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# Development of a Salmon Estuarine Habitat Index (SEHI)

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# Objective



**Develop a numerical model of estuarine habitat and juvenile salmonids to evaluate alternative restoration actions at a site.**

Application of the model by restoration planners would require knowledge of *baseline environmental conditions* (both existing and predicted for alternative actions).

The model uses these inputs to estimate *benefit for juvenile salmonids (i.e. growth)*.

# Onsite and offsite benefits

- Onsite benefits: benefit of site to juvenile salmon that spend time in the restoration site

  *Physical environment experienced at the site*

  *Prey available at the site*

- Offsite benefits: benefit of site to juvenile salmon that do not access the restoration site, but use areas that are hydrologically connected to the site

  *Prey and detritus exported from the site*

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**Salmon Estuarine Habitat Index (SEHI)**

**Habitat Capacity Index** * Area

Habitat Units$_{on}$ * Opportunity$_{i}$

Realized Habitat Units$_{on,i}$

**Habitat Capacity Index** * Area

Habitat Units$_{on}$ * Opportunity$_{on}$

Realized Habitat Units$_{on}$

**Exported Benefits Index** * Area

Habitat Units$_{off}$ * Connectivity$_{off}$

Realized Habitat Units$_{off}$

**Habitat Capacity Index** * Area

Habitat Units$_{on}$ * Opportunity$_{on}$

Realized Habitat Units$_{on}$

**Exported Benefits Index** * Area

Habitat Units$_{off}$ * Connectivity$_{off}$

Realized Habitat Units$_{off}$

**Salmon Estuarine Habitat Index**

# Conceptual Model

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## Physical

- Hydrogeologic environment
- Water Properties
- Sediment/soil

## Salmon

- Physiological Responses
- Population metrics

# Conceptual Model



## Physical

- Hydrogeologic environment
- Water Properties
- Sediment/soil

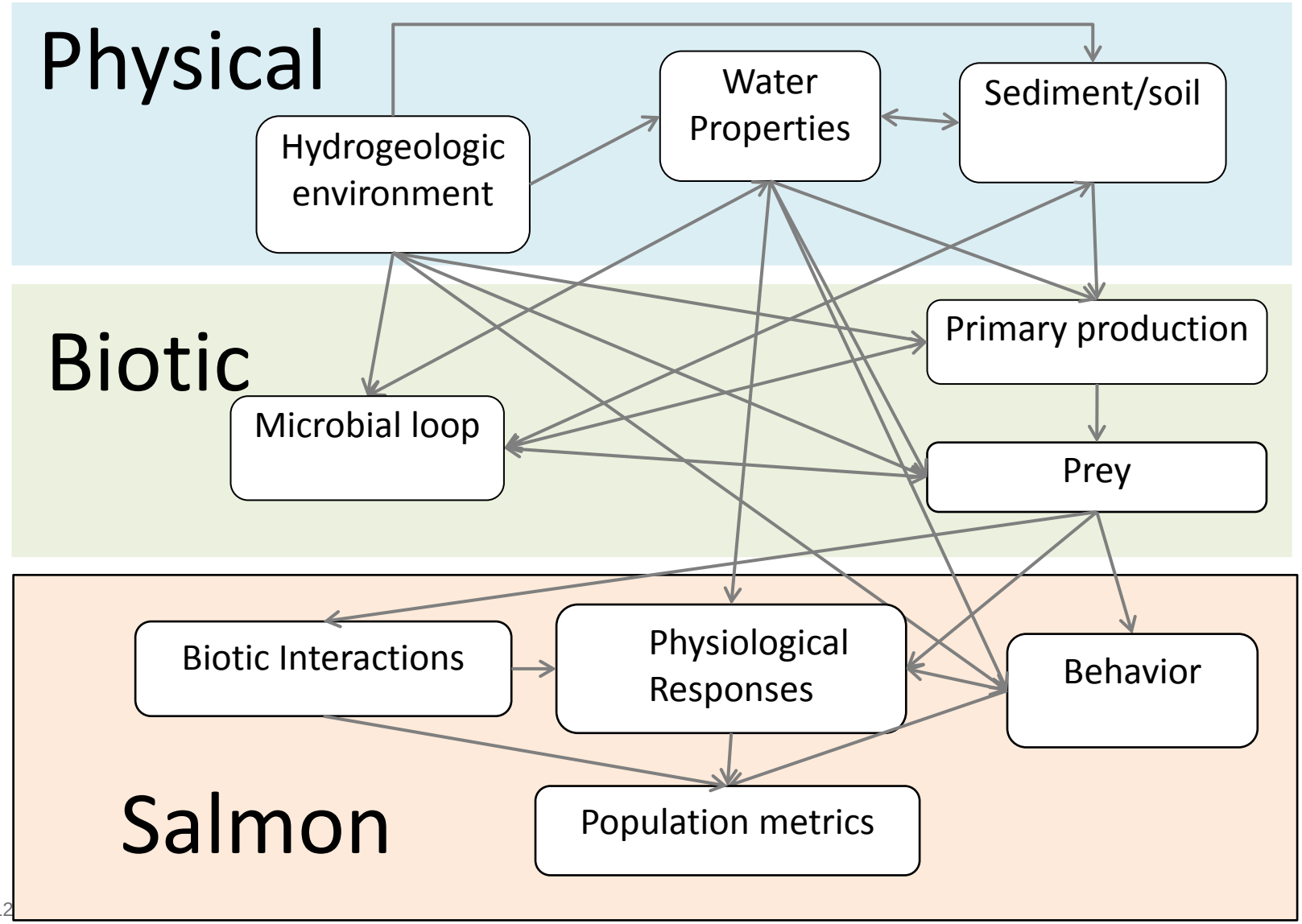
## Biotic

- Microbial loop
- Primary production
- Prey

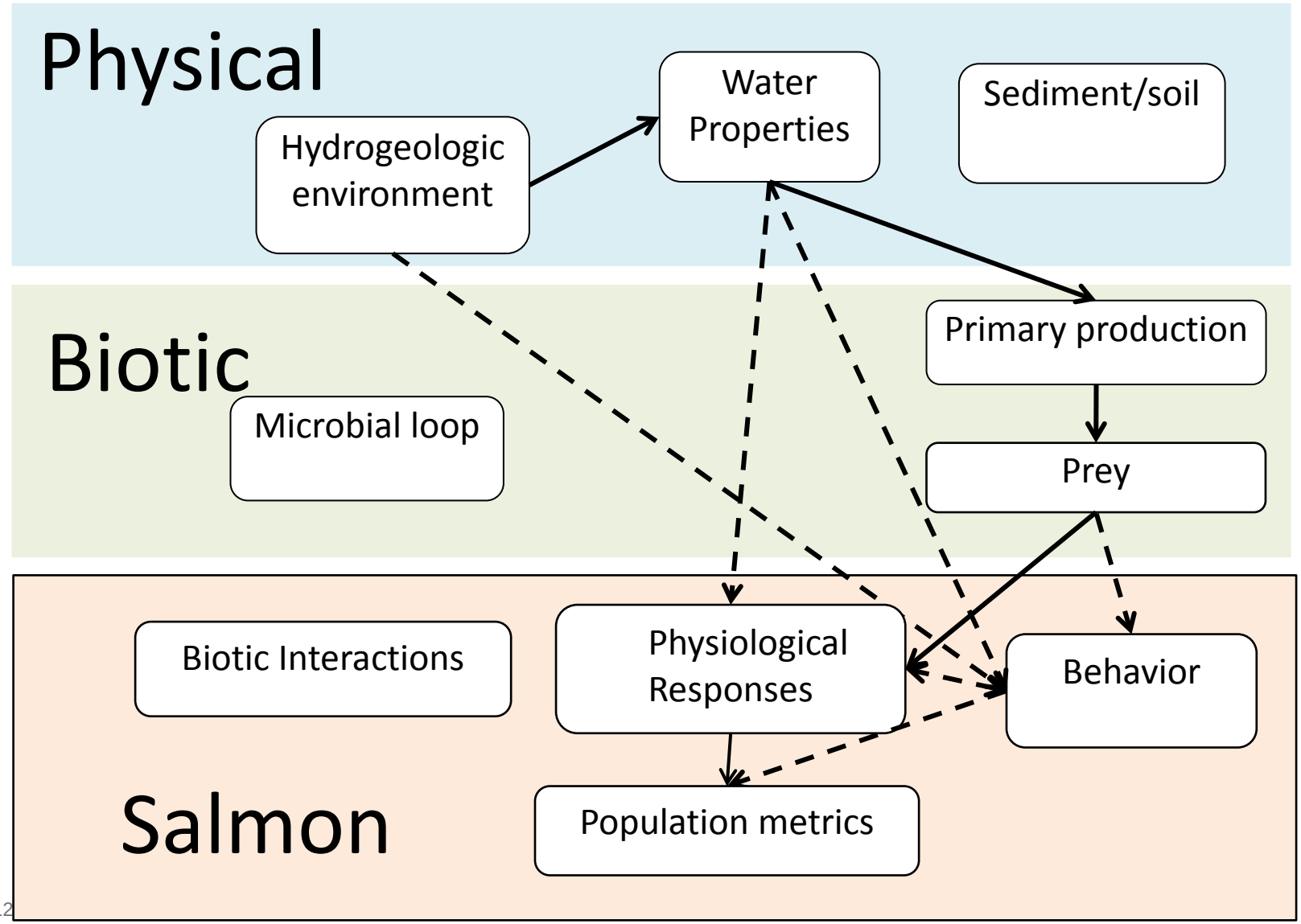
## Salmon

- Biotic Interactions
- Physiological Responses
- Behavior
- Population metrics

# Conceptual Model



# Conceptual Model



# Rapid Prototyping of Habitat Capacity Index

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- PNNL researchers with expertise in elements of the conceptual model
- Chose key elements and metrics to include in model
- Estimated functions and parameters
- **Built a working model prototype**
  - test the model immediately
  - evaluate assumptions
  - make adjustments

# Bayesian Belief Network models

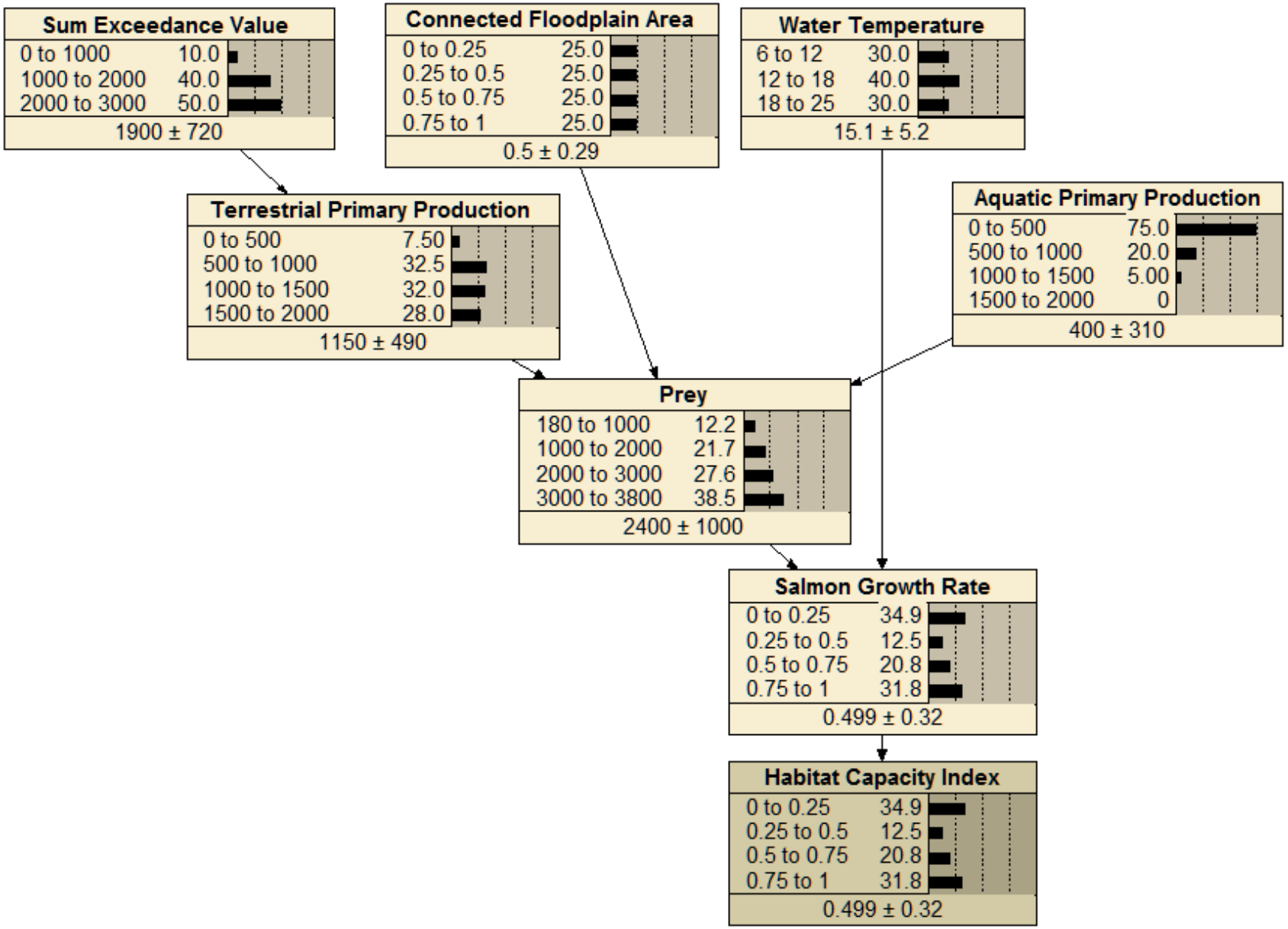


- Use probabilities of input values to determine the probabilities of outputs
- Combines different forms of information
- Explicit uncertainty
- Sensitivity analysis
- Model can learn from test cases

http://www.norsys.com/netica.htm

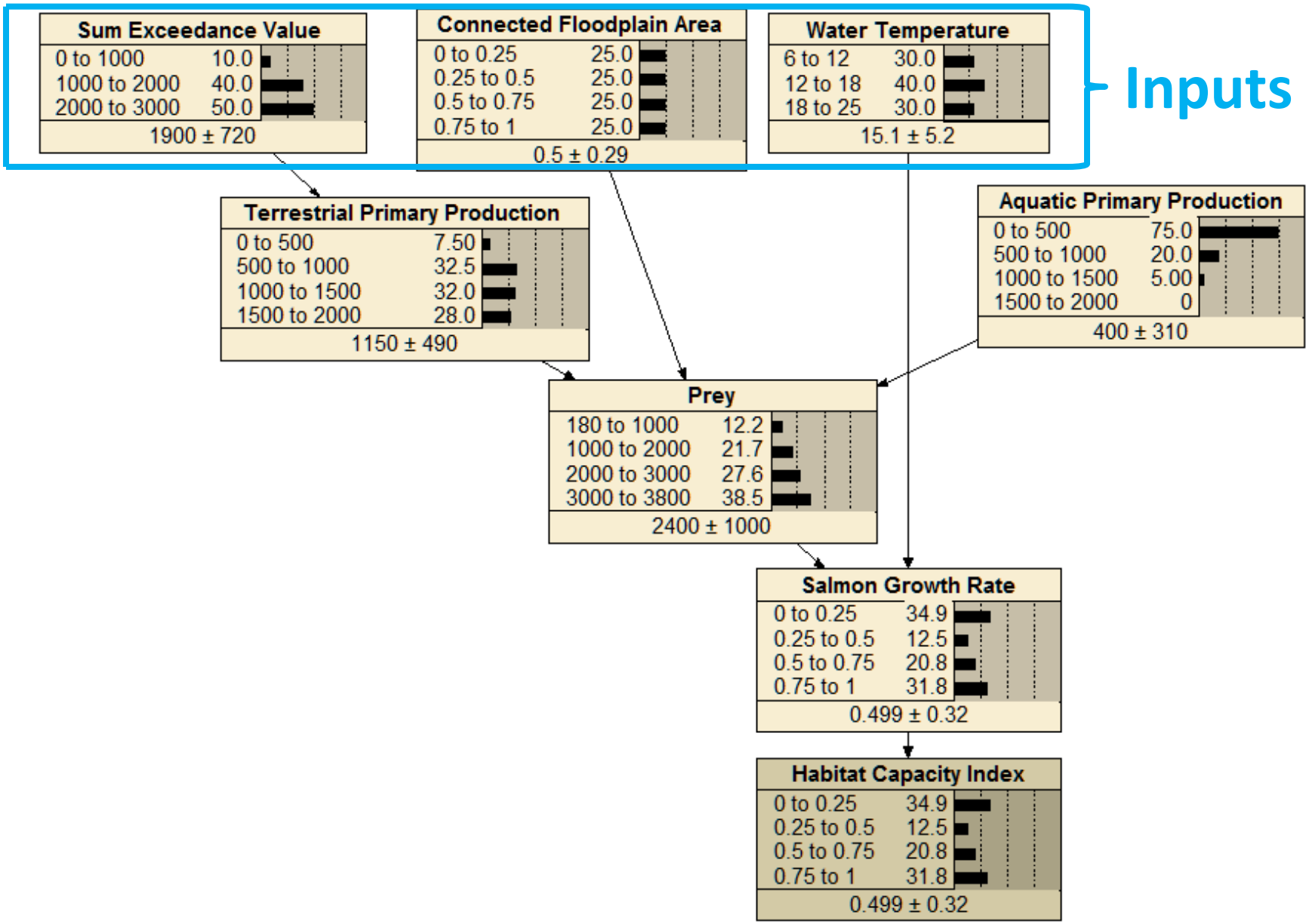
Marcot et al. 2001. Forest Ecology and Management 153:29-42

# Result of rapid prototyping



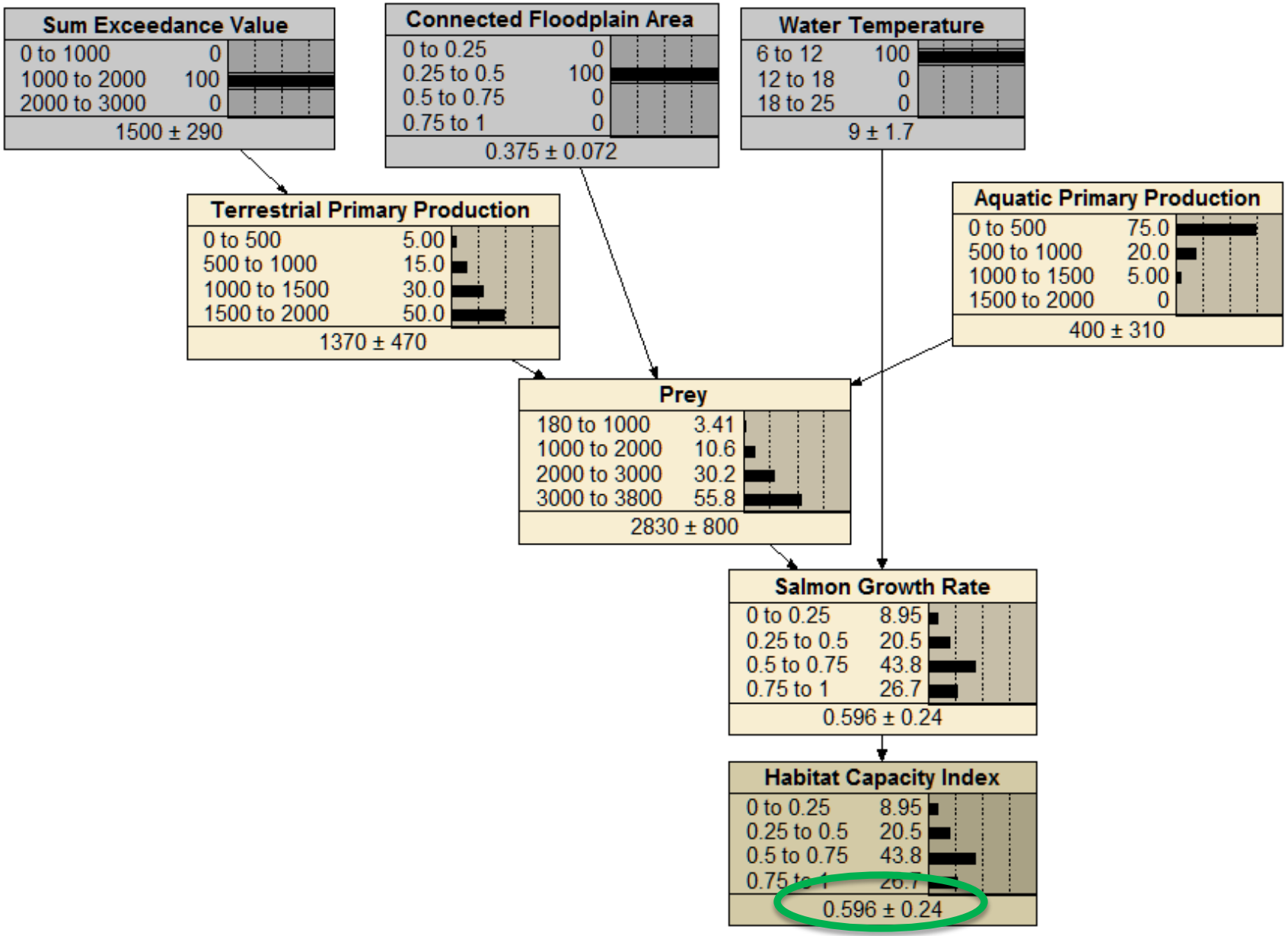
# Result of rapid prototyping



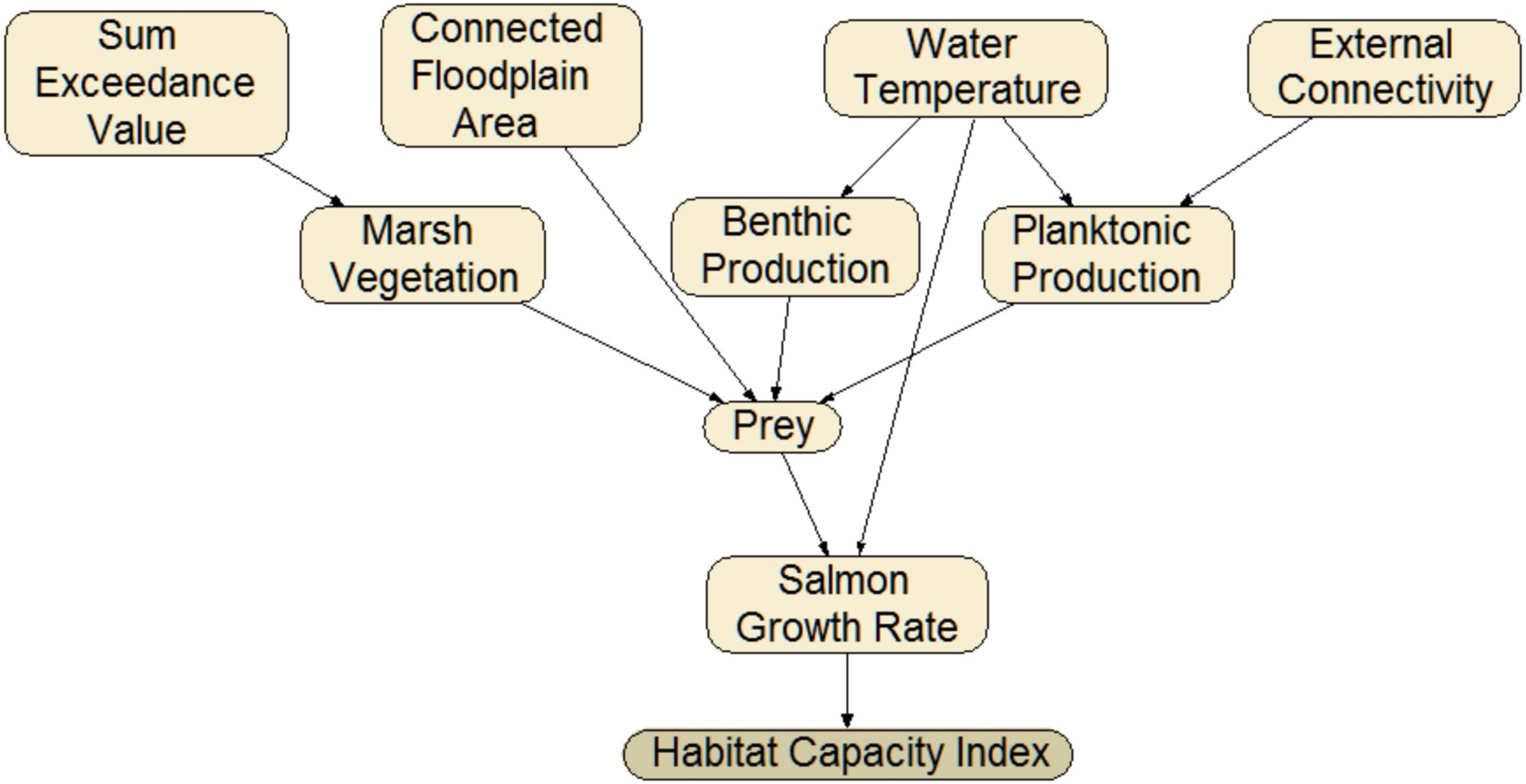


# Example of working prototype

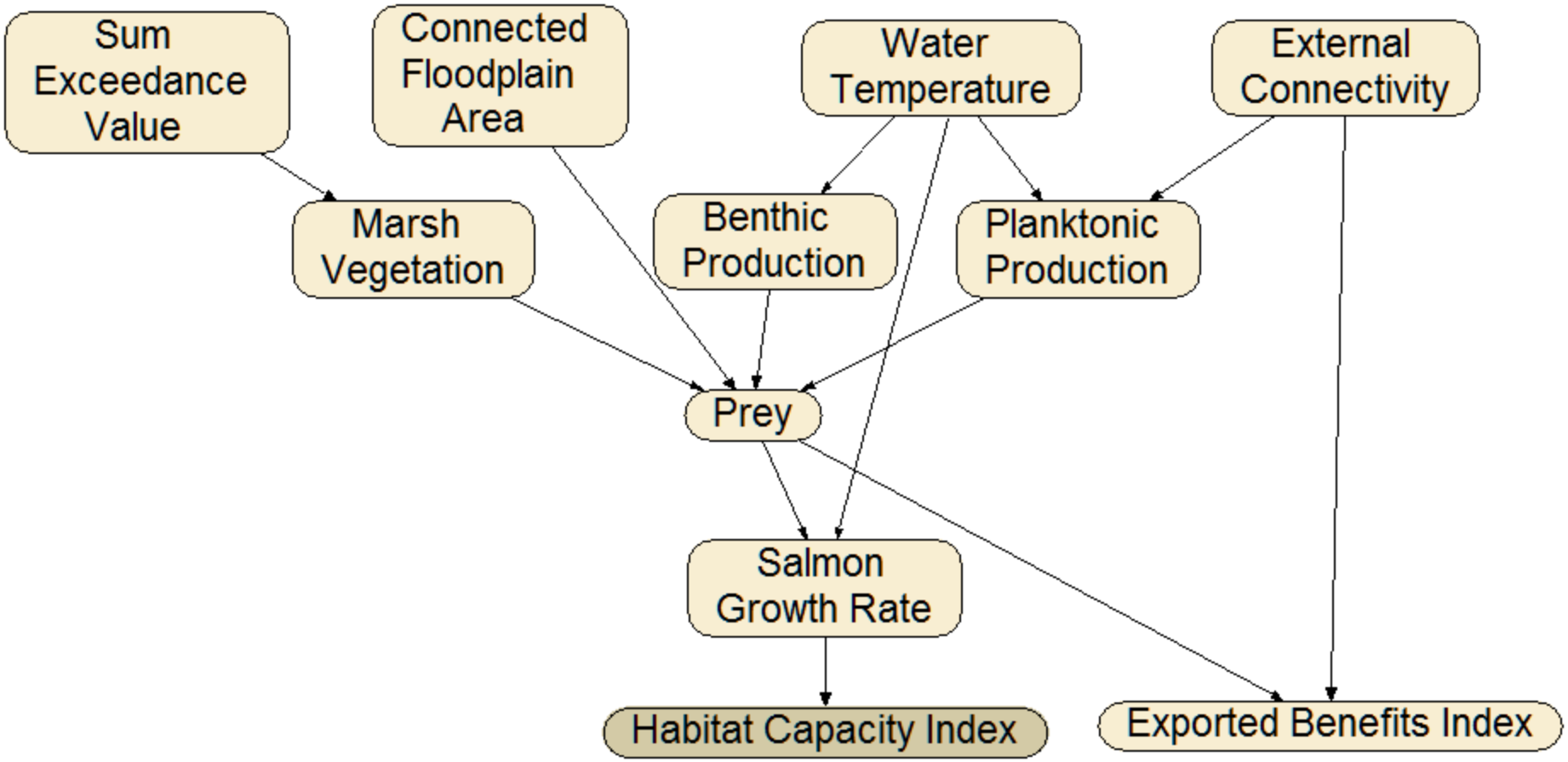




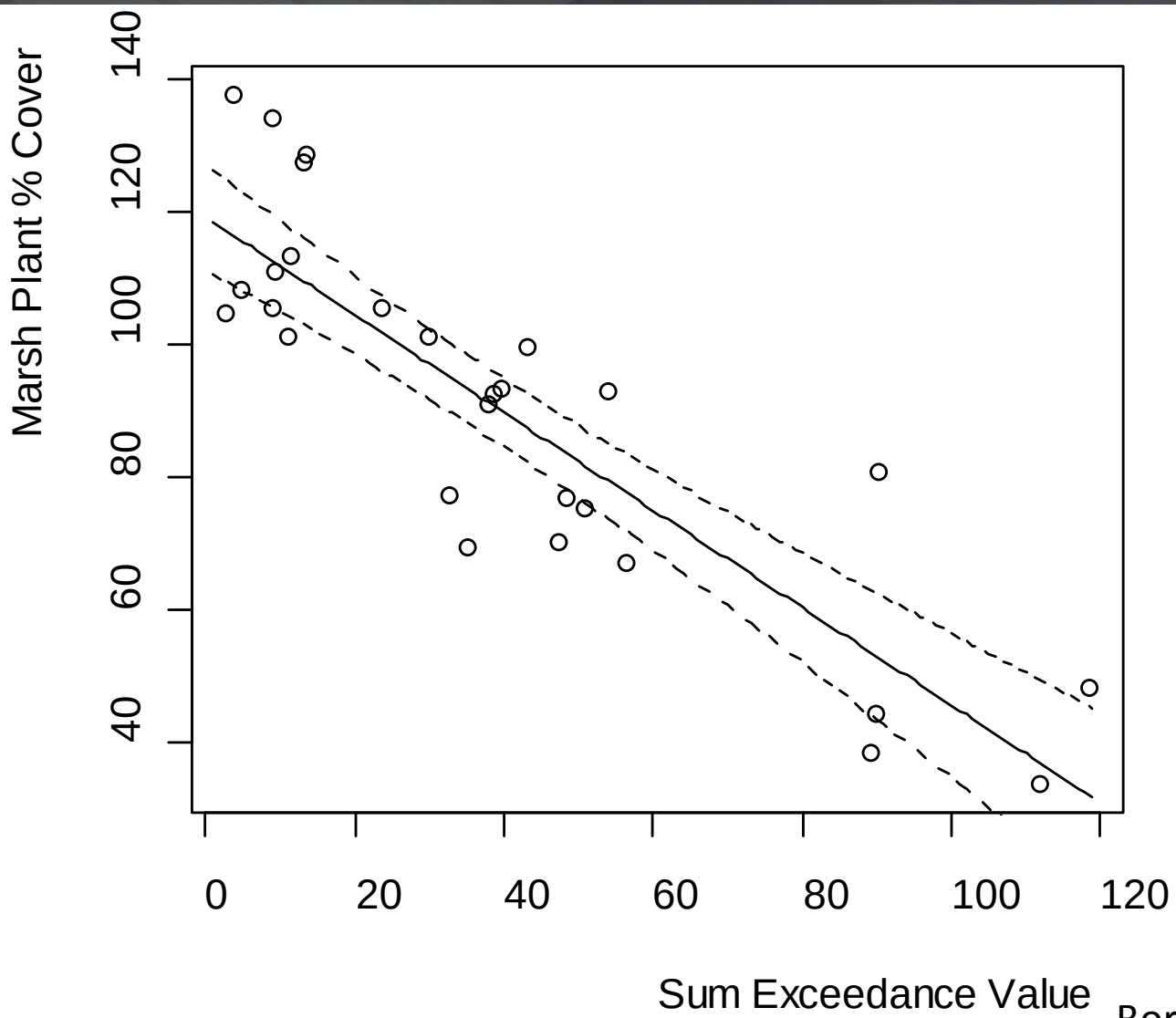
# Ongoing development



# Ongoing development

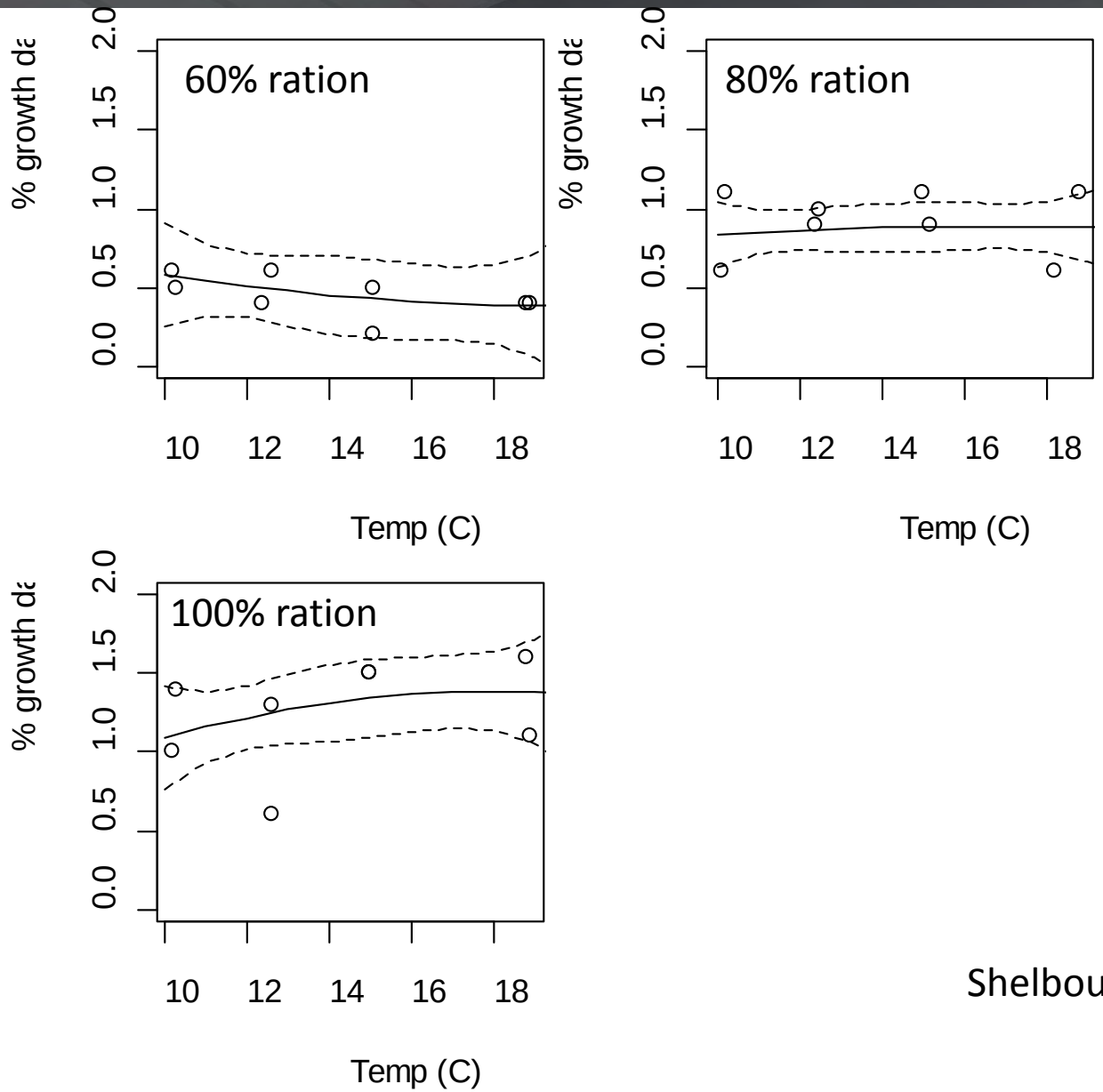


# Data: hydrology and vegetation




Borde et al. 2012

# Data: water temperature, food consumption, and growth




Shelbourn et al. 1995

# Hypothetical application

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| | Existing Conditions | | Alternative 1: Dike Breach | | Alternative 2: Culvert | |
|---|---|---|---|---|---|---|
| Max temp Mar-Jun (C) | 19 ± 2 | | 14 ± 3 | | 15 ± 3 | |
| Connected floodplain area | 0.2 ± 0.05 | | 0.65 ± 0.14 | | 0.5 ± 0.08 | |
| Sum exceedance value | 30 ± 5 | | 80 ± 15 | | 55 ± 12 | |
| | *Onsite* | *Offsite* | *Onsite* | *Offsite* | *Onsite* | *Offsite* |
| **Habitat Capacity Index** | **0.25** | **0.24** | **0.54** | **0.59** | **0.45** | **0.46** |
| Area | 60 | | 60 | | 60 | |
| **Habitat Units** | **15.09** | **14.38** | **32.42** | **35.56** | **26.73** | **27.63** |
| Opportunity/Connectivity | 0.2 | 0.2 | 0.6 | 0.8 | 0.5 | 0.6 |
| **Realized Habitat Units** | **3.02** | **2.88** | **19.45** | **28.45** | **13.37** | **16.58** |
| **SEHI** | **5.90 ± 1.45** | | **47.90 ± 10.49** | | **29.94 ± 6.7** | |

# Interim Conclusions and Lessons Learned



- Challenges of integrating quantitative information across systems and disciplines
- High natural variability in space and time

# Interim Conclusions and Lessons Learned



- Direct physical effects on fish
  - Existing data with adaptations
- Prey: can we resolve differences and drivers?
  - Are there differences in prey between sites or types of restoration?
  - Can we detect differences that exist?
  - Can we determine what is driving any differences?

# Next Steps



- Continue finding and integrating information
- Sensitivity analysis—what information is most important and most useful?
- Case study
- Beta testing in 2013

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Dana Woodruff

**Review:**

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Ron Thom

**USACE:**

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Blaine Ebberts

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