The Interplay between Land User Decisions and Land Cover Change in Coastal Ecosystems and Working Lands Under Sea Level Rise in the Mid- Atlantic U.S.

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NASA LCLUC

Science Team Meeting 2024

Photo: Jarrod Miller

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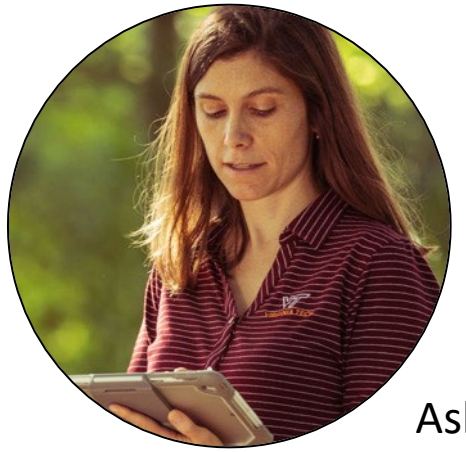

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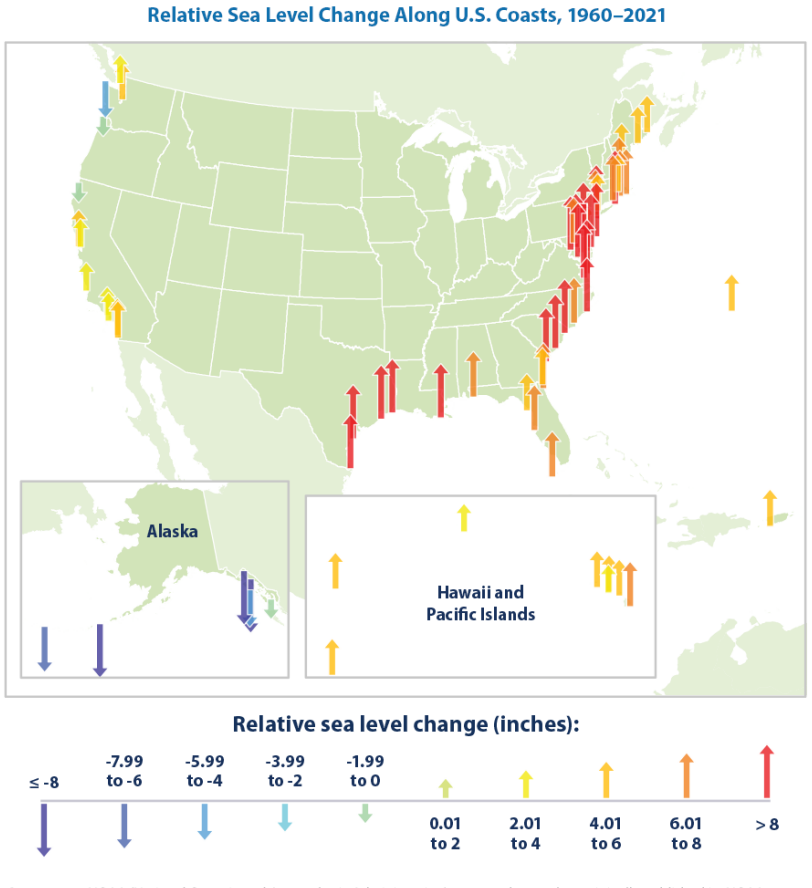
Sea Level Rise (SLR) on the mid-Atlantic US coast

- Relative SLR rates are 2-4x higher than global average
- Naturally, salt marshes migrate onto upland forests with SLR



English Creek, New Jersey - 2002

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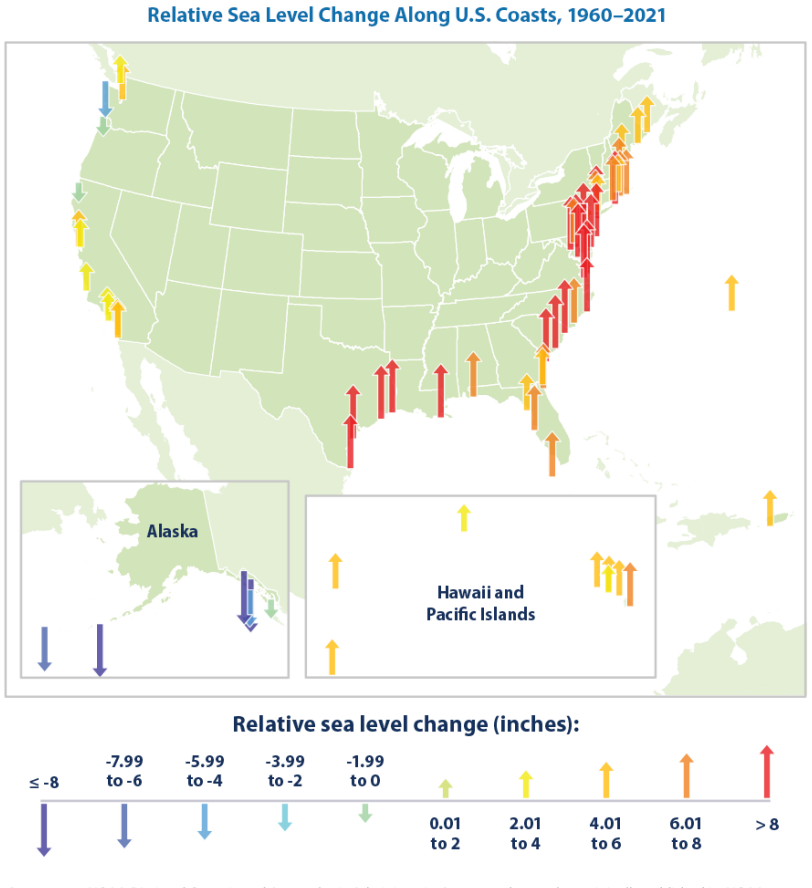
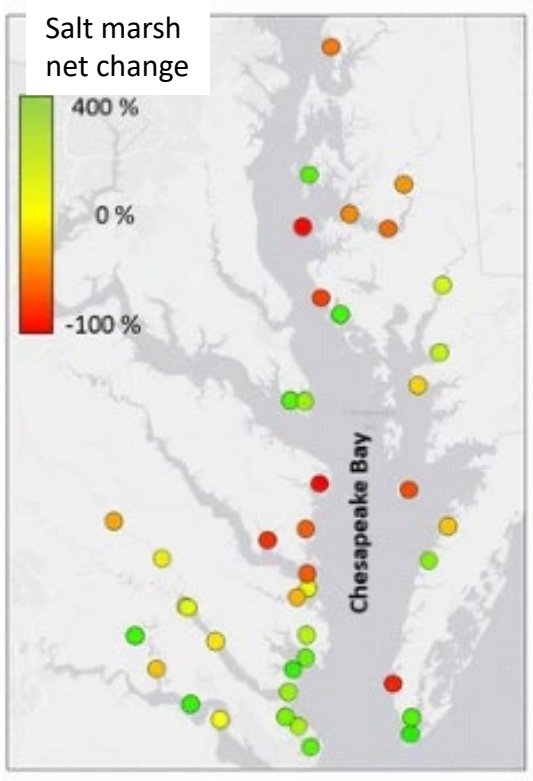


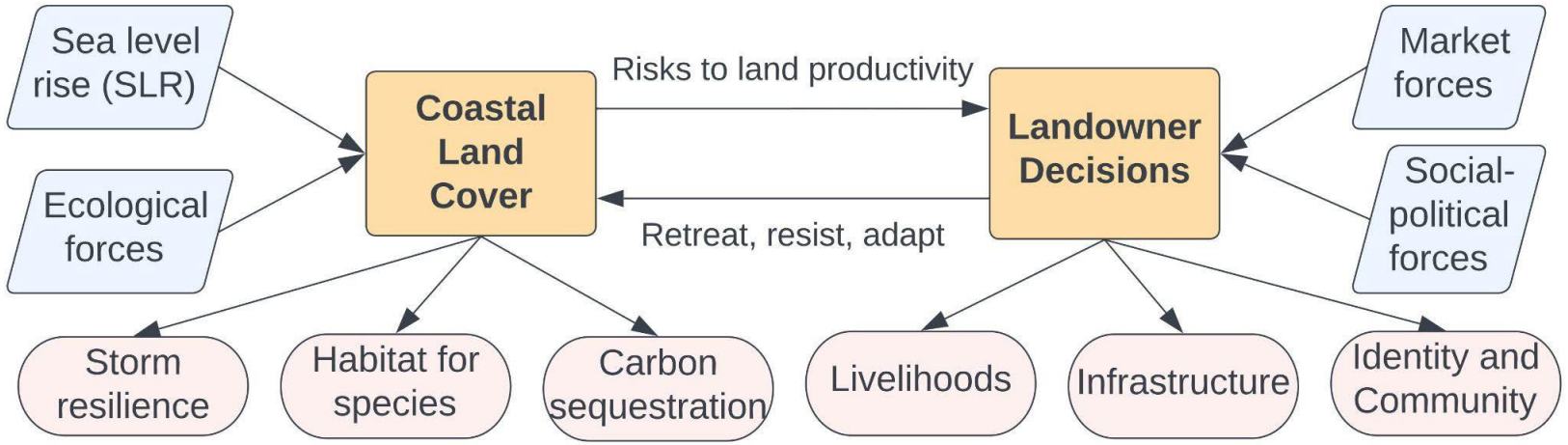
English Creek, New Jersey - 2023

Land Cover change with SLR

But, >65% of mid-Atlantic coast is privately owned, with majority of those lands being “working lands” (agriculture or forestry)



Schieder et al. 2018



Sea Level Rise on Working Lands

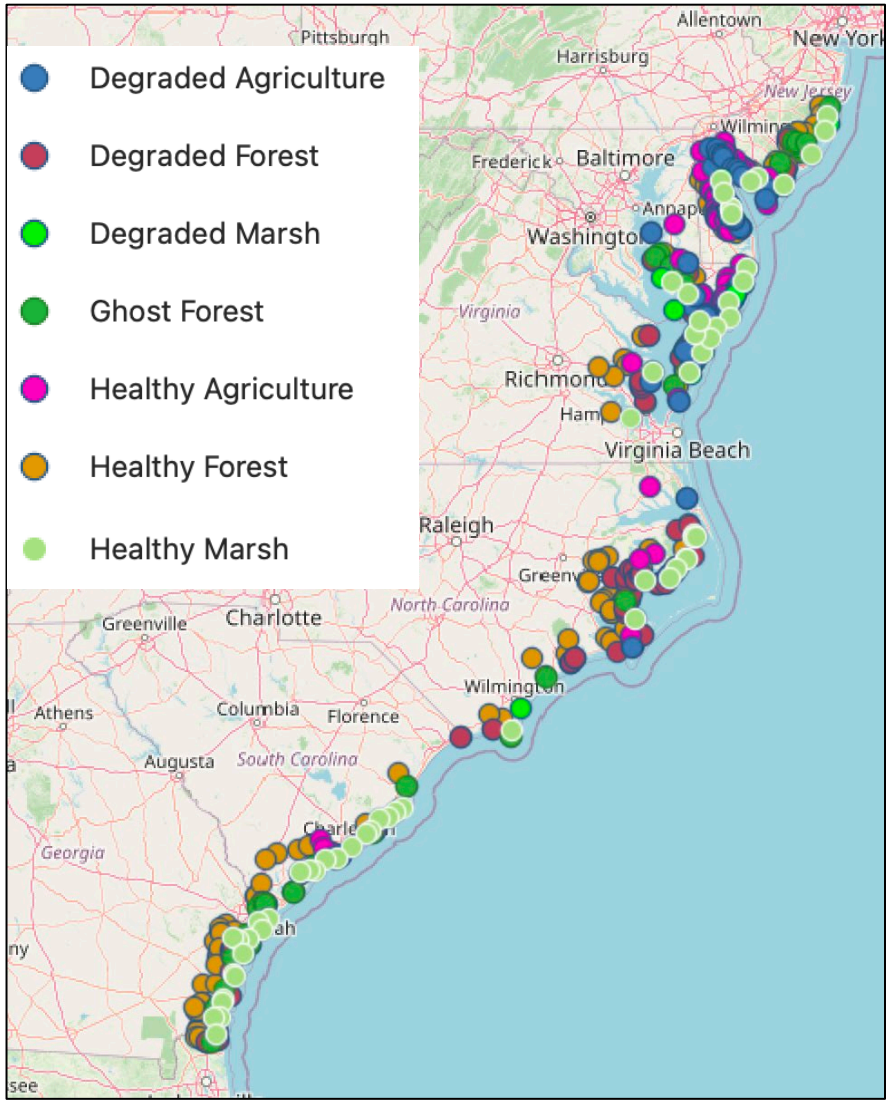
- Objectives:
  - 1. Identify where SLR-caused landcover change and salinization on working lands is occurring and whether this change can be detected by satellite remote sensing on a yearly time scale.
  - 2. Estimate whether the proximity or severity of SLR-caused coastal landcover change influence landowner decisions.
  - 3. Estimate whether coastal landowner decisions influence land cover of both working lands and natural ecosystems.

Approach for modeling land cover change

- Goal is to accurately identify SLR-caused degradation, not to create a classifier
- Random Forest classification models conducted at two resolutions:
  - Moderate resolution (Sentinel-2, Landsat, and existing canopy height products)
    - Enable early results to help guide social science survey
    - Ensure contiguous coverage
    - Help refine decision rules for applying the model to the study area
    - Identify regions of classification error
  - High resolution (PlanetScope, MAXAR, and lidar)
    - Likely needed to produce high performing model

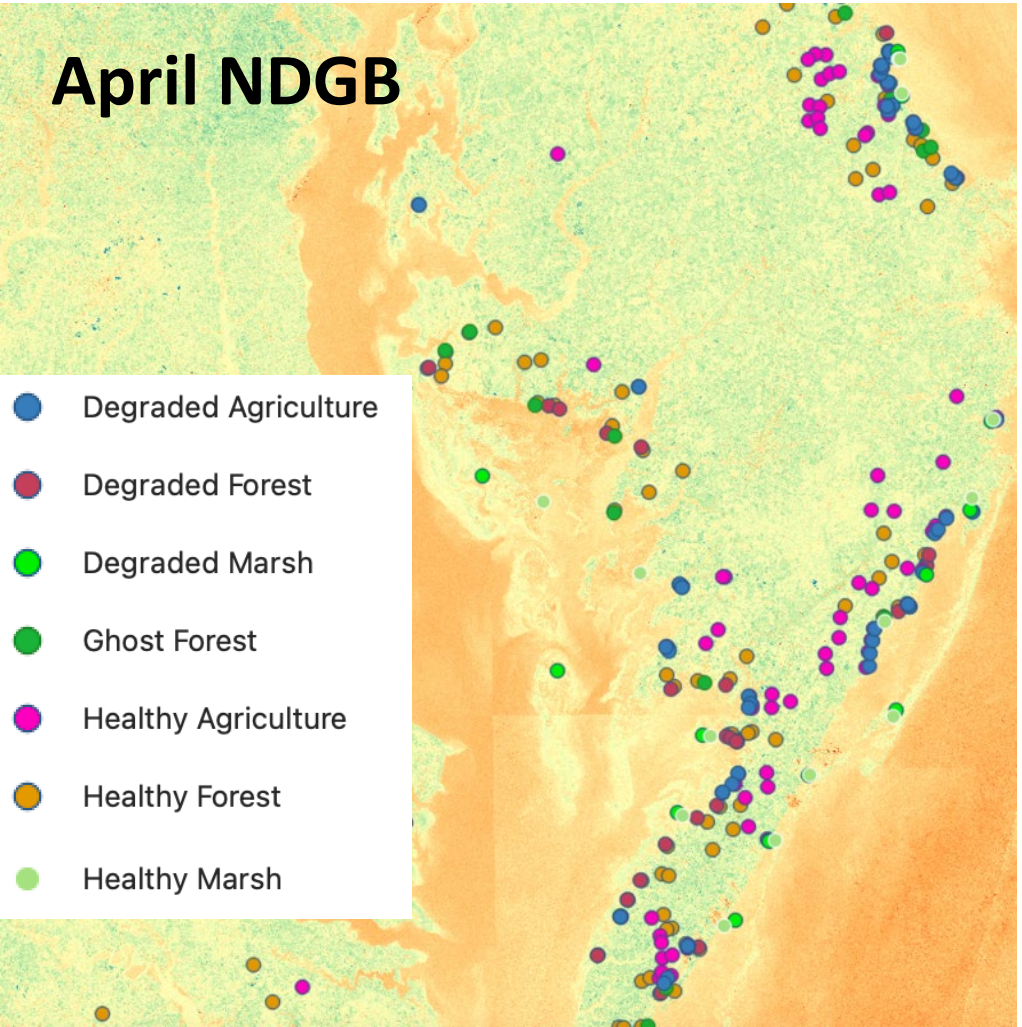
Training Locations

Category	Count
Healthy Forest	289
Degraded Forest	114
Ghost Forest	56
Healthy Agriculture	146
Degraded Agriculture	74
Healthy Marsh	61
Degraded Marsh	61
TOTAL	**801**



- Methods of identification:
  - Personal observation in the field
  - Published observations and model predictions
  - Examination of multiple years of imagery

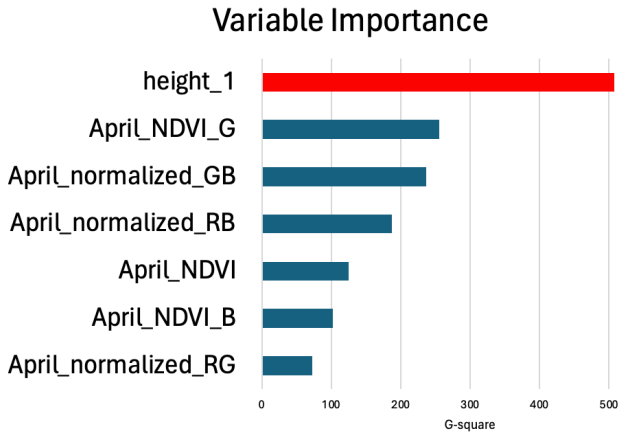
Full Extent Model – moderate resolution



- 10m Sentinel-2 surface reflectance bands
  - To help account for multiple scenes and dates, we calculated normalized difference indices
    - NDVI
    - NDVIg (NIR-G/NIR+G)
    - NDVIb (NIR-B/NIR+B)
    - NDRB (R-B/R+B)
    - NDGB (G-B/G+B)
    - NDRG (R-G/R+B)
- April and September, 2023
  - As cloud free as possible. Cloudy areas masked out.
- For heights, we used the 2020 10m ETH Global Sentinel-2 Canopy Height product
  - Still processing lidar height change data

Random forest analysis showed the importance of both height and reflectance

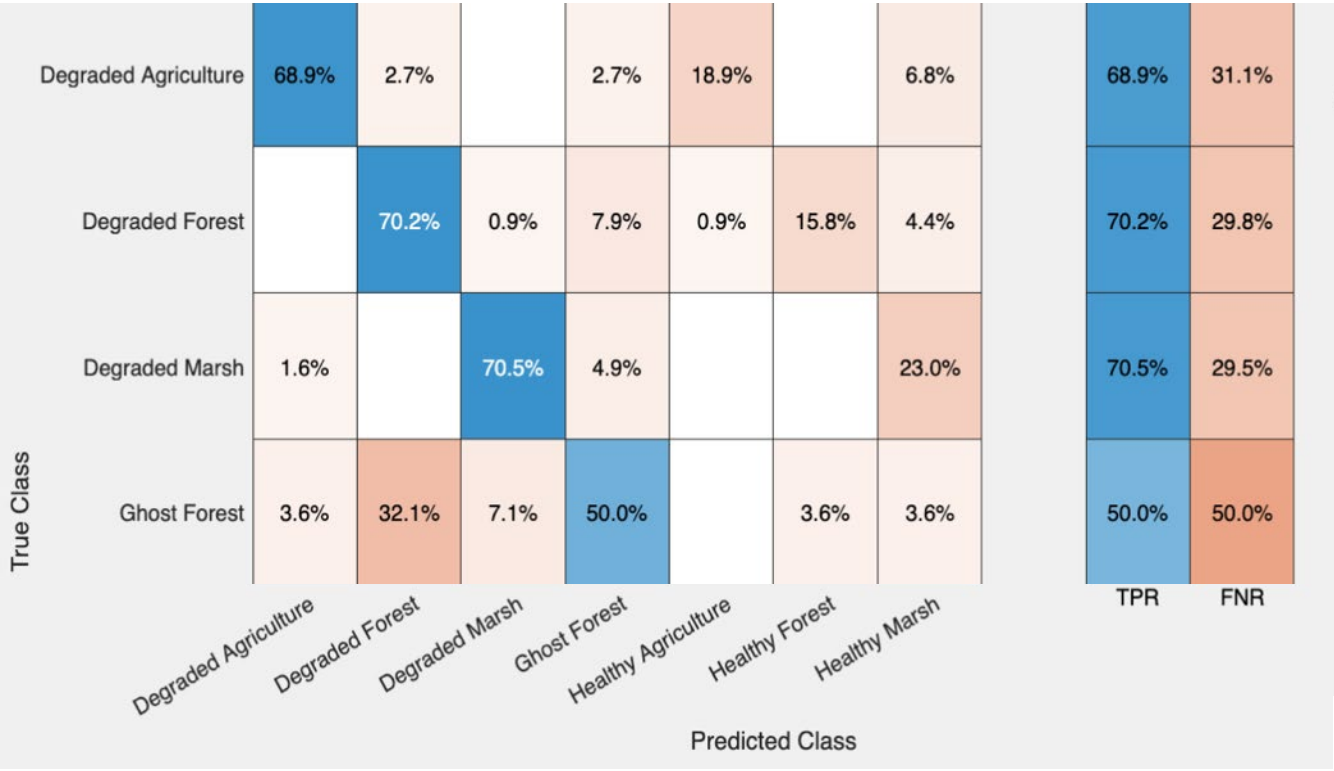
- Confusion in degraded classes (using all training data as reference data)
  - Especially degraded vs healthy forest and degraded vs healthy agriculture
  - Many field edges categorized as degraded (even if not salt impacted)
    - -> Adding categories for non-degraded field edges

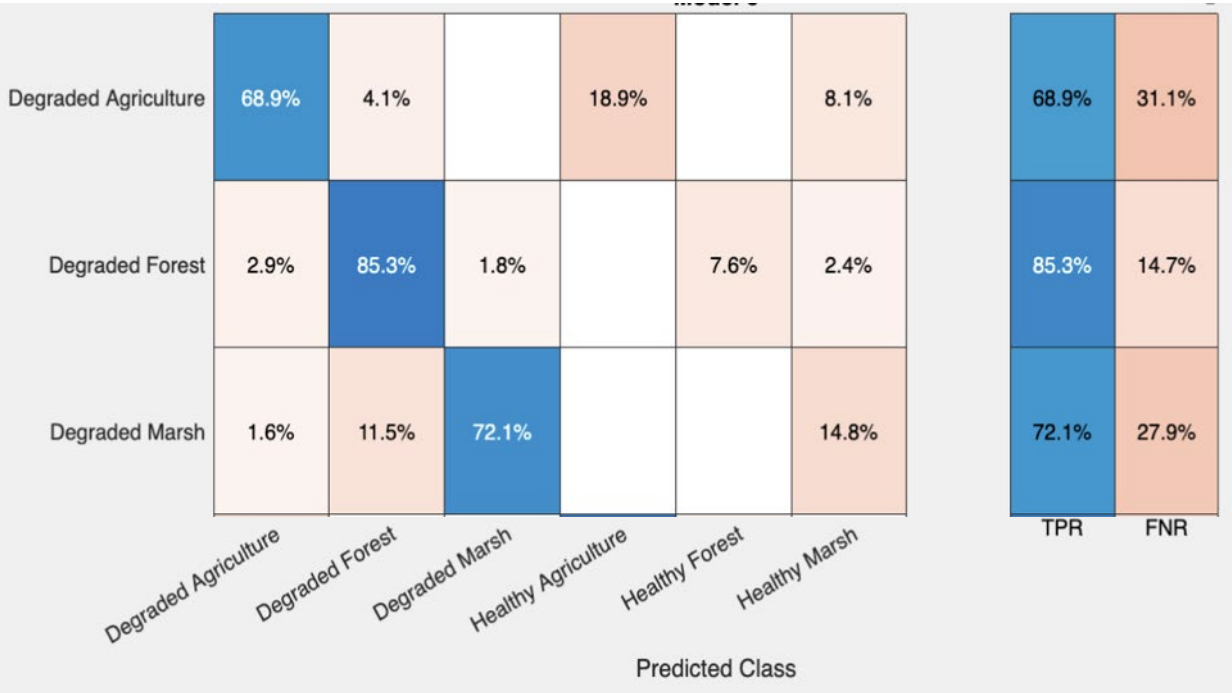


Actual Class	Predicted Rate: Degraded Agriculture	Degraded Forest	Degraded Marsh	Ghost Forest	Healthy Agriculture	Healthy Forest	Healthy Marsh
Degraded Agriculture	0.824	0.041	0.000	0.000	0.108	0.014	0.014
Degraded Forest	0.018	0.860	0.000	0.026	0.000	0.096	0.000
Degraded Marsh	0.033	0.033	0.902	0.016	0.000	0.000	0.016
Ghost Forest	0.000	0.107	0.036	0.804	0.018	0.036	0.000
Healthy Agriculture	0.034	0.000	0.007	0.000	0.938	0.007	0.014
Healthy Forest	0.000	0.017	0.000	0.000	0.010	0.969	0.003
Healthy Marsh	0.049	0.082	0.016	0.033	0.000	0.000	0.820

Cross-validation (K=50 folds)

- Goal is to get to >85% true positive rate for degraded classes
- Lumping ghost forest with degraded forest…



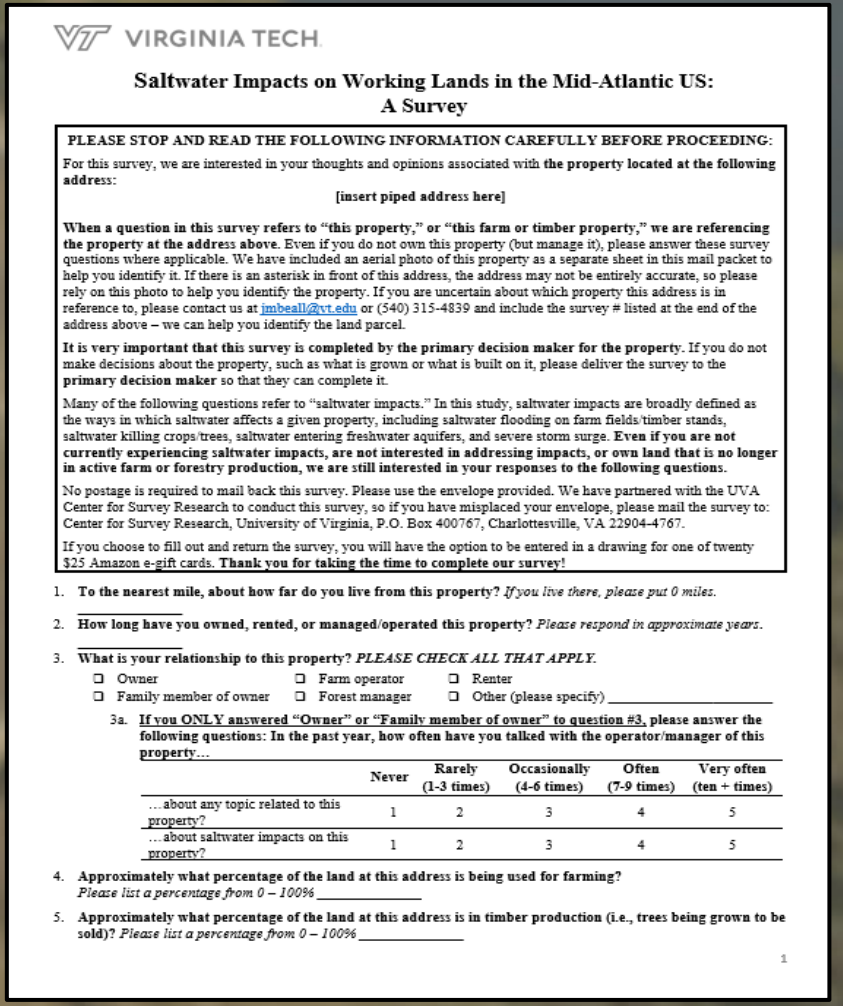


Upcoming Remote Sensing Project Activities

- Classification
  - Finish lidar, PlanetScope/MAXAR analysis for high resolution classification
  - Fully independent validation and accuracy assessment:
    - Stratified random sampling – field and imagery (Olofsson et al. 2014),
      - Allocation across strata TBD – likely closer to equal than proportional, as degradation is rare
    - Population error matrix
- Other Activities
  - Time series analysis of ghost/degraded forests and degraded agriculture at selected sites (D. Donahoe)
  - High resolution microtopography DEM from lidar
    - Identify anthropogenic adaptations to SLR (ditches, tiling, berms, etc.)

Sea Level Rise on Working Lands

- Objective 2: Landowner responses to SLR
- Survey landowners
  - Determine whether landowners are experiencing SLR impacts, and if they have made any decisions/actions in response
  - Estimate how psychological, social, and ecological factors influence landowner decisions regarding SLR



VIRGINIA TECH

Saltwater Impacts on Working Lands in the Mid-Atlantic US: A Survey

PLEASE STOP AND READ THE FOLLOWING INFORMATION CAREFULLY BEFORE PROCEEDING:

For this survey, we are interested in your thoughts and opinions associated with **the property located at the following address**:

[insert piped address here]

When a question in this survey refers to "this property," or "this farm or timber property," we are referencing the property at the address above. Even if you do not own this property (but manage it), please answer these survey questions where applicable. We have included an aerial photo of this property as a separate sheet in this mail packet to help you identify it. If there is an asterisk in front of this address, the address may not be entirely accurate, so please rely on this photo to help you identify the property. If you are uncertain about which property this address is in reference to, please contact us at jmbeall@vt.edu or (540) 315-4839 and include the survey # listed at the end of the address above – we can help you identify the land parcel.

It is very important that this survey is completed by the primary decision maker for the property. If you do not make decisions about the property, such as what is grown or what is built on it, please deliver the survey to the **primary decision maker** so that they can complete it.

Many of the following questions refer to "saltwater impacts." In this study, saltwater impacts are broadly defined as the ways in which saltwater affects a given property, including saltwater flooding on farm fields/timber stands, saltwater killing crops/trees, saltwater entering freshwater aquifers, and severe storm surge. **Even if you are not currently experiencing saltwater impacts, are not interested in addressing impacts, or own land that is no longer in active farm or forestry production, we are still interested in your responses to the following questions.**

No postage is required to mail back this survey. Please use the envelope provided. We have partnered with the UVA Center for Survey Research to conduct this survey, so if you have misplaced your envelope, please mail the survey to: Center for Survey Research, University of Virginia, P.O. Box 400767, Charlottesville, VA 22904-4767.

If you choose to fill out and return the survey, you will have the option to be entered in a drawing for one of twenty $25 Amazon e-gift cards. **Thank you for taking the time to complete our survey!**

1. **To the nearest mile, about how far do you live from this property?** *If you live there, please put 0 miles.*
   _____
2. **How long have you owned, rented, or managed/operated this property?** *Please respond in approximate years.*
   _____
3. **What is your relationship to this property?** ***PLEASE CHECK ALL THAT APPLY.***
   - ❑ Owner
   - ❑ Family member of owner
   - ❑ Farm operator
   - ❑ Forest manager
   - ❑ Renter
   - ❑ Other (please specify) _____

   3a. **If you ONLY answered "Owner" or "Family member of owner" to question #3, please answer the following questions: In the past year, how often have you talked with the operator/manager of this property…**

	Never	Rarely (1-3 times)	Occasionally (4-6 times)	Often (7-9 times)	Very often (ten + times)
…about any topic related to this property?	1	2	3	4	5
…about saltwater impacts on this property?	1	2	3	4	5

4. **Approximately what percentage of the land at this address is being used for farming?** *Please list a percentage from 0 – 100%* _____
5. **Approximately what percentage of the land at this address is in timber production (i.e., trees being grown to be sold)?** *Please list a percentage from 0 – 100%* _____

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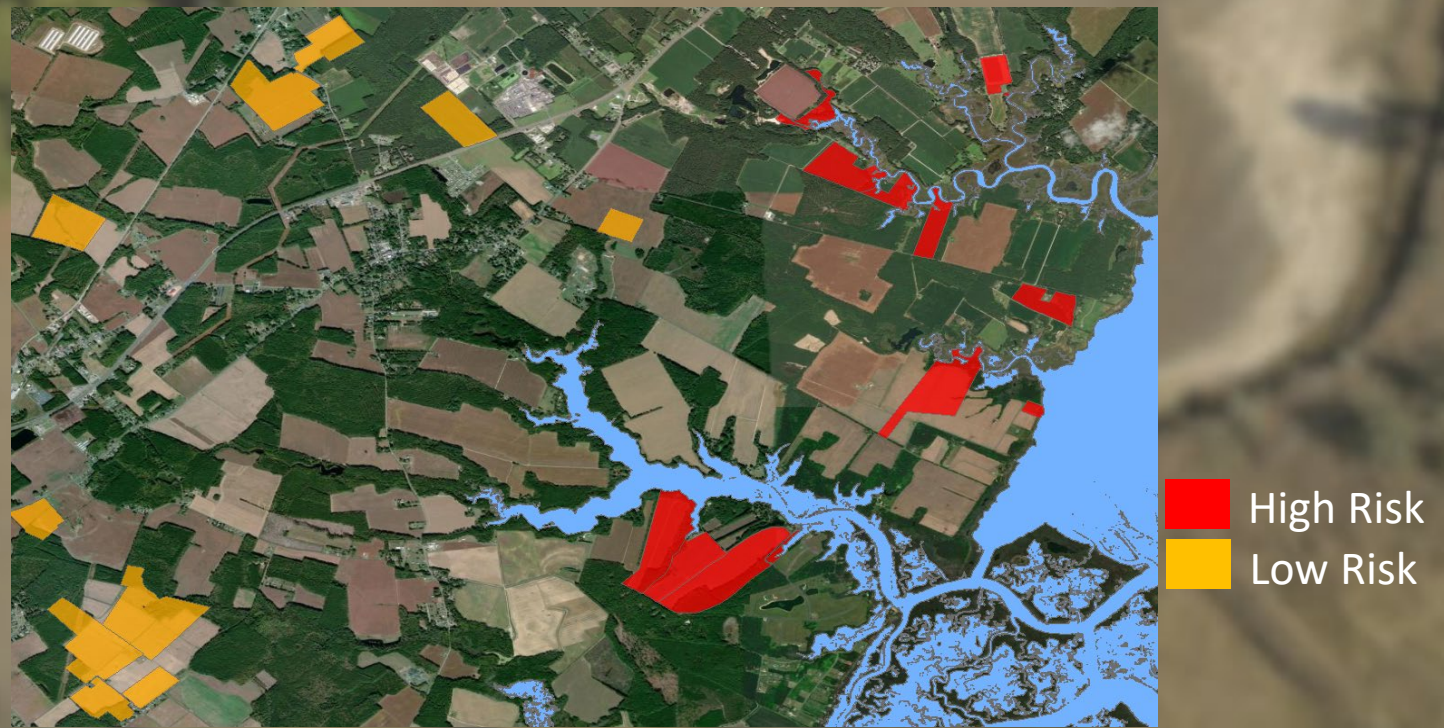
Survey of coastal landowners

- Sending survey to 8,400 landowners
  - Stratified by landcover/use and risk – using LightBox parcel dataset
    - Only included parcels that were >60% agriculture or forestry
    - High risk: <5m elevation; Low risk: >5m elevation (using USGS 3DEP 10m DEM)
      - High risk parcels >10x more degraded pixels than low risk parcels
  - Survey has been mailed and all responses expected by this summer

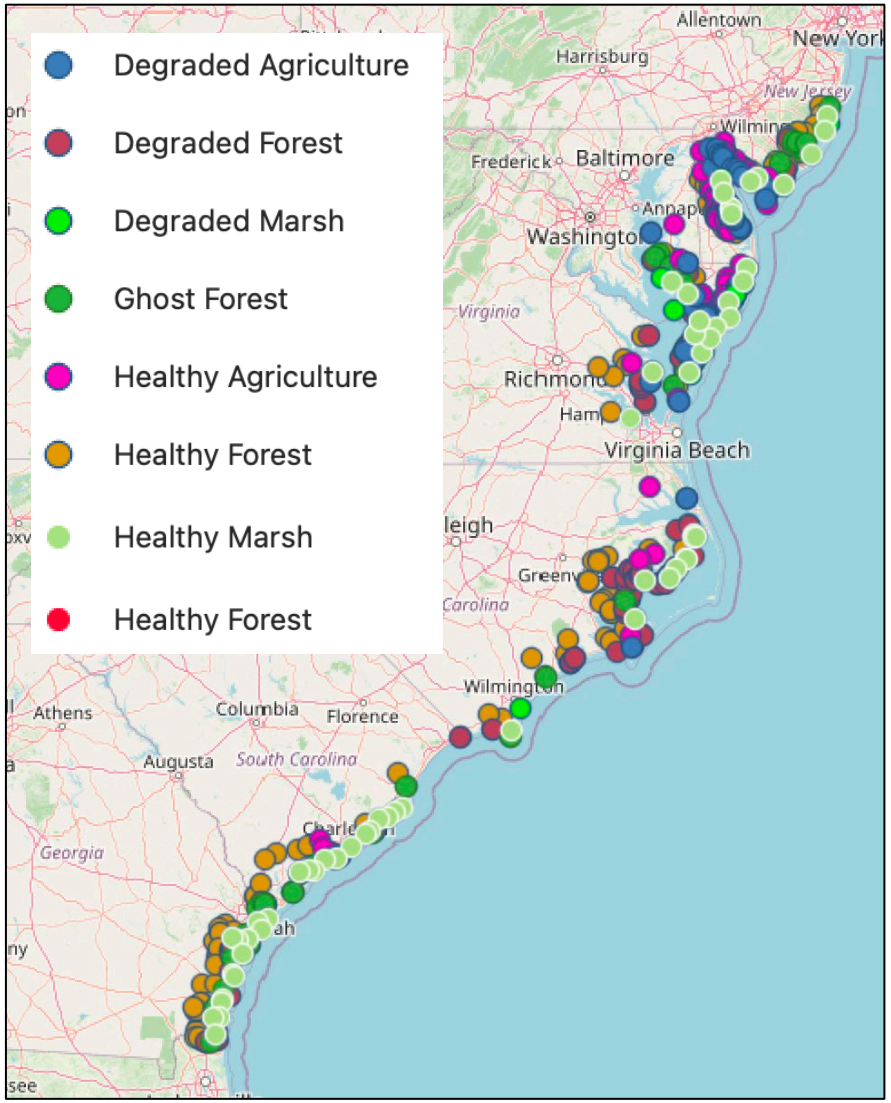


Thank you!

Photo: Jarrod Miller

Training Locations

Category	Count
Healthy Natural Forest – close (1NC)	112
Healthy Natural Forest – far (1NF)	112
Healthy Production Forest – close (1PC)	33
Healthy Production Forest – far (1PF)	32
Degraded Natural Forest (2N)	82
Degraded Production Forest (2P)	32
Ghost Forest (3)	56
Healthy Agriculture – close (4C)	74
Healthy Agriculture – far (4F)	72
Degraded Agriculture (5)	74
Degraded Marsh (6)	61
Healthy Marsh (7)	61
TOTAL	**801**



Improving performance with decision rules

- Additional Rules:
  - Only elevations where salinization due to SLR is possible were considered
    - Elevation ≦5 m for degraded classes
  - Only landcover classes that existed within the training data
    - Based on ESA Worldcover:
      - Tree Cover, Cropland, Grassland, Herbaceous Wetland
  - Adding rules reduced misclassification rate to 7%
    - But still challenges with field edges
- Additional changes moving forward:
  - Add categories for non-degraded field edges

High-resolution classifications in progress

- PlanetScope surface reflectance data acquired, indices calculated
  - Study area is approximately 300 scenes per date
- Lidar analysis underway
  - Significant evolutions in lidar availability since start of project
    - USGS 3DEP on AWS public bucket
    - MS Planetary Computer processed and made available 2m products from USGS 3DEP lidar

Key Survey Variables

Risk Appraisal: Perceived probability and severity of experiencing saltwater impacts

Adaptation Appraisal: Effectiveness of responses to SLR, costliness, and capability of implementing them.

Adaptation Intention: Is intention related to risk?

Past behaviors: Have they taken actions in response to SLR impacts?

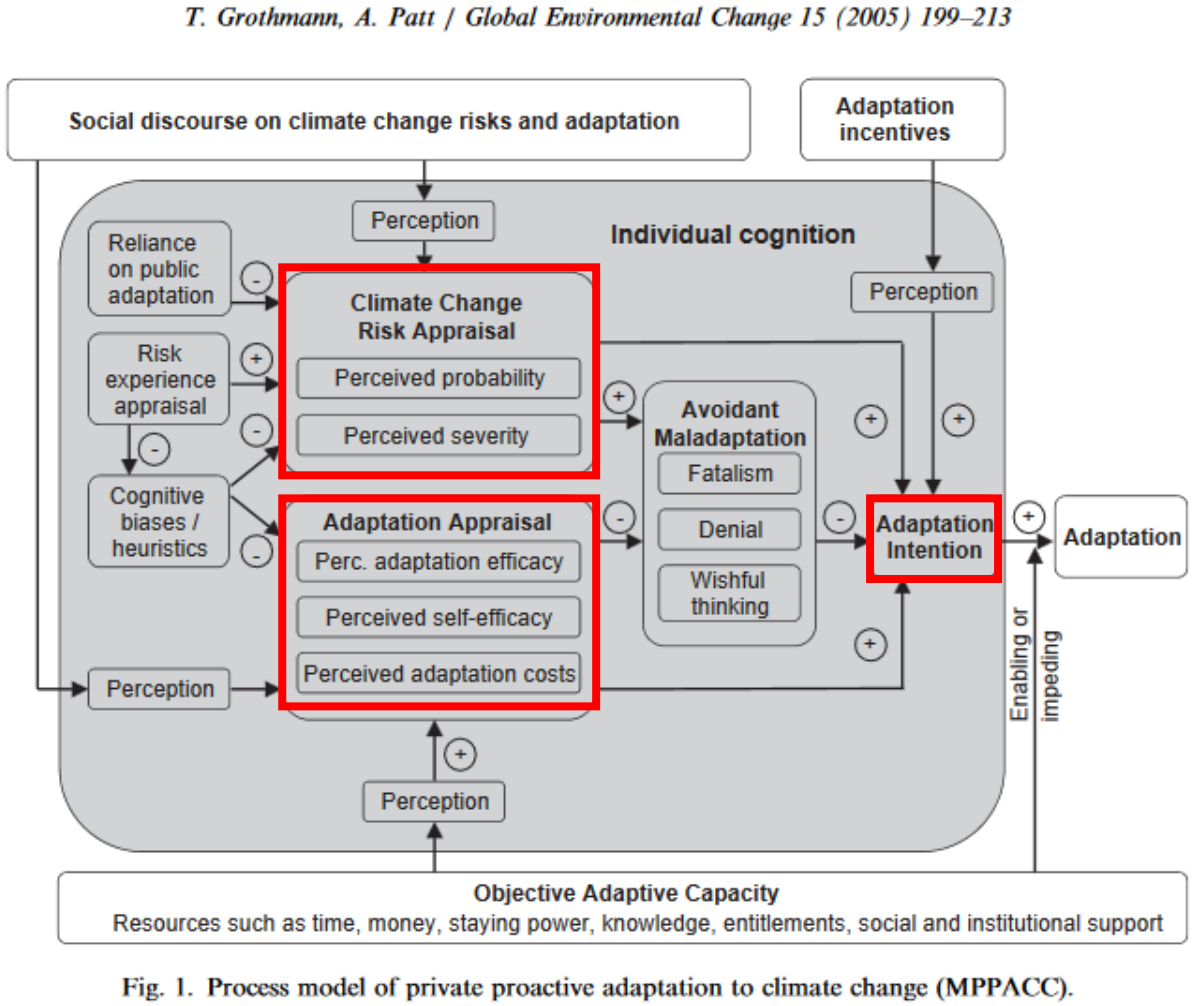


Fig. 1. Process model of private proactive adaptation to climate change (MPPACC).