Leveraging Earth Observation for Ecosystem Service Accounting in Large-scale Levee Setback Decisions

Charles B. van Rees[1], Rabindra Parajuli[1], Mark Dixon[2], Seth Wenger[1], Robb Jacobson[3], Dave Crane[4]

[1]University of Georgia; [2]University of South Dakota; [3]University of Missouri; [4]US Army Corps of Engineers

NASA BDEC Team Meeting 2025

Odum School of Ecology
River Basin Center
Institute for Re
Infrastructure
UNIVERSITY OF GEORGIA

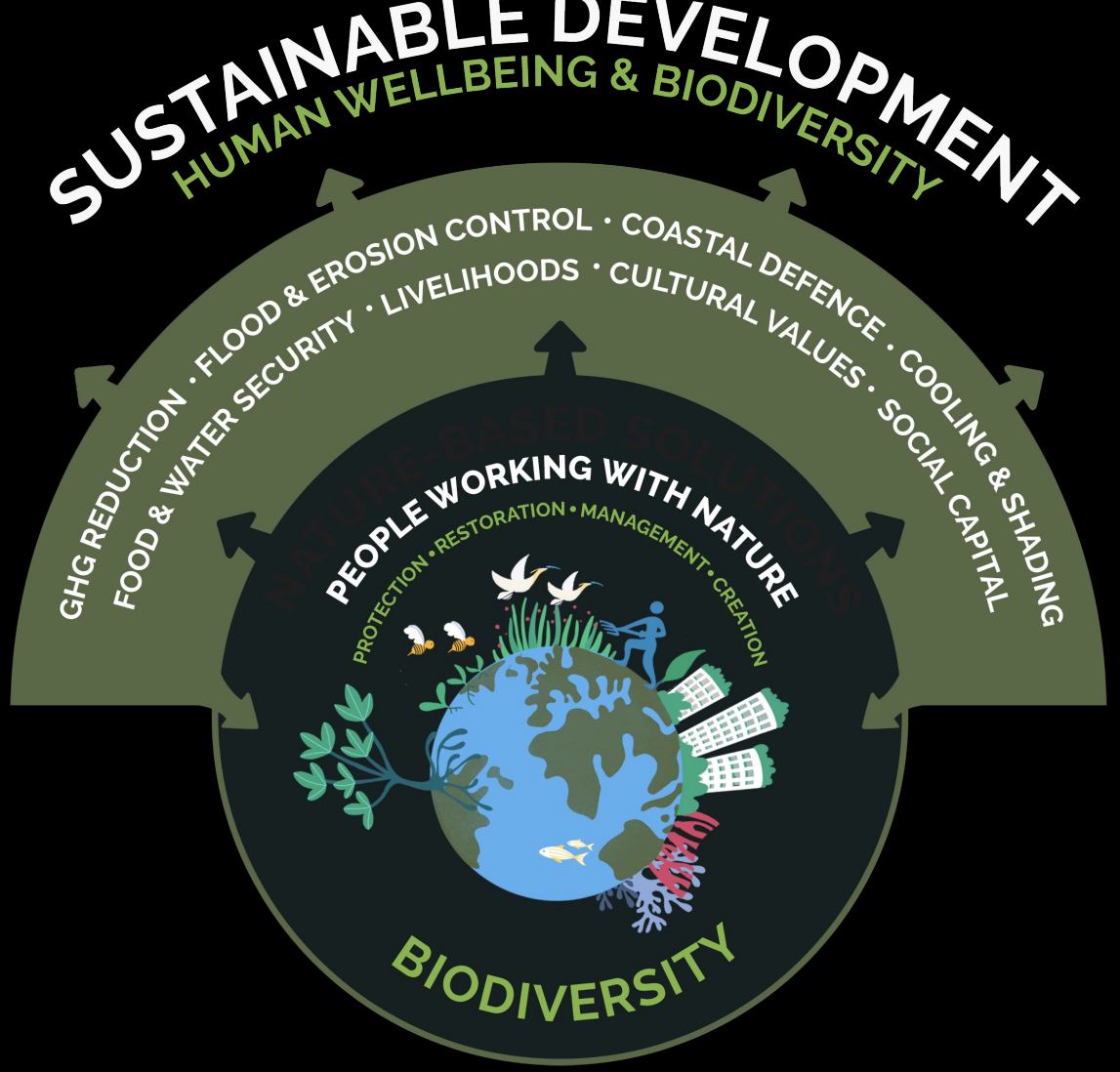
NETWORK FOR ENGINEERING WITH NATURE

NASA

@GuloThoughts

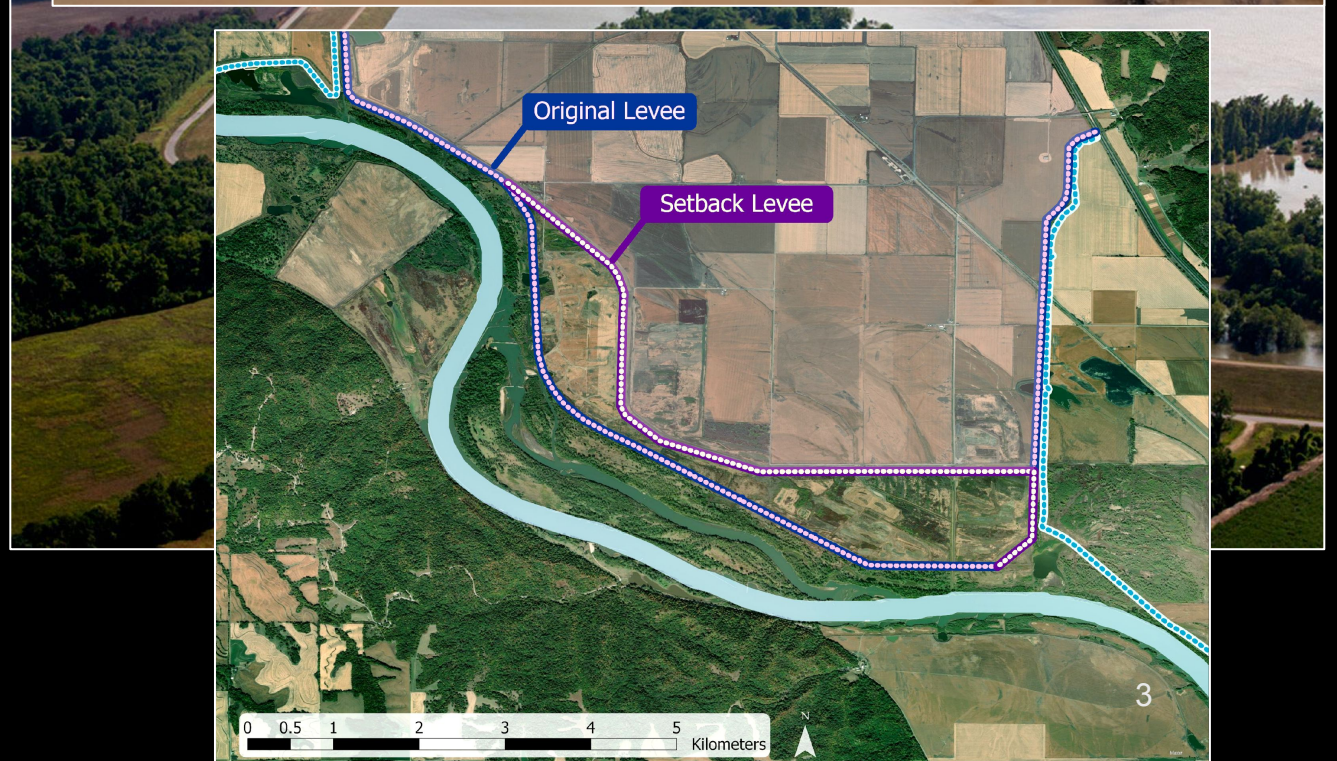
Nature-based Solutions

- Ecosystems that are restored, created, managed to address societal problems or needs
- Global surge in interest & investment
- Decision-making & modeling tools limited



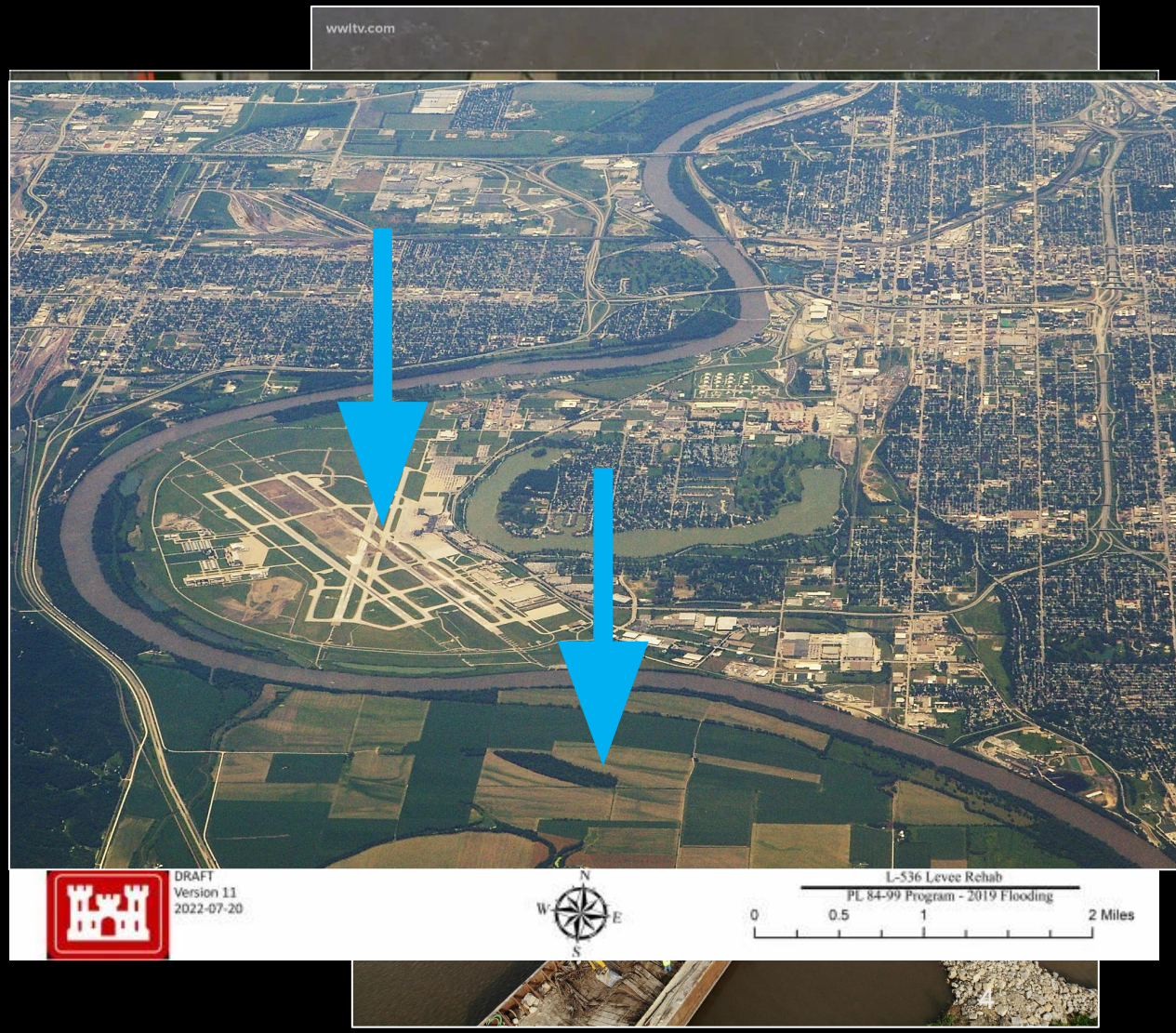
Levee setbacks

- Realignment of existing levees – restoring portion of floodplain
- “Room for the river”
- Flood control, water quality, other benefits



Levees & the Missouri River

- Historical engineering constrained channel
- Loss of floodplain & riverine habitats
- Climate change leading to failure
- USACE starting to employ levee setbacks



Biodiversity Benefits of Levee Setbacks

- USACE looking to quantify biodiversity benefits
- Project goal: Collect data, generate models to inform decision-making
  - Biodiversity benefits
  - Carbon storage
  - Flood benefits

Mizzou
University of Missouri

NASA

US Army Corps of Engineers®
Omaha District

UNIVERSITY OF SOUTH DAKOTA

UNIVERSITY OF GEORGIA
River Basin Center

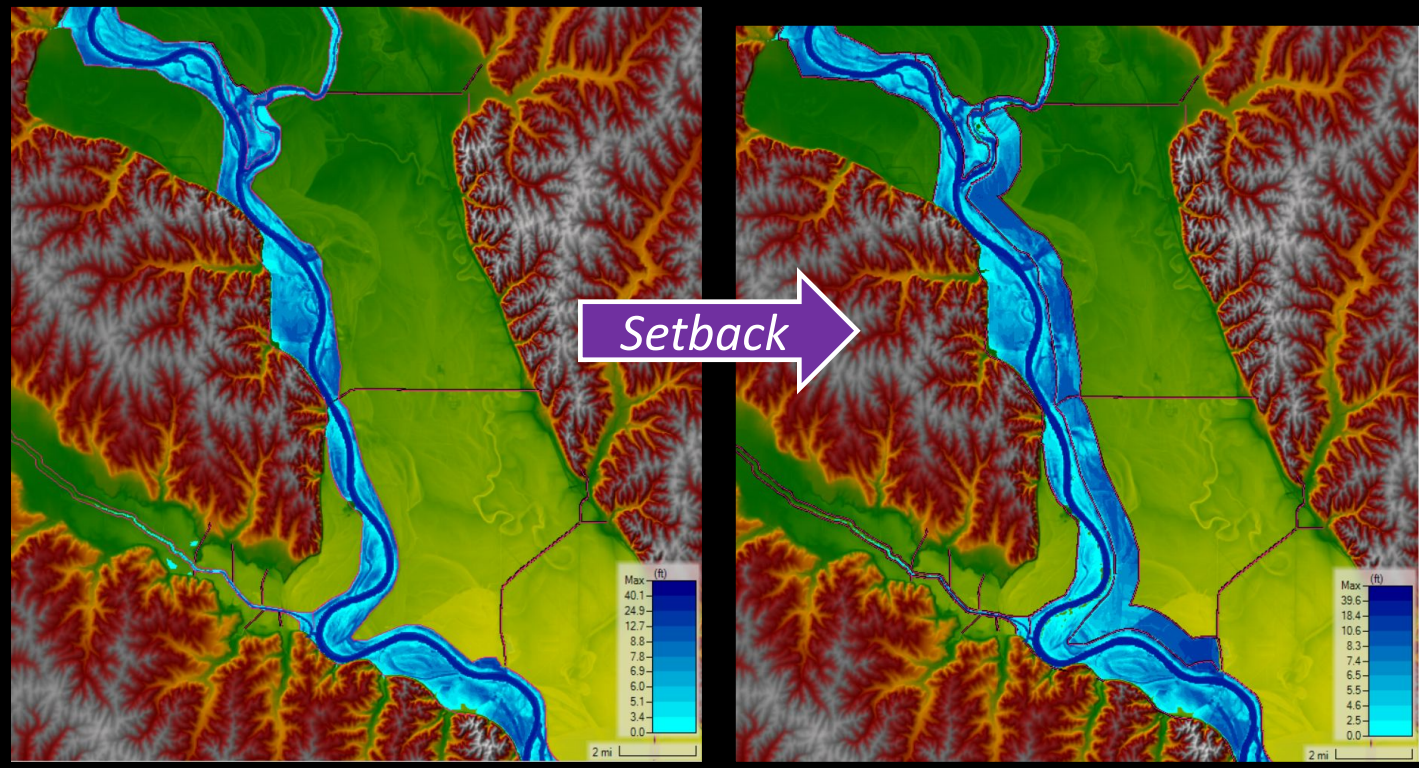
GEORGIA
Franklin College of Arts & Sciences

In Situ Data

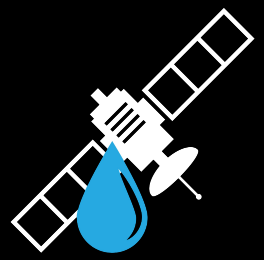
- Automated recording units
  - Bats
  - Neotropical migrant songbirds
  - Anurans (frogs & toads)
- Field surveys
  - Waterfowl
  - Tadpoles
- Forest structure & composition
- Second field season currently underway!

H&H Models

- Developed by USACE, Matt Chambers (UGA) & Rod Lammers (CMU)
- DEMs & gage time series data as inputs
- “Back-casts” & predictions of hydrology:
  - Peak velocity / scour
  - Inundation (timing, duration)
  - Validated w/ EO



Remote Sensing Workflow



Veg. LCs

- Vegetation land cover nomenclature
- Field samples, EO and spatial data acquisition
- Vegetation LCs classification – OBML

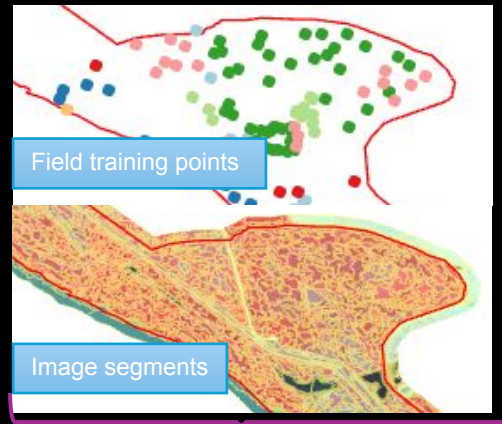
Timeseries

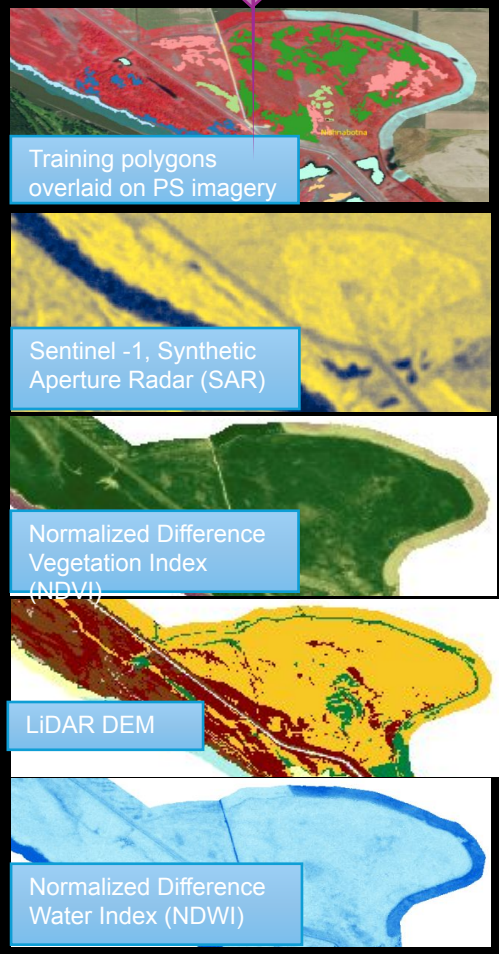
- Training samples from Vegetation LCs
- Timeseries of EO and indices
- Annual vegetation LCs timeseries – ML in GEE

Predictions

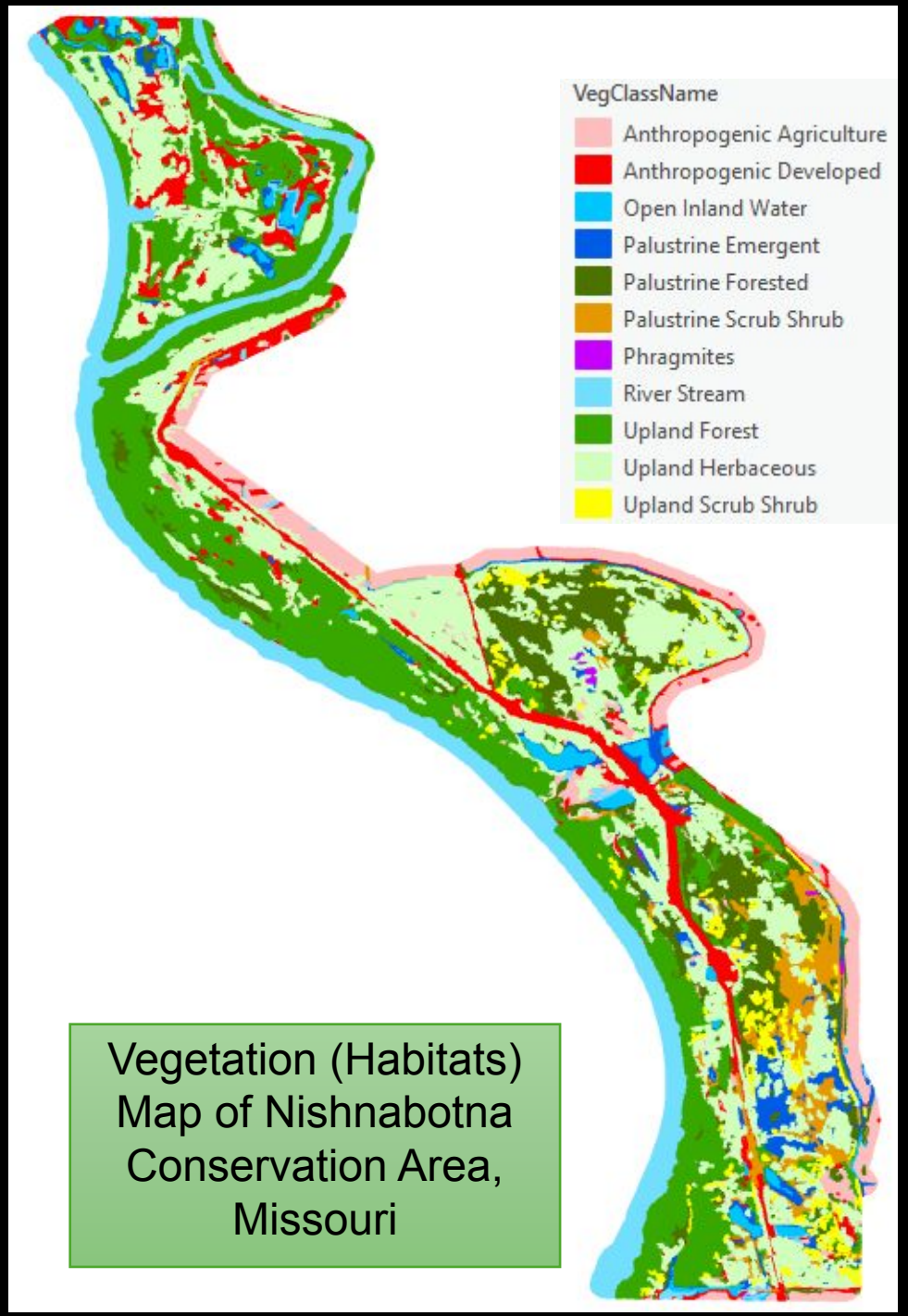
- Stacking timeseries raster as a 4D tensor
- Model test & implement – DL in Cloud/GPU
- Forecasting veg. LCs in a yearly timestep

Habitat (Veg & Land Cover) Classification



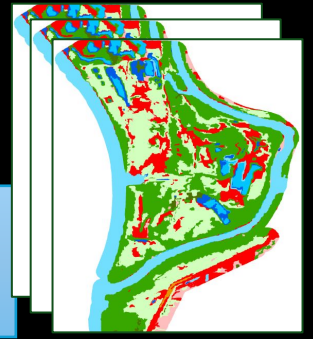


Ensemble OBML classification

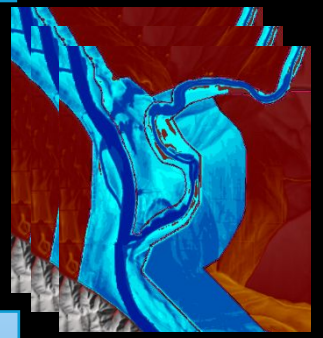


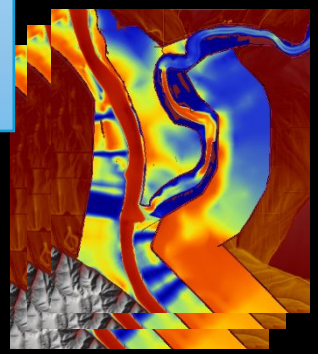
Vegetation (Habitats) Map of Nishnabotna Conservation Area, Missouri

Vegetation land covers timeseries



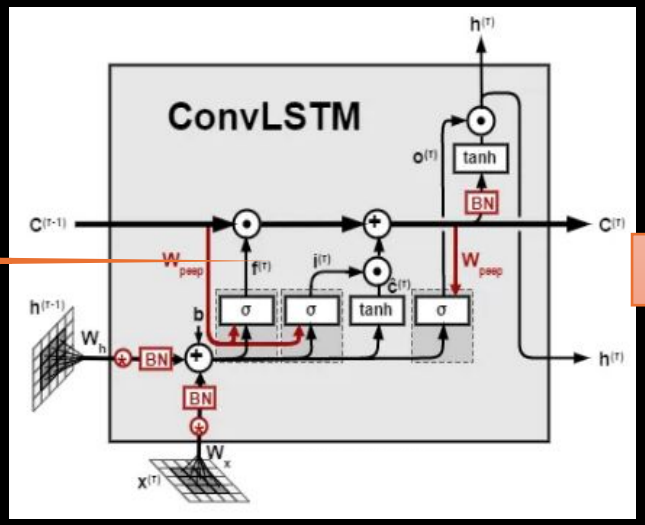
Hydrological variables timeseries

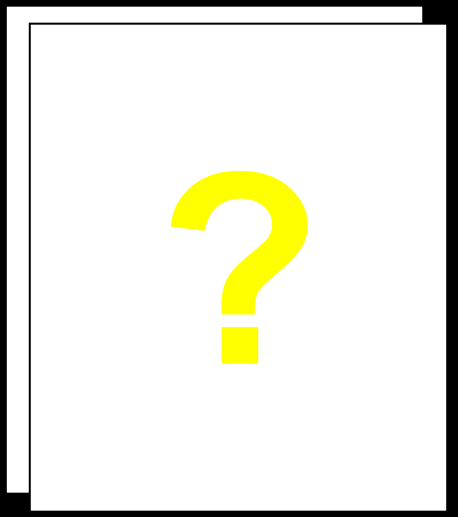




Other biophysical variable(s)

Primary Ecological Model (Hab/Veg)





Forecasted Vegetation LCs (Habitats) in NCA, Missouri

Ecological Models

Primary model

Veg/Habitat ~ Flooding + soil + …

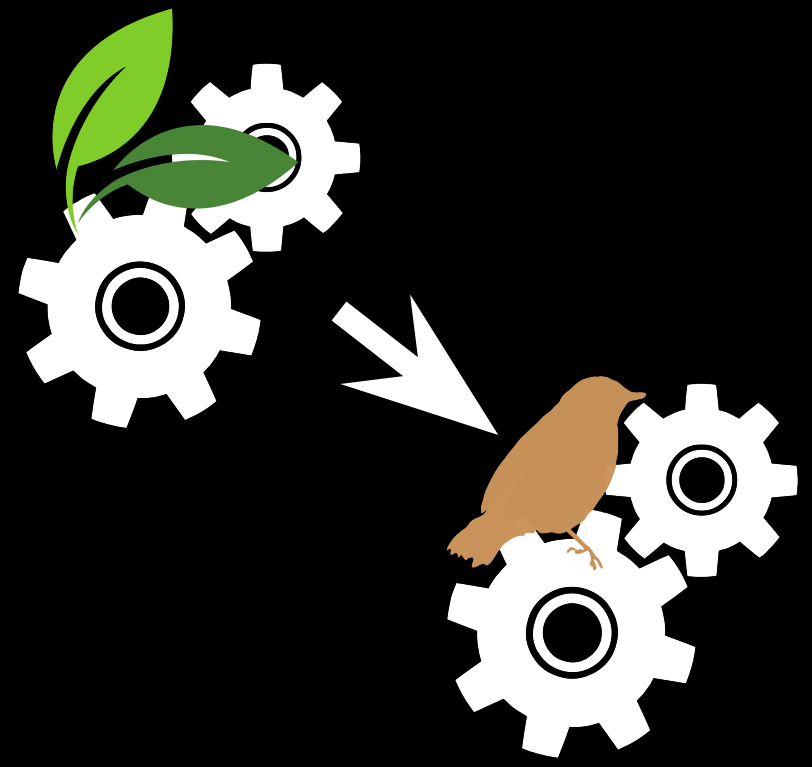
Secondary models

Wildlife ~ Veg/Habitat + Soil + …

Carbon storage ~ Veg/Habitat + …

Specific interest: what parameters can engineers actually affect?

What are the “levers”?




PLEASE STAND BY

Acknowledgments

- NASA A7 BDEC
- Wildlife & Water Lab @ UGA
- River Basin Center
- Odum School of Ecology
- Institute for Resilient Infrastructure Systems
- Center for Integrative Conservation Research
- N-EWN Biodiversity Working Group

NETWORK FOR ENGINEERING WITH NATURE

NASA

Wildlife & Water

UGA

US Army Corps of Engineers.

EWN

Engineering With Nature

Thank you!

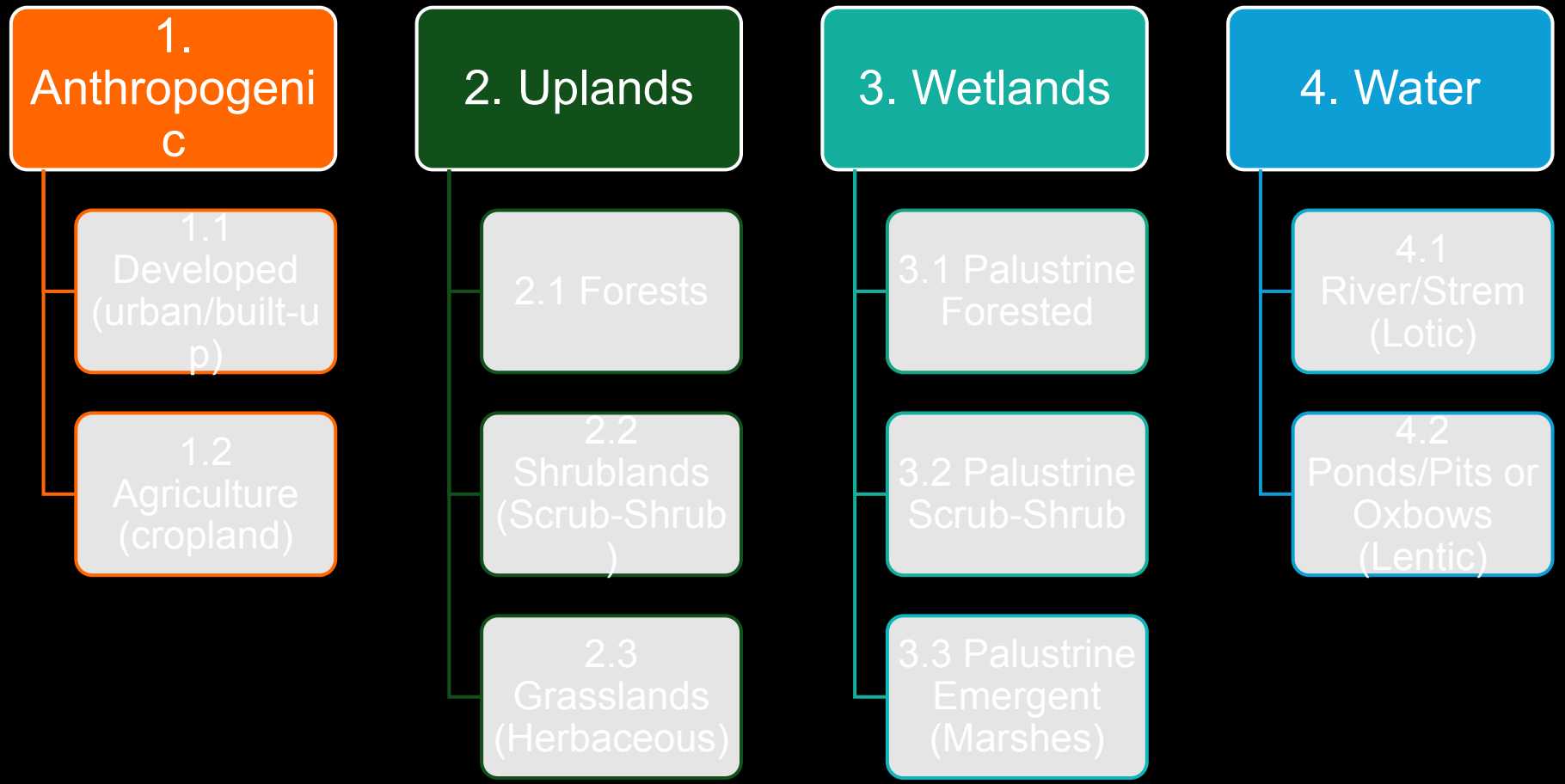
N-EWN.org

vanreeslab.ecology.uga.edu

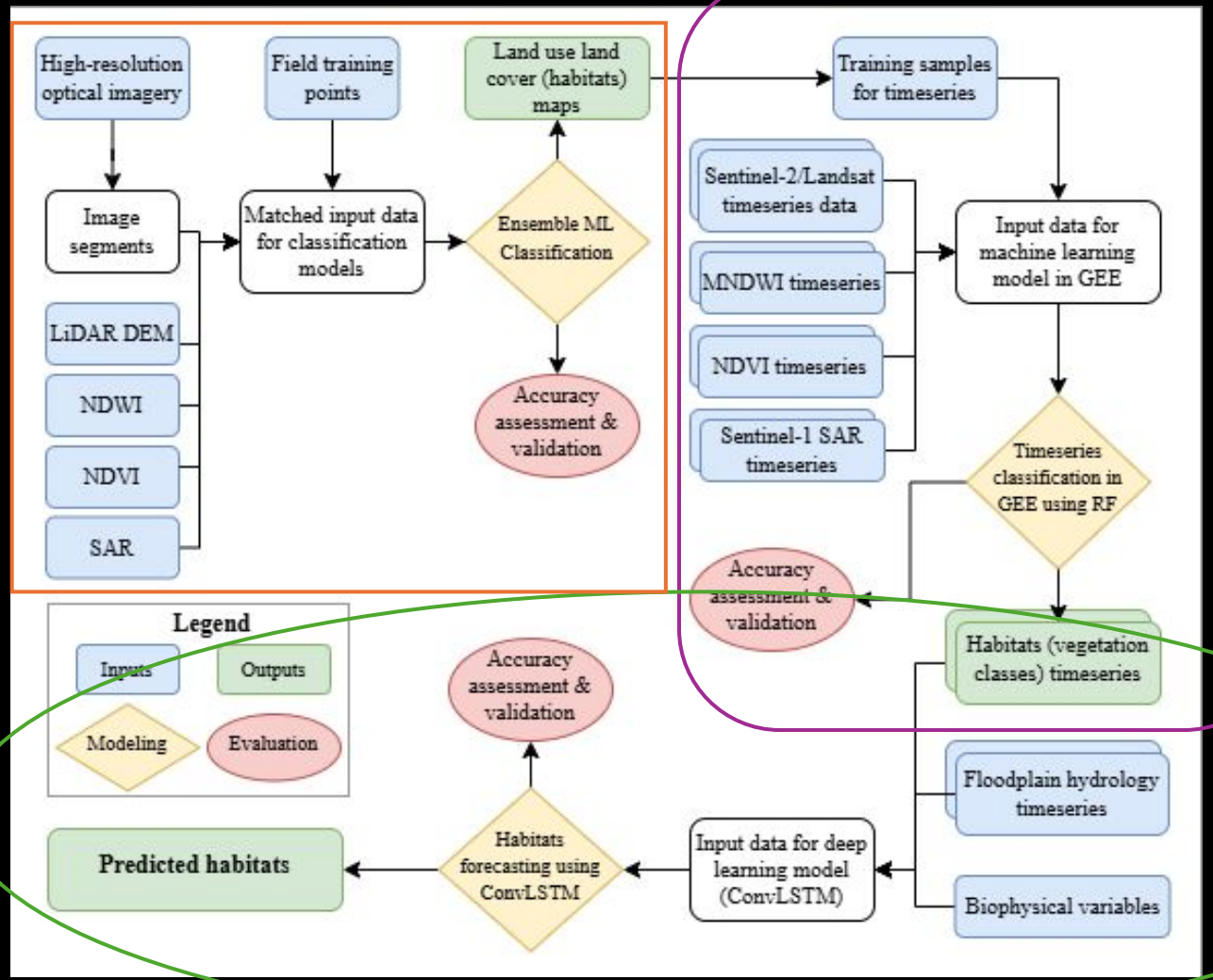
@GuloThoughts

Vegetation Classification Framework: Aligning National Standards with Local Floodplain Characteristics

Four major ecological categories based on the FGDC Vegetation and Wetland Classification Standards and the USFWS National Wetlands Inventory system:



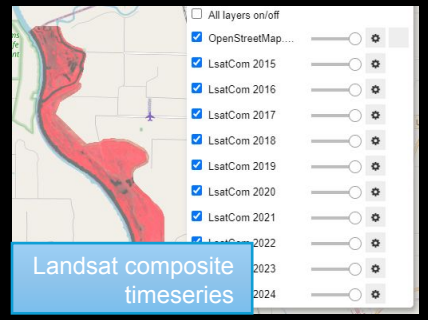
Workflow



Step-1
Veg

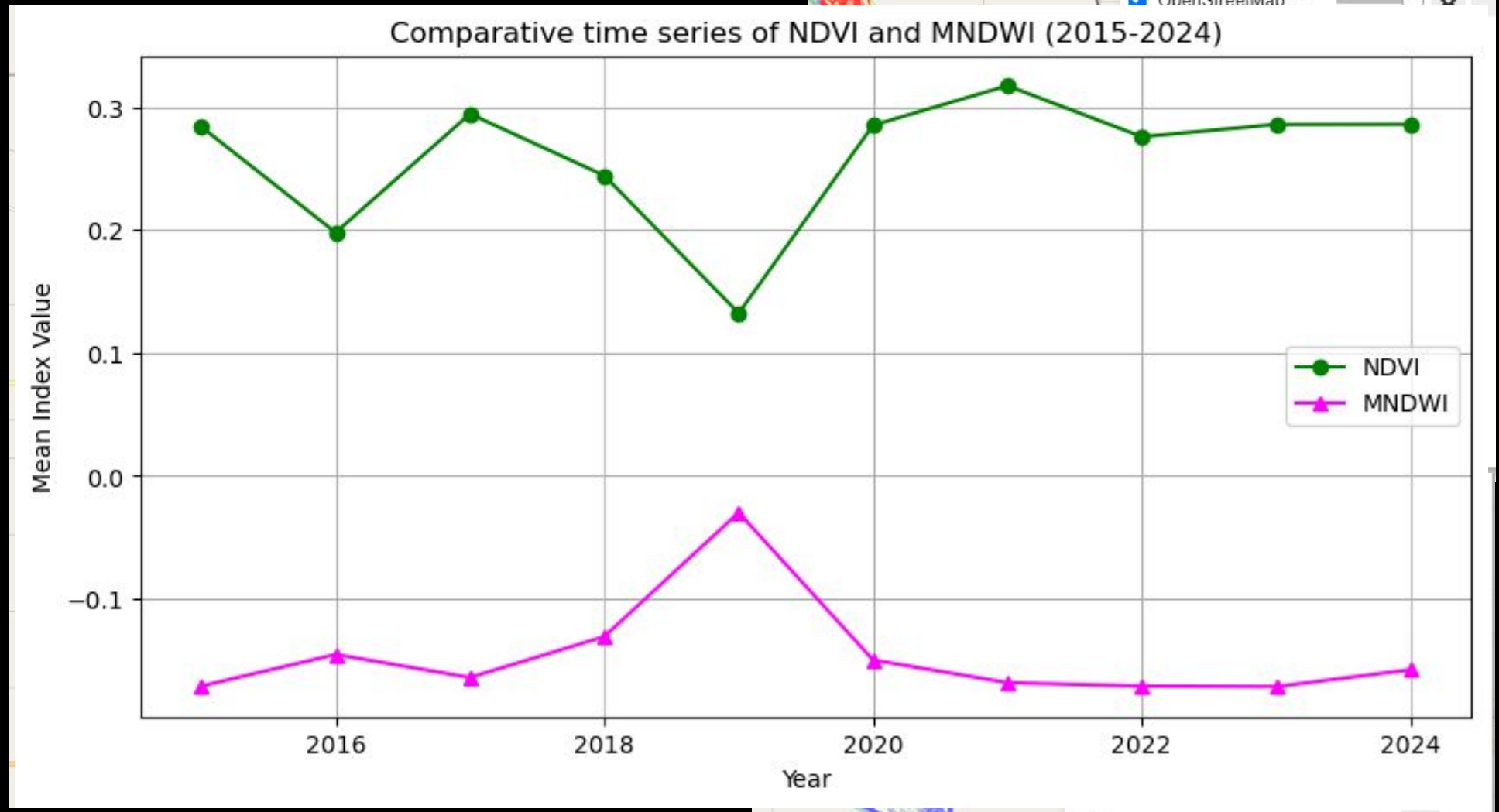
Step-2
Timeseries

Step-3
Forecasting

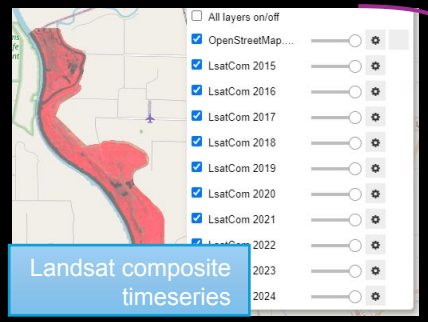


Landsat composite timeseries

Timeseries classification

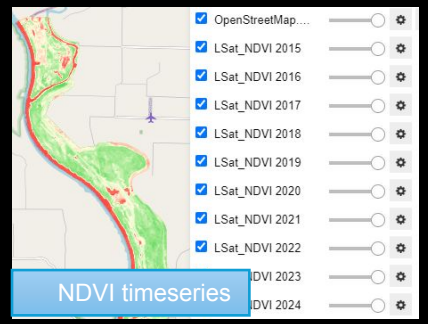

Comparative time series of NDVI and MNDWI (2015-2024)
Mean Index Value
0.3
0.2
0.1
0.0
−0.1
2016
2018
2020
2022
2024
Year
NDVI
MNDWI

All layers on/off
OpenStreetMap
Lsat_MNDWI 2020
Lsat_MNDWI 2021
Lsat_MNDWI 2022
Lsat_MNDWI 2023
Lsat_MNDWI 2024



Landsat composite timeseries

Training samples for 2024



NDVI timeseries

MNDWI timeseries

Random Forest ML algorithm

Classified vegetation LCs (habitats) pixels in Nishnabotna Conservation Area, Missouri