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The webinar will begin promptly at
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Analysis of Defense Related Ecosystem Services

May 21, 2020



Welcome and Introductions

Rula A. Deeb, Ph.D.
Webinar Coordinator



Webinar Agenda

- **Webinar Logistics** (5 minutes)
Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
Dr. Kurt Preston, SERDP and ESTCP
- **Value and Resiliency of Ecosystem Services on Department of Defense Lands** (25 minutes + Q&A)
Dr. Nate McDowell, Pacific Northwest National Laboratory
- **Model-Based Tracking and Integrated Valuation of Ecosystem Services (MoTIVES) for Military Base Land-Use and Land-Management Decisions** (25 minutes + Q&A)
Dr. Mark Borsuk, Duke University
- **Final Q&A session**

Zoom Instructions

- Download Zoom
 - <https://zoom.us/download>
- If you cannot download Zoom, you can view the slides using an internet browser
 - Create a free Zoom account (<https://zoom.us/signup>)
 - Use a compatible browser (Firefox, IE or Edge)
 - View the webinar at <https://success.zoom.us/wc/790080638/join>
- If the material is not showing on your screen or if screen freezes
 - Key in Ctrl + F5 to do a hard refresh of your browser

Zoom Instructions (Cont'd)

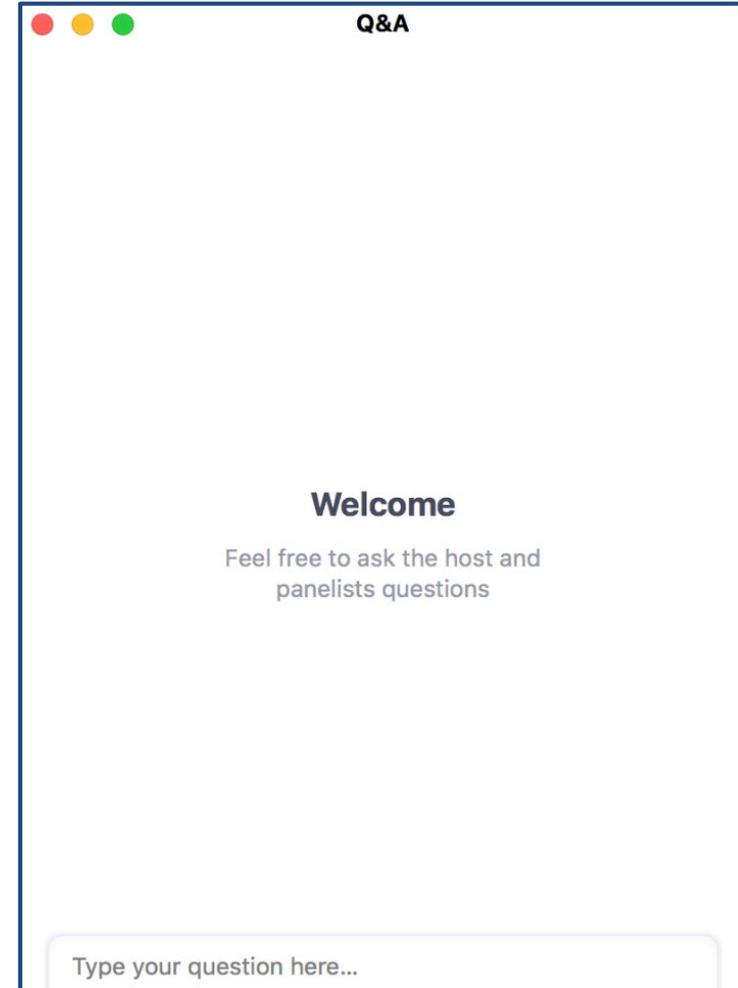
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- We will also be live streaming the webinar on the SERDP and ESTCP YouTube channel
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How to Ask Questions

- Find the Q&A button on your control bar and type in your question(s)
- Make sure to add your organization name at the end of your question so that we can identify you during the Q&A sessions



SERDP and ESTCP Overview

Kurt Preston, Ph.D.
SERDP and ESTCP



SERDP

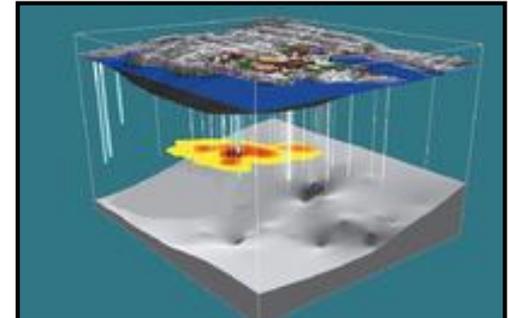
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
 - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
 - Advanced technology development to address near term needs
 - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
 - Capitalize on past investments
 - Transition technology out of the lab
- Promote implementation
 - Facilitate regulatory acceptance

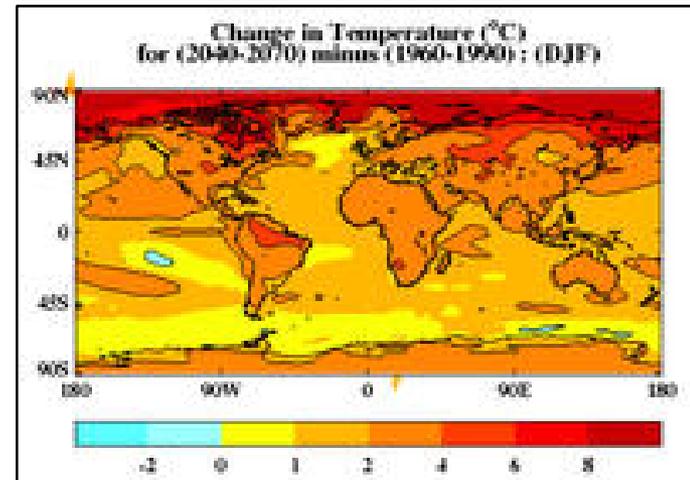
Program Areas

- Environmental Restoration
- Installation Energy and Water
- Munitions Response
- Resource Conservation and Resiliency
- Weapons Systems and Platforms



Resource Conservation and Resiliency

- Natural resources
 - Ecological forestry
 - Arid lands ecology and management
 - Cold regions ecology and management
 - Pacific island ecology and management
 - Coastal and estuarine ecology and management
 - Living marine resources ecology and management
 - Species ecology and management
 - Watershed processes and management
- Resilience
 - Vulnerability and impact assessment
 - Adaptation science
 - Land use and carbon management
- Air quality
 - Wildland fire dynamics
 - Fugitive dust



SERDP and ESTCP Webinar Series

Date	Topic
June 4, 2020	Waste Reduction and Treatment in Armed Forces Vessel Environments
June 18, 2020	Predicting PFAS Fate and Transport in Subsurface Environments, and Treatment
July 9, 2020	Software and Hardware Solutions for Securing DoD Control Systems and Infrastructure from Cyber Threats
July 23, 2020	PFAS Fate, Transport and Treatment
August 20, 2020	Addressing Threatened and Endangered Species on DoD Lands

For upcoming webinars, please visit

<http://serdp-estcp.org/Tools-and-Training/Webinar-Series>



Value and Resiliency of Ecosystem Services on DoD lands

Nate McDowell, Ph.D.
Pacific Northwest National Laboratory



Outline

- Ecosystem Services (ESs)
- Final Ecosystem Goods and Services-Classification System (FEGS-CS)
- Modeling ESs
- Integration
- Gaps
- Next steps

Objective

A Method for characterizing and valuing Ecosystem Services (ESs)

- ESs valued by DoD
 - Training areas and transport routes
 - Threatened and endangered species (TES) habitat areas
 - Harvested products
 - Land for buildings

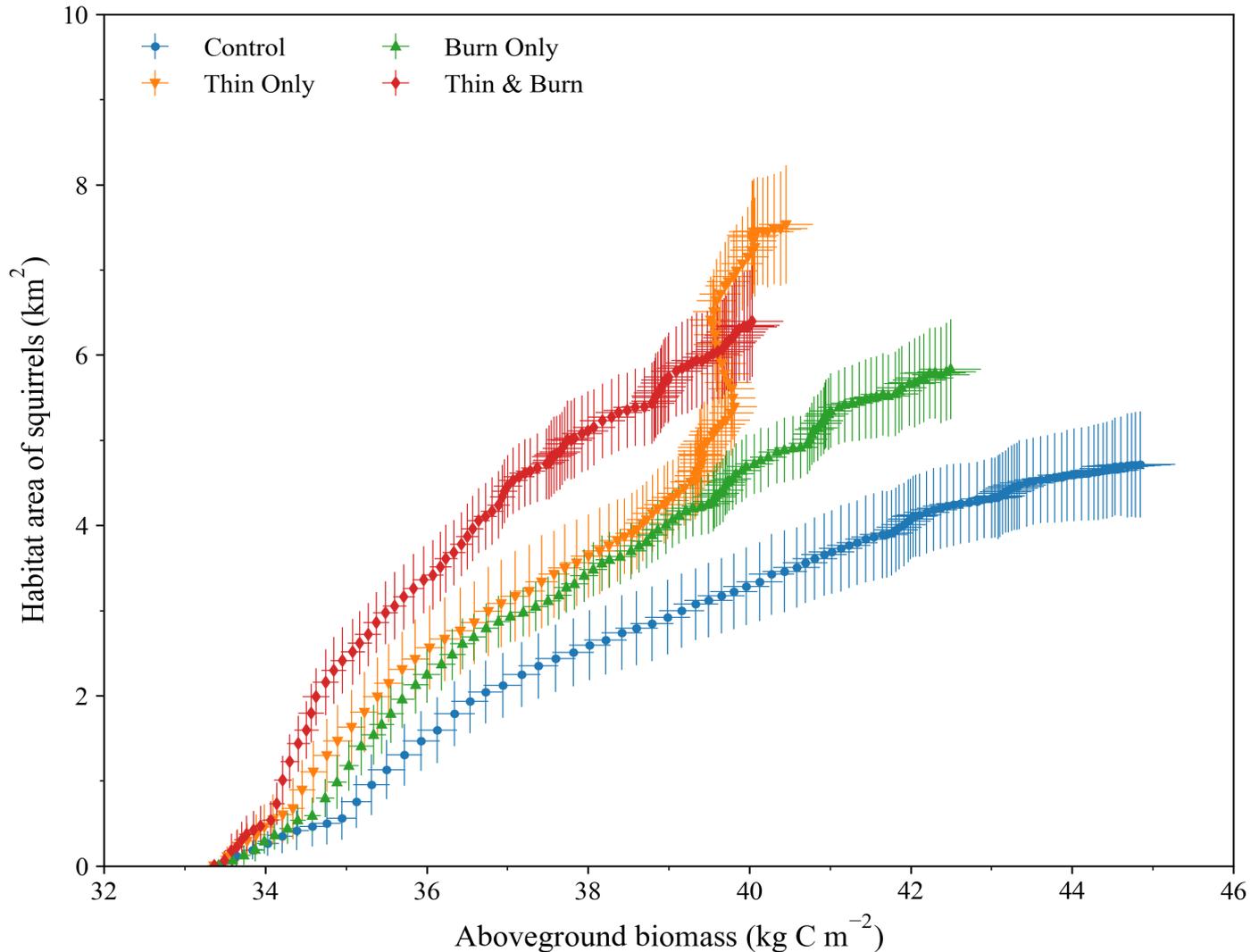
Objective (Cont'd)

- ESs valued by the public
 - Threatened and endangered species habitat areas
 - Recreational areas
 - Environment (research, education, ceremonial and spiritual, existence, and bequest uses)
- Final Ecosystem Goods and Services-Classification System (FEGS-CS)
- Ecosystem models (characterize ES under alternative scenarios)

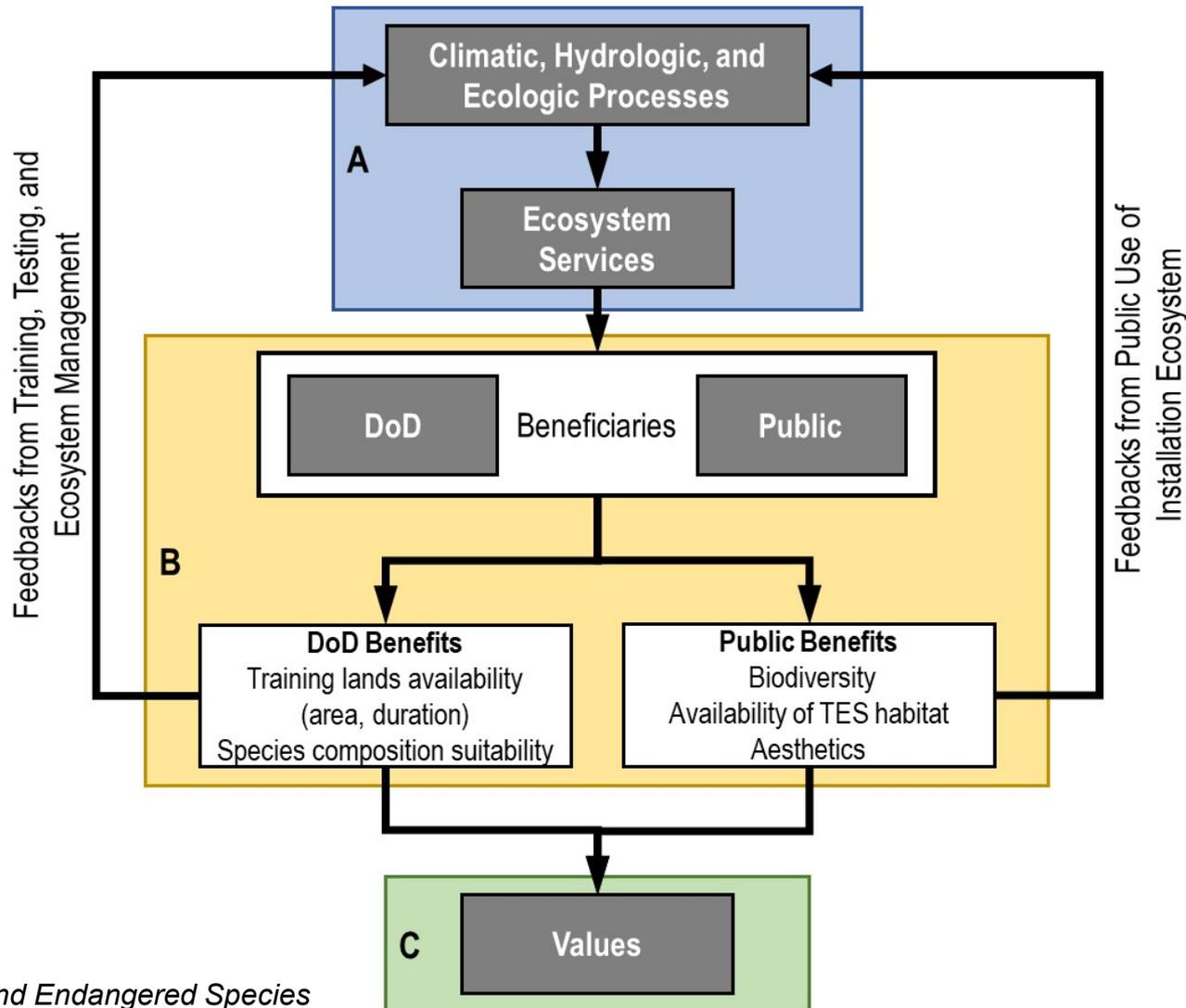
ESs on DoD and Public Lands



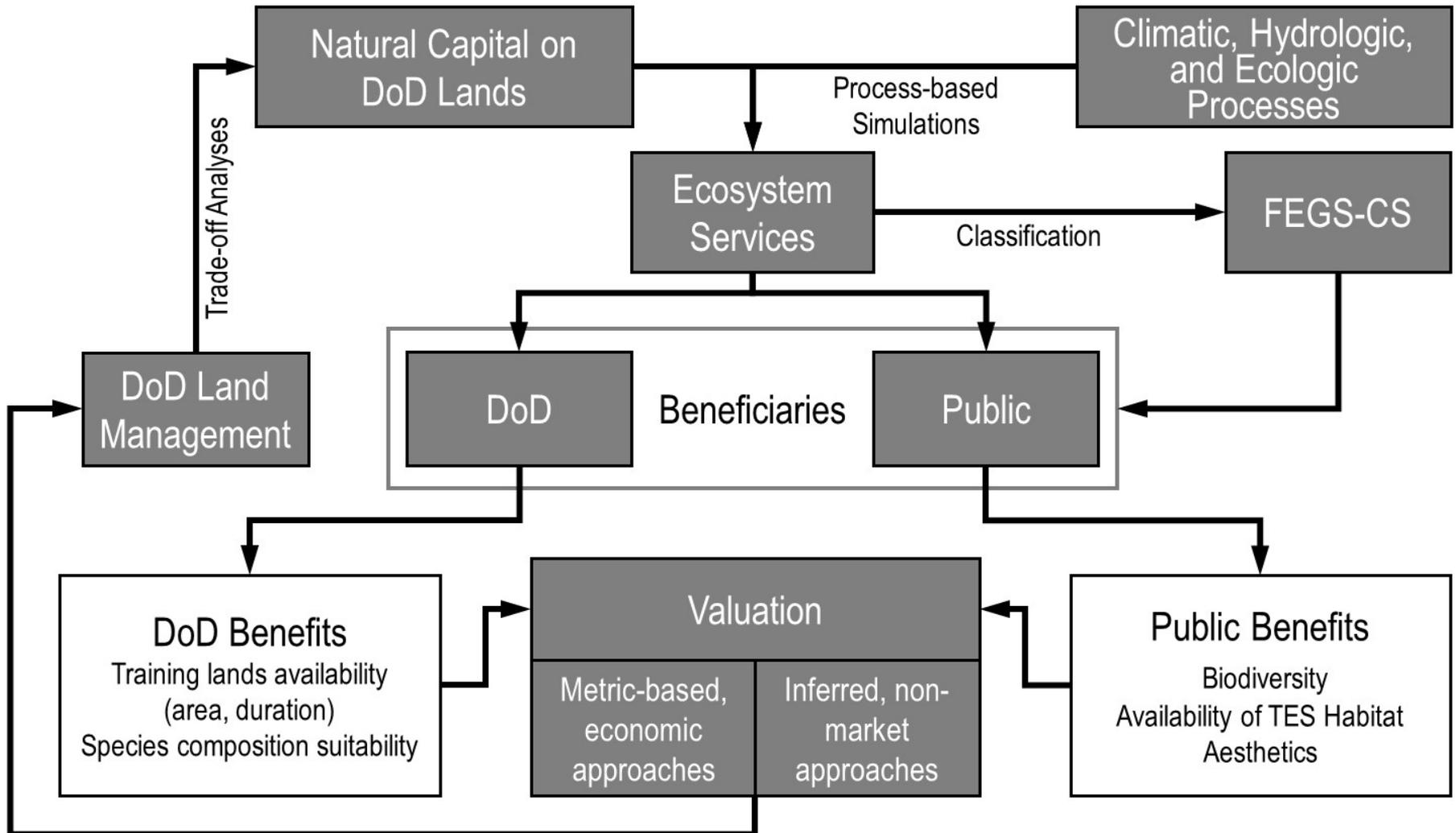
Process Models and ESs



Example Valuing ESs: Basic Concept



Valuing ESs: Concept Extended



Adapting FEGS-CS

FEGS-CS

- Two independent hierarchies
 - Environment and beneficiaries
- Three environment classes, fifteen subclasses
 - Aquatic – six subclasses
 - Terrestrial – eight subclasses
 - Atmospheric – one subclass
- Ten beneficiary categories
 - 38 subcategories
- A 15×38 matrix of potential benefits (the FEGS)

DoD-Specific FEGS-CS Matrix

- Limited environment to terrestrial class only
- Identified and refined beneficiaries
 - DoD beneficiaries
 - Public beneficiaries
- 3×16 matrix of benefits from DoD lands

DoD Terrestrial Classes

Beneficiary Category	Beneficiary Description	Environmental Subclasses		
		XY=21 (Forests)	XY=24 (Grasslands)	XY=25 (Scrublands/ Shrublands)
XY.01 Agricultural				
XY.0107	DoD foresters	X	X	X
XY.0108	DoD wildlife biologists	X	X	X
XY.02 Commercial and Industrial				
XY.0202	Timber extractors	X		
XY.0206	Resource-dependent businesses	X	X	
XY.03 Government, Municipal, and Residential				
XY.0303	DoD property owners	X	X	X
XY.0304	DoD military trainers	X	X	X
XY.04 Commercial/Military Transportation				
XY.0401	DoD transporters of goods		X	X
XY.0402	DoD transporters of people		X	X
XY.06 Recreational				
XY.0601	Experiencers and viewers	X	X	X
XY.0603	Hunters	X	X	
XY.07 Inspirational				
XY.0701	Spiritual and ceremonial (tribal)	X	X	X
XY.08 Learning				
XY.0801	Educators and students	X	X	X
XY.0802	Non-DoD researchers	X	X	X
XY.0803	DoD researchers	X	X	X
XY.09 Non-Use				
XY.0901	People who care (existence)	X	X	X
XY.0902	People who care (option/bequest)	X	X	X

Ecosystem Metrics for FEGS from DoD Lands

Beneficiary Category	Beneficiary Description	FEGS	Ecosystem Metrics (Ecosystem Units)
XY.0107	DoD foresters	harvested products, TES habitat	harvested quantity (tons) area (km ²), fragmentation
XY.0108	DoD wildlife biologists	TES habitat	area (km ²), biome, fragmentation ¹
XY.0202	Timber extractors	harvested timber	harvested quantity (tons)
XY.0206	Resource-dependent businesses	harvested products	harvested quantity (tons)
XY.0303	DoD property owners	land for buildings	area (km ²), fragmentation
XY.0304	DoD military trainers	training lands	area (km ²), biome, frequency of availability (d/y) ²
XY.0401	DoD transporters of goods	routes	length (km), frequency of availability (d/y)
XY.0402	DoD transporters of people	routes	length (km), frequency of availability (d/y)
XY.0601	Experiencers and viewers	recreation	area (km ²), frequency of access (d/y)
XY.0603	Hunters	recreation	area (km ²), frequency of access (d/y)
XY.0701	Spiritual and ceremonial (tribal)	the environment	area (km ²), frequency of access (d/y)
XY.0801	Educators and students	the environment	area (km ²), frequency of access (d/y)
XY.0802	Non-DoD researchers	the environment	area (km ²), frequency of access (d/y)
XY.0803	DoD researchers	the environment	area (km ²), frequency of access (d/y)
XY.0901	People who care (existence)	the environment	area (km ²)
XY.0902	People who care (option/bequest)	the environment	area (km ²), long-term availability (km ²)

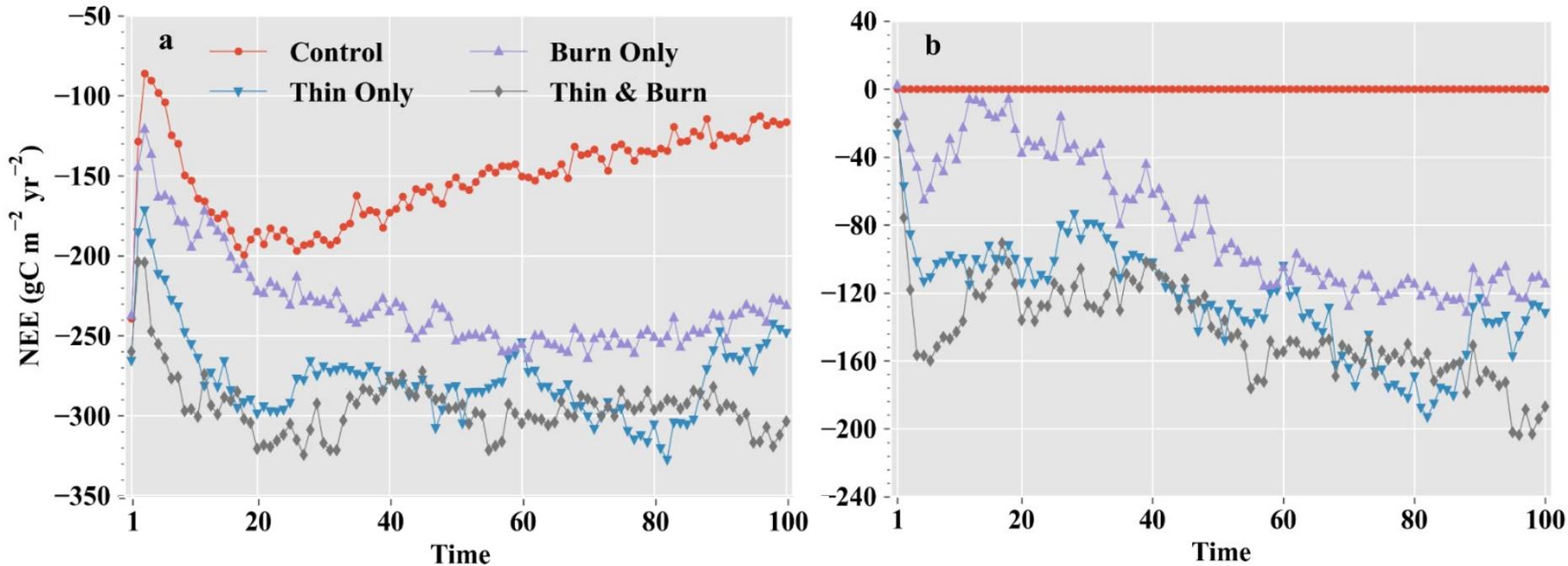
¹ Fragmentation occurs when the area related to a FEGS is broken up into smaller, more isolated patches. Fragmentation is measured by spatial characteristics like total edge length and edge density of FEGS parcels (e.g., area suitable for a TES).

² D/Y stands for days per year.

Simulating ESs

- LANDIS-II simulations
 - Biomass outputs and species age under future climate scenario and various land management alternatives
 - Defined training areas
 - Training – mounted: grasslands/savanna + shrublands/scrublands
 - Training – dismounted: forests – (habitat + ceremonial)
 - Defined habitat areas
 - Endangered species
 - Defined harvest areas
 - Defined non-use environment areas (habitat + ceremonial)

Example Results from Joint Base Lewis-McChord (JBLM)

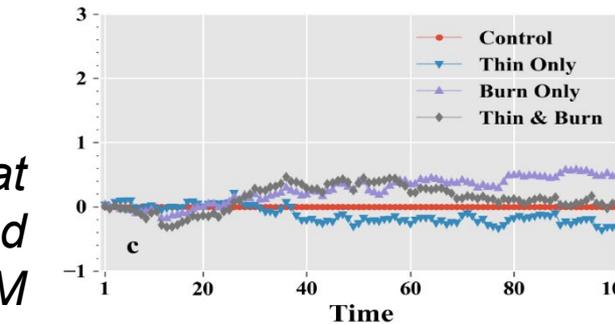
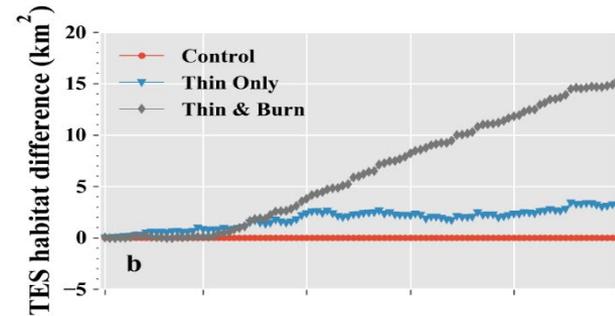
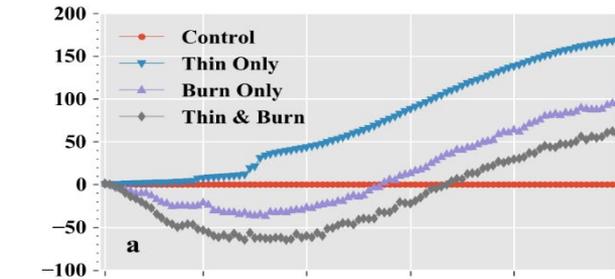
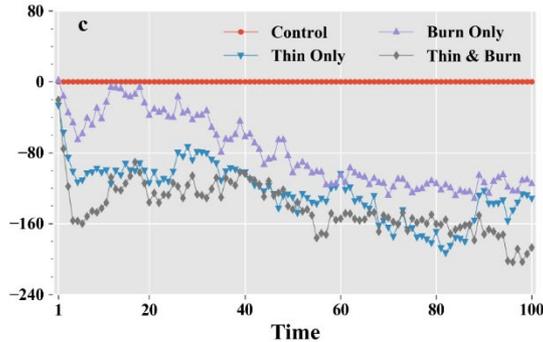
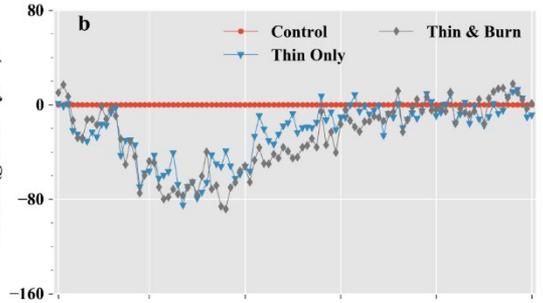
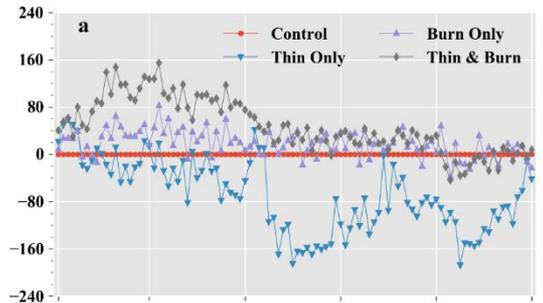


Relative to the control (red) stands, treated stands have greater carbon uptake (more negative NEE)

Note: NEE = Net Ecosystem CO₂ Exchange

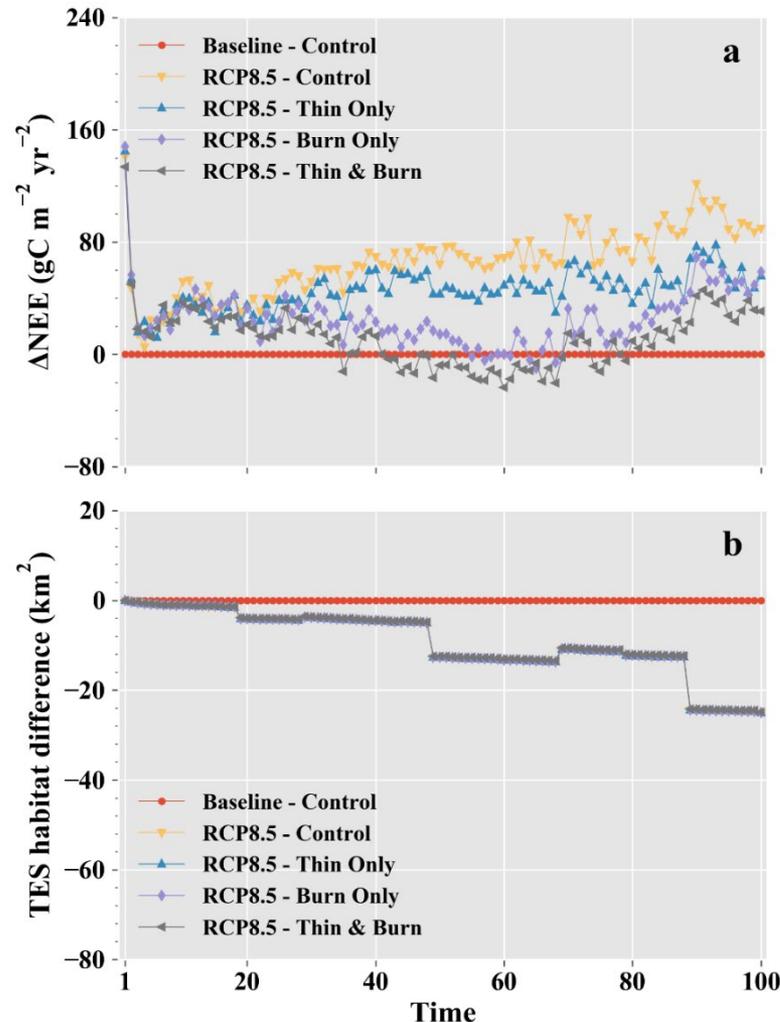
Variability, but TES Habitat Enhanced by Treatments

NEE at Fort Benning (FB), Camp Navajo (CN) and JBLM



TES area at FB, CN and JBLM

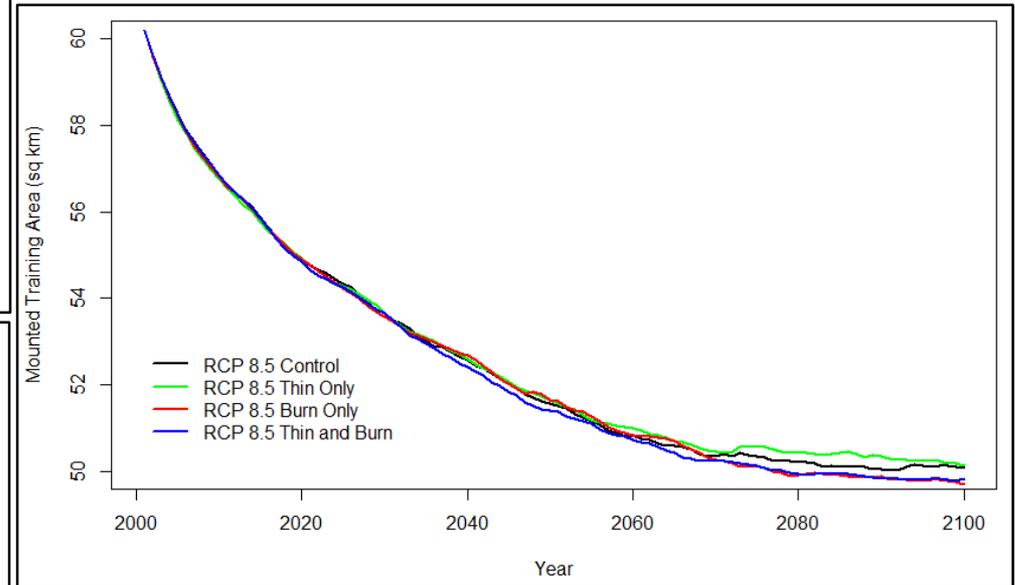
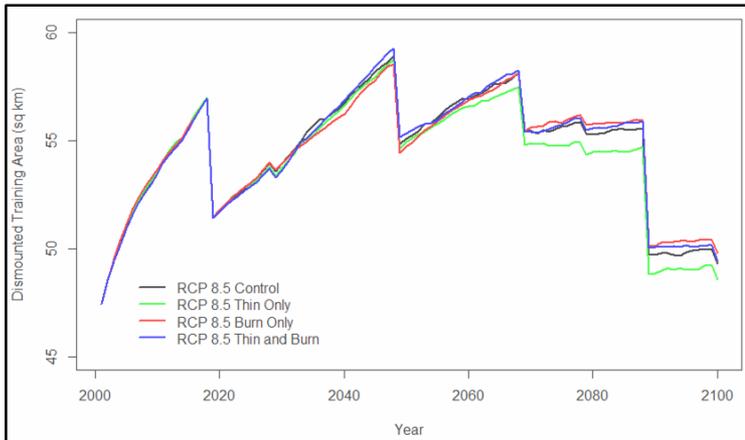
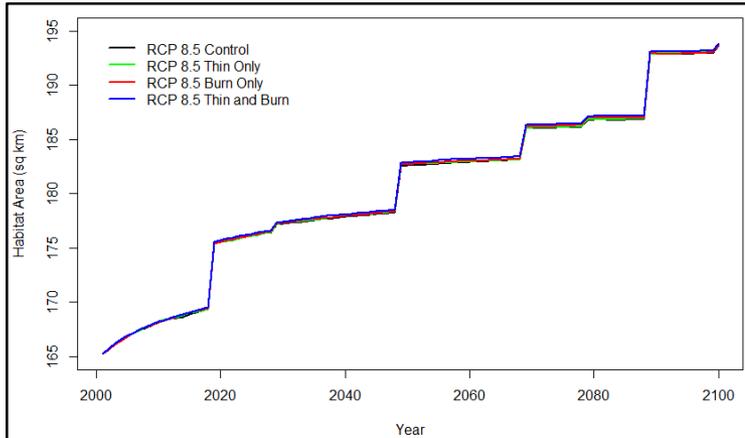
Warming Overwhelms the Benefits of Treatments



Proof-of-Principle Application (JBLM)

- Objectives
 - Estimate FEGS for DoD (training and TES habitat) and the public (harvest, recreation, and the environment) in ecosystem units (areas)
 - Estimate values of FEGS for DoD and the public in economic metrics
 - Compare values derived by the DoD and the public under different land management scenarios
- Assumptions/notes
 - Habitat area, as defined, occurs in forests
 - Mounted training area has no forests, so no habitat
 - Dismounted training area is forests less habitat
 - Effect of training on habitat loss is not yet incorporated in simulations

Training Lands: Warming Impacts



Warming reduces training area

Preliminary FEES-CS-Process Model Results from JBLM

- Differences among land management alternatives minimal
- Even in RCP 8.5 scenario, forest seems to encroach on grassland/savanna and shrubland/scrubland
- Mounted training area has the potential to decrease by 17%
- Dismounted training area has increasing tendencies during first half of the century, but shows slowdown and decline in the second half of the century

Preliminary FEES-CS-Process Model Results from JBLM (Cont'd)

- Habitat area seems to steadily increase – up to 18% by the end of the century, primarily because of expansion of Douglas-fir
- Opportunity for DoD to maintain timber harvest both as a revenue stream and to maintain availability of mounted training area
- Need to carefully plan training, particularly dismounted training
- There appears to be sufficient natural capital for public non-use benefits

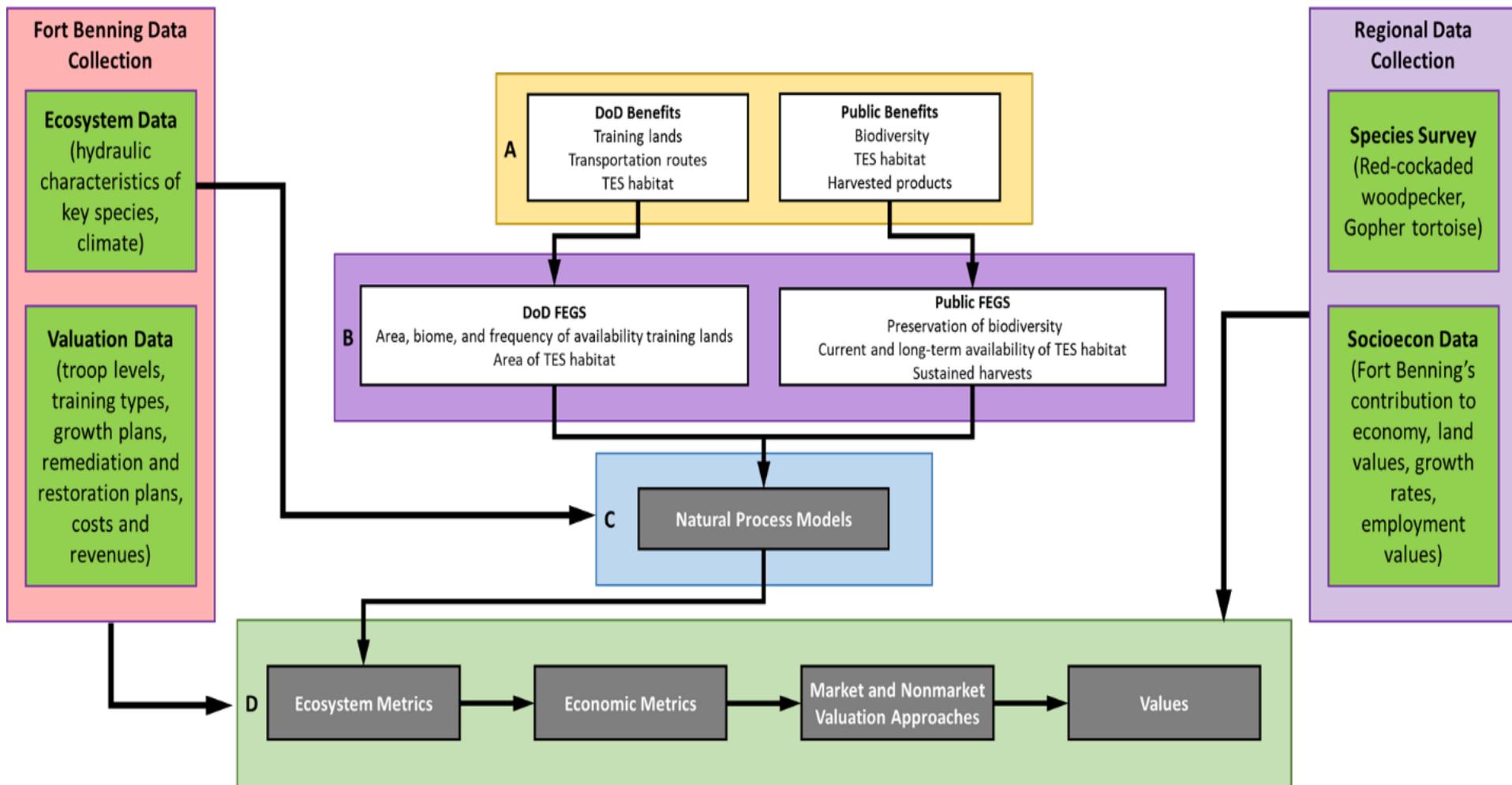
Gaps Identified

- Regarding ecosystem services characterization
 - Limited to terrestrial class
 - Need to model effects of training on habitat areas
 - Seasonal, rather than annual simulation results
- Regarding valuation
 - Need DoD values of training lands (area, frequency, seasonality, costs)
 - Need site-specific public non-use values (existence, bequest)
 - Need to connect habitat areas to TES species abundance and values
 - Need to further investigate the relationship between abundance of non-use FEGS and their value

Next Steps

- Simulations – modeling ES
 - Potentially try a more mechanistic and representative model
 - Evaluate generalizable principles that allow scaling across DoD bases
 - Explicitly model effects of training on various land categories
- Valuation
 - Connect habitat areas to TES species abundance and values
 - Site-specific public non-use values (existence, bequest)
 - Further investigate the relationship between abundance of non-use FEGS and their value

Going Forward



DoD Benefits

- Fair valuation of ESs
- Ability to forecast ES responses to climate and management
- Decision making tool
- Improved public relationships through ES valuation

Conclusions

- The process model appears accurate, but must be improved for more mechanistic predictions
 - Species poorly characterized, poorly tested
- The valuation framework is logical, but also must be tested
 - In depth study of Fort Benning proposed; allows focused analyses on the value of the FEGS-CS-process model approach to valuation of training lands
- Improved representation of end-user needs is critical
 - Training lands
 - Other habitat requirements

SERDP & ESTCP Webinar Series

For additional information, please visit
<https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/RC18-1605>

Speaker Contact Information

nate.mcdowell@pnnl.gov; 505-412-7158



Q&A Session 1



Assessing Ecosystem Service Benefits from Military Installations Using MoTIVES

Mark Borsuk, Ph.D.
Duke University



Agenda

- Military bases provide important ecosystem services
- Base management will influence these services
- Monetary values can be estimated using MoTIVES
- Proof of concept
 - Eglin Air Force Base
- The approach is robust and transferable

Ecosystem Services

- Direct and indirect contributions of ecosystems to human well-being
- US military lands provide important non-military ecosystem services to the public



*U.S. Air Force photo by
Senior Airman Cody
Miller*

- These include flood protection, habitat provision, outdoor recreation, and carbon storage

Base Management

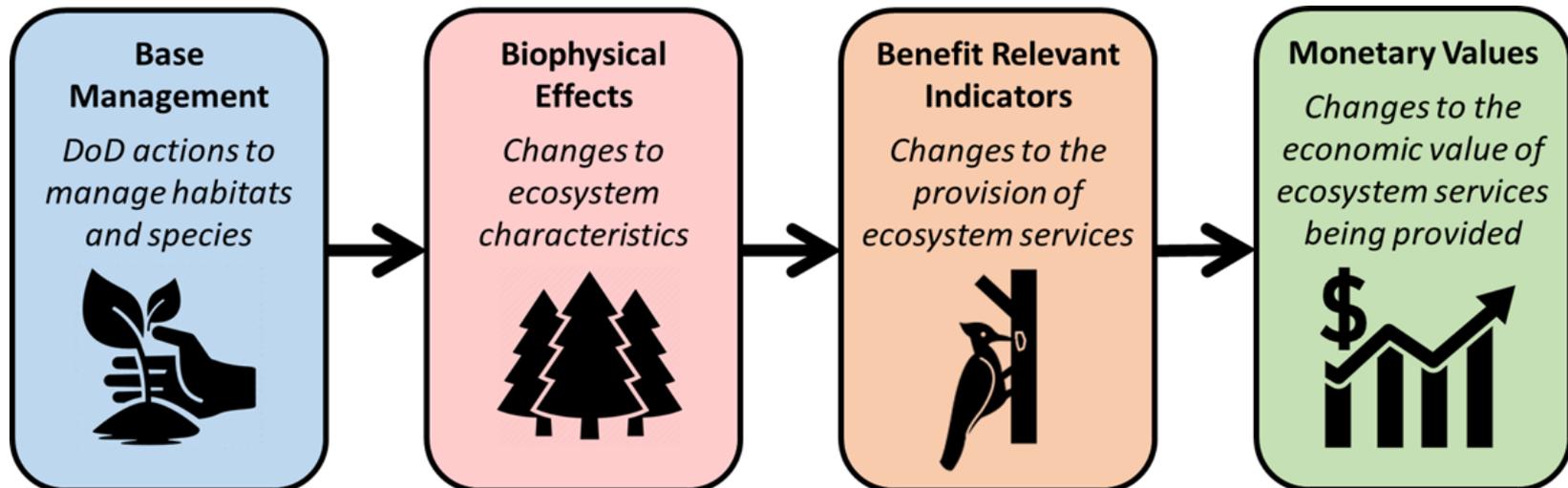
- Normal base activities and natural resource management will influence ecosystem services
- Mechanisms include fire, forestry, erosion control, habitat restoration, and land conversion



*U.S. Air Force photo
by Staff Sgt. Mike Meares*

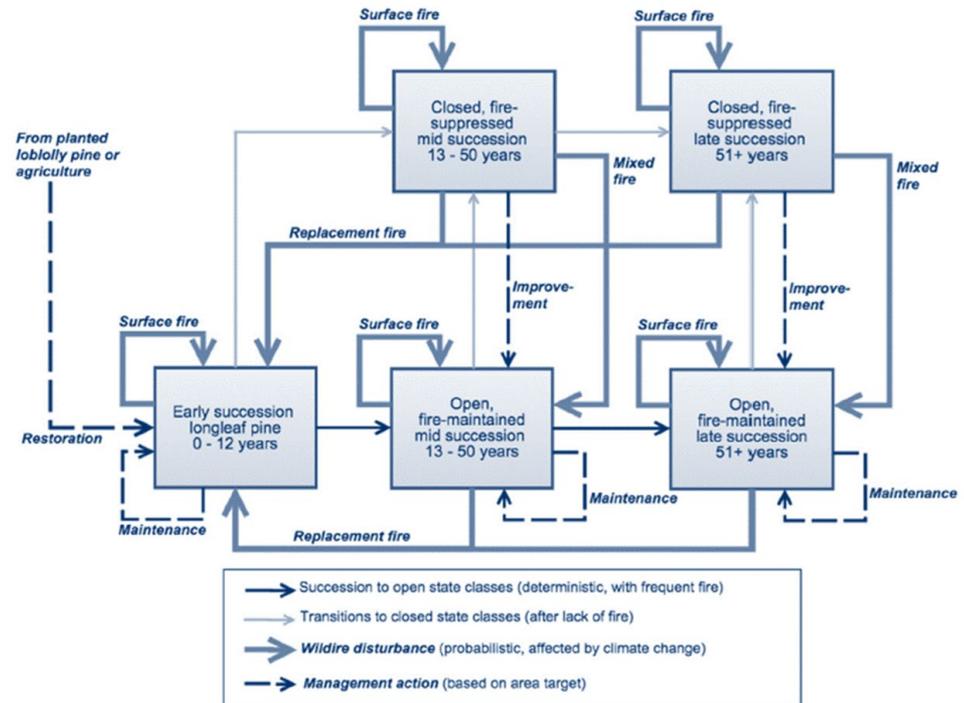
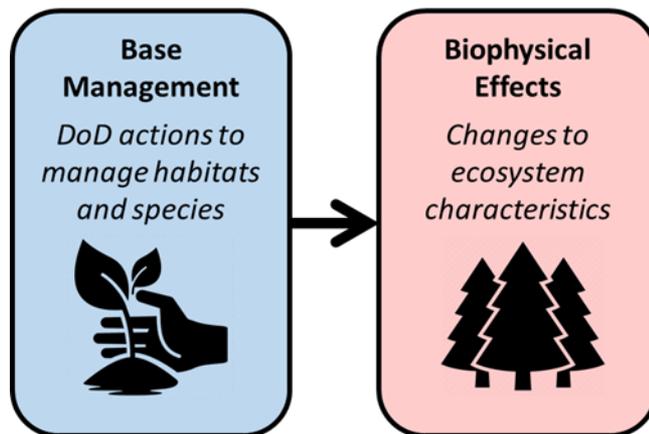
Project Objectives

- Develop a model that can:
 - Estimate the monetary value of ecosystem services provided by U.S. military bases
 - Link base management activities to ecosystem service values



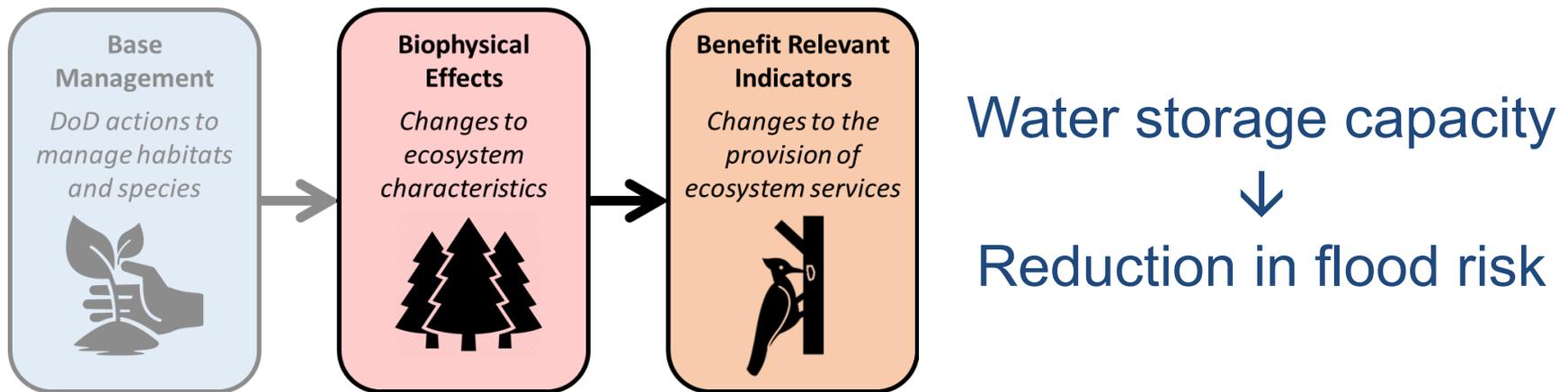
Biophysical Effects

- To link management actions to biophysical effects, we developed ecological simulation models



Benefit Relevant Indicators (BRIs)

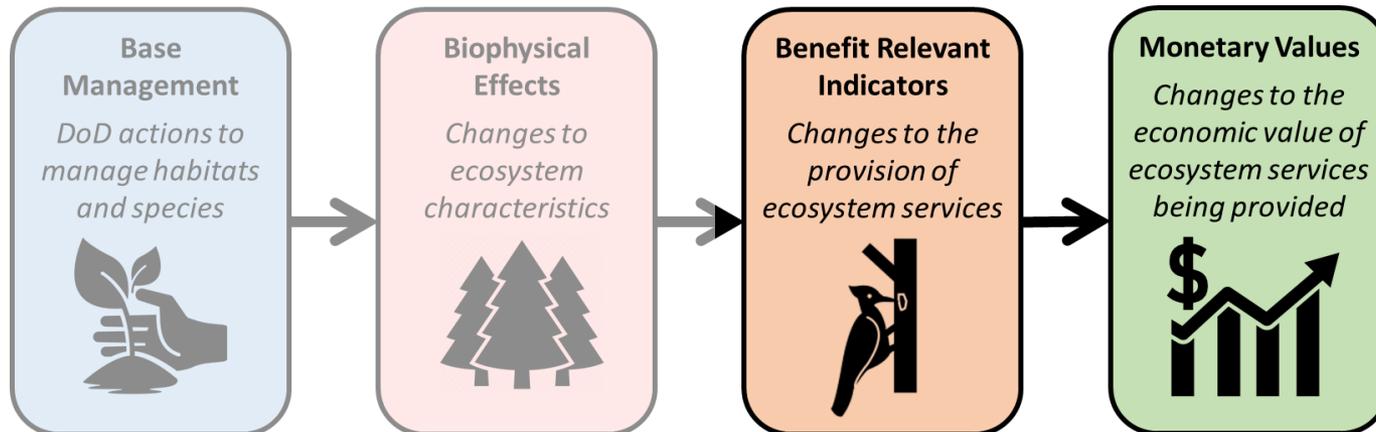
- BRIs translate biophysical effects to ecosystem services



- Using, for example:
 - Flood risk models (HEC-FIA, HEC-RAS)
 - Smoke exposure model (CMAQ)
 - Storm surge model (SLOSH)
 - Data analysis

Economic Valuation

- We assign monetary values to BRIs whenever possible

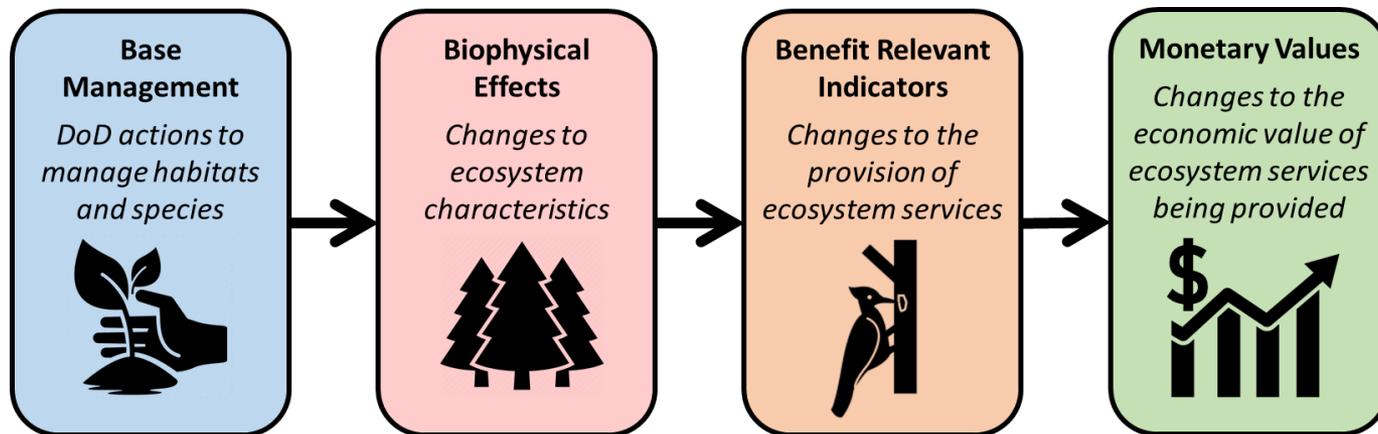


- Market values
- Avoided costs
- Willingness to pay

- Social cost of carbon
- Benefits transfer

Model Integration

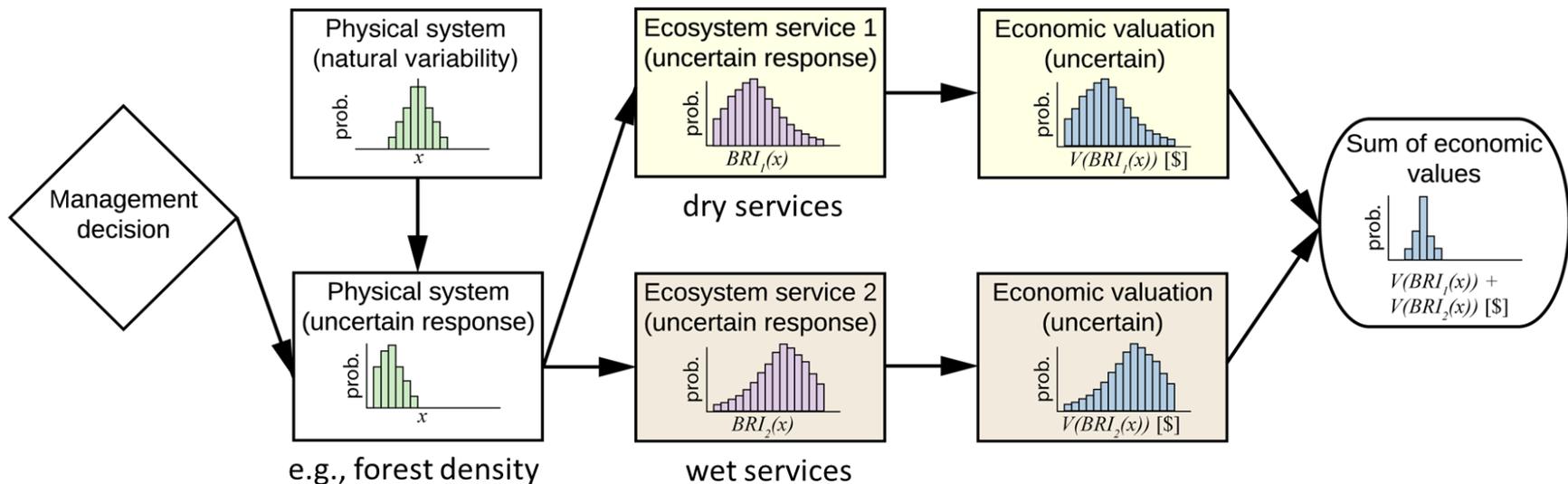
- We connect all components to account for cumulative effects, co-benefits, and feedbacks



Model-based Tracking and Integrated Valuation of Ecosystem Services (MoTIVES)

Model Integration

- Holistic tracking of uncertainty improves predictive accuracy and precision



Proof of Concept: Eglin AF Base

- Coastal waters support at-risk fish species and desirable fishing spots
- Includes much of Santa Rosa Island, a Gulf of Mexico barrier island
- Provides habitat for turtles, endangered shorebirds, threatened lichen
- Protects communities from storm surges and coastal flooding



*U.S. Air Force photo by
Master Sgt. Donald R. Allen*

Base Management Scenarios

1. Current management scenario

- Prescribed burning to create conditions favorable to longleaf pine and associated wildlife species

2. No-management scenario

- Continued military operations but no (current or historical) management for natural resources

3. No-base scenario

- Counterfactual scenario in which the base never existed



U.S. Air Force photo by Staff Sgt. Mike Meares

Base Management
DoD actions to manage habitats and species

Biophysical Effects
Changes to ecosystem characteristics

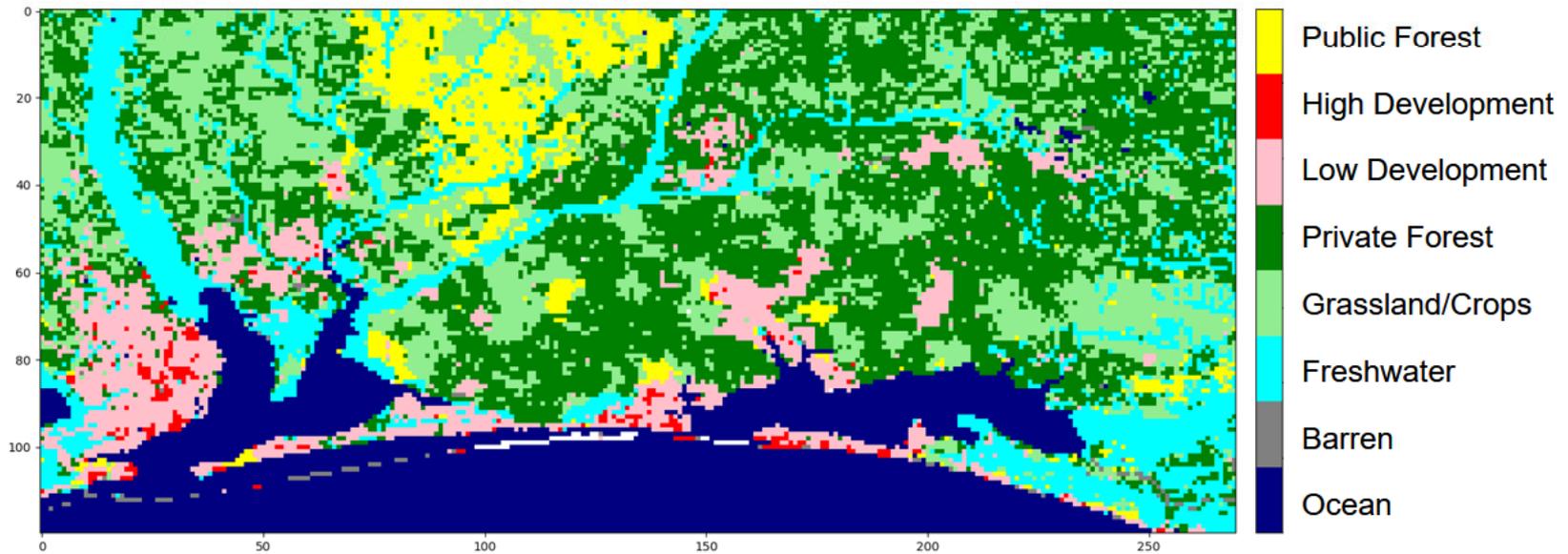
Benefit Relevant Indicators
Changes to the provision of ecosystem services

Monetary Values
Changes to the economic value of ecosystem services being provided

Base Management Scenarios

3. No-Base Scenario

- Replace current base footprint with hypothetical land use patterns by sampling logical combinations of adjacent land uses

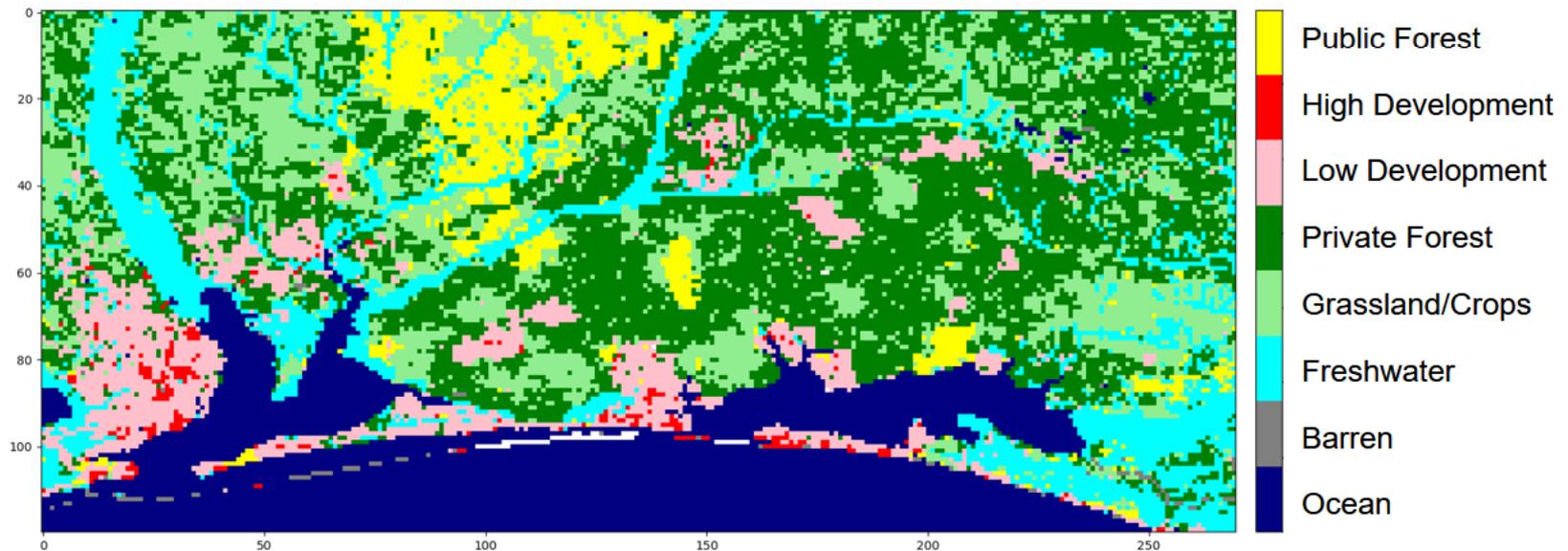


This is done using a novel Bayesian machine learning algorithm

Base Management Scenarios

3. No-Base Scenario

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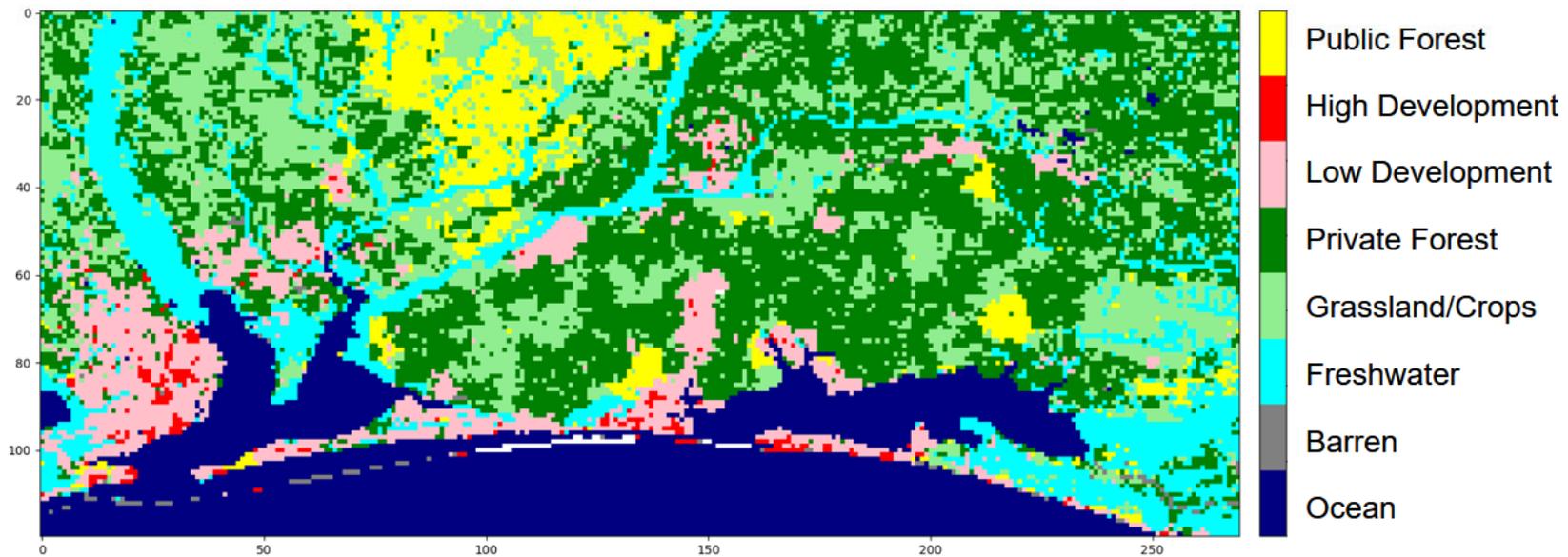


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Base Management Scenarios

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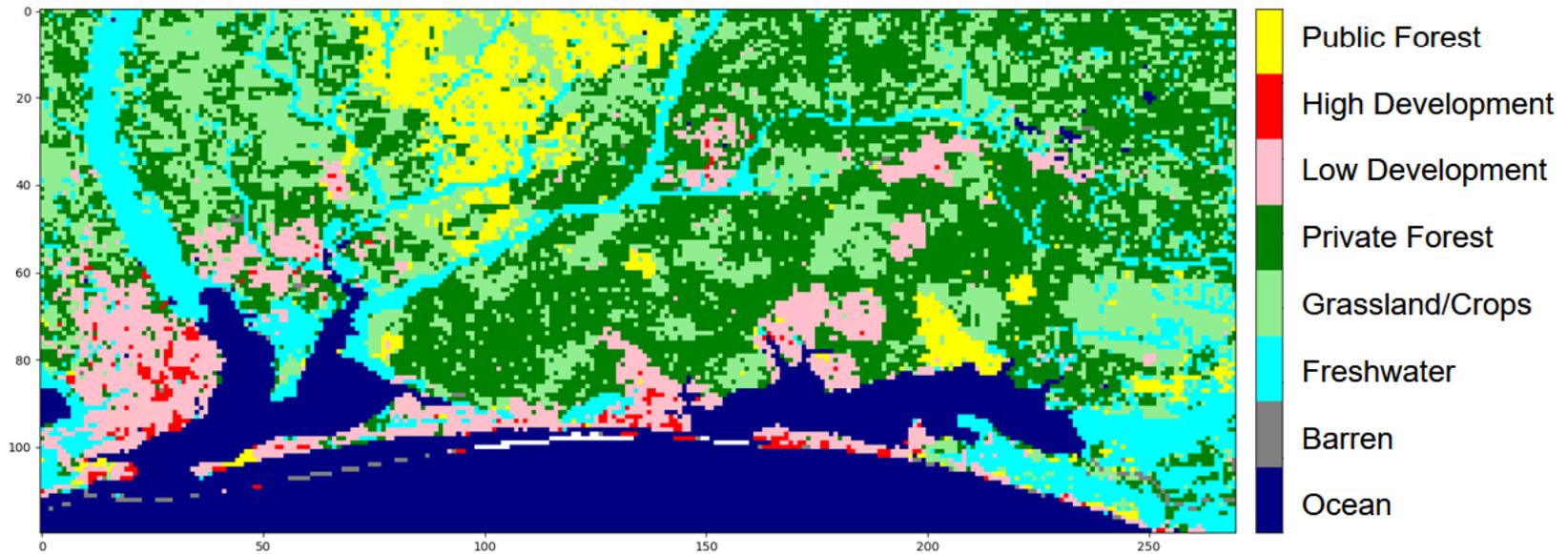


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Base Management Scenarios

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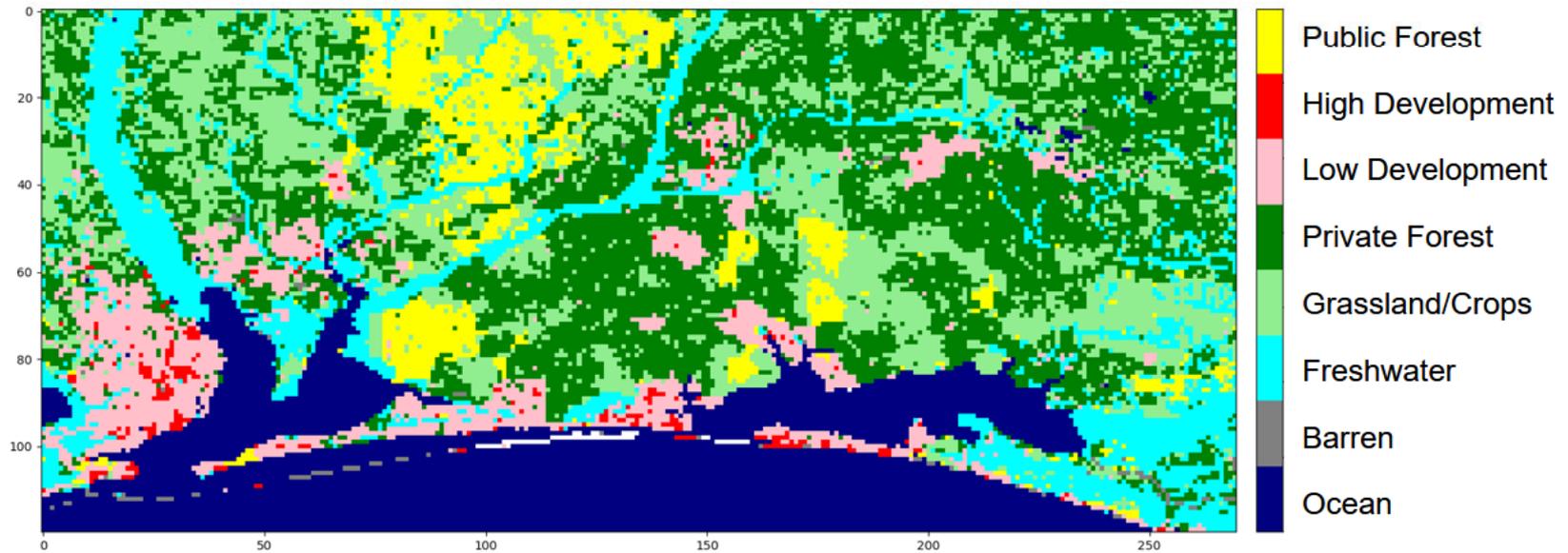


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Base Management Scenarios

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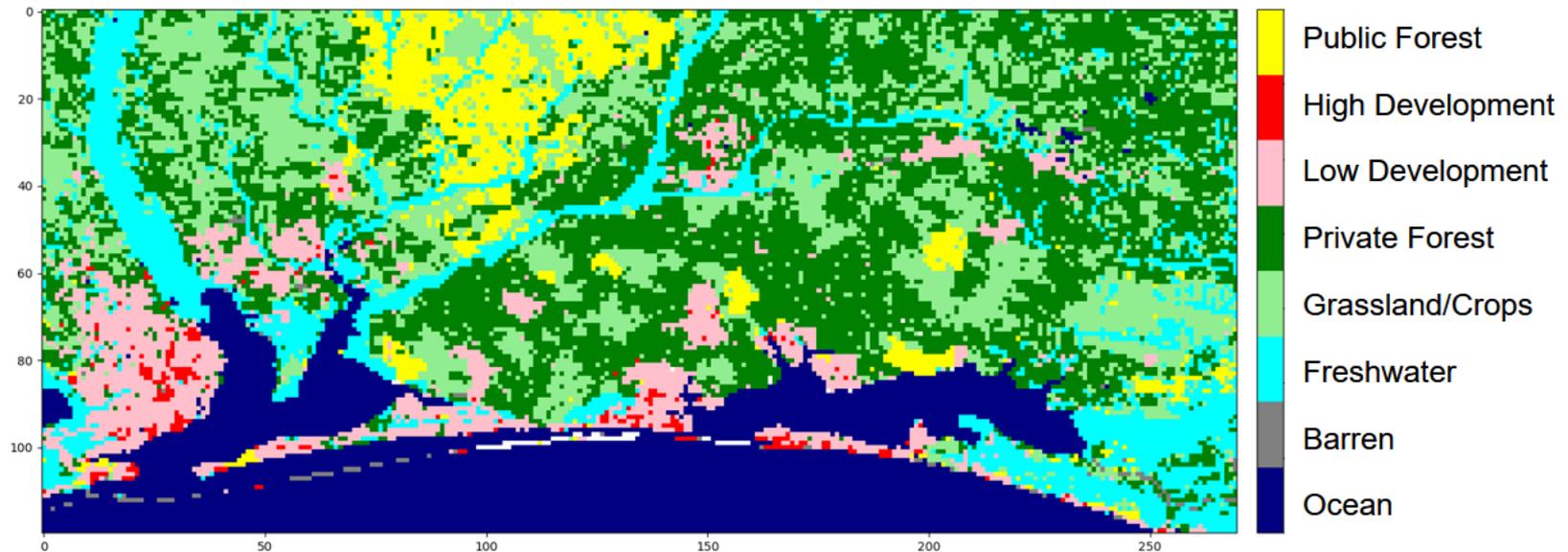


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Base Management Scenarios

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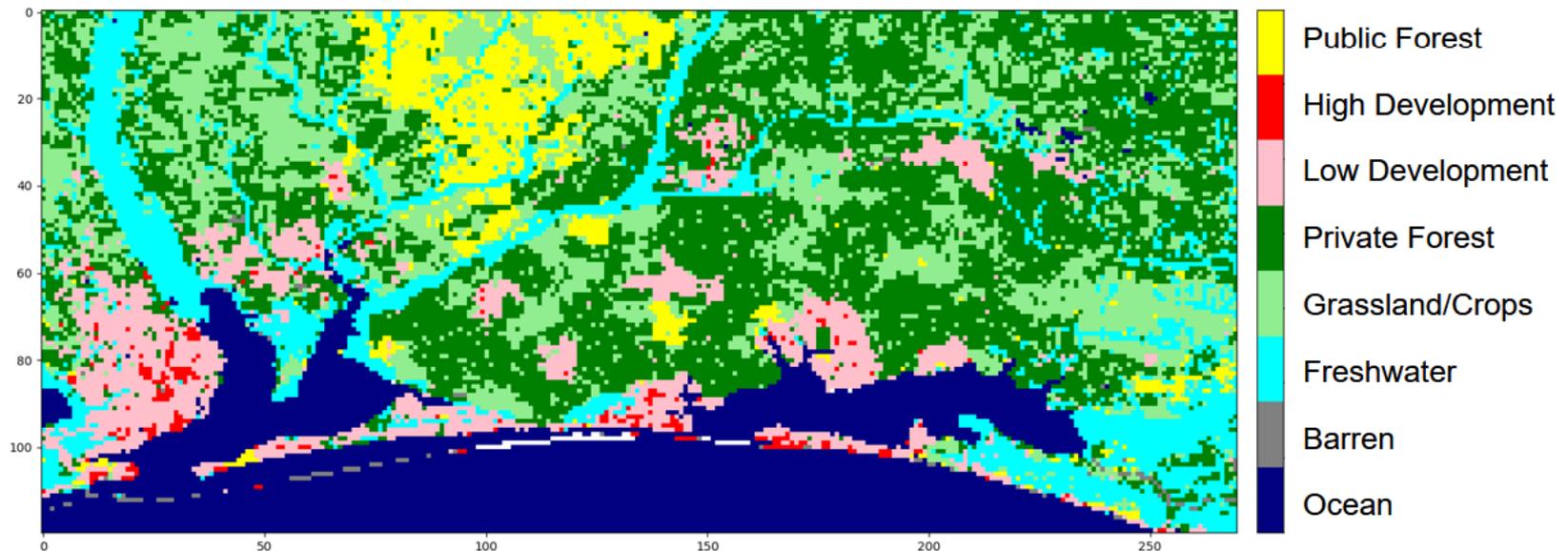


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Base Management Scenarios

3. No-Base Scenario

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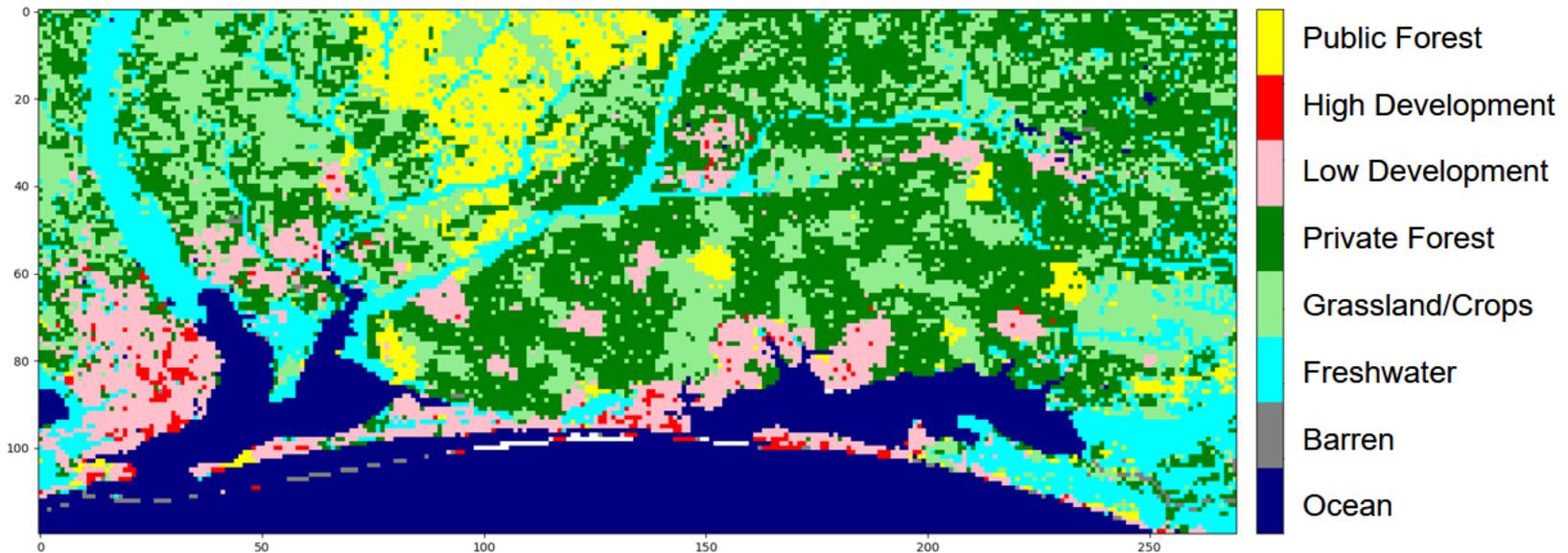


This is done using a novel Bayesian machine learning algorithm

Base Management Scenarios

3. No-Base Scenario

- Replace current base footprint with hypothetical land use patterns by sampling logical combinations of adjacent land uses



This is done using a novel Bayesian machine learning algorithm

Results: Biophysical Effects

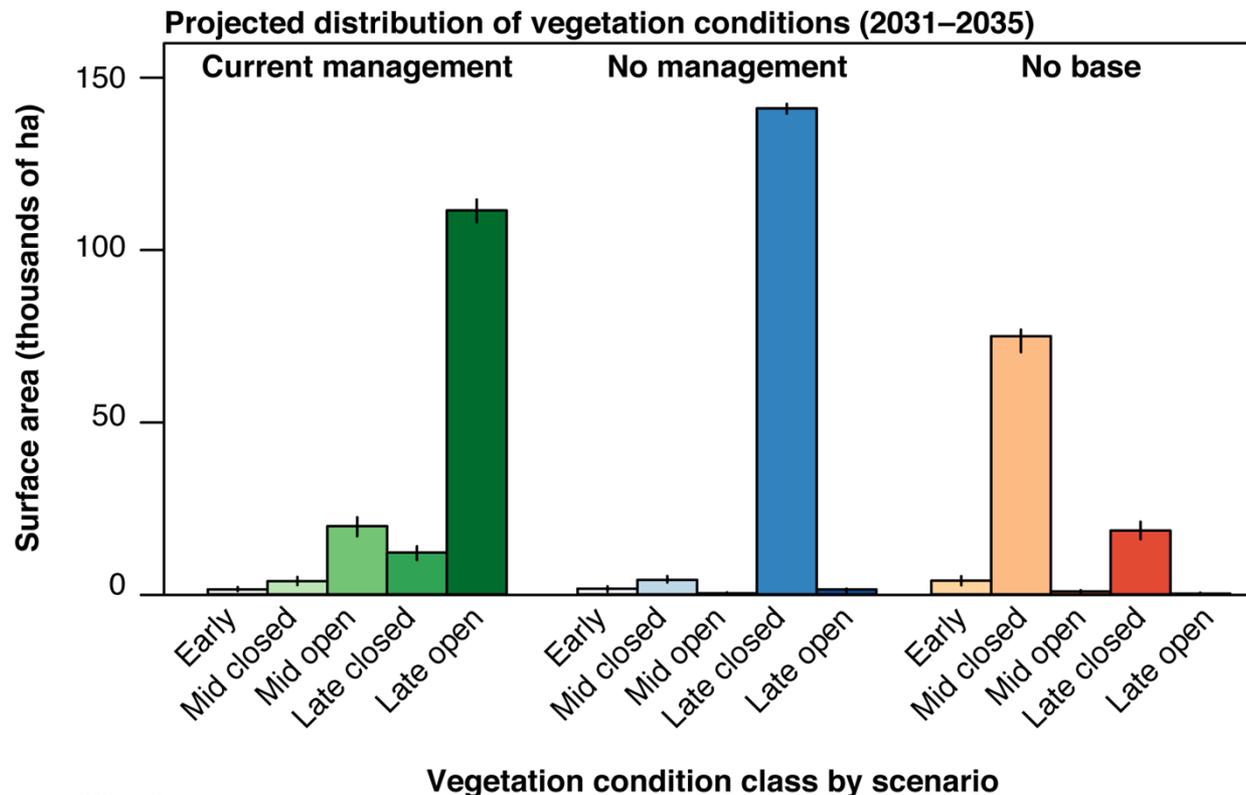
- Without active management, longleaf pine condition degrades from open (desirable) to closed (undesirable) forest conditions

Base Management
DoD actions to manage habitats and species

Biophysical Effects
Changes to ecosystem characteristics

Benefit Relevant Indicators
Changes to the provision of ecosystem services

Monetary Values
Changes to the economic value of ecosystem services being provided



Results: Benefit Relevant Indicators

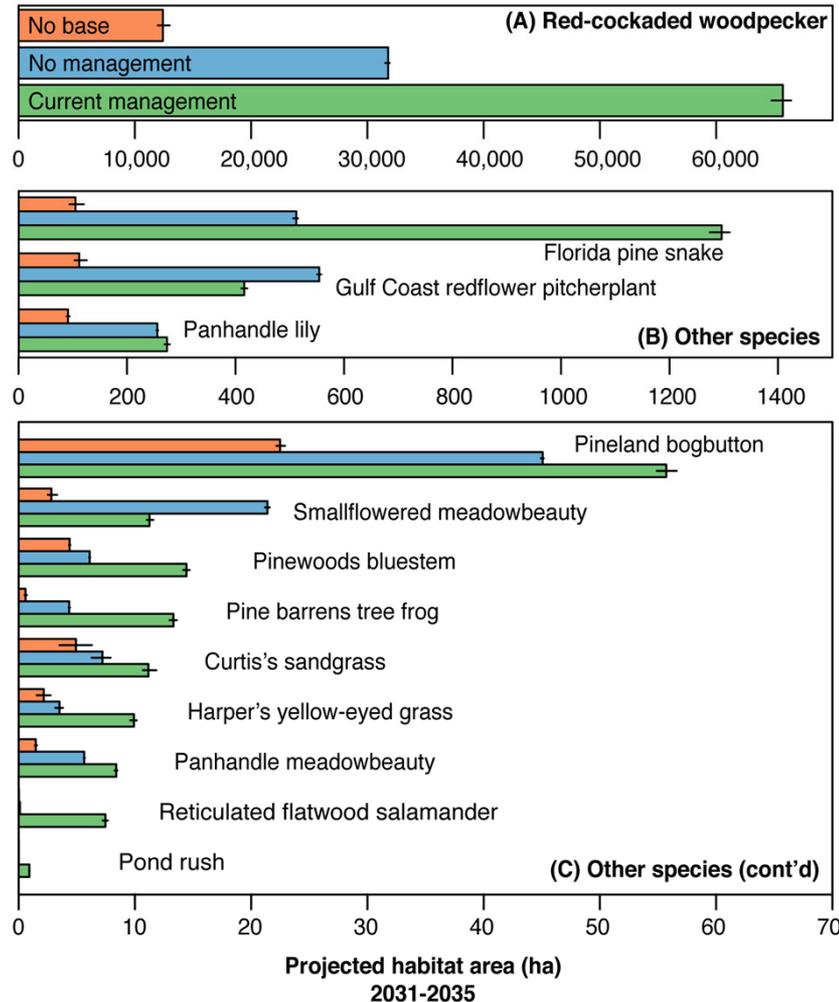
- Current management practices greatly enhance habitat area for most threatened species, relative to both the 'no management' and the 'no-base' scenarios

Base Management
DoD actions to manage habitats and species

Biophysical Effects
Changes to ecosystem characteristics

Benefit Relevant Indicators
Changes to the provision of ecosystem services

Monetary Values
Changes to the economic value of ecosystem services being provided



Results: Monetary Value

- Current management generates \$76 million per year more in ecosystem services than the 'no management' scenario and \$58 million per year more than the 'no-base' scenario

Base Management
DoD actions to manage habitats and species



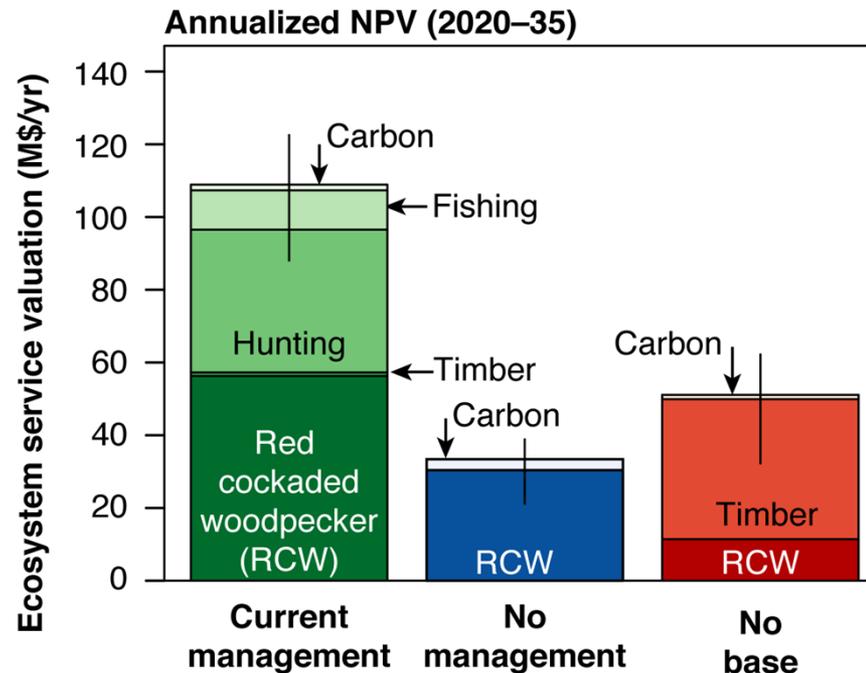
Biophysical Effects
Changes to ecosystem characteristics



Benefit Relevant Indicators
Changes to the provision of ecosystem services



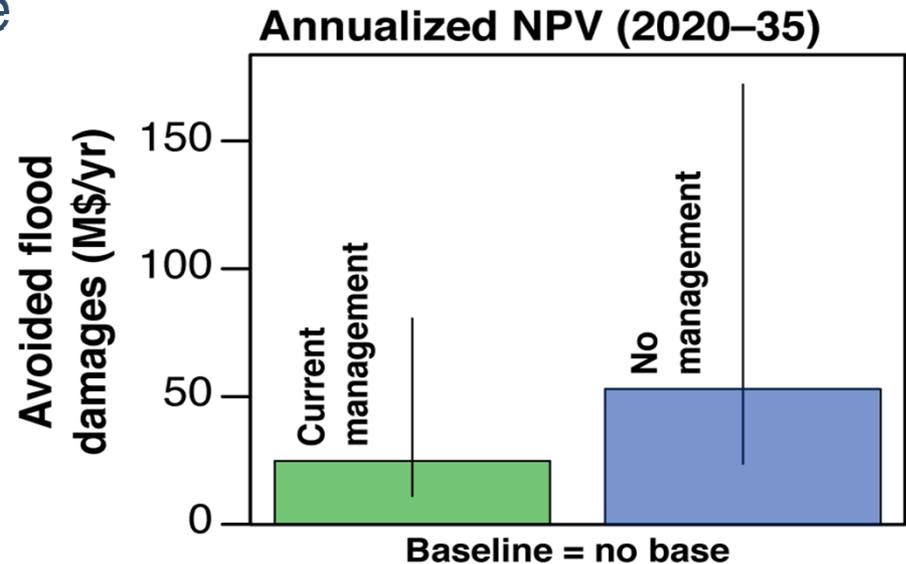
Monetary Values
Changes to the economic value of ecosystem services being provided

Note: NPV = Net Present Value

Results: Monetary Value

- Current management practices avoid flood damages of \$26 million compared to the ‘no base’ scenario
 - This is \$30 million per year less in avoided flood damages than the ‘no management’ scenario
 - Difference is outweighed by enhancement of other ecosystem services



Base Management
DoD actions to manage habitats and species

Biophysical Effects
Changes to ecosystem characteristics

Benefit Relevant Indicators
Changes to the provision of ecosystem services

Monetary Values
Changes to the economic value of ecosystem services being provided

Conclusions

- Holistic and rigorous accounting of uncertainty, allows for robust quantification of differences between scenarios
- Bayesian machine learning algorithm simulates land use if base were never installed
- Current management at Eglin Air Force Base generates \$75.6 million per year in ecosystem services
- To ensure generalizability, we will apply MoTIVES to a diverse set of bases

Benefits to DoD

- This project enhances the DoD's ability to:
 - Document the value that military bases provide to local communities in the form of ecosystem services
 - Predict the impact of future land use and land management activities on ecosystem service production



U.S. Air Force photo/Ilka Cole

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Q&A Session 2



The next webinar is on
June 4, 2020

*Waste Reduction and Treatment in
Armed Forces Vessel
Environments*



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