A Bayesian belief network to prioritize conservation need among diverse aquatic taxa

Investigators

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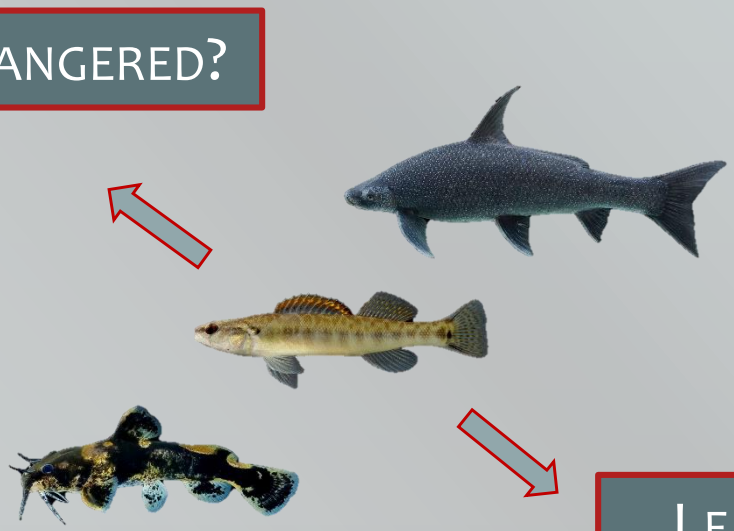

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Need for Conservation Priorities

Conservation maintains "representative" biodiversity within administrative boundaries

- Aesthetic & economic values
- Ecosystem services
- Intrinsic value of life

- Financial resources are limited
  - Need to prioritize geographic areas, species, or populations

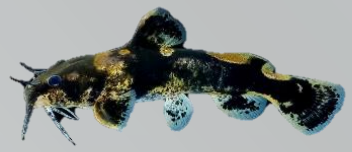
Given resources to conserve few species, which do you choose?

How do you decide?

Establishing Conservation Priorities

- State and federal legislation list threatened & endangered species
  - Relatively few target species
- Many conservation-prioritization frameworks exist
  - Use similar biological criteria & known threats
  - Assess extinction risk - most vulnerable and irreplaceable
  - Inform management decisions

Sensitivity to:



Demographic stochasticity

Environmental stochasticity

Low risk

High risk

Need for a New Approach

- No universally applicable conservation prioritization model
  1. Unable to represent uncertainty
  2. Operate at fixed spatial scales
  3. Unknown sensitivity to biological criteria
  4. High resource & labor demands

- Aquatic taxa feature especially poorly
  - Extinction risk: Aquatic > terrestrial taxa
  - Relatively understudied worldwide
  - Often excluded despite potential conservation significance

Data Deficiencies

46% of Chondrichthyes

44% of Upper Yangtze River species

Current conservation status assigned to only ~20% of fishes

~32,000 fish species are unassigned

Introducing Flexibility – Bayesian Belief Network

Objective: Demonstrate the utility of a Bayesian network analysis to identify fishes in need of conservation attention

- Accessible biological criteria & well-known threats
  - Ex. Life-history traits & museum databases
- Consistent with the concepts of redundancy, resiliency & representation (US Fish and Wildlife Service)

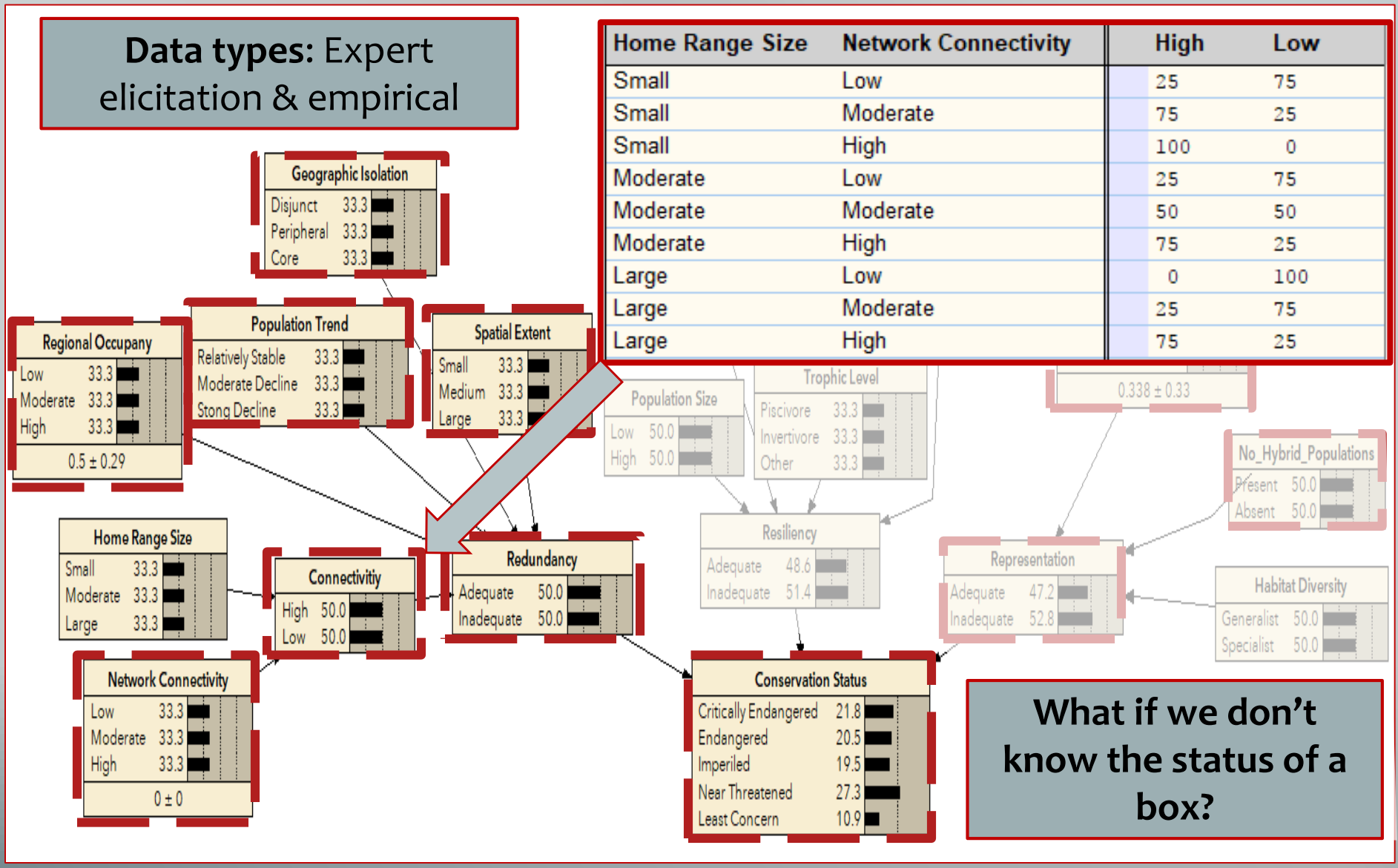
Improvements to future status assessments:

1. **Uncertainty**
   - Method to assess potentially rare but poorly known taxa
2. **Spatial Scale**
   - Applicable at different administrative & geographic scales
3. **Sensitivity to specific biological criteria**
   - Identify components driving status designation

Bayes Net – A Probabilistic Model

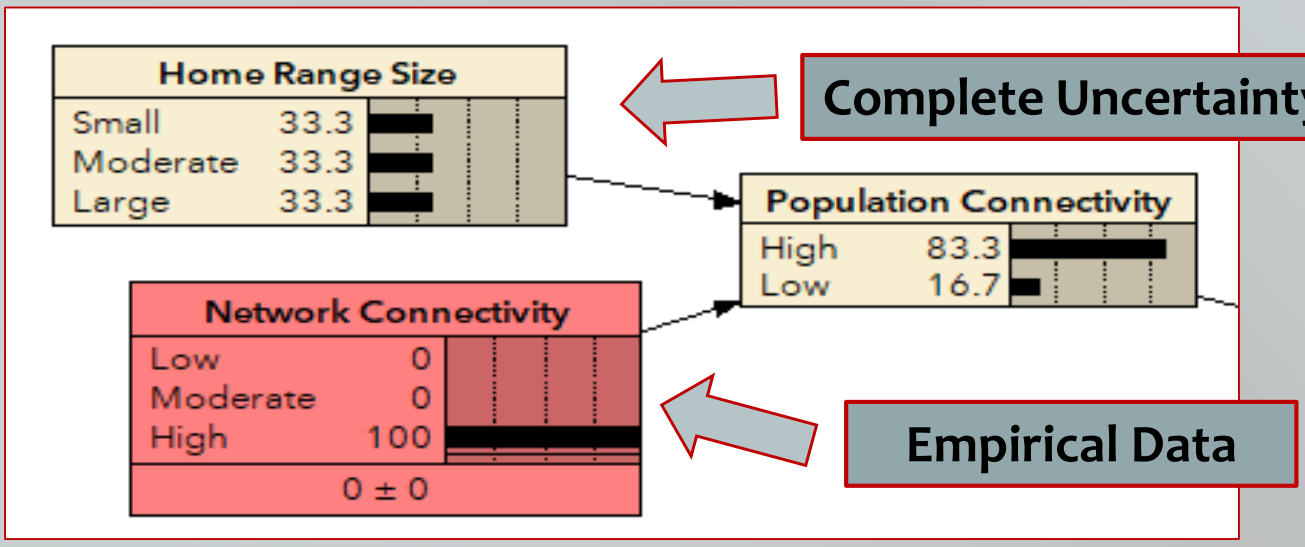
Data types: Expert elicitation & empirical

Home Range Size	Network Connectivity	High	Low
Small	Low	25	75
Small	Moderate	75	25
Small	High	100	0
Moderate	Low	25	75
Moderate	Moderate	50	50
Moderate	High	75	25
Large	Low	0	100
Large	Moderate	25	75
Large	High	75	25

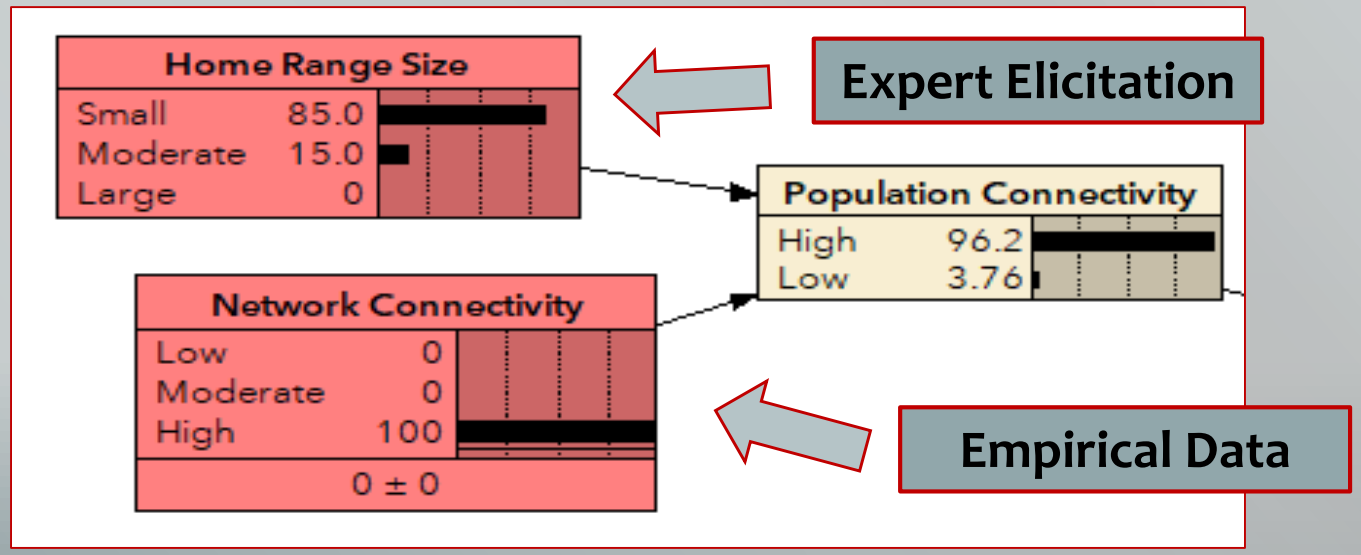


What if we don't know the status of a box?

Uncertainty & Expert Elicitation



Speckled Darter



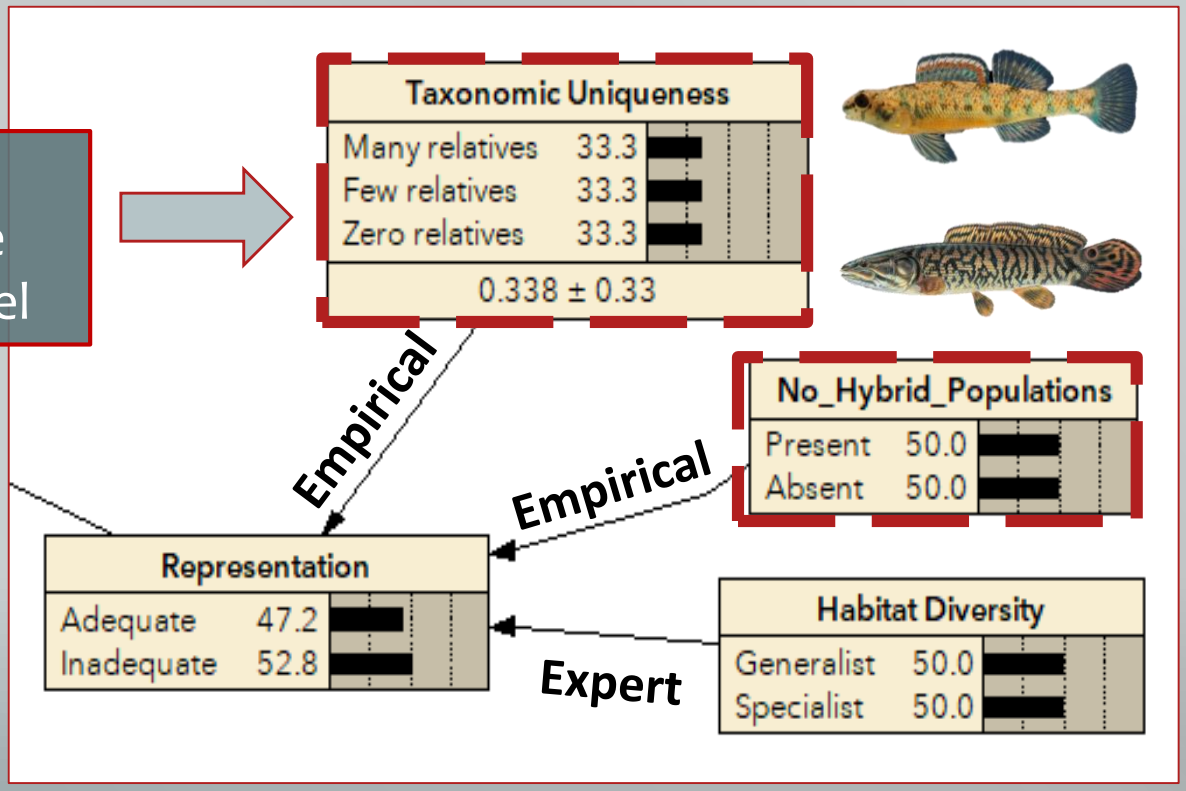
Representation

Definition: The ability to adapt to changing environmental conditions over time

- Breadth of genetic & environmental diversity - within & among populations
- Adequate: risk is spread among genetically diverse populations in diverse habitats

Continuous variable: represents diversity at the species, genus & family level

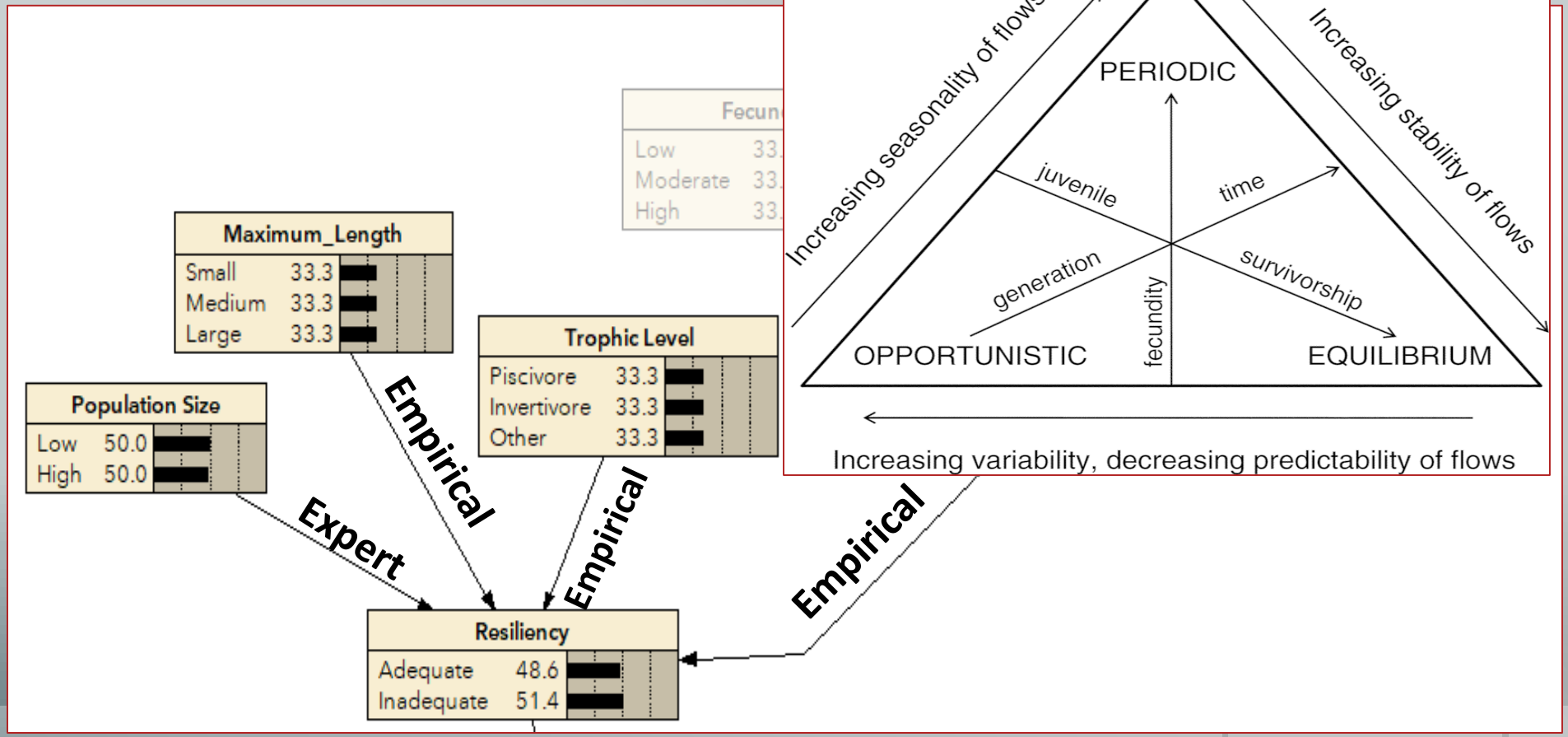
Calculation: Inverse of the product of the number of cladogram branches at the genus, family & order nodes



Resiliency

Definition: The ability to withstand environmental stochasticity & localized disturbance events

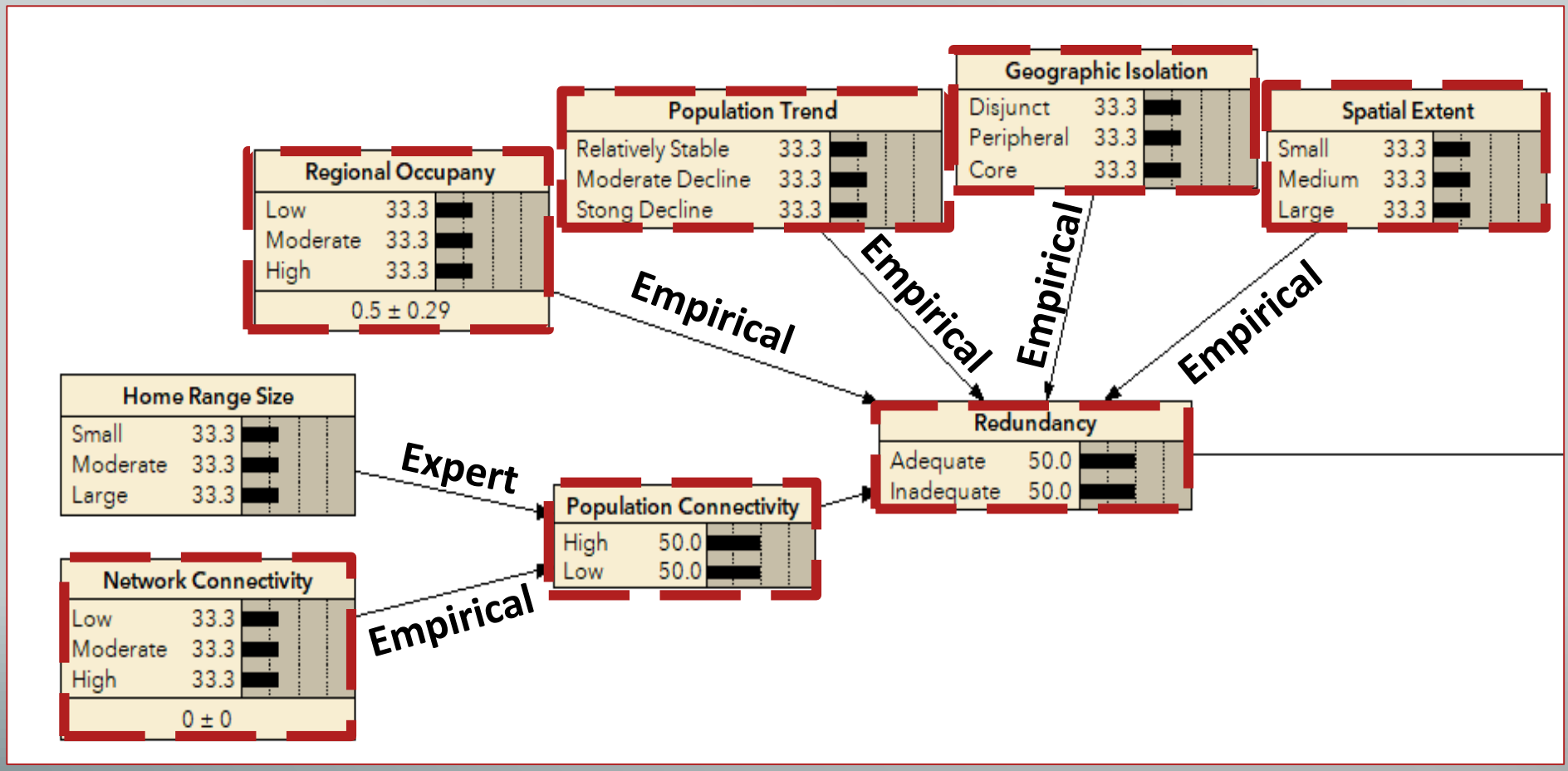
- Related to population demographics, species ecology & life-history traits
- Adequate: abundant individuals occupy habitats patches of suitable quality to maintain survival & reproduction



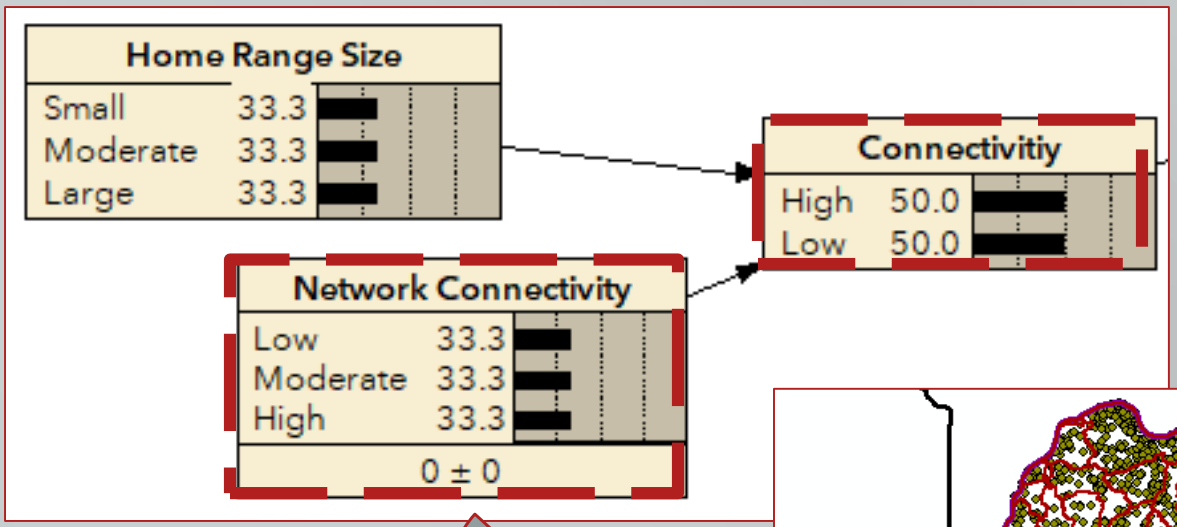
Redundancy

Definition: The ability to withstand catastrophic events

- Related to the number, distribution & connectivity of populations
- Adequate: risk is spread among multiple, interacting populations



Redundancy – Quantifying Population Connectivity



Home Range Size

Categorical variable:

- Small – within segment
- Moderate – within stream
- Large – among streams

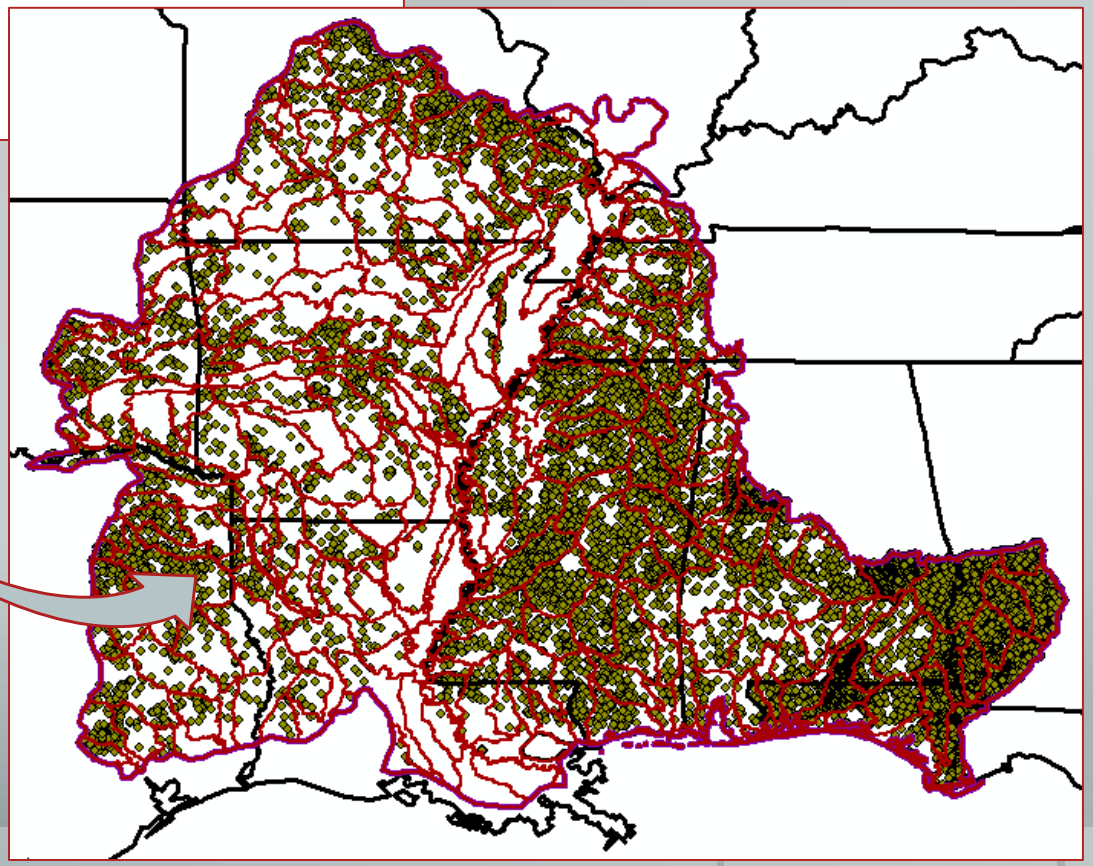
Network Connectivity

Continuous variable:

Mean unimpeded river distance (km)

Grouped as:

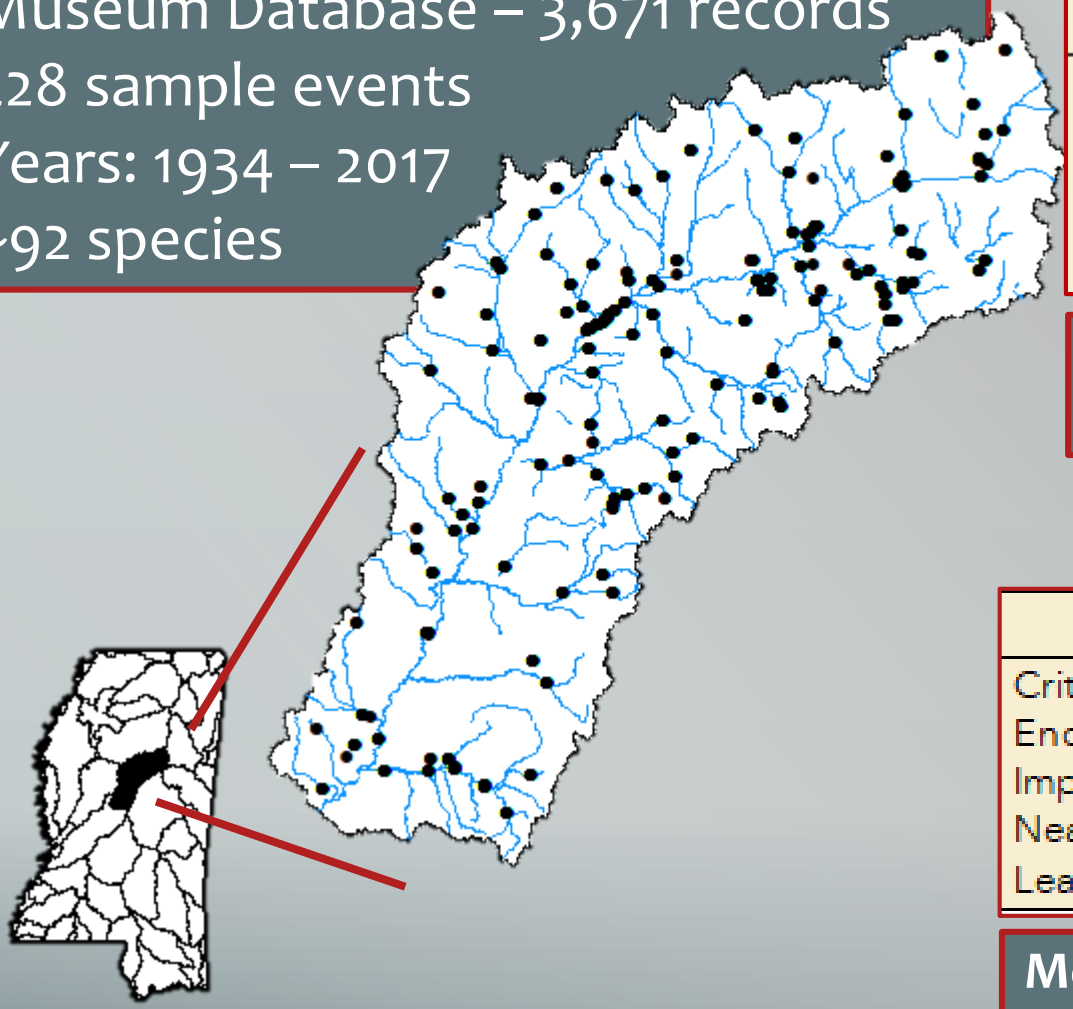
Low, Moderate, High



Example Outputs for One Mississippi Basin

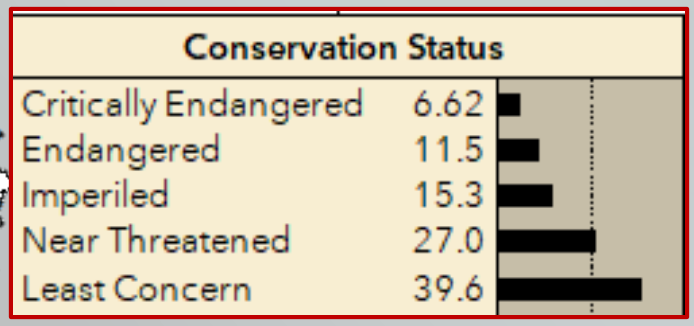
Upper Big Black basin, Mississippi

- Museum Database – 3,671 records
- 228 sample events
- Years: 1934 – 2017
- ~92 species



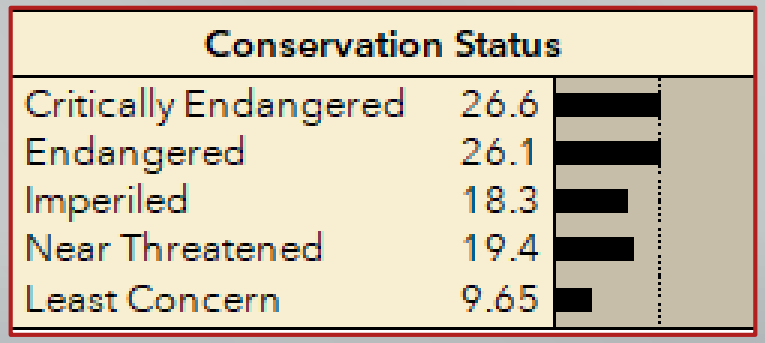
Upper Big Black (HUC-8), MS

Johnny Darter



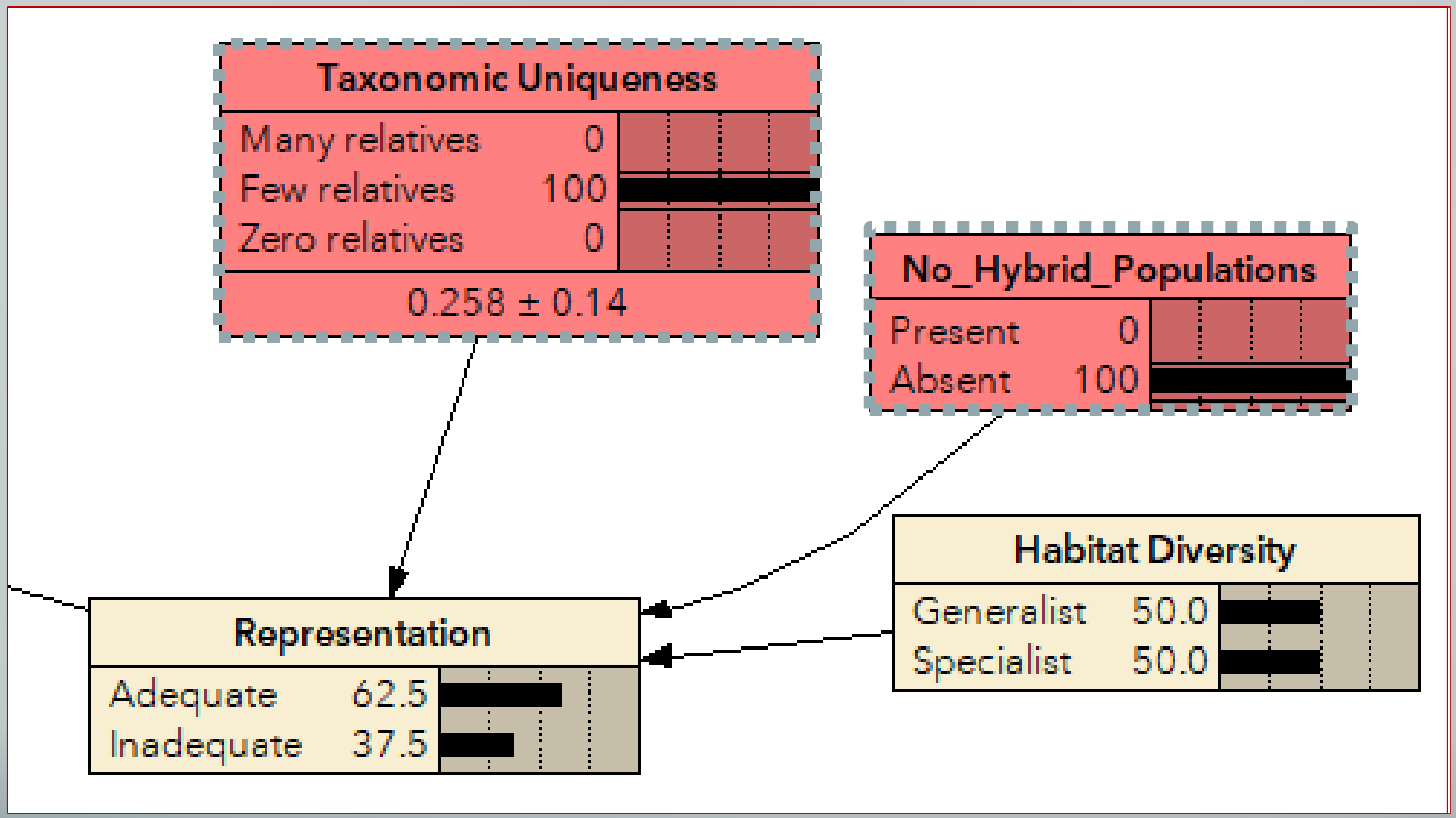
More threatened: Recapture rate at historic sites

Piebald Madtom

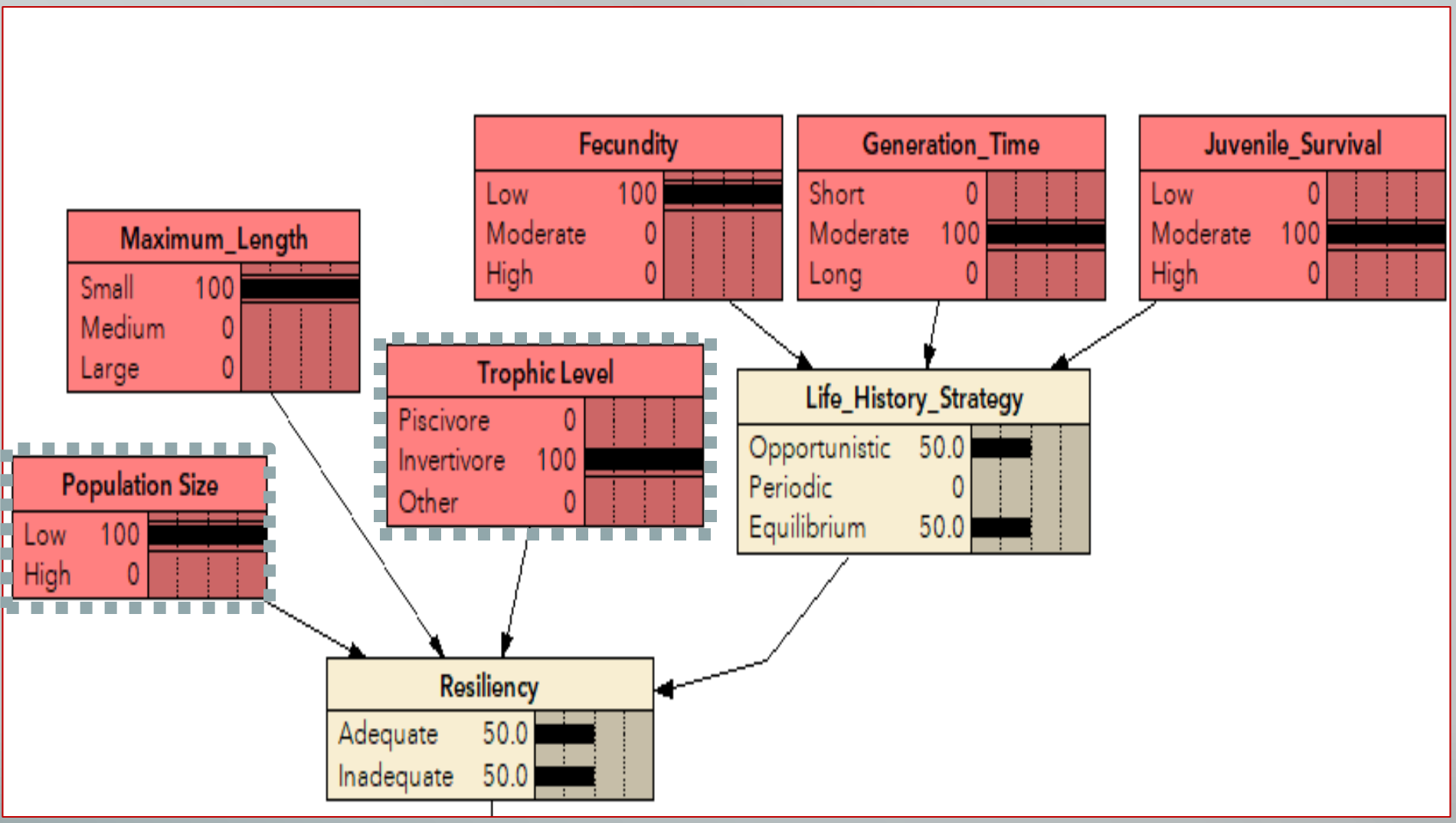


More threatened: Number and extent of populations

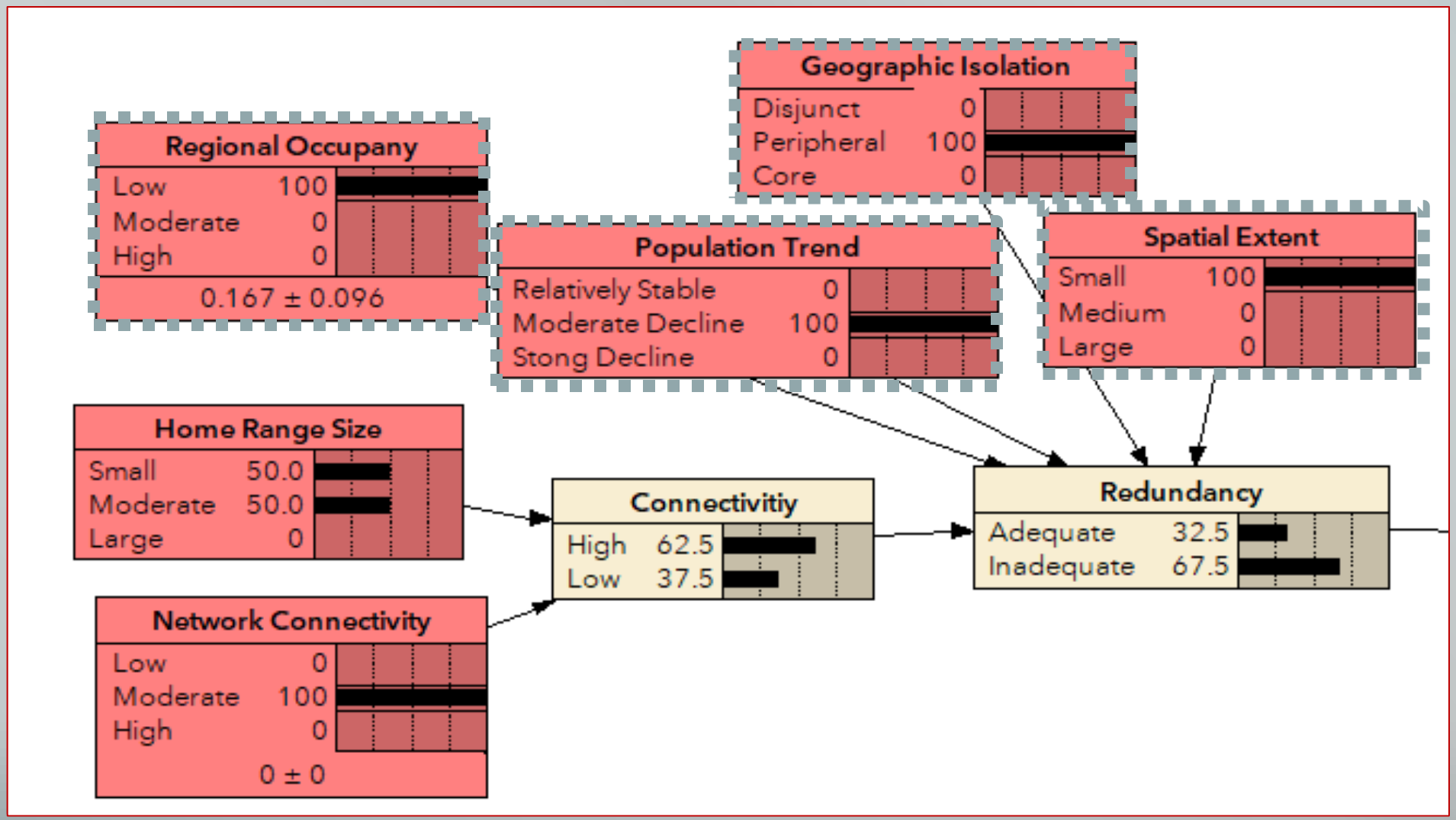
Piebald Madtom – Model Walkthrough



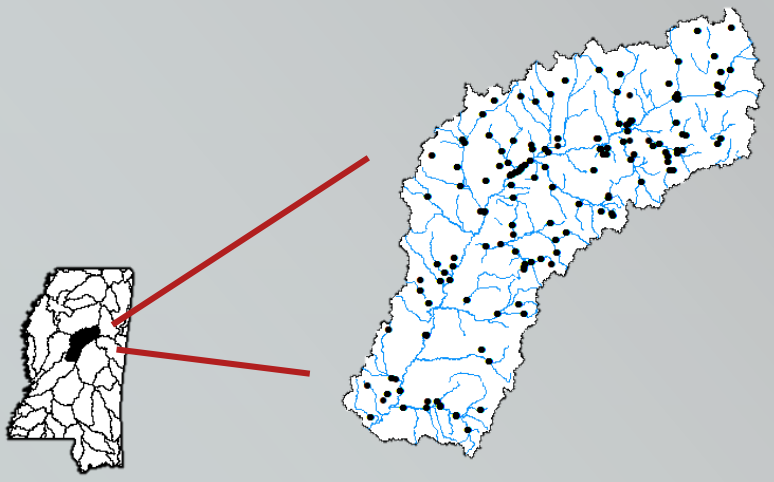
Piebald Madtom – Model Walkthrough



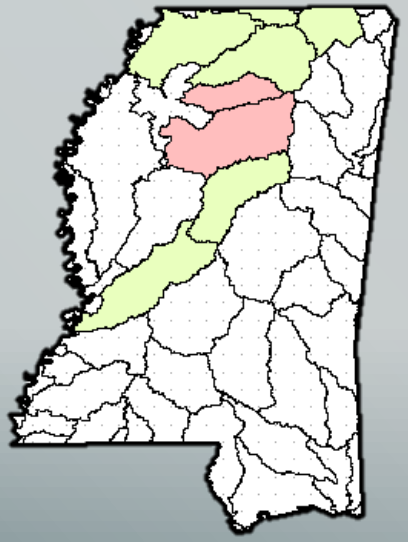
Piebald Madtom – Model Walkthrough



What happens if we change the scale?



Upper Big Black (HUC-8), MS



State of Mississippi

Piebald Madtom Status

Conservation Status	
Critically Endangered	26.6
Endangered	26.1
Imperiled	18.3
Near Threatened	19.4
Least Concern	9.65

Upper Big Black basin

Conservation Status	
Critically Endangered	21.3
Endangered	23.6
Imperiled	18.1
Near Threatened	21.3
Least Concern	15.8

Mississippi

Prioritizing Conservation Efforts for Aquatic Taxa

A new tool to identify species in need of conservation attention

- Addresses concerns with other prioritization systems when applied to aquatic species
    1. Uncertainty – poorly known species & data limitations
    2. Spatial Scale – any spatial or administrative scale
    3. Straightforward parameterization & prompt decision
- Broad applicability to diverse aquatic taxa
    - Ex. Panama City Crayfish

Moving forward:

- Further validation of the model structure
    - Federal partners assessing assigned & petitioned aquatic taxa
    - Training the model using species designated by USFWS