
Photo Credit: FWS 2014

Considering Tradeoffs in the Great Dismal Swamp National Wildlife Refuge: *An Ecosystem Services Portfolio Approach*

Emily Pindilli, Dianna Hogan, Rachel Sleeter, Bryan Parthum, and Brianna Williams

A Community on Ecosystem Services
December 2016

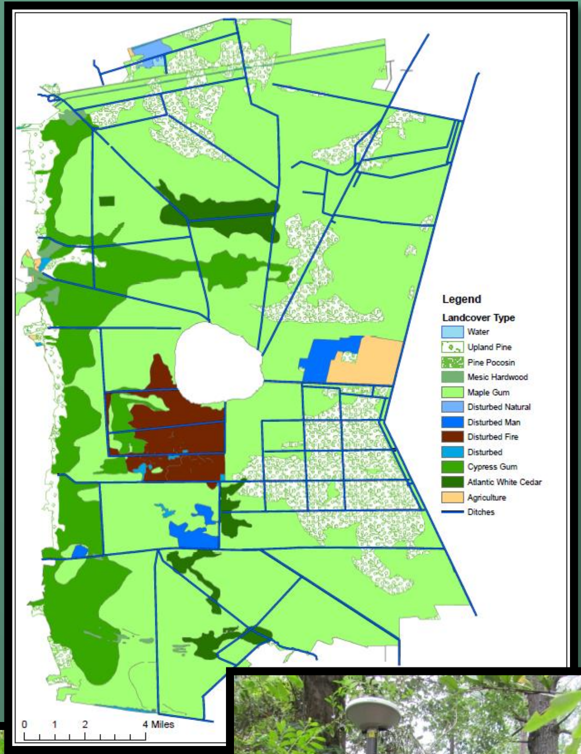
U.S. Department of the Interior
U.S. Geological Survey

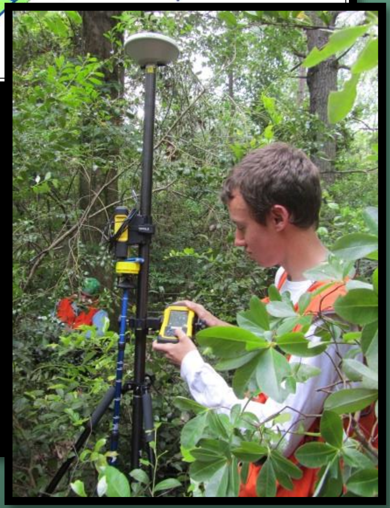
USGS

Great Dismal Swamp Project

Background

- **Application of USGS LandCarbon**
  - **Produce regional- and local-scale C estimates (fluxes, ecosystem balance, and long-term sequestration rate) to include in ecosystem service evaluations in support of DOI land management**
- **Multi-partner project**
  - **FWS; TNC; USGS; George Mason, Southern Methodist, and Clemson Universities**

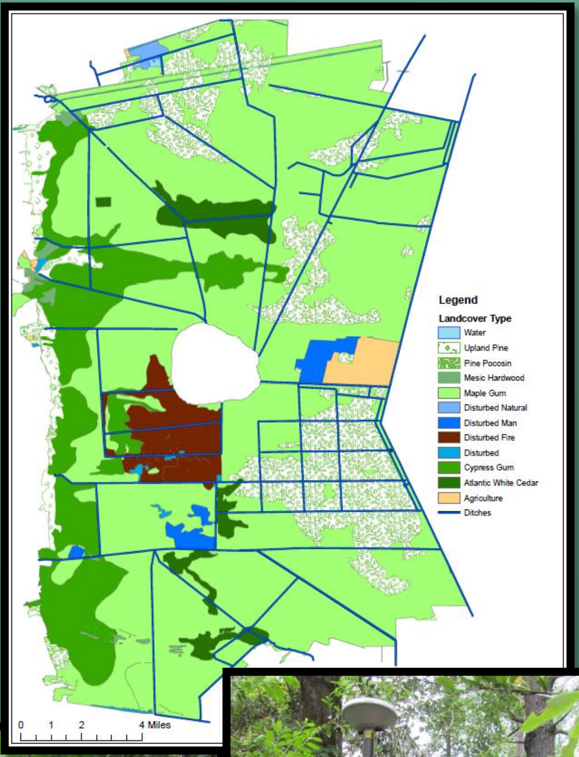


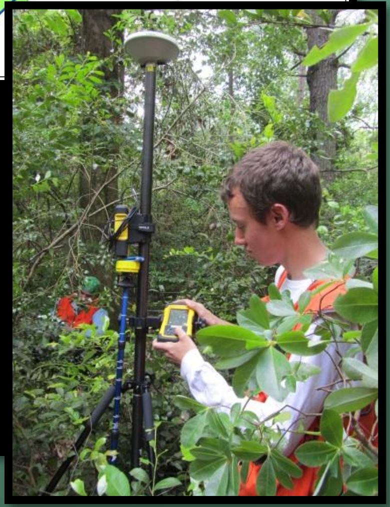


USGS

Great Dismal Swamp Project

- **Estimate local-scale C storage and flux:**
  - **Carbon and hydrologic research: sequestration and peat storage, CO_2 CH_4 flux, soil moisture, hydrology (groundwater, and carbon flux through water)**
  - **Remote sensing: aboveground biomass (field verification), properties such as soil moisture and peat depth, and wildfire burn severity**
- **Assess ecosystem services in relation to selected management and restoration actions**

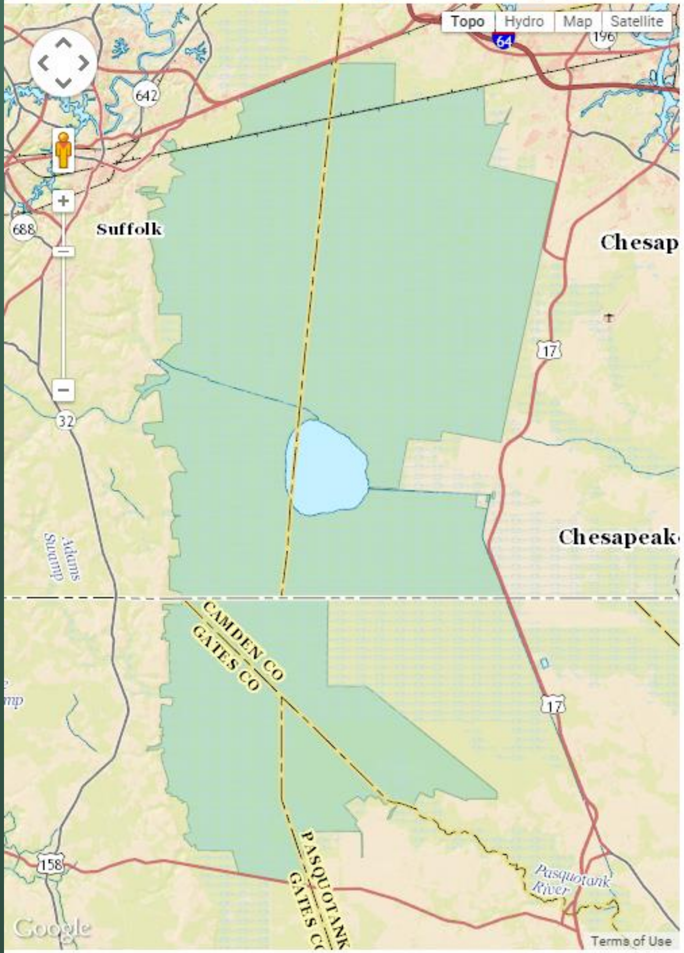




USGS

http://www.usgs.gov/climate_landuse/lcs/great_dismal_swamp/default.asp

Home | About the Project | Data | Publications | Updates | People



The Great Dismal Swamp Carbon Project

The purpose of The Great Dismal Swamp Carbon Project is to gain information on carbon balance at the swamp. Specifically, it is to understand how management and/or restoration could potentially increase carbon storage, understand the key controlling processes of carbon sequestration, and estimate effects of refuge hydrologic management on carbon sequestration, fire management, and selected vegetation communities.

Read more about our research activites that make up the Great Dismal Swamp project.

History of the Great Dismal Swamp ecosystems

Great Dismal Swamp is located in southern Virginia and northern North Carolina approximately 15-20 miles from the Atlantic coast, and includes over 112,900 acres of forested wetlands. In 1763, a company led by George Washington began draining and logging the swamp to provide fertile agricultural lands and valuable timber for building. These activities continued for centuries and greatly changed the swamp hydrology and habitat; there are now approximately 150 miles of ditches which control the hydrology in the swamp.

One of the greatest threats to the swamp today is wildfires. The frequency, severity, and intensity of wildfires have increased dramatically in recent years. The ditches drain precipitation quickly, leading to a drier swamp. In addition, frequent and prolonged drought has significantly lowered the water table, leaving peat soils vulnerable to wildfire, soil subsidence, and oxidation of carbon.

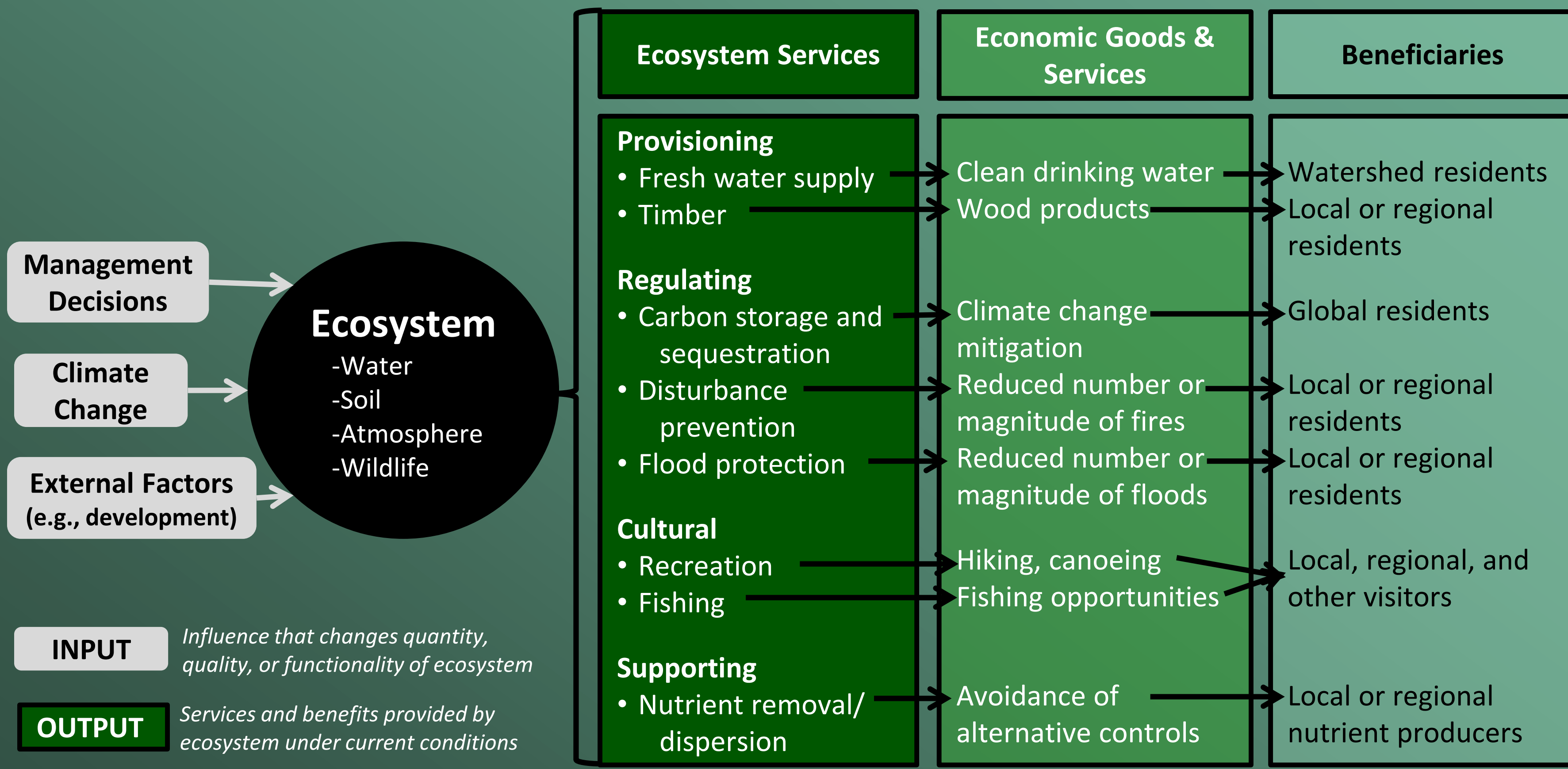
Efforts to preserve the swamp begin in the mid-20th century, leading to the Dismal Swamp Act of 1974 which established the Great Dismal Swamp National Wildlife Refuge (GDS NWR). Ongoing preservation efforts continue to this day.

Collaborators

A project of USGS with collaborators from George Mason University, the U.S. Fish and Wildlife Service, and The Nature Conservancy, Southern Methodist University, and Clemson University.

GEORGE MASON UNIVERSITY | SMU | CLEMSON UNIVERSITY | The Nature Conservancy | USGS

Ecosystem Services Framework



USGS

Priority Services and Evaluation Methods

Ecosystem Service	Methodology	
	Biophysical	Economic
Carbon Sequestration	• Plot data on biomass scaled up to GDS NWR via ST-SIM • Converted to carbon biomass using literature values • Will be improved with carbon values from monitoring as available	• Interagency Working Group on Social Cost of Carbon (SCC) applied to INCREMENTAL CO_2 emissions (tons per year) • 2014 value is $42.55 (adjusted using BLS info)
Wildlife Viewing	• Using visitation rates provided by GDS NWR (2014) • Assuming all “non-consumptive” visitation	• Valuation based on consumer surplus or “willingness to pay” above actual costs incurred • Using FWS survey (2006) data
Fire Mitigation	• Only considers “catastrophic fire” • Determined by annual probability of fire and effects of catastrophic fire • Effects considered: air quality/human health impacts, carbon emissions, recreation lost, and tourism lost	• Human health impacts value based on Cost of Illness • Carbon emissions - SCC • Recreation lost due to full or partial closures during event • Tourism lost in communities considered qualitatively

Fire Mitigation Ecosystem Service

- **Ecological Function: hydrologic regime**
- **Economic Goods and Services: fire mitigation**


Photo Credit: FWS

Hydrologic balance:
- reduces dry vegetation/ ignition material
- reduces infiltration of fire to deep peat
- allows for prescribed burn


Photo Credit: FWS

Fire probability reduced
- magnitude, and/or
- frequency

Photo Credit: NASA

Fire damages reduced
- Air quality/human health impacts
- Carbon emissions
- Recreation lost
- Tourism lost

Biophysical Evaluation of Fire Mitigation ES

- Fire mitigation ES assessment only considers "catastrophic fire"
  - Fires of sufficient economic and ecological magnitude
- Two high-level factors considered in biophysical evaluation of catastrophic fires
  - Probability of catastrophic fire (annually)
  - Effects of catastrophic fire
- Effects considered:
  - Air quality/human health impacts
  - Carbon emissions
  - Recreation lost
  - Tourism lost

Quantifying Human Exposure to Wildfire Smoke

- Estimating human health impacts using method developed by Rappold et al. (2011)[1]
  - Aerosol Optical Depth (AOD) readings from satellite imagery provide areas of concern and duration of impacts
  - During periods above AOD threshold, Rappold study observed an increase in hospital visitation for respiratory and cardio-pulmonary symptoms
- Methods are being applied to GDS using local hospital visitation data and AOD readings during 2008 South One Fire
- Study is being taken another step by assigning monetary value to health outcomes

USGS

1. Rappold et al. (2011). *Peat Bog Wildfire Smoke Exposure in Rural North Carolina*. Environmental Health Perspectives, Vol 119, No.10, October 2011.

Human Health Effects of Wildfire Smoke Exposure

- Wildfire smoke exposure increases incidence of:
  - Asthma
  - Chronic Obstructive Pulmonary Disease (COPD)
  - Pneumonia/acute bronchitis
  - Heart failure (CHF)
  - Cardiopulmonary symptoms
- Valuation uses Cost of Illness (COI)[1]
  - Focuses on HIGHEST costs
  - Includes actual costs incurred (medical bills)
  - Includes opportunity cost (lost wages/value of time lost)
- Other studies have indicated a willingness to pay to avoid health effects to be substantially higher than COI

USGS

1. Localized COI values derived using EPA's BenMAP estimates

Wildfire: Preliminary Results

- Preliminary results suggest catastrophic wildfire has COI of $2.2 million (currently only direct costs)*
- Catastrophic wildfire has annual probability of 2% (2 events in 100-year period)
- Annual COI under current conditions $44,000*
- Does not include other costs of catastrophic wildfire:
  - Reduced tourism (nearby)
  - Reduced recreation (on refuge)
  - Carbon emissions
- Management (rewetting) can reduce the risk of catastrophic wildfire

USGS

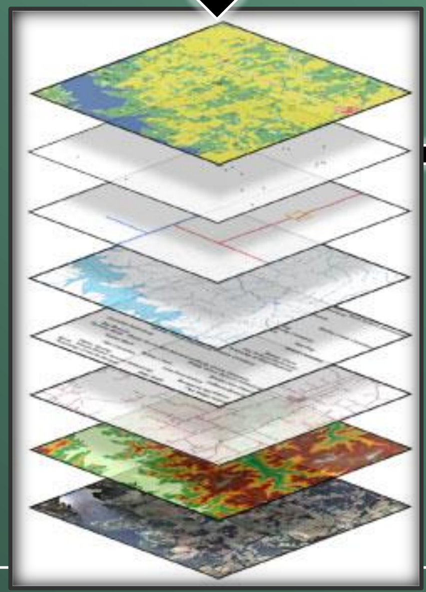
*These data are preliminary and are subject to revision. They are being provided to meet the need for timely 'best science' information. The assessment is provided on the condition that neither the U.S. Geological Survey nor the United States Government may be held liable for any damages resulting from the authorized or unauthorized use of the assessment.

Scenario Modeling and Ecosystem Services

IDENTIFY & QUANTIFY:
EXISTING BIO-PHYSICAL CONDITIONS, DISTURBANCES & BEHAVIORAL RESPONSE

SCENARIO MODELING:
PROVIDES A RANGE OF ALTERNATIVE OUTCOMES GIVEN DIFFERENT ASSUMPTIONS

EXTERNAL STRESSORS/ MANAGEMENT ACTIONS:
CLIMATE CHANGE
FOREST RESTORATION
HYDROLOGY
FIRE SUPPRESSION



ANNUAL MAPS OF LANDSCAPE CHANGE

ANALYZE TRADEOFFS FOR ECOSYSTEM SERVICES

STAKEHOLDER PARTICIPATION

USGS

Future Scenario Development

SCENARIO ASSUMPTIONS:

VEGETATION AND CARBON BIOMASS

Initial vegetation quantities

SOIL MOISTURE:

- ~ __% DRIER; __% WETTER (RELATIVE)

Proportion of the refuge that is dry versus wet

NATURAL DISTURBANCE:

- STORMS
- DRAINAGE
- FIRE (PROBABILITY OF FIRE EVENTS)
- INVASION OF UNDESIRED SPECIES

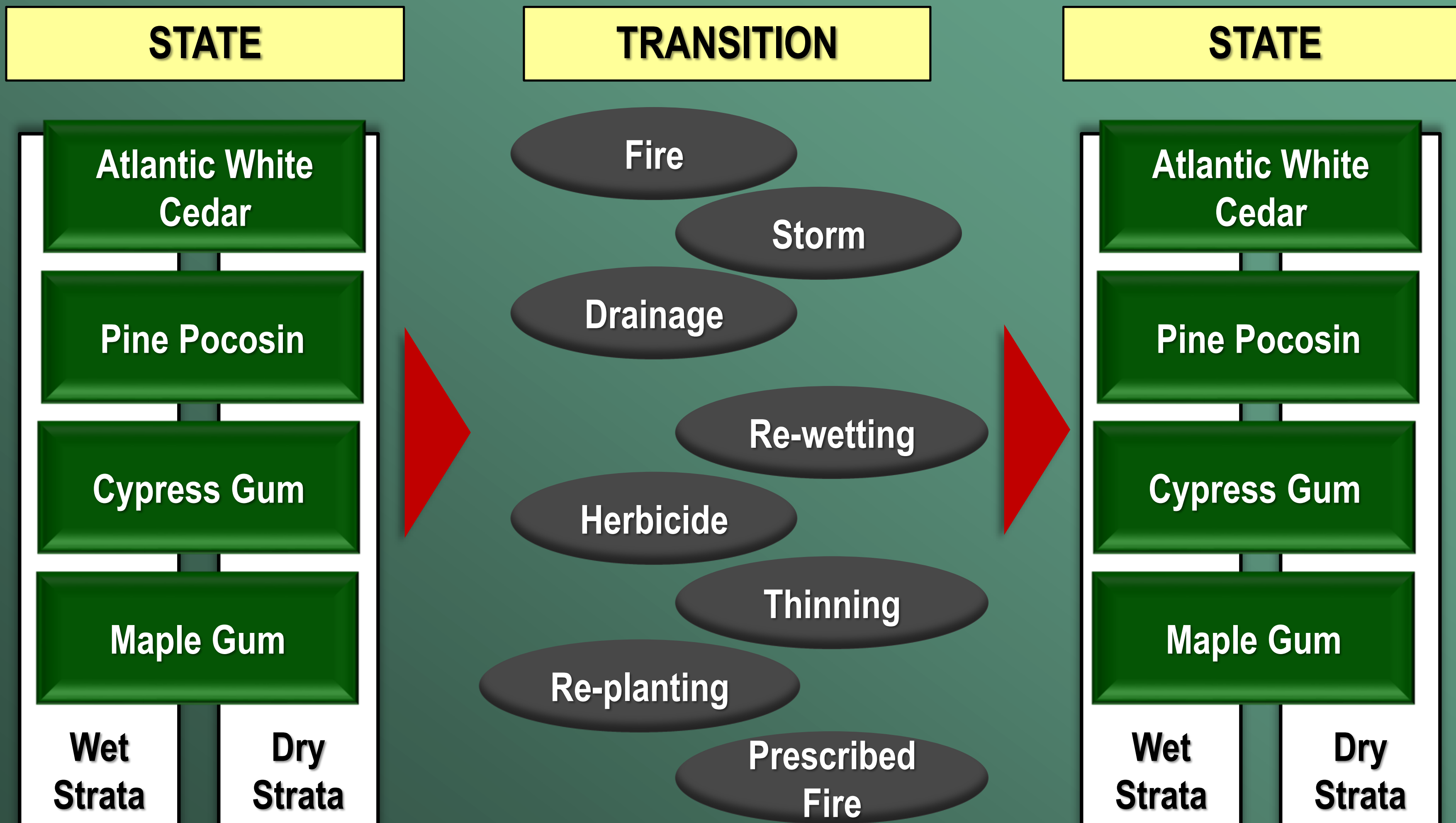
Frequency (probability, i.e. 5 fires in the next 100 years)
Amount of disturbance (how many acres in the refuge)
Location (where in the refuge)

MANAGEMENT

- PRESCRIBED FIRE
- SELECTIVE LOGGING/THINNING
- CLEARCUT LOGGING
- HERBICIDE TREATMENT
- REPLANTING
- REWETTING

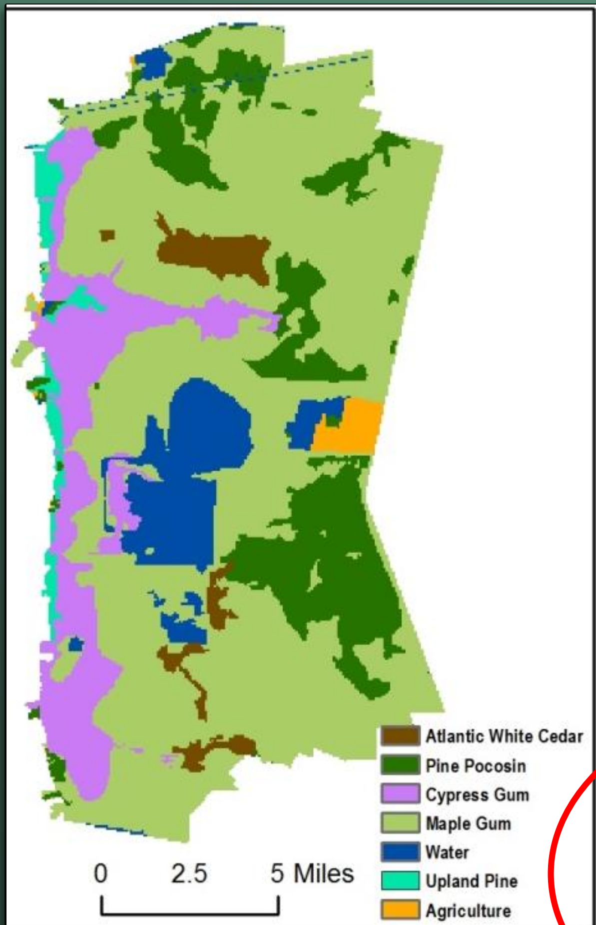
Frequency (how often is action undertaken)
Timing (in which years is action undertaken)
Amount of management (how many acres in the refuge)
Location (where in the refuge)

State-and-transition Model (ST-SIM)



Scenario 1: Reference Conditions

2015 ← **50 YEARS** → **2065**



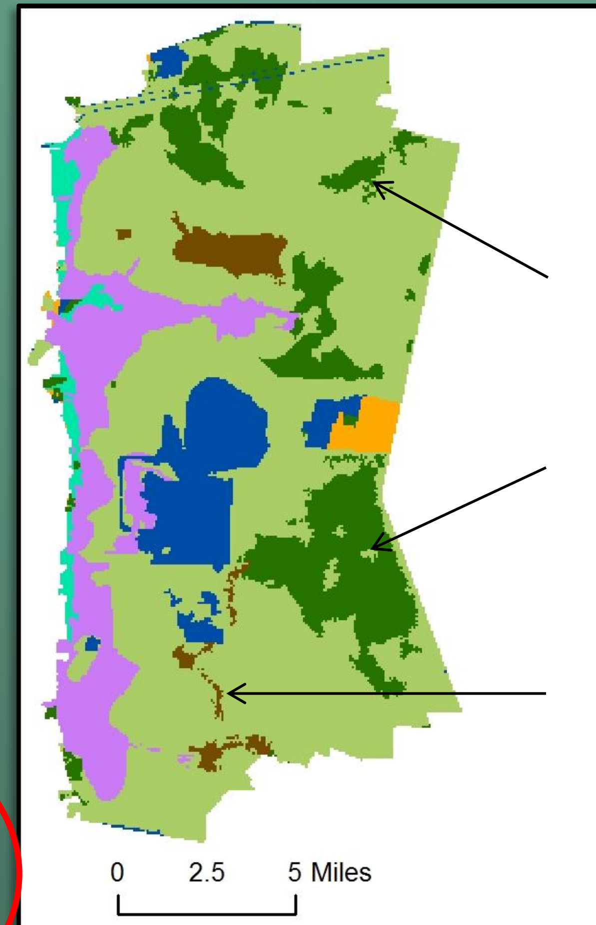
SCENARIO ASSUMPTIONS:

CURRENT VEGETATION AND CARBON BIOMASS

SOIL MOISTURE:
- ~ 65% DRIER; ~35% WETTER (RELATIVE)

NATURAL DISTURBANCE:
- WIND/STRESS
- FIRE (Probability of 1 Extreme Fire Event within 100 YRS)
- INVASION OF UNDESIRED SPECIES (MAPLE GUM)

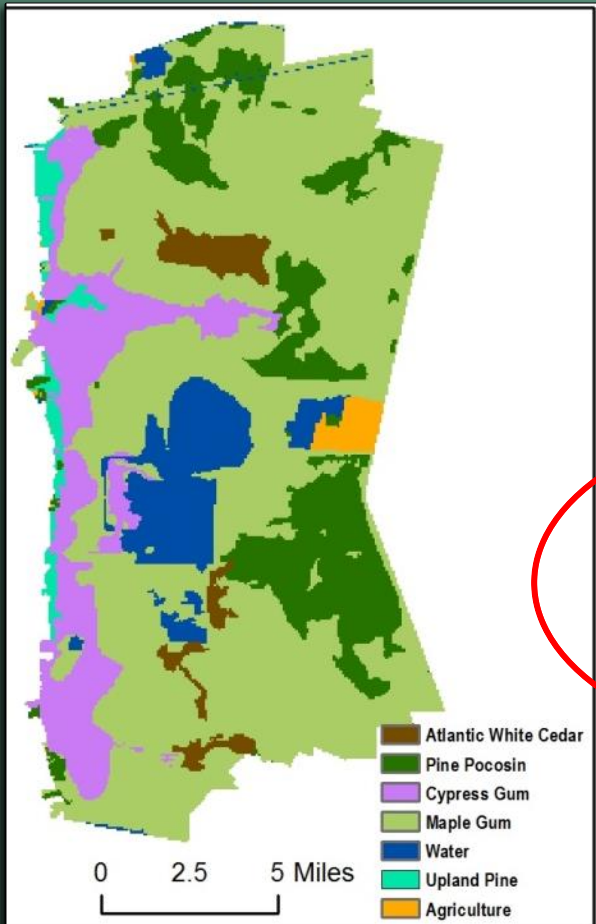
NO MANAGEMENT
- NO FIRE SUPPRESSION (PRESCRIBED FIRES OR THINNING)
- NO REWETTING
- NO FOREST RESTORATION (THINNING, REPLANTING, HERBICIDE)



USGS

Scenario 2: Extreme Fire Event

2015 ← 50 YEARS → **2065**



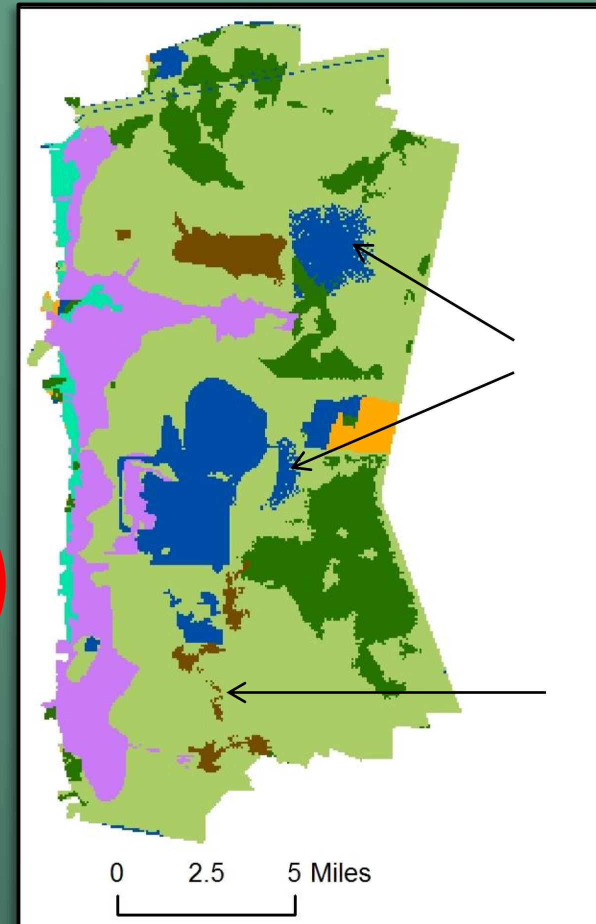
SCENARIO ASSUMPTIONS:

CURRENT VEGETATION AND CARBON BIOMASS

SOIL MOISTURE:
- ~ 65% DRIER; ~35% WETTER (RELATIVE)

NATURAL DISTURBANCE:
- WIND/STRESS
- FIRE – 2 LARGE FIRES OCCUR ON SAME PATCH WITHIN 5 YRS
- INVASION OF UNDESIRED SPECIES (MAPLE GUM)

NO MANAGEMENT
- NO FIRE SUPPRESSION (PRESCRIBED FIRES OR THINNING)
- NO REWETTING
- NO FOREST RESTORATION (THINNING, REPLANTING, HERBICIDE)



USGS

Conclusions

- Management actions effect quantity and quality of ecosystem services delivered
- Additional drivers (i.e., climate change) also impact ecosystem services
- Managing for one service alone could have unintended consequences
- A portfolio approach increases information to decision-makers on how management effects people

Acknowledgements

- **This work is a multi-disciplinary, multi-agency partnership. The project relies on the extensive expertise of all of the team members, with leadership and integration by Dr. Dianna Hogan.**

Ecosystem Services Assessment and Carbon Monitoring Team	
Coordination Team	• FWS (John Schmerfeld, Sara Ward), USGS (Zhiliang Zhu, Brad Reed, Dianna Hogan), NWR managers (Chris Lowie, Fred Wurster, Howard Phillips), State Park (Joy Greenwood, Adam Carver), TNC (Christine Pickens, Chuck Peoples, Brian van Eerden)
Dianna Hogan	• Coordination and communications, ecosystem services analysis, model development, field research
Ken Krauss, Nicole Cormier, Rebecca Moss, Courtney Lee, Jamie Duberstein, Josh Salter, Laurel Gutenberg, Chris Wright	• Field research – carbon storage and flux
Judy Drexler	• Field and lab research – carbon storage in soils (peat)
Gary Speiran	• Field research – hydrologic measurements
Todd Hawbaker, Zhong Lu, John Qu, Laurel Gutenberg	• Biomass and soil moisture measurements and fire characterization
Emily Pindilli, Bryan Parthum	• Economics analysis, model development
Rachel Sleeter	• ST-SIM model development
Kim Angeli, Gary Fisher	• Remote sensing

USGS

Questions?