Thank you for signing in early

The webinar will begin promptly at 12:00 pm ET, 9:00 am PT
SERDP and ESTCP Webinar Series

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    - (669) 900-6833 or (929) 205-6099
    - Required webinar ID: 790-080-638
  - YouTube live stream
    - https://www.youtube.com/user/SERDPESTCP
- For questions or technical issues, please email serdp-estcp@noblis.org or call 571-372-6565
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

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Zoom Instructions (Cont’d)

- If you are connecting to computer audio
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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

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>June 4, 2020</td>
<td>Waste Reduction and Treatment in Armed Forces Vessel Environments</td>
</tr>
<tr>
<td>June 18, 2020</td>
<td>Predicting PFAS Fate and Transport in Subsurface Environments, and Treatment</td>
</tr>
<tr>
<td>July 9, 2020</td>
<td>Software and Hardware Solutions for Securing DoD Control Systems and Infrastructure from Cyber Threats</td>
</tr>
<tr>
<td>July 23, 2020</td>
<td>PFAS Fate, Transport and Treatment</td>
</tr>
<tr>
<td>August 20, 2020</td>
<td>Addressing Threatened and Endangered Species on DoD Lands</td>
</tr>
</tbody>
</table>
For upcoming webinars, please visit

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

The graph shows the relationship between habitat area of squirrels (in km²) and aboveground biomass (in kg C m⁻²). Four treatments are compared:

- **Control** (blue diamonds)
- **Burn Only** (green plus signs)
- **Thin Only** (orange triangle)
- **Thin & Burn** (red squares)

The graph indicates that the thinning and burning treatments (Thin Only and Thin & Burn) result in a greater increase in aboveground biomass compared to the control and burn-only treatments.
Example Valuing ESs: Basic Concept

TES = Threatened and Endangered Species
Valuing ESs: Concept Extended

Natural Capital on DoD Lands

Climatic, Hydrologic, and Ecologic Processes

Process-based Simulations

Classification

Ecosystem Services

FEGS-CS

Trade-off Analyses

DoD Land Management

DoD

Beneficiaries

Public

DoD Benefits
Training lands availability (area, duration)
Species composition suitability

Valuation
Metric-based, economic approaches
Inferred, non-market approaches

Public Benefits
Biodiversity
Availability of TES Habitat
Aesthetics
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

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

<table>
<thead>
<tr>
<th>Beneficiary Category</th>
<th>Beneficiary Description</th>
<th>FEGS</th>
<th>Ecosystem Metrics (Ecosystem Units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XY.0107</td>
<td>DoD foresters</td>
<td>harvested products,</td>
<td>harvested quantity (tons), area (km²), fragmentation</td>
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<tr>
<td></td>
<td></td>
<td>TES habitat</td>
<td></td>
</tr>
<tr>
<td>XY.0108</td>
<td>DoD wildlife biologists</td>
<td>TES habitat</td>
<td>area (km²), biome, fragmentation¹</td>
</tr>
<tr>
<td>XY.0202</td>
<td>Timber extractors</td>
<td>harvested timber</td>
<td>harvested quantity (tons)</td>
</tr>
<tr>
<td>XY.0206</td>
<td>Resource-dependent businesses</td>
<td>harvested products</td>
<td>harvested quantity (tons)</td>
</tr>
<tr>
<td>XY.0303</td>
<td>DoD property owners</td>
<td>land for buildings</td>
<td>area (km²), fragmentation</td>
</tr>
<tr>
<td>XY.0304</td>
<td>DoD military trainers</td>
<td>training lands</td>
<td>area (km²), biome, frequency of availability (d/y)²</td>
</tr>
<tr>
<td>XY.0401</td>
<td>DoD transporters of goods</td>
<td>routes</td>
<td>length (km), frequency of availability (d/y)</td>
</tr>
<tr>
<td>XY.0402</td>
<td>DoD transporters of people</td>
<td>routes</td>
<td>length (km), frequency of availability (d/y)</td>
</tr>
<tr>
<td>XY.0601</td>
<td>Experiencers and viewers</td>
<td>recreation</td>
<td>area (km²), frequency of access (d/y)</td>
</tr>
<tr>
<td>XY.0603</td>
<td>Hunters</td>
<td>recreation</td>
<td>area (km²), frequency of access (d/y)</td>
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<tr>
<td>XY.0701</td>
<td>Spiritual and ceremonial (tribal)</td>
<td>the environment</td>
<td>area (km²), frequency of access (d/y)</td>
</tr>
<tr>
<td>XY.0801</td>
<td>Educators and students</td>
<td>the environment</td>
<td>area (km²), frequency of access (d/y)</td>
</tr>
<tr>
<td>XY.0802</td>
<td>Non-DoD researchers</td>
<td>the environment</td>
<td>area (km²), frequency of access (d/y)</td>
</tr>
<tr>
<td>XY.0803</td>
<td>DoD researchers</td>
<td>the environment</td>
<td>area (km²), frequency of access (d/y)</td>
</tr>
<tr>
<td>XY.0901</td>
<td>People who care (existence)</td>
<td>the environment</td>
<td>area (km²)</td>
</tr>
<tr>
<td>XY.0902</td>
<td>People who care (option/bequest)</td>
<td>the environment</td>
<td>area (km²), long-term availability (km²)</td>
</tr>
</tbody>
</table>

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

Note: RCP 8.5 = business as usual climate scenario
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 FEGS-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 FEGS-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
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
For additional information, please visit

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

U.S. Air Force photo by Senior Airman Cody Miller
Base Management

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

<table>
<thead>
<tr>
<th>Base Management</th>
<th>Biophysical Effects</th>
<th>Benefit Relevant Indicators</th>
<th>Monetary Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>DoD actions to manage habitats and species</em></td>
<td><em>Changes to ecosystem characteristics</em></td>
<td><em>Changes to the provision of ecosystem services</em></td>
<td><em>Changes to the economic value of ecosystem services being provided</em></td>
</tr>
</tbody>
</table>
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

- Largest forested military base in United States
- Largest remaining mature longleaf pine forest in world
- Habitat for 24 listed threatened or endangered species
- Extensive freshwater and estuarine wetlands, ponds and riparian meadows
- Supports outdoor recreation, hunting, and fishing
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
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

- 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

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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.
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.
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.

*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

![Graph showing annualized NPV (2020–35)]
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
Project Team

James Kagan, Institute for Natural Resources, Oregon State University

Lydia Olander, Nicholas Institute for Environmental Policy Solutions, Duke University

Mark Borsuk, Department of Civil and Environmental Engineering, Duke University

Megan Creutzburg, Institute for Natural Resources, Oregon State University

Andrew Plantinga, Bren School of Environmental Science & Management, UC Santa Barbara

Celine Robinson, Department of Civil and Environmental Engineering, Duke University

Ryan Calder, Department of Civil and Environmental Engineering, Duke University

Sara Mason, Nicholas Institute for Environmental Policy Solutions, Duke University

Andrew Plantinga, Bren School of Environmental Science & Management, UC Santa Barbara

Celine Robinson, Department of Civil and Environmental Engineering, Duke University
Acknowledgements

- Brett Williams, Eglin Wildland Support Module Lead
- Dan Hipes and Jon Otting, Florida Natural Areas Inventory of Florida State University
- Amber Dankert, Virginia Sanders, and David Preston, Fort Hood
- Charlotte Reemts, The Nature Conservancy
- Jen Costanza, North Carolina State University
For additional information, please visit

Speaker Contact Information
mark.borsuk@duke.edu; 603-667-7454
Q&A Session 2
The next webinar is on June 4, 2020

Waste Reduction and Treatment in Armed Forces Vessel Environments
Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends.