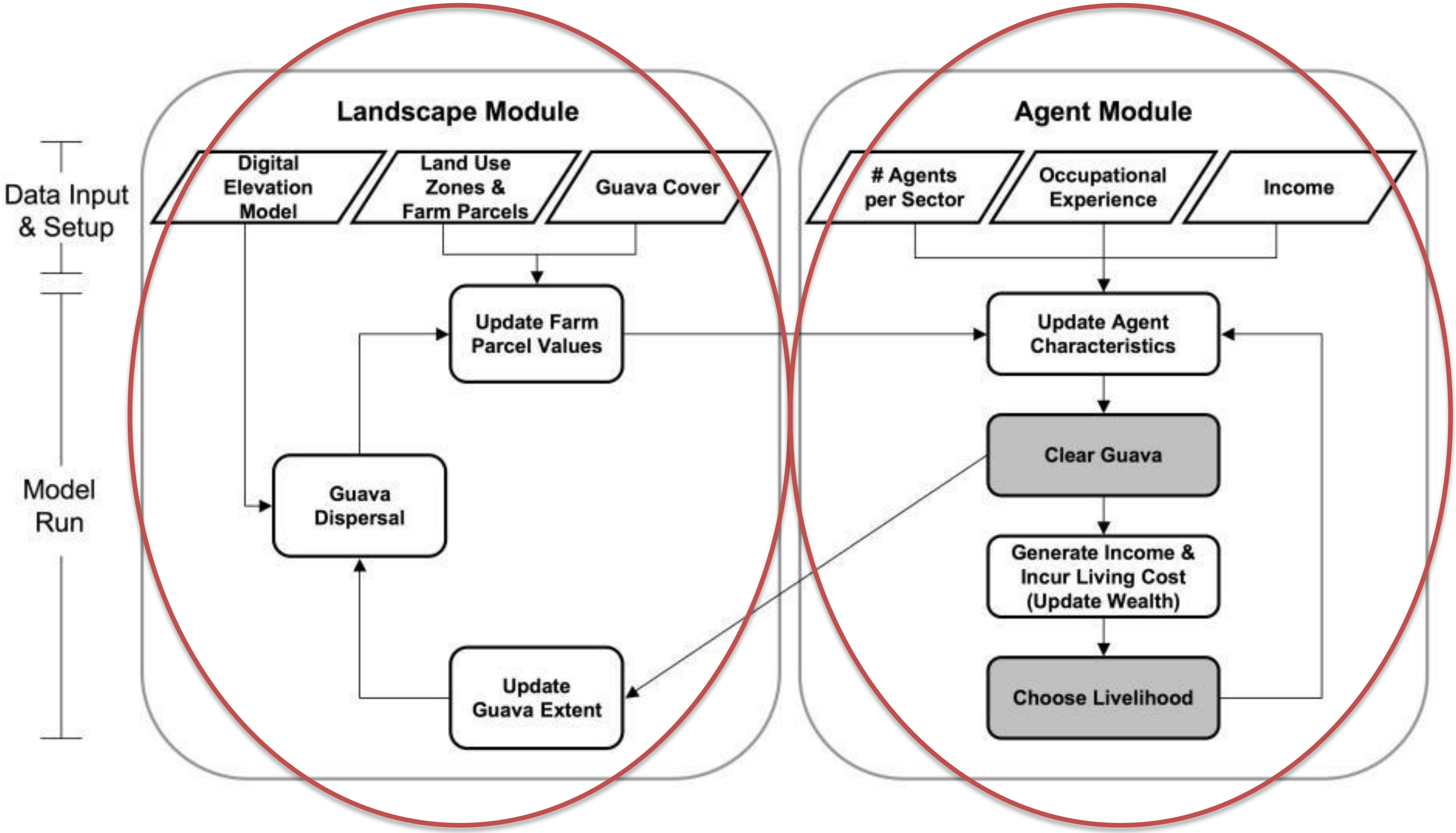
Agent-Based Models

- Bringing people into the picture
- Components
  - Dynamic Environment
  - Dynamic Agents
  - Rules





www.css.gmu.edu



Miller BW, et al. 2010. Using stylized agent-based models for population-environment research: a case study from the Galápagos Islands. *Population and Environment* 31(6):401-426

Results

- Management scenarios
  - Subsidize farmer income

  - Subsidize invasive control

Miller BW, et al. 2010. Using stylized agent-based models for population-environment research: a case study from the Galápagos Islands. *Population and Environment* 31(6):401-426

Results

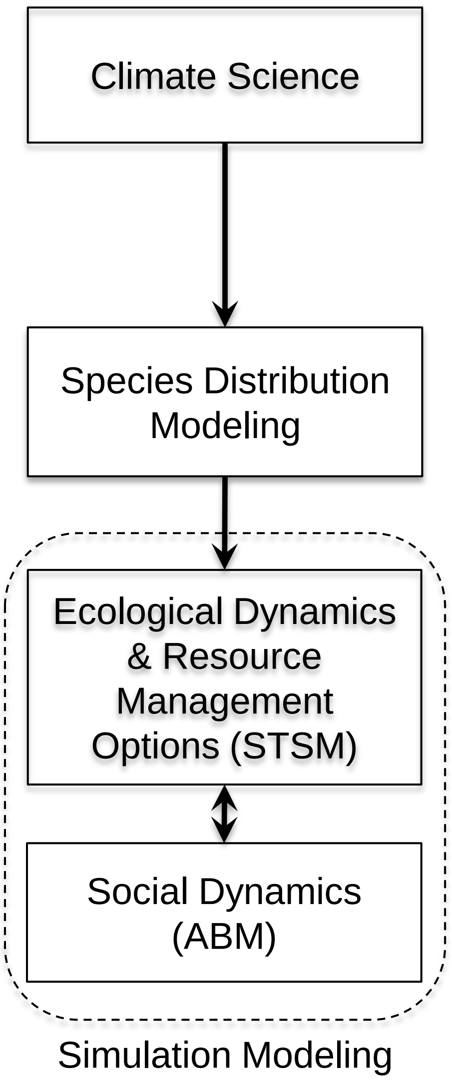
- Management scenarios
  - Subsidize farmer income
    = greatest increase in farming population
  - Subsidize invasive control
    = greatest decrease in invasive

Miller BW, et al. 2010. Using stylized agent-based models for population-environment research: a case study from the Galápagos Islands. *Population and Environment* 31(6):401-426

Results

- Management scenarios
  - Subsidize farmer income
    = greatest increase in farming population
  - Subsidize invasive control
    = greatest decrease in invasive
  - Farming pop. & invasive linked, not mutually dependent

Miller BW, et al. 2010. Using stylized agent-based models for population-environment research: a case study from the Galápagos Islands. *Population and Environment* 31(6):401-426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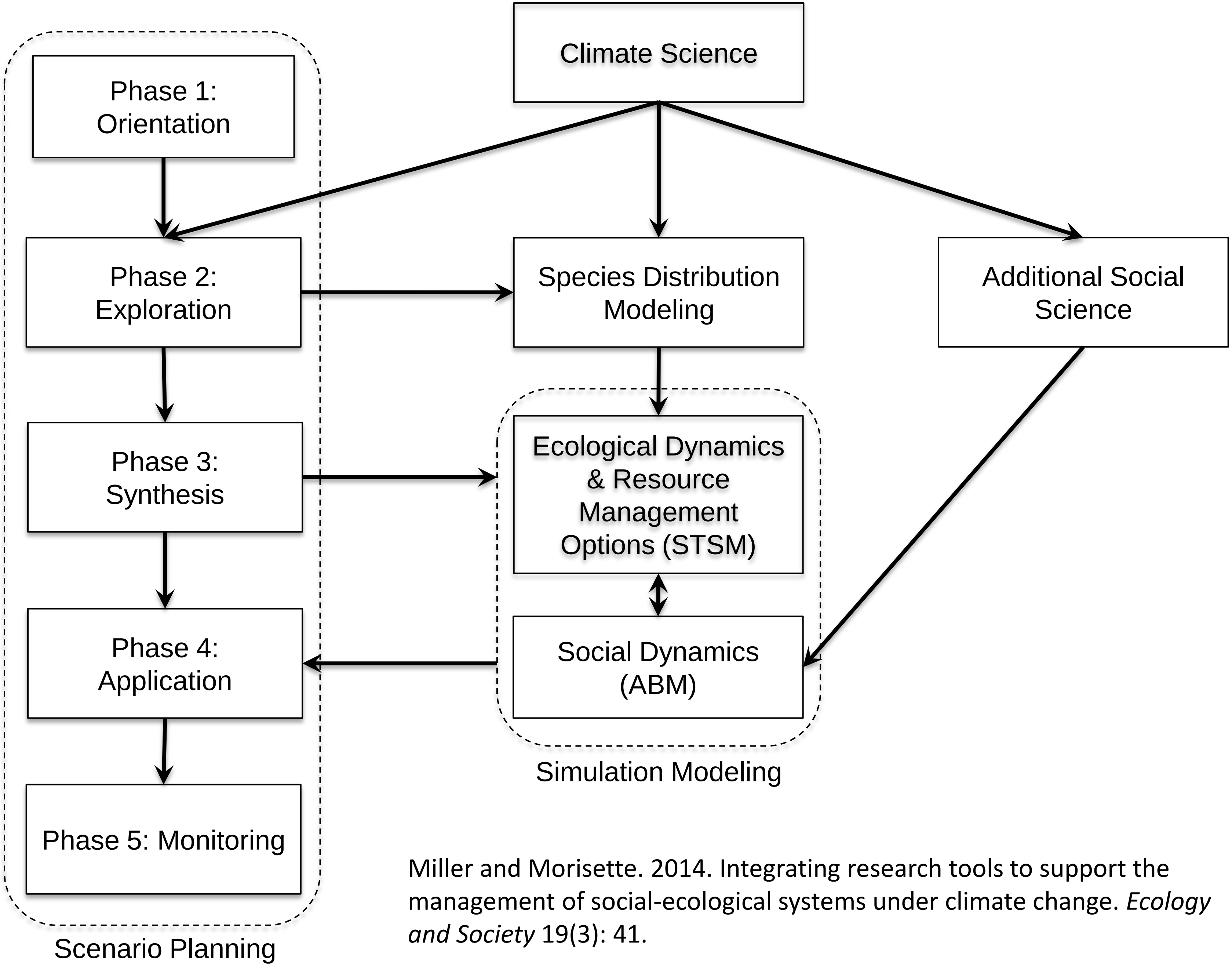


Miller and Morisette. 2014. Integrating research tools to support the management of social-ecological systems under climate change. *Ecology and Society* 19(3): 41.

2015 Invasive Species Webinar Series

ENVIRONMENTAL LAW • INSTITUTE®

Invasive Species and Climate Change: Addressing the Intersecting Drivers of Ecosystem Transformation

Thursday, February 26, 2015 • 1:00pm-3:00pm ET

INTRODUCING:

Bruce Stein

Senior Director, National Climate Change Adaptation National Advocacy Center, National Wildlife Federation

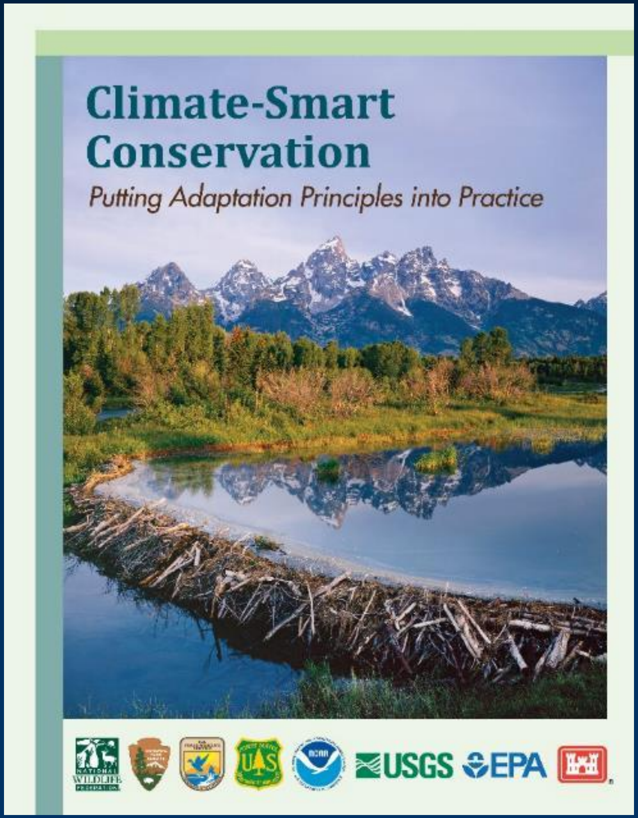
Dr. Bruce A. Stein is Director, Climate Change Adaptation with the National Wildlife Federation (NWF). Dr. Stein leads NWF's work on safeguarding people and wildlife from the impacts of climate change. He is author of numerous publications on biodiversity conservation and climate change, including a widely used guide to climate change vulnerability assessment (Scanning the Conservation Horizon) and a recently released guide to climate adaptation for natural resource practitioners (Climate-Smart Conservation). Dr. Stein serves on scientific advisory committees for the Department of Interior's Climate Science Centers and the Department of Defense's Strategic Environmental Research and Development Program. Dr. Stein was involved in establishing the non-profit organization NatureServe, where he served as Vice President and Chief Scientist, and earlier was a senior scientist with The Nature Conservancy involved in both U.S. and international conservation activities. Noteworthy among his publications is the book Precious Heritage (Oxford Univ. Press), which has been described by Harvard biologist E.O. Wilson as "the definitive text on U.S. biodiversity."

A botanist by training, Dr. Stein received his Bachelor's degree from the University of California, Santa Cruz, and his Ph.D. from Washington University, St. Louis and the Missouri Botanical Garden.

Connecting the Dots
Climate Adaptation and Invasive Species

Dr. Bruce Stein
Senior Director,
Climate Adaptation and Resilience
National Wildlife Federation

Environmental Law Institute
Invasive Species and Climate Change Webinar
February 26, 2015



The Climate Change/Invasive Species Conundrum

- Climate change may reduce the ability of ecosystems to resist biological invasions

- Biological invasions may reduce the resiliency of ecosystems to climate impacts

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Climate Adaptation

- The process of adjustment to actual or expected climate and its effects

--- IPCC AR5 (2014)

  - In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities
  - In natural systems, human intervention may facilitate adjustment to expected climate and its effects

In other words:

- Prepare for …
- Cope with …
- Adjust to …

“I skate to where the puck is going to be, not where it has been.”

--- Wayne Gretsky

Adaptation in a Nutshell

- Act with intentionality
- Manage for change, not just persistence
- Reconsider goals, not just strategies
- Integrate adaptation into existing work

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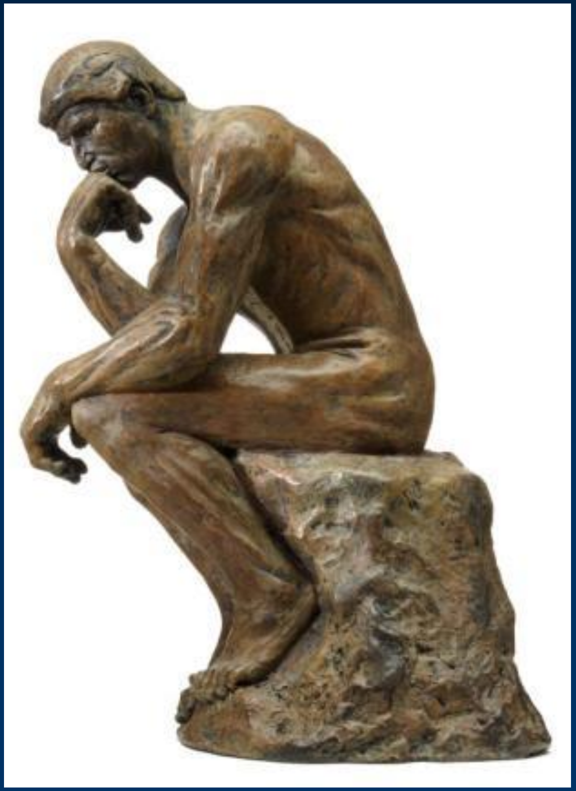
1. Act with Intentionality

In the face of climate change, good conservation just isn't good enough!

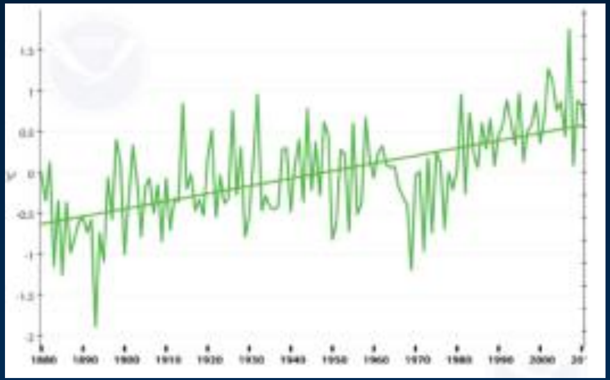
- Link Actions to Climate Impacts
  - How will actions address key vulnerabilities?
  - Not enough to just "enhance resilience"
- Show your work!
  - Whether novel approaches are indicated
  - Or existing approaches and actions validated



2. Manage for Change

Not Just Persistence

- Adaptation will largely be about preparing for and managing change
- Adaptation is a process, not an end point



Continuum of Change
From Persistence to Transformation

- Resistance
  - Focus on persistence of existing conditions
- Resilience
  - Current usage mostly focuses on rebound to status quo conditions
  - Should emphasize maintaining functionality
- Realignment
  - Manage for inevitable transformations to help achieve acceptable outcomes
  - In some/many cases will involve permanent presence of non-natives/invasives

Key Considerations in Managing Change

- Change can involve different levels of biological organization
  - Composition, structure, function
  - Genes, species, ecosystems
- Management often focuses on “composition”
  - “Historical fidelity” of species assemblages
  - Native vs. non-native status
- As “novel ecosystems” emerge:
  - Emphasis on functional attributes and system level properties will be increasingly important

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3. Reconsider Conservation Goals
Not Just Strategies

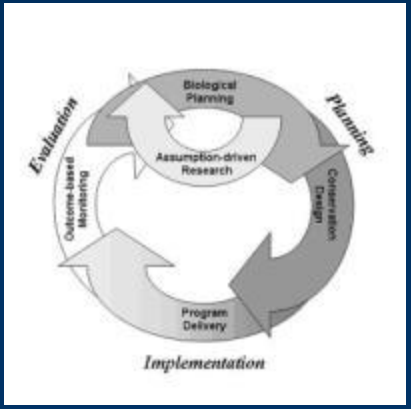
- Goals are the *ends*; strategies the *means*
- Goals are a reflection of human values and can evolve
  - Many goals and objectives may no longer be feasible with rapid changes
- Need for forward-looking rather than retrospective goals

Crafting Climate-Informed Goals
Are Changes Needed In?

- What
  - Conservation targets/focus
- Why
  - Intended outcome or desired condition
- Where
  - Relevant geographic scope
- When
  - Relevant timeframe

4. Integrate with Existing Work

Not Just Stand-Alone Adaptation Plans



Key Characteristics of Climate-Smart Conservation

- Actions linked to climate impacts
- Forward looking goals
- Broader landscape context
- Robust in an uncertain future
- Agile and informed management
- Minimizes carbon footprint
- Climate influence on project success
- Safeguards people and nature
- Avoids maladaptation

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Connecting Climate Adaptation and Invasive Species Management

- Prevention
  - Novel introduction pathways
  - Assessing risk for changing conditions
  - Use of invasives for climate mitigation (bioenergy)
- Early Detection
  - Target EDRR work based on future conditions/predictions
- Control/Management
  - How to think about movement of natives into new regions?
  - Prioritize control based on effects on ecosystem function/resilience and climate-related vulnerabilities
  - Use of forward-looking restoration in invasive control/management efforts

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2015 Invasive Species Webinar Series

Invasive Species and Climate Change: Addressing the Intersecting Drivers of Ecosystem Transformation

Thursday, February 26, 2015 • 1:00pm-3:00pm ET

INTRODUCING:

Ruark L. "Rook" Cleary

NECIS Liaison to Board of Directors for Natural Areas Association & Invasion Biologist, Florida Fish and Wildlife Conservation Commission

Ruark L. Cleary is an Invasion Biologist (ESIII) with the Florida Fish and Wildlife Conservation Commission, Invasive Plant Management Section. He received his Master's degree in Biology in 1985 from the University of Central Florida. From 1987 to 2000, he worked for the Department of Environmental Protection in conservation planning and reserve design for the Preservation 2000 program. As the agency's P2000 liaison, Ruark participated in the review, selection, and acquisition of 1.3 million acres of conservation land with a purchase value of $3 billion. Since 2001, he has worked in the terrestrial invasive plant management (or "Uplands") program, which was transferred from DEP to FWC in 2008. Since 1997, the Uplands Program has expended $135 million to treat invasive plant species on 2.4 million acres. Although trained as a herpetologist, with an inordinate fondness for geckoes, Ruark notes that the only difference between invasive plants and animals is that the plants don't run away (usually).

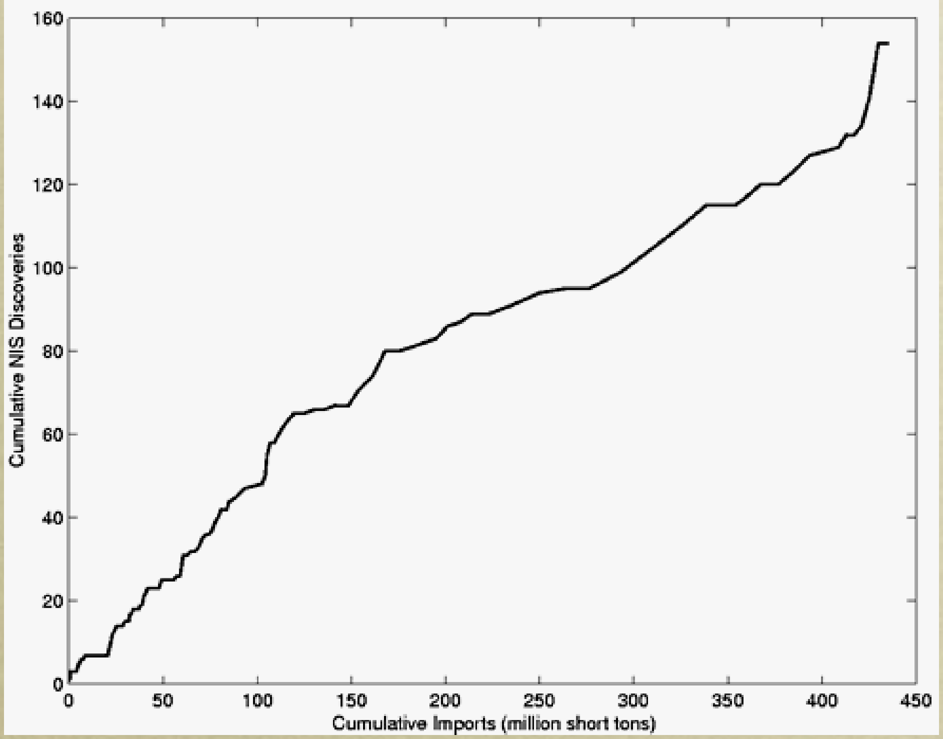
Invasive Species-Climate Change Interactions

Lessons Learned, Lessons Yet To Be Learned

Rook Cleary, MS
Invasion Biologist
ruark.cleary@myfwc.com

Invasive Species
Management Problems

One year of shipping in the Pacific Region



Cumulative NIS Discoveries vs. Cumulative Imports

Figure 2 from *Policy and Risk Processes of Trade-Related Biological Invasion/CCR-41*, Economic Research Service, USDA. http://www.ers.usda.gov/Publications/CCR41/CCR41.pdf

Invasive Species

Management Problems

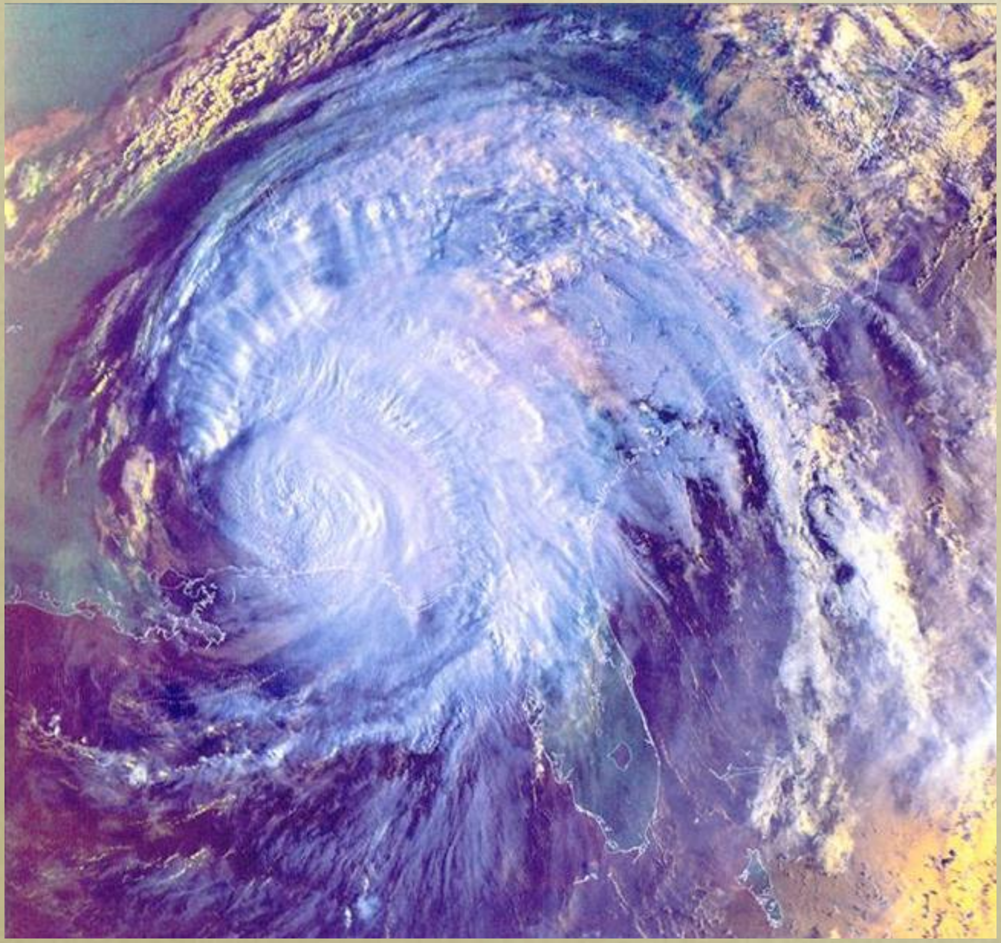
Some Proposed Biofuel Crops, 2005-Present

Jatropha (*Jatropha curcas*)
Giant Reed (*Arundo donax*)
Chinese Tallow Tree (*Triadica sebifera*)
Reed Canary Grass (*Phalaris arundinacea*)
Neem Tree (*Azadirachta indica*)
Switchgrass (*Panicum virgatum*)
Miscanthus (*Miscanthus* species)
Spartina (*Spartina* species)
Castor Oil Plant (*Ricinis communis*)
Chinee Apple (*Zizyphus mauritiana*)
Moringa (*Moringa pterygosperma*)
Pongamia Tree (*Milletia pinnata*)
Calotrope (*Calotropis procera*)
Caper Spurge (*Euphorbia lathyris*)

Giant Reed (*Arundo donax*)
a.k.a. Energy Cane

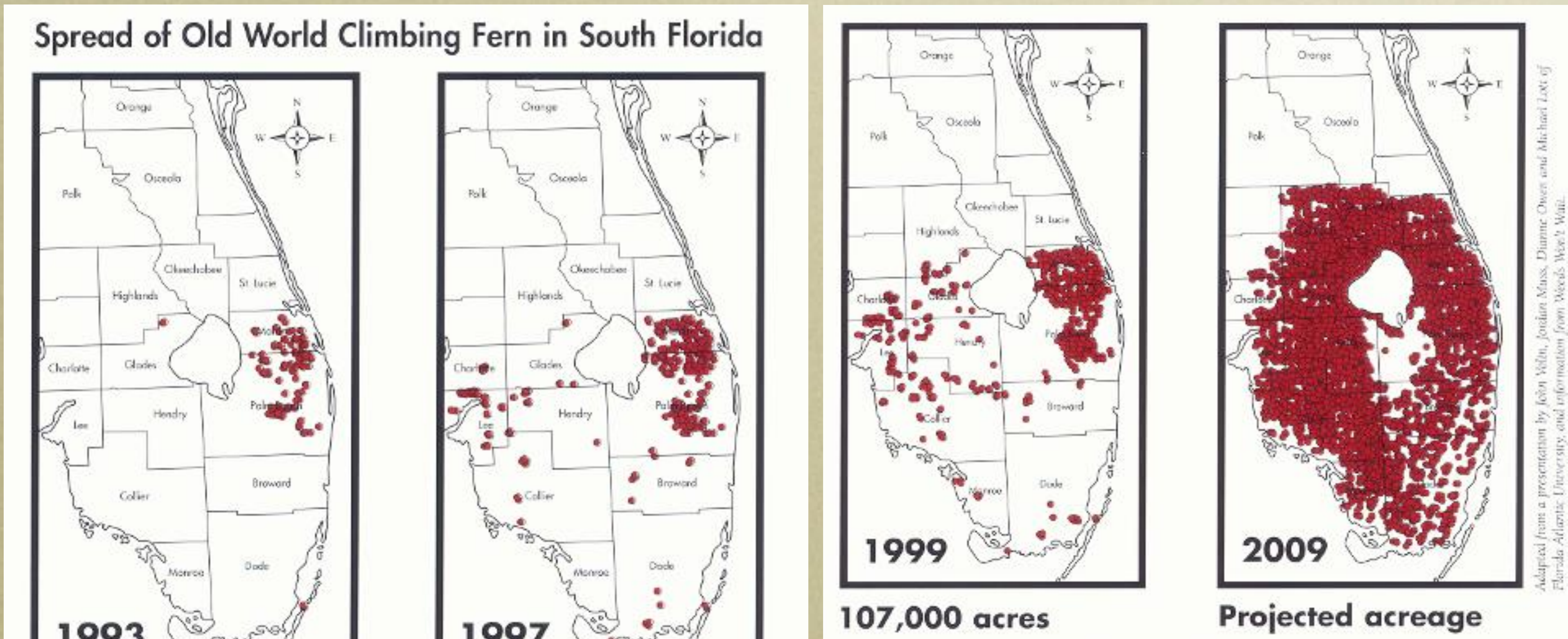
In 2006, seven scientists published an article in the journal *Science*, pointing out that two grasses with potential as biofuel crops—giant reed and reed canary grass—are invasive weeds in America. In 2007, the UN noted "the potential risks that, in an effort to increase production and meet growing demand for biofuels, energy crops that present many characteristics of a weed, such as jatropha, may become invasive (Executive Secretary, UN-Energy).

Plants are moving around!



Invasive Species

Management Problems

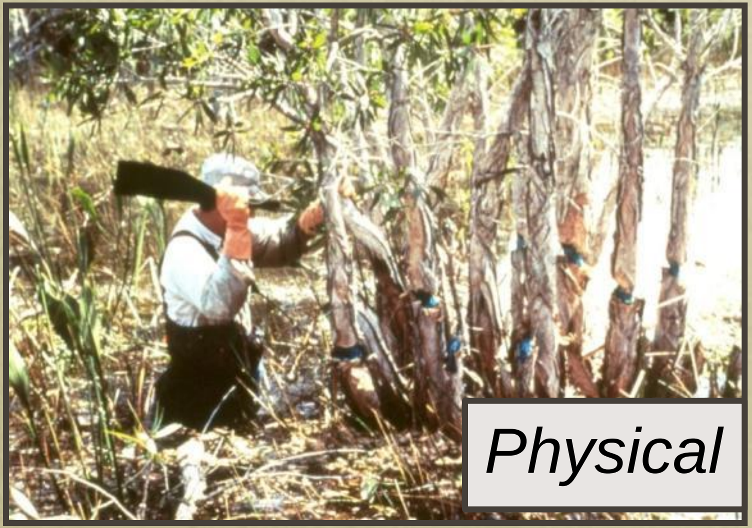


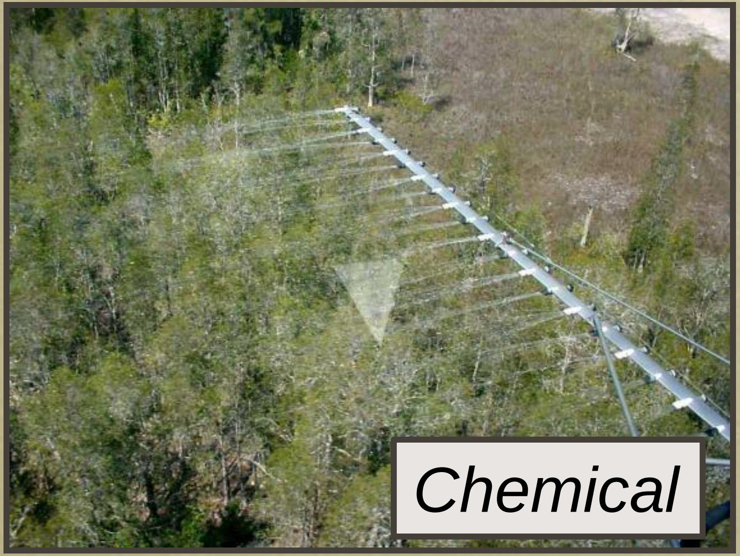
Invasive species spread unchecked. For example, Old World climbing fern cover in south Florida increased by 328% between 1993 and 1999. If not controlled, models predict that the species will invade across almost all south Florida counties.

LYGODIUM MICROPHYLLUM

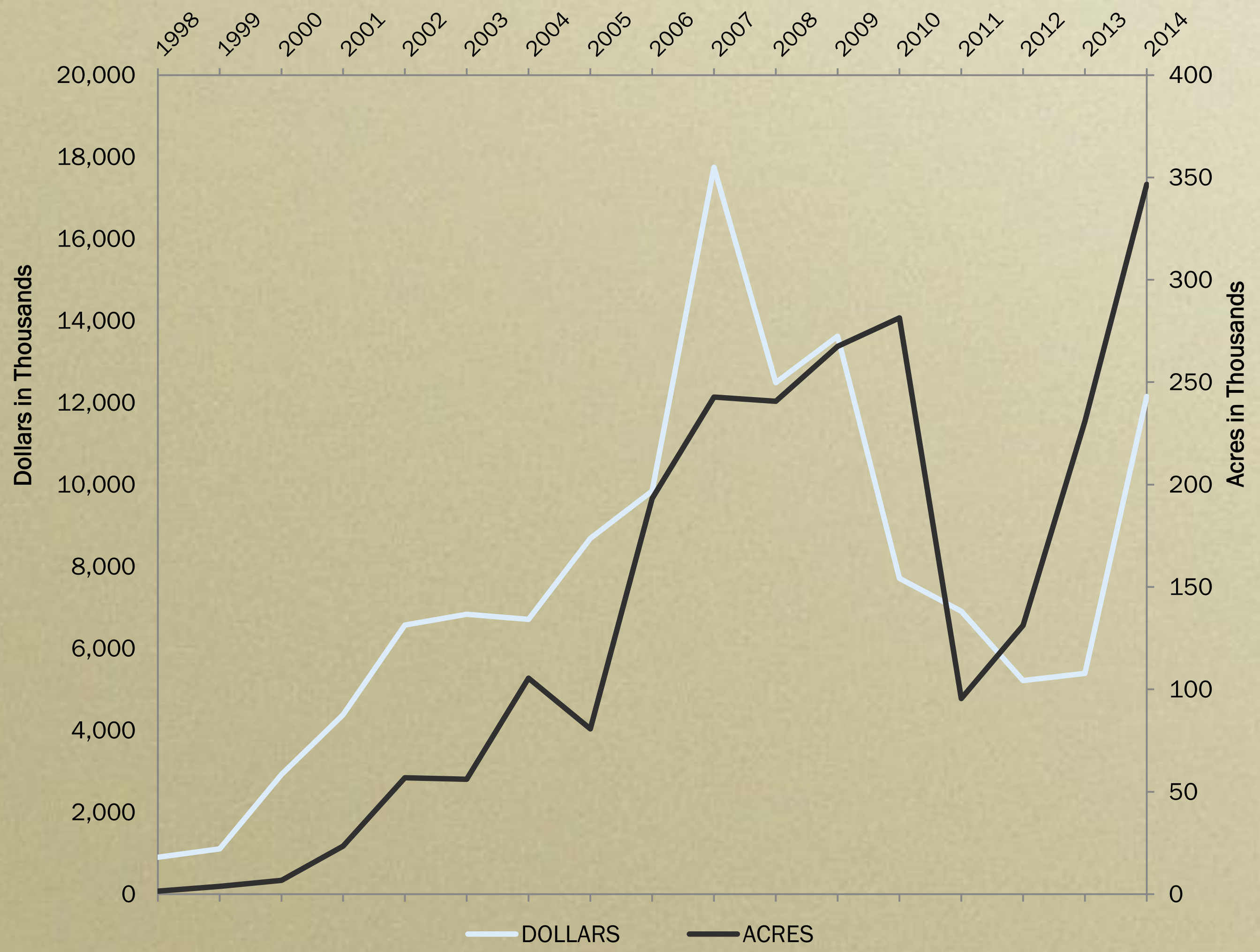
- Estimated 250,000 acres pre-2004 hurricanes
- Airborne spores spread statewide
- 1998-2005:   11,615 acres treated (5% of total)
- 2006-2012: 198,000 acres treated (37% of total)
- Reached 52% of acres treated in FY11-12

Upland Invasive Plant
Management Program



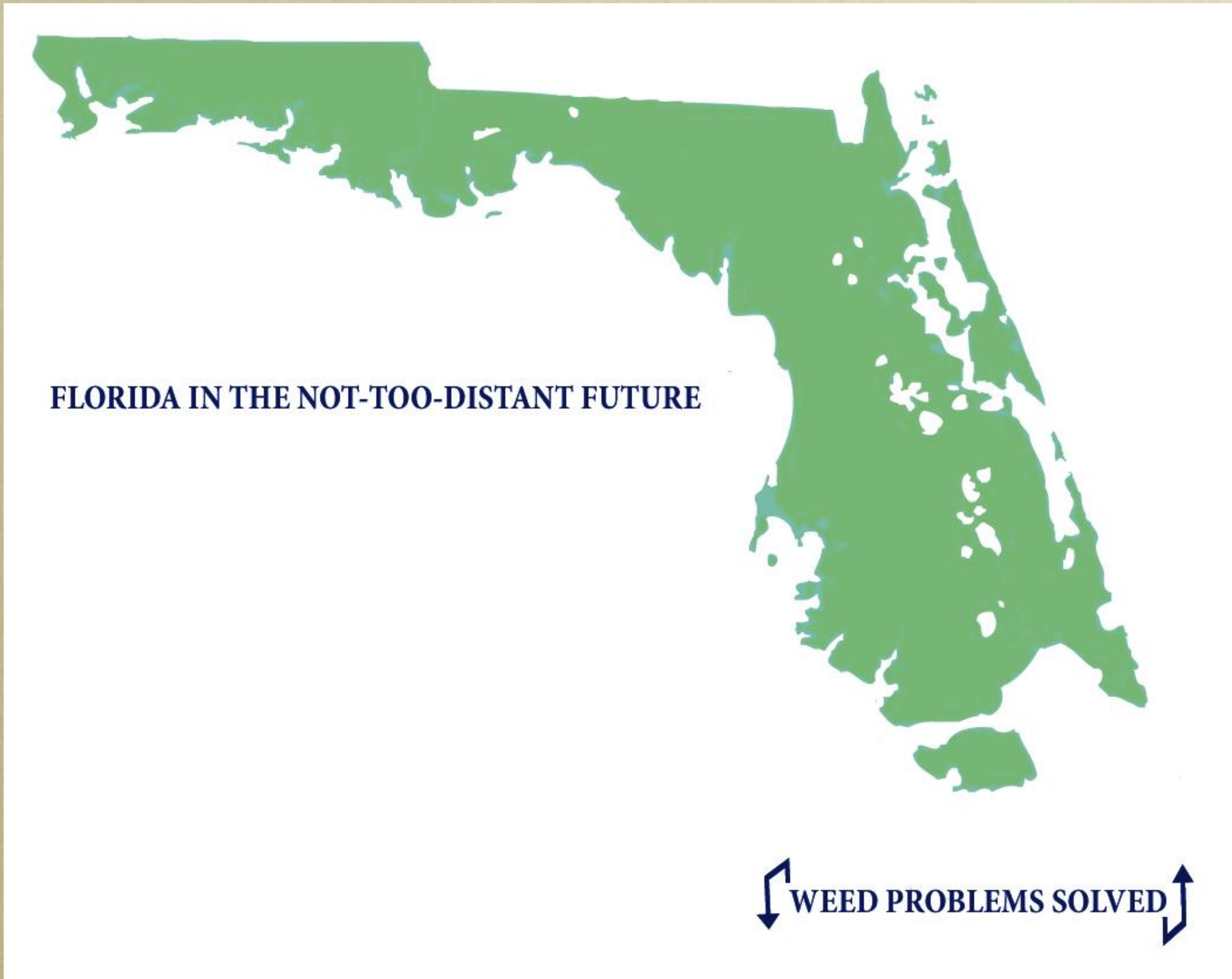


FY1998-2014 Totals for Uplands Invasive Plant Control



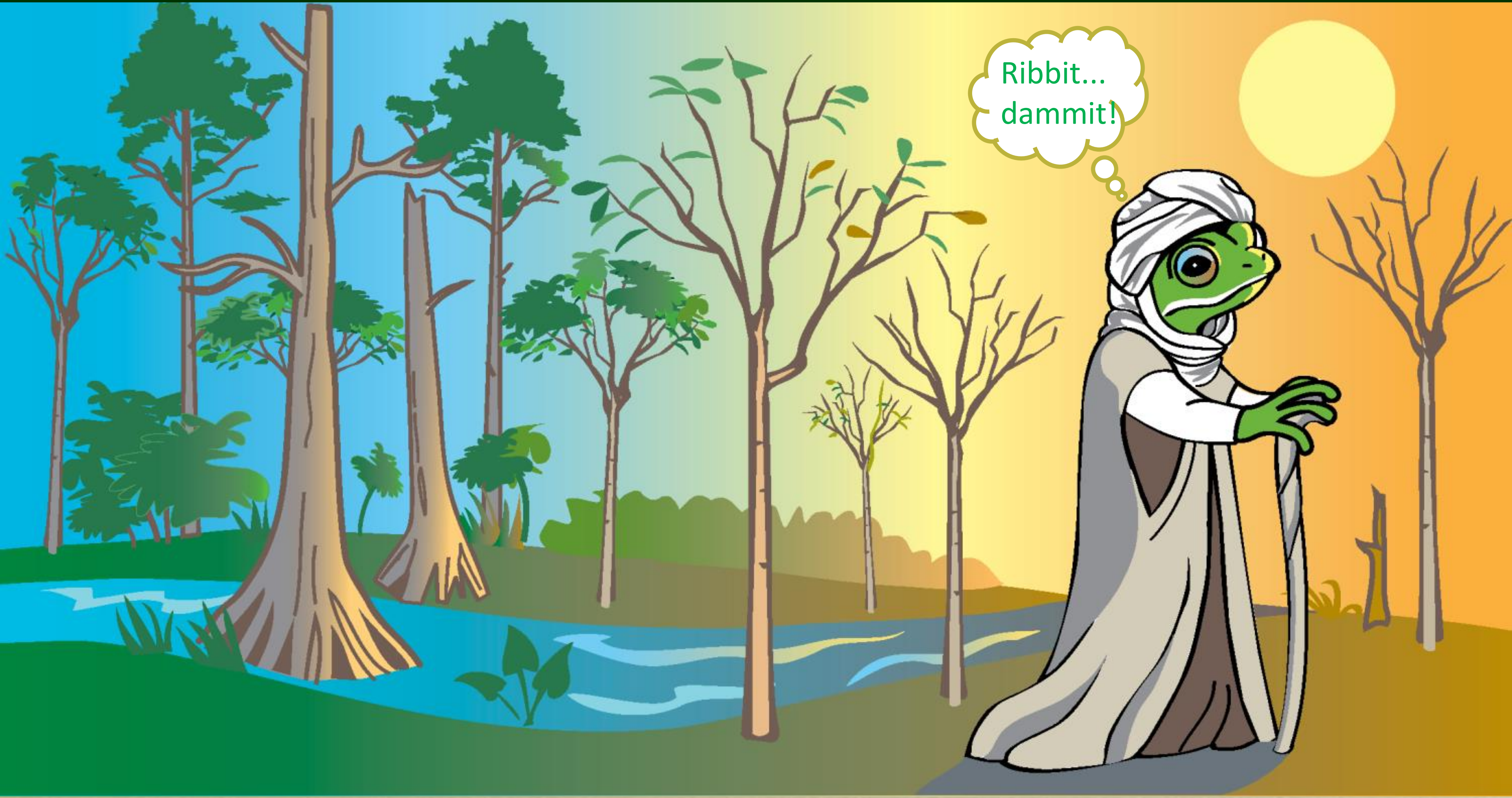
Invasive Species – Climate Change

Management Problems(?)



Invasive Species – Climate Change

Management Problems(?)



"INVASIVE SPECIES" MEANS AN ALIEN (NON-NATIVE, NON-INDIGENOUS, FOREIGN, EXOTIC) SPECIES WHICH BECOMES ESTABLISHED IN NATURAL OR SEMI-NATURAL ECOSYSTEMS OR HABITAT, IS AN AGENT OF CHANGE, AND THREATENS NATIVE BIOLOGICAL DIVERSITY. FURTHER, "ALIEN SPECIES" MEANS A SPECIES, SUBSPECIES, OR LOWER TAXON OCCURRING OUTSIDE OF ITS NATURAL RANGE (PAST OR PRESENT) AND DISPERSAL POTENTIAL (I.E. OUTSIDE THE RANGE IT OCCUPIES NATURALLY OR COULD NOT OCCUPY WITHOUT DIRECT OR INDIRECT INTRODUCTION OR CARE BY HUMANS) AND INCLUDES ANY PART, GAMETES OR PROPAGULE OF SUCH SPECIES THAT MIGHT SURVIVE AND SUBSEQUENTLY REPRODUCE. –IUCN

An invasive species is defined as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Further, an alien species is defined as, "with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem." (NISC, Executive Order 13112)

Invasive Species Definitions Do Not Include "NATIVE"

EAB vs MPB

INVASIVE
INTRODUCED BY TRADE
HUGE IMPACT ON ASH SPP.
25 STATES SINCE 1ST RECORD
CONTINUES TO SPREAD
PRETTY, COLORFUL

NATIVE
NATURAL RANGE
HUGE IMPACT ON PINE SPP.
OUTBREAK DUE TO MILDER WINTERS ALLOWING TWO GENERATIONS, HOT/DRY SUMMERS STRESS TREES
PLAIN, DRAB

"**Ocean acidification** has already cost the oyster industry in the Pacific Northwest nearly $110 million and jeopardized about 3,200 jobs," said Julie Ekstrom, who was lead author on the study while with NRDC. Another recent study documented how larval oysters are sensitive to a change in the "saturation state" of ocean water -- which ultimately is triggered by an increase in carbon dioxide. The inability of ecosystems to provide enough alkalinity to buffer the increase in CO_2 is what kills young oysters.

C. J. Randall, R. van Woesik. **Contemporary white-band disease in Caribbean corals driven by climate change**. *Nature Climate Change*, 2015; DOI: 10.1038/nclimate2530

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Thursday, February 26, 2015 • 1:00pm-3:00pm ET

Q & A Session

Questions for the panelists? Submit via the "Questions" box or raise your hand by clicking on the hand icon.

Please visit the event page (http://tinyurl.com/invasivesclimate) for background materials and resources.

This webinar is made possible by the generous support of the Turner Foundation.

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