



Pacific Northwest
NATIONAL LABORATORY

Valuing Ecosystem Services

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SERDP • ESTCP
SYMPOSIUM
2019 | Enhancing DoD's Mission Effectiveness

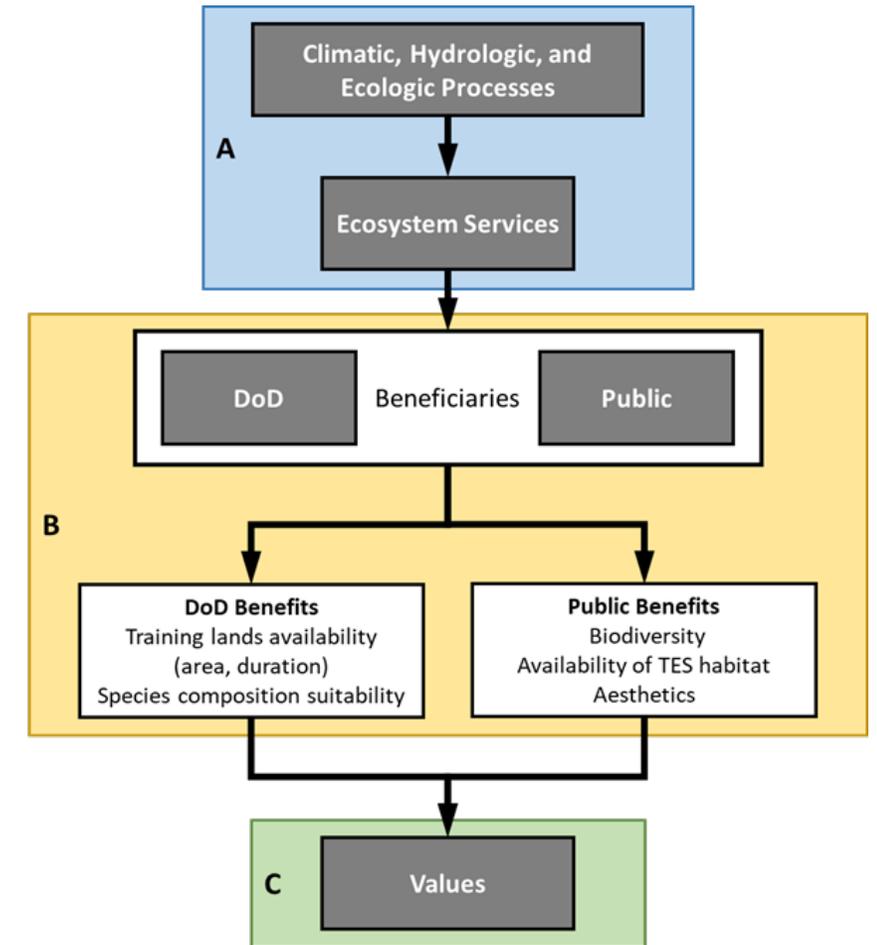
RC18-1605

Value and Resiliency of Ecosystem Services on DoD Lands

- The Team
 - Dr. Nathan McDowell, PNNL – PI
 - Dr. Rajiv Prasad, PNNL – Co-PI
 - Dr. Matthew Hurteau, University of New Mexico – Co-PI
 - Ms. Madison Moore, PNNL
 - Dr. Zeli Tan, PNNL
- Collaborators
 - Fort Benning, Camp Navajo, and Joint Base Lewis-McChord land managers
- Objective
 - A methodology for characterizing and valuing ecosystem services for DoD and the public

Simulation-Valuation Methodology Conceptual Representation

- Climatic, hydrologic and ecologic processes enable ecosystem services
- Beneficiaries consume, appreciate, and/or derive welfare from ecosystem services
- DoD and public benefits are enabled by ecosystem services provisioned on DoD lands
- Economic valuation methods, both market and non-market, are used to value the benefits



Ecosystem Services

- Ecosystem services of interest to the DoD
 - Provisioning of
 - Training and testing areas
 - Threatened and endangered species (TES) habitat
 - Harvested products
 - Land for buildings
- Ecosystem services of interest to the public
 - Provisioning of
 - TES habitat
 - Recreational areas
 - Environment (research, education, ceremonial and spiritual, existence, and bequest uses)
 - National defense

Benefits to the DoD and the Public

- DoD benefits

- Training
- TES ha
- Military

- Public b

- Harvest
- Recreat
- Spiritua
- Educati
- Non-use
- Nationa

- Final Ec

- Landers

FEGS-CS Matrix

Beneficiary Category	Beneficiary Description	Environmental Subclasses (XY)															
		Aquatic					Terrestrial										Atmospheric
		11	12	13	14	15	16	21	22	23	24	25	26	27	28	31	
XY.01 Agricultural																	
7 subcategories																	
XY.02 Commercial/Industrial																	
8 subcategories																	
XY.03 Government, Municipal, and Residential																	
4 subcategories																	
XY.04 Commercial/Military Transportation																	
2 subcategories																	
XY.05 Subsistence																	
4 subcategories																	
XY.06 Recreational																	
6 subcategories																	
XY.07 Inspirational																	
2 subcategories																	
XY.08 Learning																	
2 subcategories																	
XY.09 Non-Use																	
2 subcategories																	
XY.10 Humanity																	
1 subcategory																	

(S-CS)

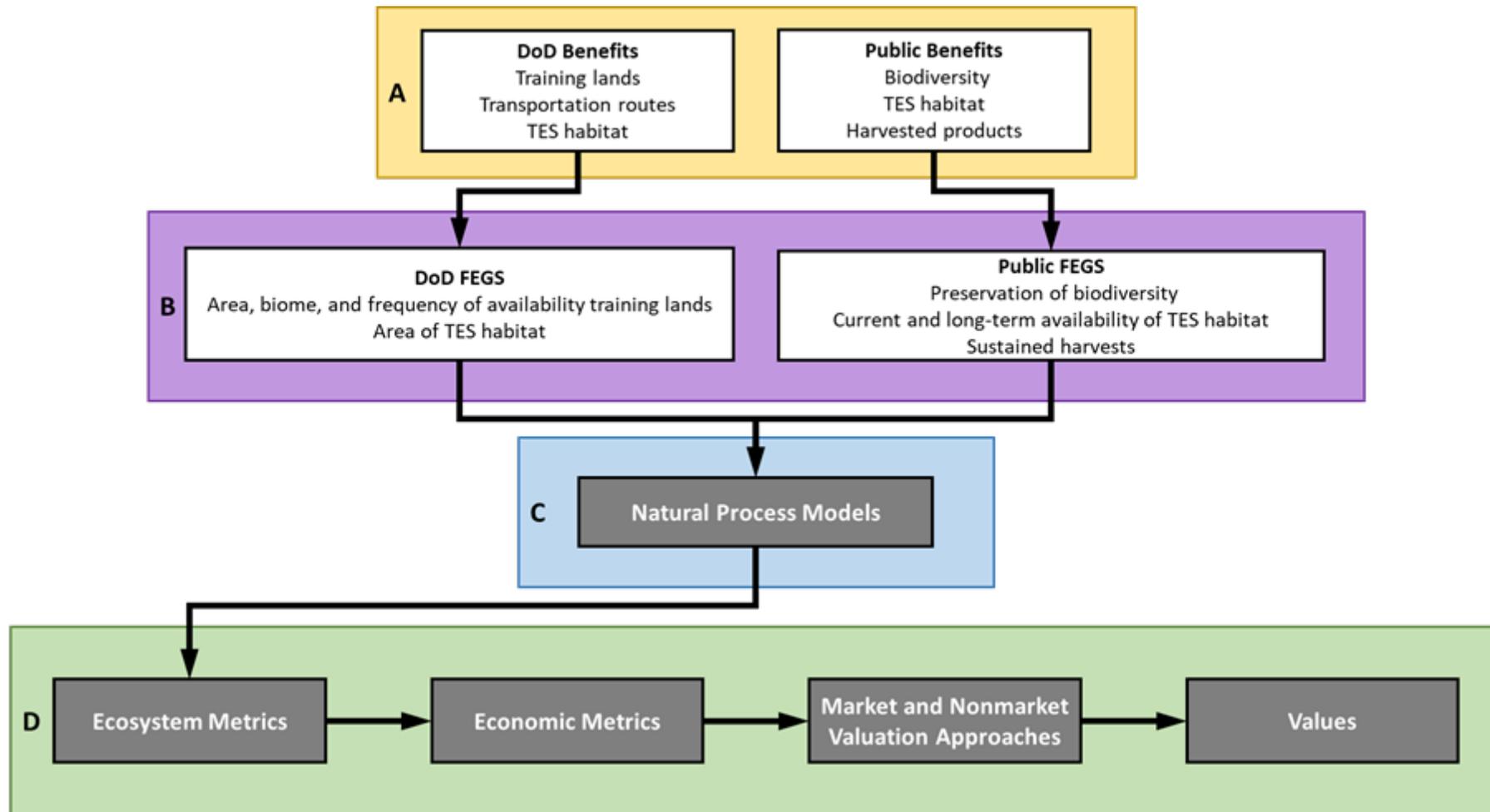
DoD-Specific FECS-CS Matrix

- Limited environment to terrestrial class only
 - and three subclasses—forests, grasslands and scrublands/shrublands
- Identified DoD beneficiaries
 - Needed refinements from original FECS-CS definitions
 - Added new DoD beneficiary subclasses
- DoD-Specific FECS-CS Matrix
 - 19 beneficiary subcategories
 - 3 environmental subclasses

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.0305	DoD military branches	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.0804	DoD soldiers	X	X	X
XY.09 Non-Use				
XY.0901	Non-users—existence	X	X	X
XY.0902	Non-users—option/bequest	X	X	X
XY.11 National Defense				
XY.1101	Citizens	X	X	X

Extending FECS-CS

Characterizing Ecosystem Services for Valuation



Economic Metrics Associated With Ecosystem Metrics

FEGS	Ecosystem Metrics	Economic Metrics
training lands	area (km ²), biome, frequency of availability (d/y)	<ol style="list-style-type: none"> 1. Cost of land used for training 2. Value of diverse training conditions 3. Distance and cost to travel to training areas

FEGS	Ecosystem Metrics	Economic Metrics
TES habitat	area (km ²), fragmentation	<ol style="list-style-type: none"> 1. Cost of alternative land management 2. Cost of restoring and maintaining habitat 3. Contribution of TES to ecosystem productivity 4. Willingness to pay (per km²) for species preservation
training	area (km ²), biome, frequency of availability (d/y)	<ol style="list-style-type: none"> 1. Value attributed to training (e.g., meeting training goals) 2. Value of obtained skillset in military and post-military professions
military readiness	sustained military training capacity (area (km ²), biome, frequency of availability (d/y; y/10y))	<ol style="list-style-type: none"> 1. Value of sustained national production 2. Cost to restore lost national production from compromised national assets

military readiness	sustained military training capacity (area (km ²), biome, frequency of availability (d/y; y/10y))	<ol style="list-style-type: none"> 1. Value of sustained national production 2. Cost to restore lost national production from compromised national assets
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Economic Valuation Approaches

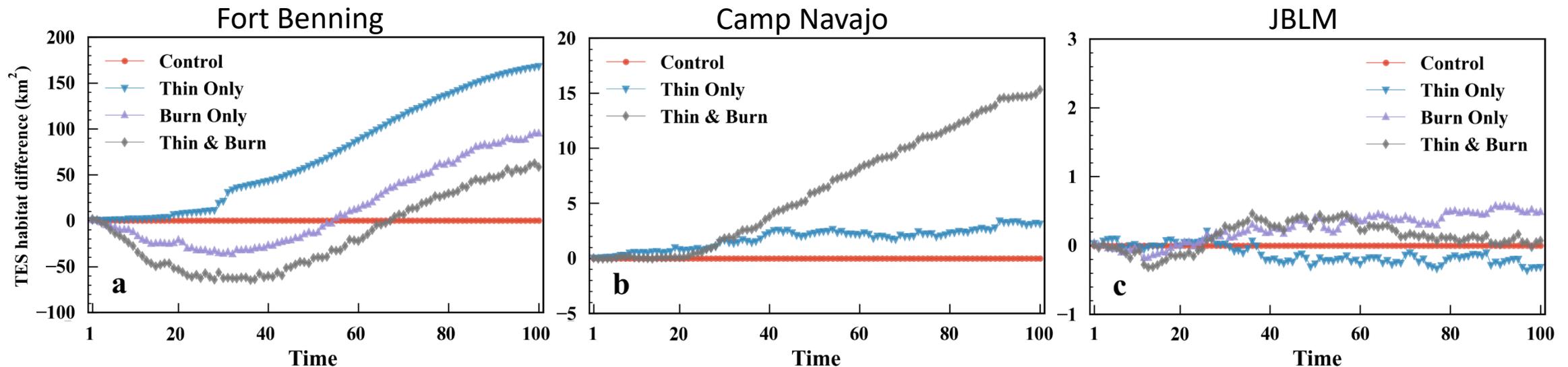
- Market valuation approaches
 - For FEGS that are traded in a marketplace
 - Examples: timber, housing, land
 - Methods: Production Function Approaches
- Nonmarket valuation approaches
 - For FEGS that do not have a market associated with them
 - Example: TES habitat, military training, national defense
 - Methods: Replacement Cost Approach, Hedonic Approach, Travel Cost Approach, Contingent Valuation Method, Benefit Transfer Method

Results: Science Insights

- LANDIS-II simulations
 - Fort Benning, Camp Navajo, and JBLM
 - Martin et al. 2015, Hurteau et al. 2016, Laflower et al. 2016
 - Century Succession extension to simulate ecosystem carbon dynamics
 - Leaf Biomass Harvest and Dynamic Fire and Fuels extensions to simulate disturbance
 - Fire is simulated stochastically (Camp Navajo and JBLM)
 - User-defined fire size distribution, probability of occurrence, and spread characteristics
 - Combinations of thinning and prescribed burning at all three sites
 - LANDIS-II simulations used historical climate scenarios at all three sites and also future climate scenarios at JBLM

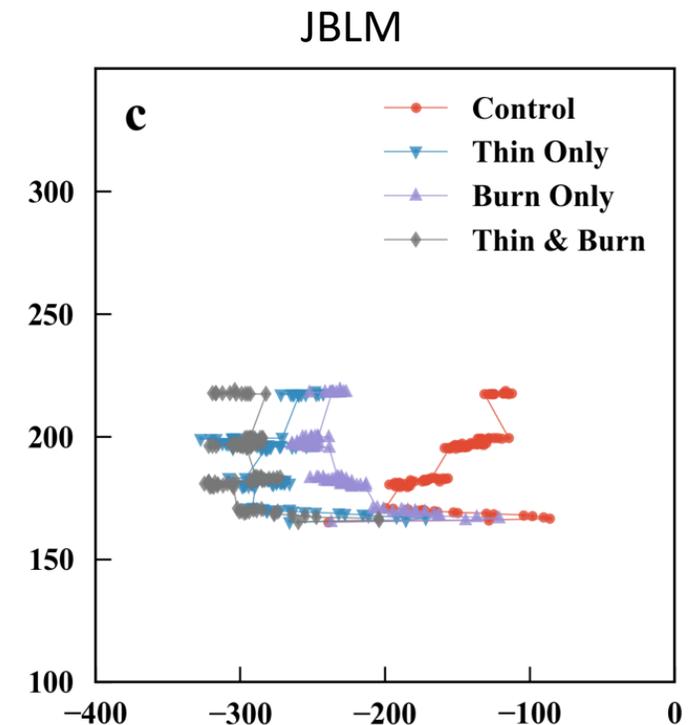
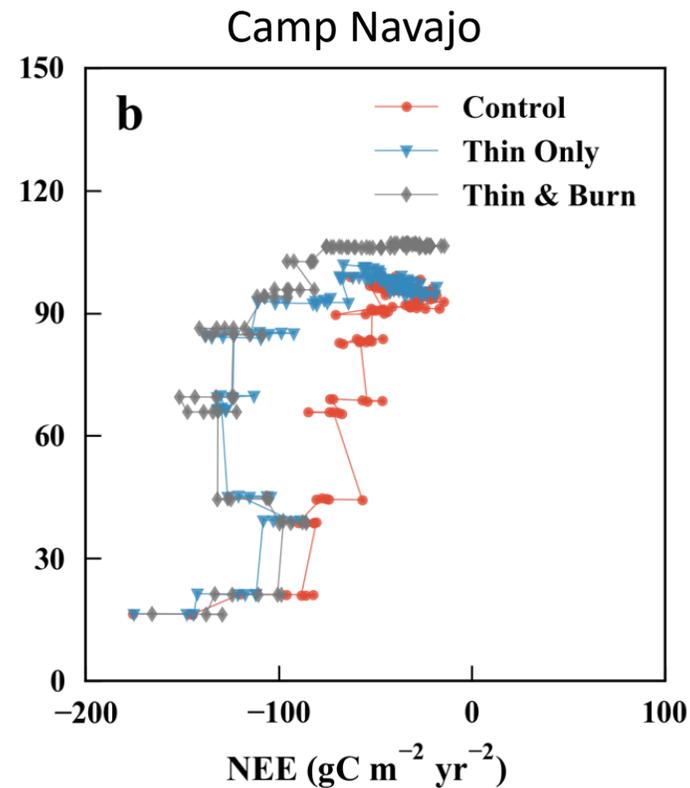
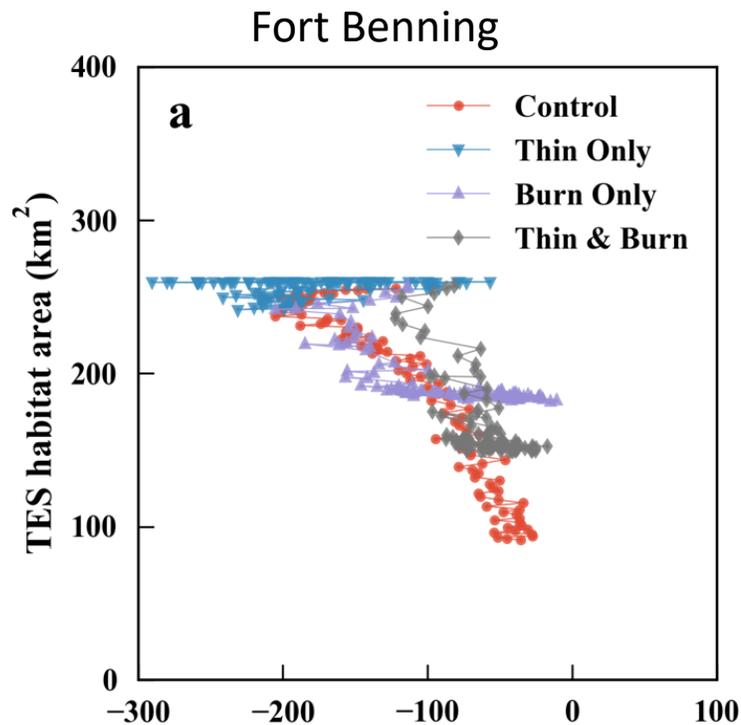
Results: Science Insights

- TES habitat area from LANDIS-II
 - Fort Benning: open stands of longleaf pine (red-cockaded woodpecker)
 - Camp Navajo: high canopy cover of larger trees (Mexican spotted owl)
 - JBLM: old-growth forest (northern spotted owl)



Results: Science Insights

- Net ecosystem carbon exchange vs. TES habitat area
 - Carbon uptake increased with TES habitat area at Fort Benning



Results: Proof-of-Principle Application

- Value DoD and public benefits on JBLM
 - Quantify DoD and public FEGS using ecosystem metrics
 - Estimate values of DoD and public FEGS using economic metrics
 - Compare values of DoD and public FEGS under various land management scenarios

FEGS (Provisioned Areas)		Ecological Description
The DoD	Training – Mounted	Grasslands + Scrublands/Shrublands
	Training – Dismounted	(Forests) – (Habitat + Ceremonial)
	Habitat	(Bald Eagle + WGS + NSO)
The Public	Harvest	Harvested forest area
	Recreation	(Training) – (DoD-restricted areas [§] + Lakes/Wetlands)
	The Environment	Habitat + Ceremonial

[§] DoD restricted area consists of Close-in Training Area F and Artillery, South, and Central Impact Areas (*Joint Base Lewis-McChord Draft Land Management Plan, JBLM 2017*).

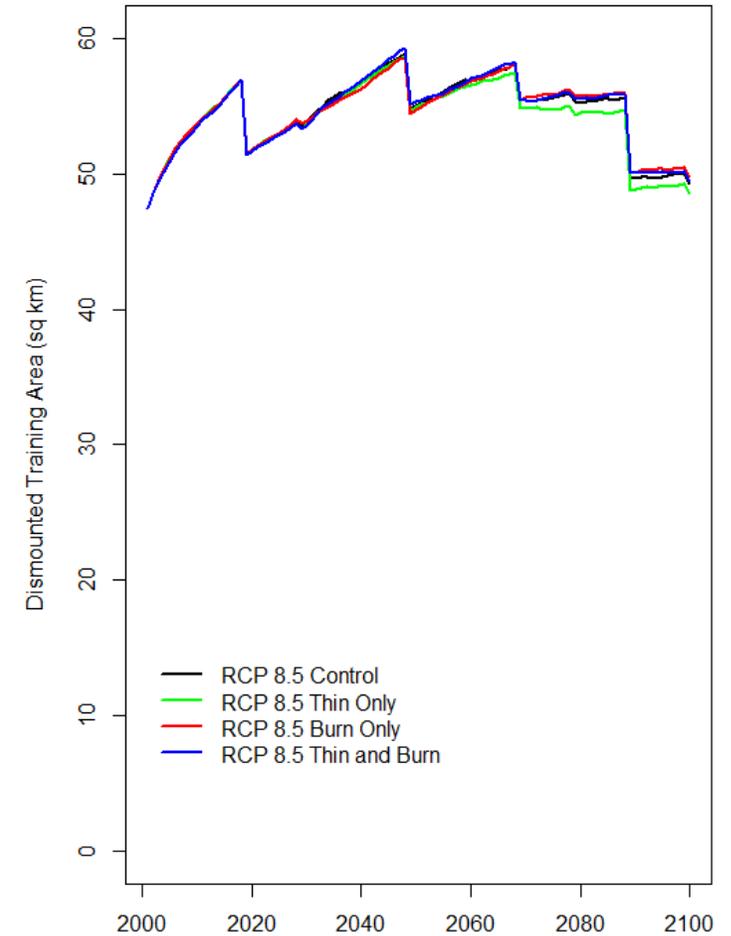
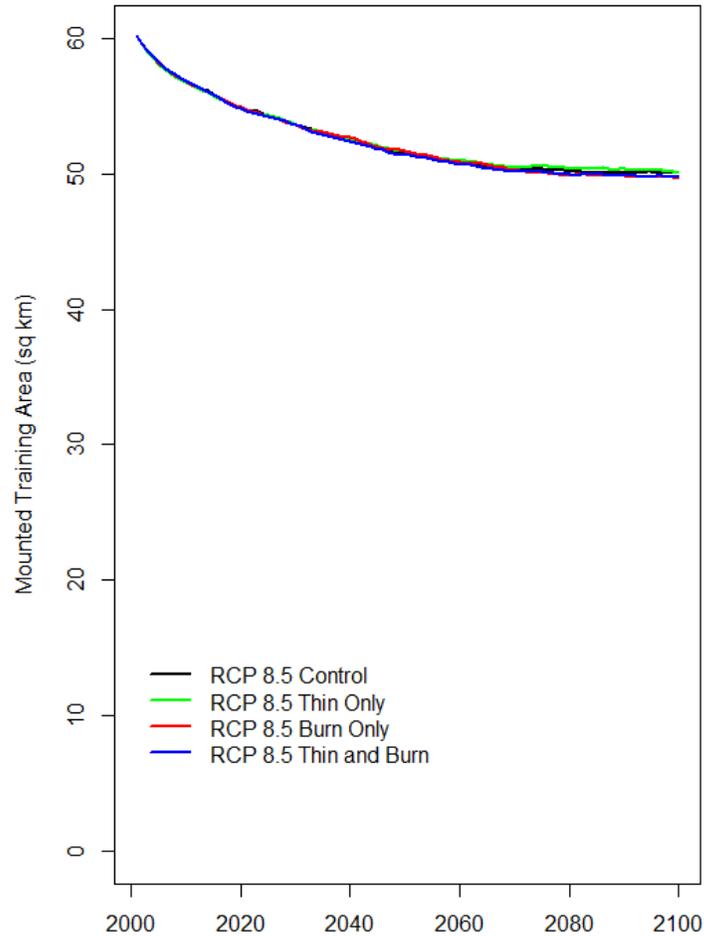
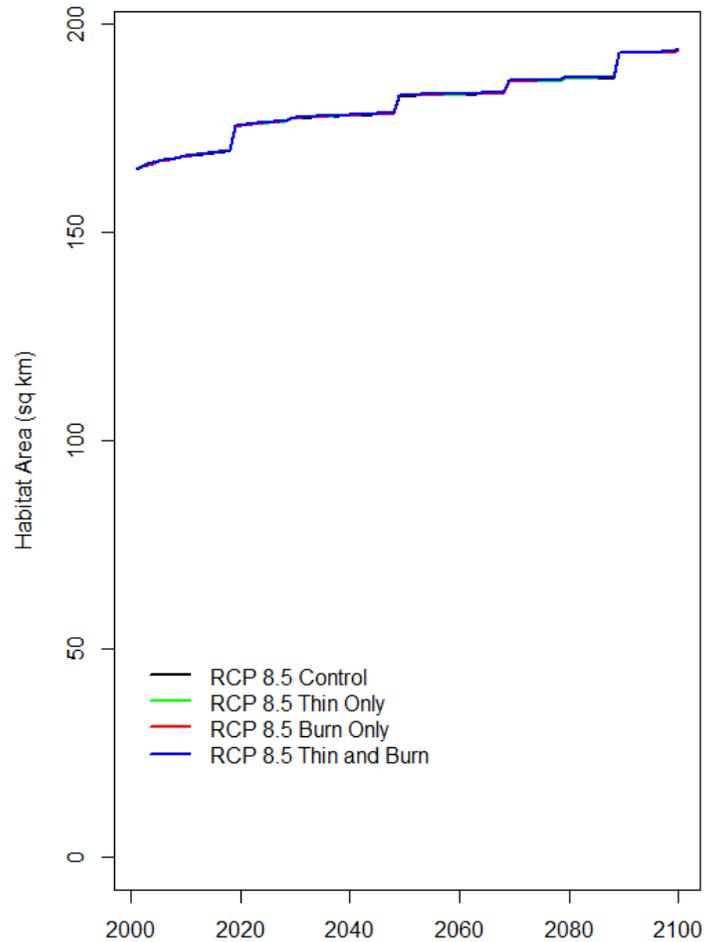
Results: Proof-of-Principle Application

- Natural-process model (LANDIS-II) simulated parameters used to quantify DoD and public FEGS in ecosystem units

Provisioned Area Description		LANDIS-II Modeled Parameters
Habitat	Bald Eagle	Forest grid cell within an 800-m buffer along Muck Creek and Nisqually River
	NSO	Forest grid cells with ≥ 100 years-old Douglas Fir trees
	WGS	Grid cells with Garry Oak within an 800-m buffer adjacent to grassland, shrubland/scrubland, or savanna
Training – Mounted		Grassland, shrubland/scrubland, and savanna grid cells
Training – Dismounted		Forest grid cells excluding habitat and ceremonial areas
Harvest		Grid cells within forest, grassland, shrubland/scrubland, or savanna areas, if removed biomass was larger than zero for the control and thin only treatments or if the removed biomass was larger than the removed biomass by burning only for the thin-and-burn treatment

Note: Areas provisioned for recreation and the environment are derived from those listed in this table and the ceremonial area (which is assumed fixed at 3.9 km²).

Results: Proof-of-Principle Application



Results: Proof-of-Principle Application

- Currently available valuation data from literature relevant for JBLM

FEGS		Average Annual WTP (2006 USD)
TES	Bald Eagle	\$39 per household
	Owl	\$65 per household
	Striped Shiner	\$8 per household
	Washington State anadromous fish populations	\$241 per household
	Woodpecker	\$16 per household
Old-growth Forest		\$28 per acre
Critical Habitat		\$49.6 million to \$99 million statewide
Recreation		\$69 per person per day

Results: Proof-of-Principle Application

- We were able to value habitats for bald eagle and northern spotted owl on JBLM using the benefit transfer method

FEGS	Average Annual WTP (2006 USD)	JBLM Annual Value (2006 USD)
TES – Bald Eagle	\$39 per household	\$14,000 - \$28,000
TES - Owl	\$65 per household	\$1.9 million
Old-growth Forest	\$28 per acre	\$1.1 million to \$1.3 million
Critical Habitat	\$86 million to \$171 million statewide	Less than \$86 million to \$171 million

Conclusions

- The simulation-valuation methodology successfully extended FEGS-CS to include military-unique ecosystem services
- The simulation-valuation methodology can comprehensively and consistently identify, characterize, and quantify benefits derived from ecosystem services provisioned on DoD lands
- The simulation-valuation methodology provides insights into the hydroecological functions that underpin the provisioning of ecosystem functions under alternative management and climate scenarios
- The simulation-valuation methodology is a viable method

Identified Research Gaps

- DoD-specific FEGS-CS gaps
 - Inclusion of the aquatic and atmospheric environments
 - Accounting of interactions among environments
 - Verify and validate newly added beneficiaries and benefits
- Natural-process model gaps
 - Explicit accounting of effects of military training and testing on the environment
 - Better spatio-temporal resolution
 - Accounting of interactions among environments
 - Accounting of uncertainties in model predictions
- Valuation gaps
 - Installation-specific data (e.g., troop levels, harvest fees, restoration costs)
 - Site-specific valuation data (e.g., WTP for restoration, recreation, military readiness)

Questions?



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