Evaluating Ecological Vulnerabilities of the Greater Everglades Ecosystem Using Bayesian Network Models

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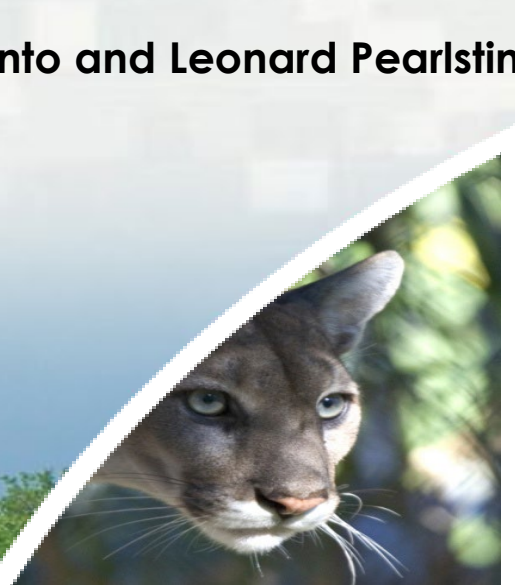
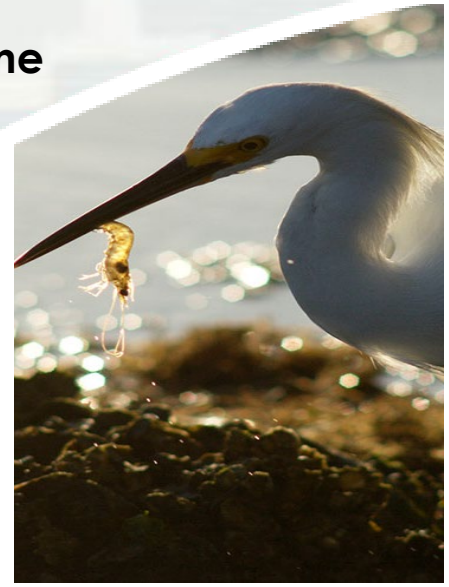
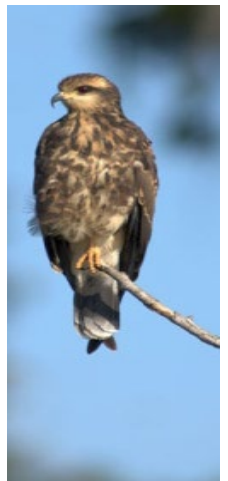






Outline

1. Vulnerability Analysis Goals and Objectives
2. Bayesian Belief Network
3. Greater Everglades Case Studies
4. Next Steps
5. Information Needed

Comprehensive Everglades Restoration Plan (CERP) System-Wide Science

REstoration COordination and VERification

Why RECOVER?

- Science behind CERP
- Communicates and coordinates the results of these evaluations and assessments
- Scientific support for decision-making

"Science will be the foundation of restoration." – 2003 Programmatic Regulations

Vulnerability Analysis Goals and Objectives

- **The goal of the Vulnerability Analysis is to provide recommendations on programmatic modifications and specific adaptations to mitigate or minimize vulnerability**
  - **identify areas, ecological components, and processes that are vulnerable to stress of various types**
- **Applications**
  1. **Inform RECOVER interim goals/targets, performance measures, review of the MAP**
  2. **Inform the Integrated Delivery Schedule (IDS)**
  3. **Adaptive management implications**
  4. **Identify information gaps**

Bayesian Belief Network

- A probabilistic graphical model using Bayesian inference for probability computation
- Can utilize existing RECOVER ecological conceptual models and hypothesis clusters as model frameworks
- Integrate best available ecological information from diverse sources
- Explicitly express model uncertainties (probability distributions)
- Readily updated as new information becomes available
- Provide a flexible, modular structure that can be customized to address a diversity of questions
- Constructed as a transparent decision-support and communication tool

Greater Everglades Vulnerability Analysis Task

- Contracted USGS with the National Park Service and South Florida Natural Resources Center to develop a methodology to evaluate multi-scale ecosystem risk within the greater Everglades ecosystem
- Test methodology for selected case studies
  - Peat collapse - uncertainty in how the system works
  - Trophic hypothesis - well-understood system with established models – how to integrate species models to identify vulnerabilities
- Draft modeling framework that can be expanded into additional system components
- Evaluate effect of management actions concurrent with hydrologic and climatic variability

Bayesian Belief Network Workflow

- Conceptual Development
- Predictive Model Development
- Build Spatiotemporal Dynamics

Current work has addressed these three parts of the workflow

- Decision Support for Management or Climate Change

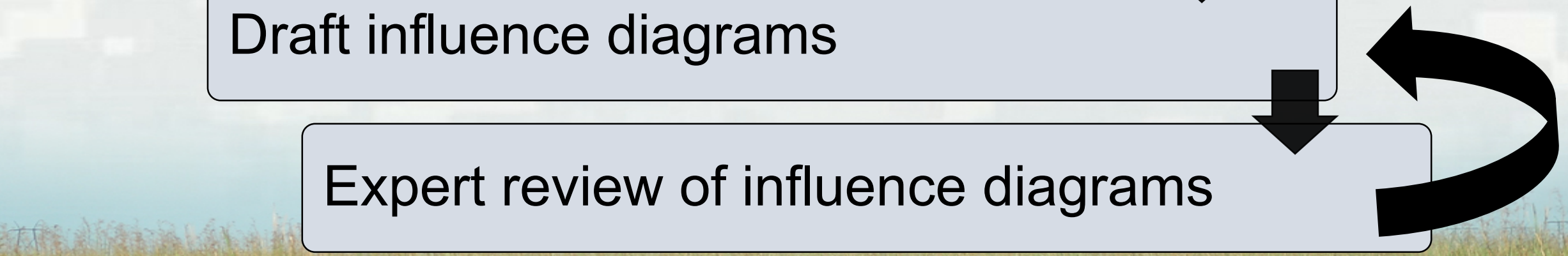
Conceptual Development

Literature Review

Consult Expert Ecologists

Draft influence diagrams

Expert review of influence diagrams



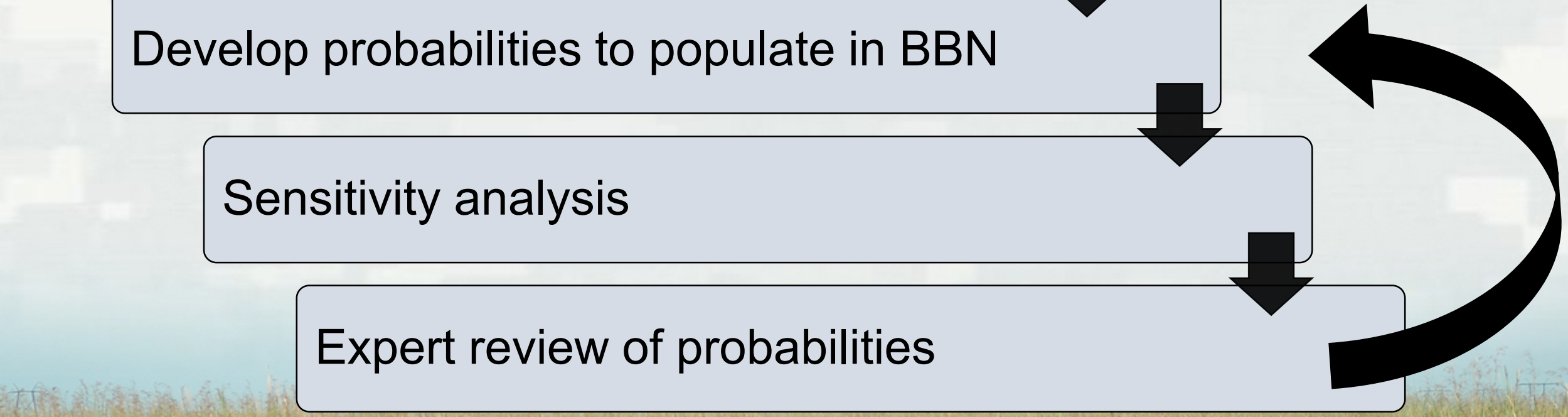
Predictive Model Development

Convert influence diagram to BBN

Develop probabilities to populate in BBN

Sensitivity analysis

Expert review of probabilities



Build Spatiotemporal Dynamics

Generate spatially and temporally explicit inputs

Conduct sensitivity analysis on landscape and over time

Expert review of outputs

Management or Climate Change Scenarios

Generate spatially and temporally explicit inputs indicative of scenarios

Explore output and uncertainty around it

Map output and use for decision support

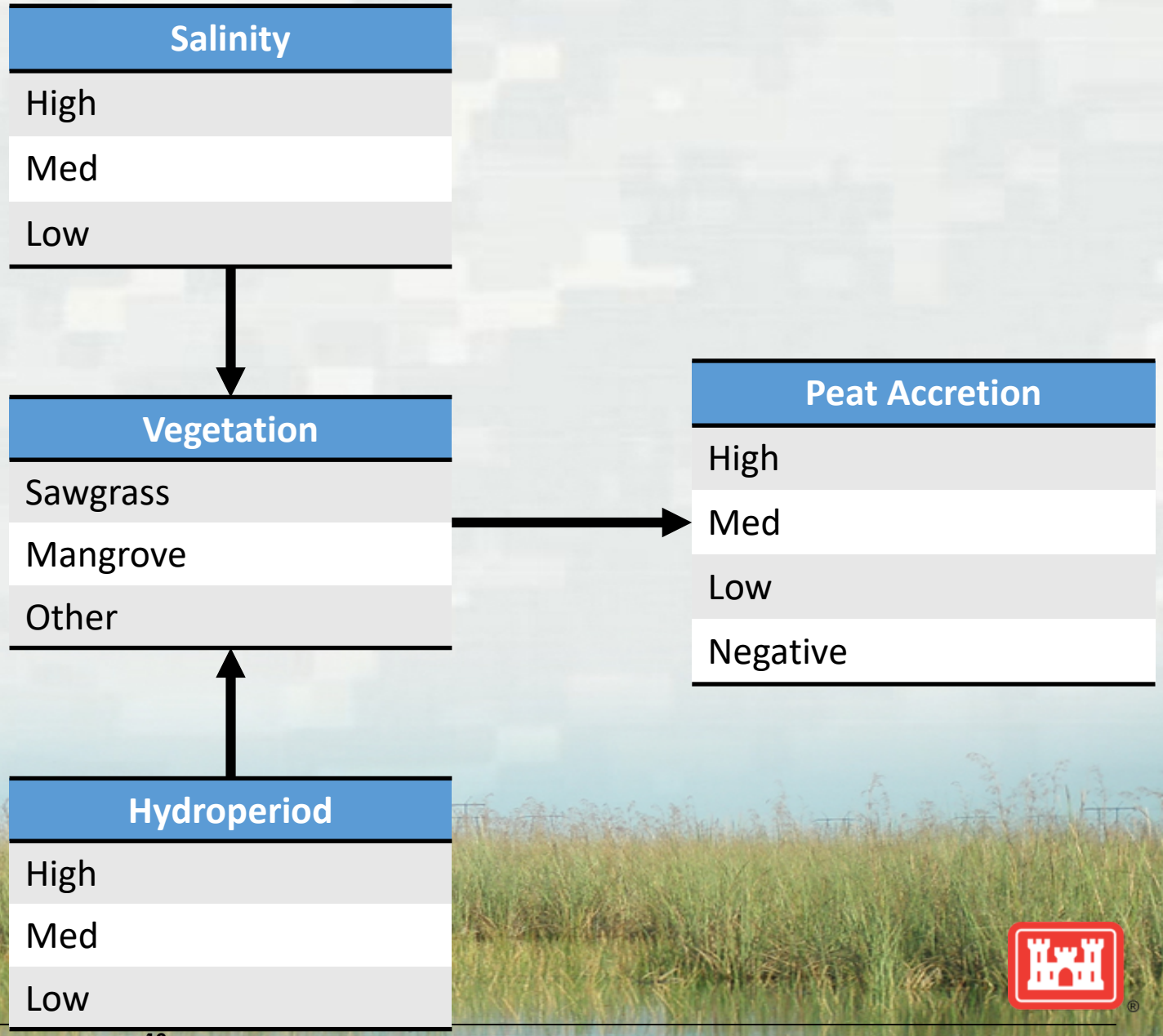
Peat Collapse/Accretion BBN

What we have:

- **Quantitative parameters**
- **Sawgrass peat loss**

Information needed:

- **Potential range of salinity in Everglades**
- **Potential range of Hydroperiod in Everglades**
- **Salinity & hydroperiod tolerance for vegetation type**
- **Peat accretion rates under each vegetation type**

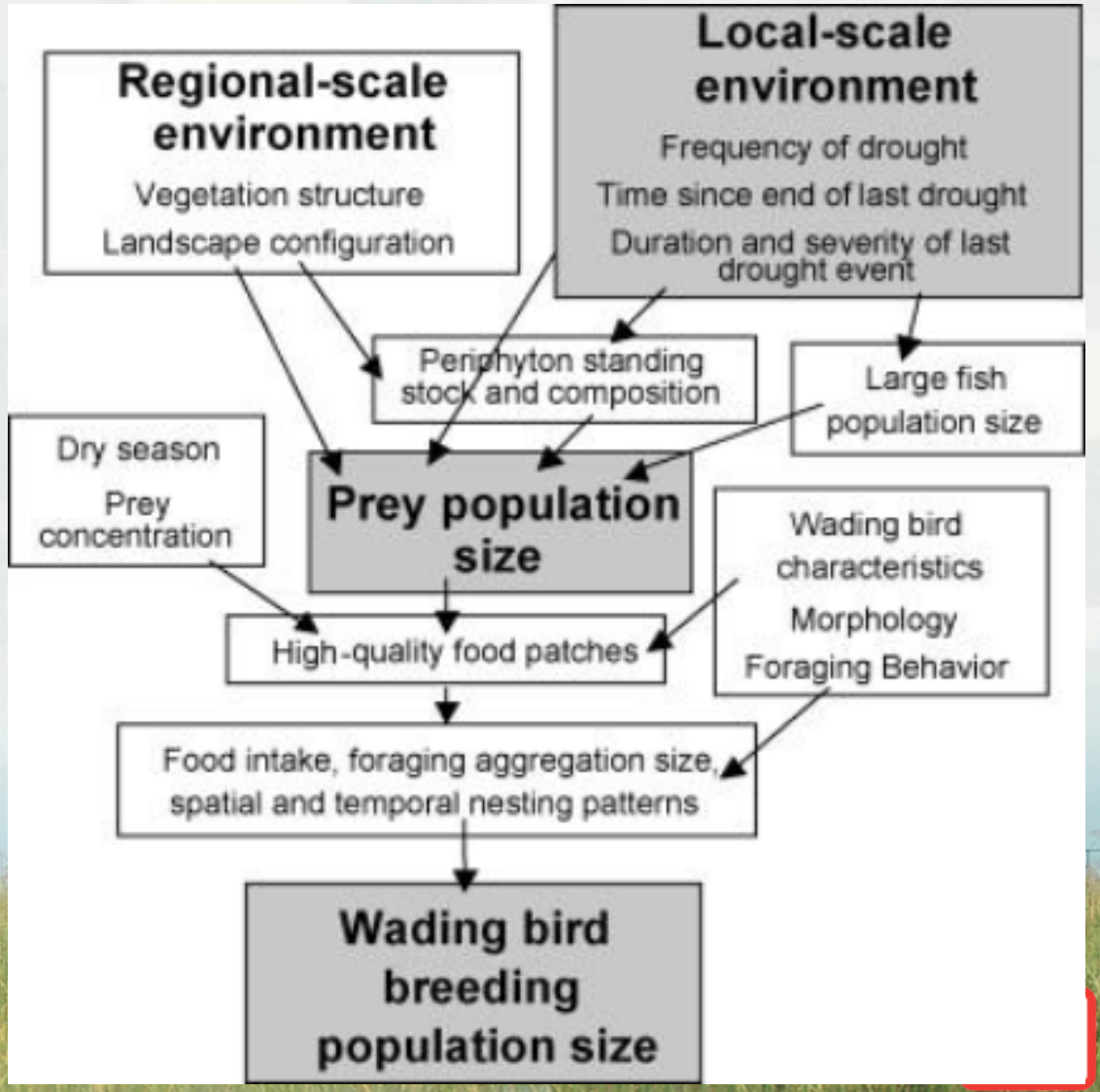


Trophic Hypothesis

Trexler and Goss 2009

What we have:

- **Published ideas of how the system works and how nodes are influenced**
- **Data and Models (e.g. suite of JEM models) we can use to construct conditional probabilities**
- **An idea of our certainty around each node**



Wading Birds

Hydro model →

Water depth
> -50 cm
-51 to 0 cm
1 to 50 cm
> 50 cm

Veg BN model output →

Vegetation
Open water
Sawgrass
Cattail
Marl Prairie
Brush
Mangrove

Suitability for White Ibis
High
Med
Low

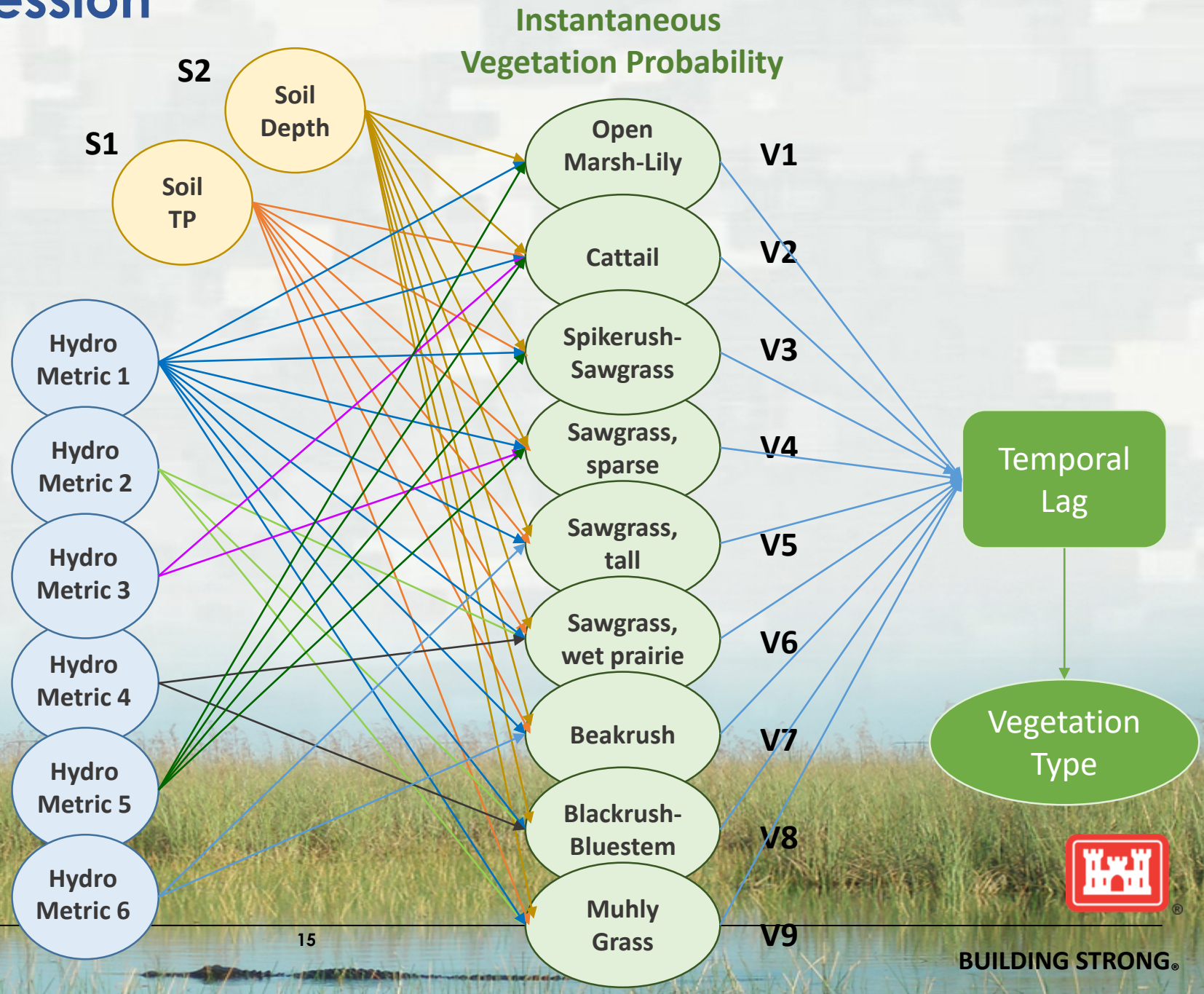
Suitability for Wood stork
High
Med
Low

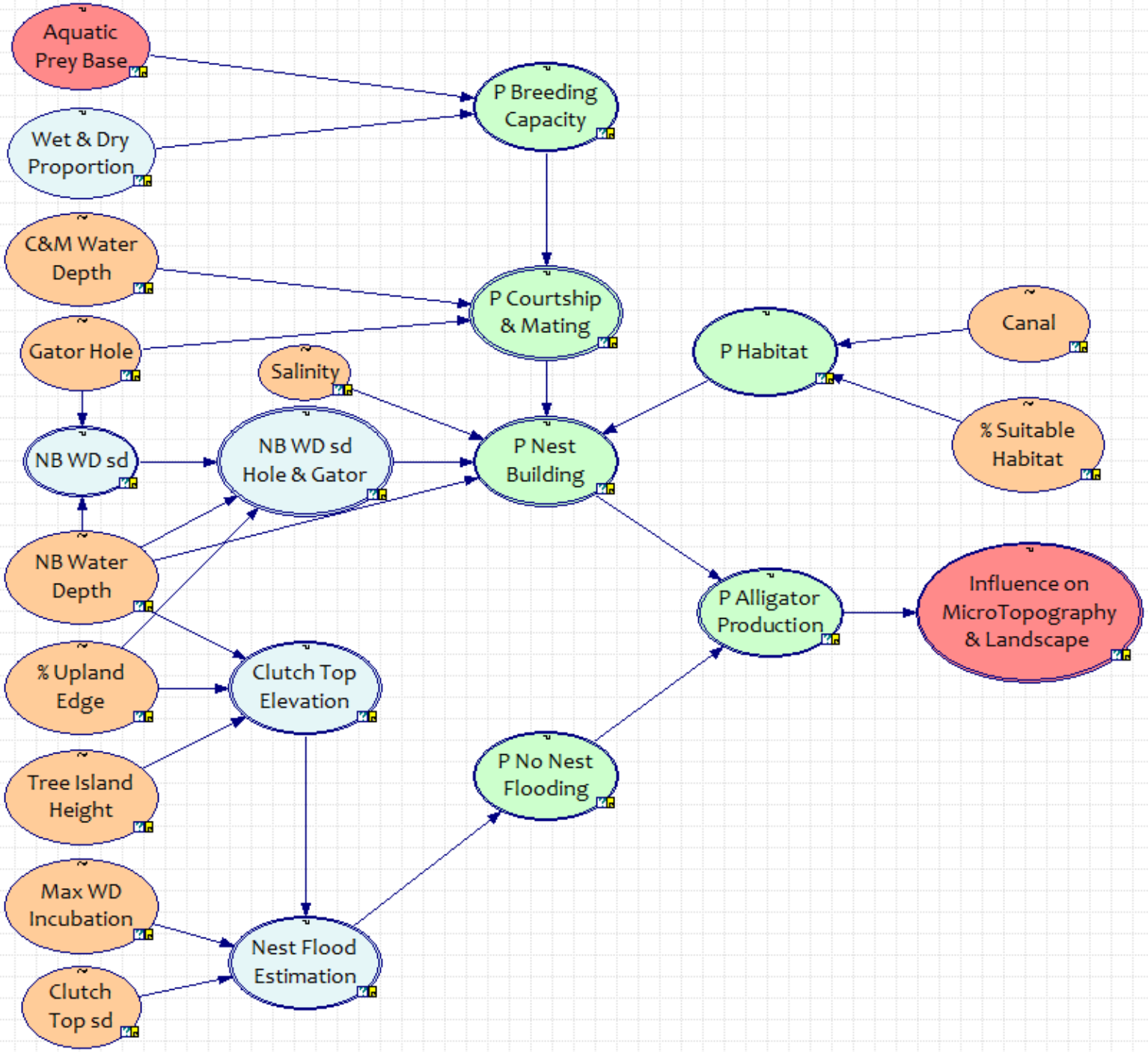
Suitability for Great egret
High
Med
Low

- **Currently developing updated relationships between vegetation, hydrology variables and wading bird presence for the BBN**

Freshwater Marsh Succession

- Currently building multinomial logistic regression models to identify hydro metrics to map vegetation across the system
- Need better metrics





Alligator

- **Currently parameterized according to the model developed by Shinde et al. 2015**

BBN Next Steps

- Parameterize the peat loss model
- Link the trophic sub-models together (Vegetation, Birds, Alligator)
- Streamline spatiotemporal capacity
- Construct a draft, flexible and modular modeling framework for the case studies that can be expanded upon for a model of the full Everglades landscape
  - Analyze ecosystem risk across the system
  - Evaluate the effects of management actions (CERP projects and water management operations, nutrient management, invasive exotics species management)
  - Concurrently evaluate with changing unmanaged drivers (sea-level rise, changing rainfall and temperature, and potentially changes in storm frequency and intensity)

RECOVER Use

- One of RECOVER's Five Year Plan Science Integration tasks
- Evaluate ecosystem vulnerability and provide decision support for Everglades Restoration management actions within CERP
- Identify and diagnose the most vulnerable locations, species, and ecological components and functions in the system
- Identify appropriate locations and scales of action for resolving crucial vulnerabilities
- Inform the RECOVER Monitoring and Assessment Plan
- Identify uncertainties as they relate to the Program-Level Adaptive Management Plan
- Define potential triggers/thresholds that indicate good CERP performance or need for adaptive management action

Information Needed: a call for input from GEER colleagues

- Refined and vetted information on distribution & amount of abiotic drivers within the system (salinity levels, phosphorous)
- Information on how disturbances such as fire and storms influence vegetation dynamics and abiotic drivers
- Refining our understanding of the ecological responses along the coast
- Suggestions of important dynamics or drivers we are missing

Questions?