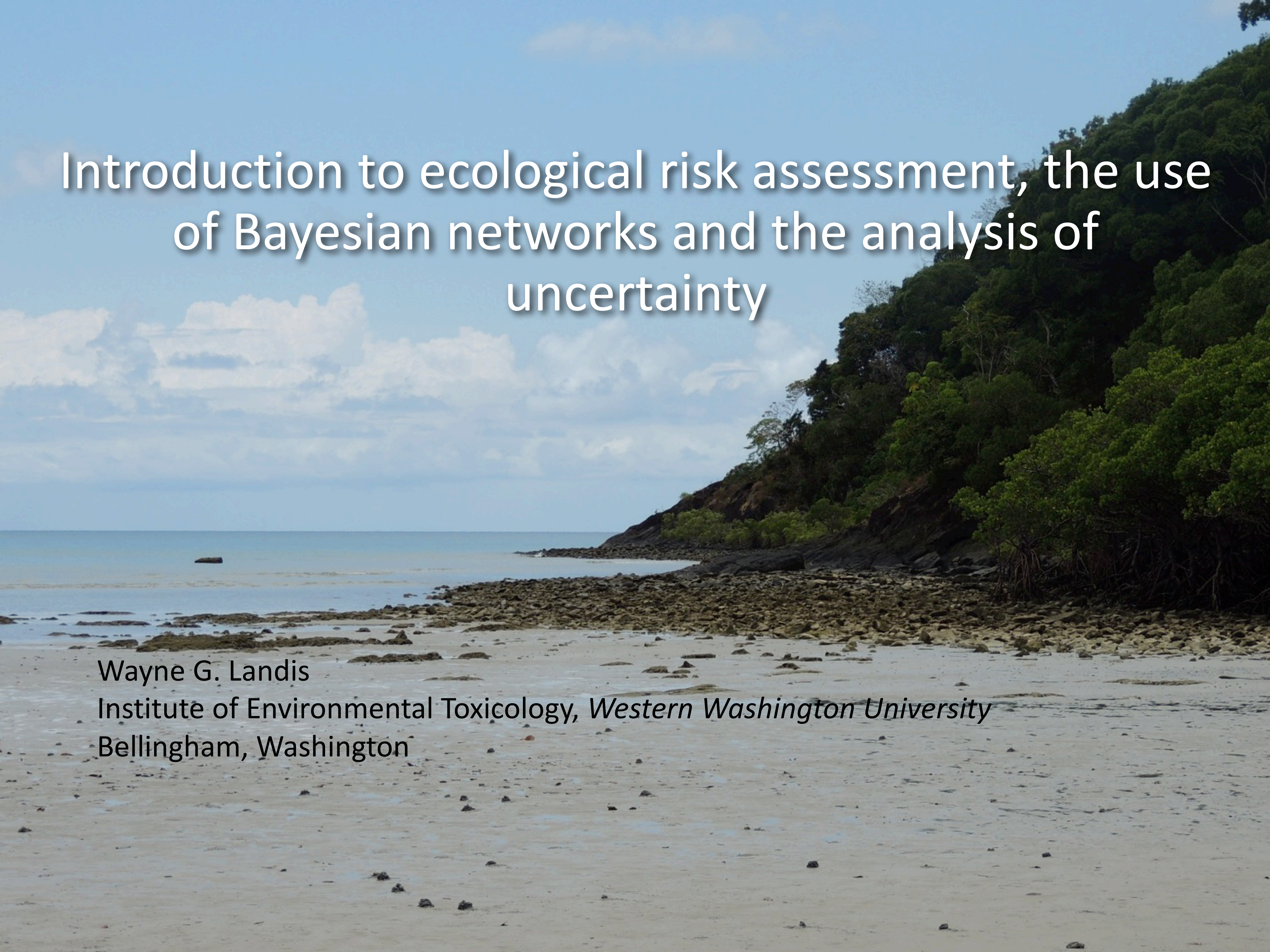

Introduction to ecological risk assessment, the use of Bayesian networks and the analysis of uncertainty

Wayne G. Landis
Institute of Environmental Toxicology, *Western Washington University*
Bellingham, Washington

How about a story?

- I has been a twenty-one year journey to get to this point in the development of regional risk assessment.
- People remember stories.
- The Story also provides context.

Introduction to risk, risk assessment, Bayesian networks, and why.

- A definition of risk.
- From Port Valdez to the application Bayesian networks to the INLAS forest
- Uncertainty as an old friend.

Part 1. Definition of Risk-probability based

Technical definition: The ***probability*** of an effect on one or more specific endpoints due to a specific stressor or stressors.

In other words, risk reflects how often a specific change or changes in the environment will affect something of value to society, such as human health, outdoor recreation, or the survival of an endangered species.

Not the definition from Wiki

Risk = probability of an event x consequence

Not sure what the calculation is to supposed to mean, not clear what the consequence is supposed to be.

Is exposure assumed? Is there a dose-response or vulnerability?

Where is the consequence going to happen?

Part 2. Beginnings

In the early to mid 1990s I served on a series of review panels for the original USEPA framework document for risk assessment and the case studies.

When asked do to a risk assessment for the Regional Citizens Advisory Committee (RCAC) for Port Valdez I said yes.

A Regional Multiple-Stressor Ecological Risk Assessment for Port Valdez, Alaska

Prepared by:

Janice K. Wiegers[1], Howard M. Feder[2], Wayne G. Landis[1], Linda S. Mortensen[1], David G. Shaw[2], Valerie J. Wilson[1]

[1] Institute of Environmental Toxicology and Chemistry, Huxley College of Environmental Studies, Western Washington University, Bellingham, Washington
[2] Institute of Marine Science, University of Alaska, Fairbanks, Alaska

March 31, 1997

After all there was the USEPA guidance so we would just follow that approach and refer to the literature for tools and approaches.

Part 2. The Journey

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In ... rly to mid 1990s I served on a series o... ...r the original USEPA f... ...ssessment and the cas...

Fortunately my research group found out that the USEPA guidance would not work for the fjord of Port Valdez.

When asked do to a risk assessmen... Regional Citizens Advisory Committee (RCAC) for Port Valdez I said yes.

After all there was the USEPA guidance so we would just follow that approach and refer to the literature for tools and approaches.

Fortunate Accident … and interesting times

The RCAC was interested in understanding the risk to multiple endpoints that existed in a variety of locations within the fjord.

While the primary interest was in the outfall from the Ballast Water Treatment Plant for the oil tankers, there were also a refinery, harbor area, the City of Port Valdez, runoff, sewage, hatcheries and other inputs to the system.

There were also multiple endpoints of interest to the good citizens, including salmon, shellfish, and contaminants.

The fjord of Port Valdez and the relative risk model.

A Regional Multiple-Stressor Ecological Risk Assessment for Port Valdez, Alaska

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March 31, 1997

Human and Ecological Risk Assessment: Vol. 3, No. 3, pp. 287-297 (1997)

PERSPECTIVE:

Design Considerations and a Suggested Approach for Regional and Comparative Ecological Risk Assessment

Wayne G. Landis and Janice A. Wiegers
Institute of Environmental Toxicology and Chemistry, Western Washington University, Bellingham, WA*

Key Words: regional risk assessment, ecological risk assessment, ranking risks

INTRODUCTION

The implicit goal of all ecological risk assessment (EcoRA) is the management of ecological structures. (Because a scientifically determinable design or blueprint does not exist for a system in ecological interactions, we believe the word "ecosystem" is a misnomer and use "ecological structure" to denote the lack of inherent planning or design.) Usually only one stressor is considered, apart from other anthropogenic and natural events. Heterogeneity of the exposure, the distribution of the impacted populations in time and space, and the interactions among the components of an ecological structure are poorly represented. Often the paradigm for the risk assessment is one based in Clementian ecology. A Clementian viewpoint (Clements 1916) is that for every

Human and Ecological Risk Assessment: Vol. 4, No. 5, pp. 1125-1173 (1998)

A Regional Multiple-Stressor Rank-Based Ecological Risk Assessment for the Fjord of Port Valdez, Alaska

Janice K. Wiegers,[1] Howard M. Feder,[2] Linda S. Mortensen,[1] David G. Shaw,[2] Valerie J. Wilson,[1] and Wayne G. Landis[1,*]
[1]Institute of Environmental Toxicology and Chemistry, Western Washington University, Bellingham, WA, 98225 USA; [2]Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, AK 99775

ABSTRACT

We conducted an ecological risk assessment of the marine environment of Port Valdez, a fjord in south-central Alaska. Because the assessment was regional rather than site-specific and contained a large number of different stressors in a variety of environments, we required a nontraditional method to estimate risks. We created a *Relative Risk Model* to rank and sum individual risks numerically within each subarea, from each source, and to each habitat. Application of this model involved division of Port Valdez into 11 subareas containing specific ecological and anthropogenic structures and activities. Within each subarea, the stressor sources were analyzed to estimate exposure

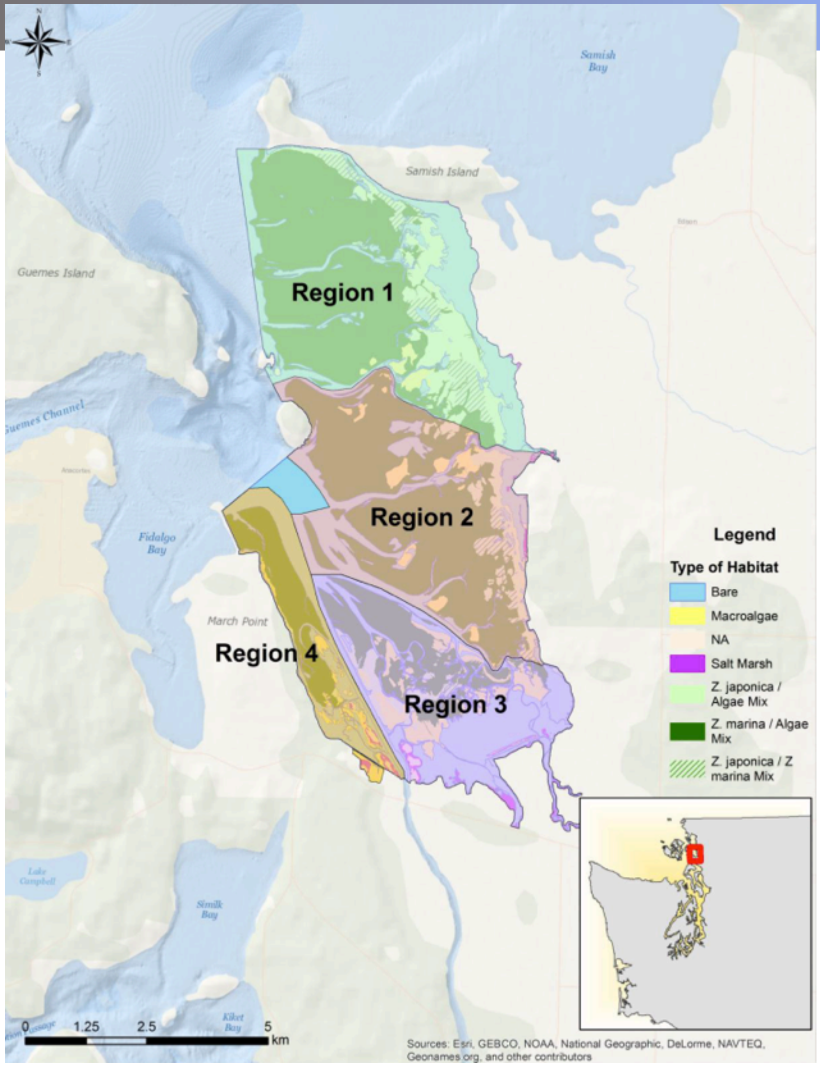
The Relative Risk Model.

What is the difference between conventional risk assessment and regional risk assessment?

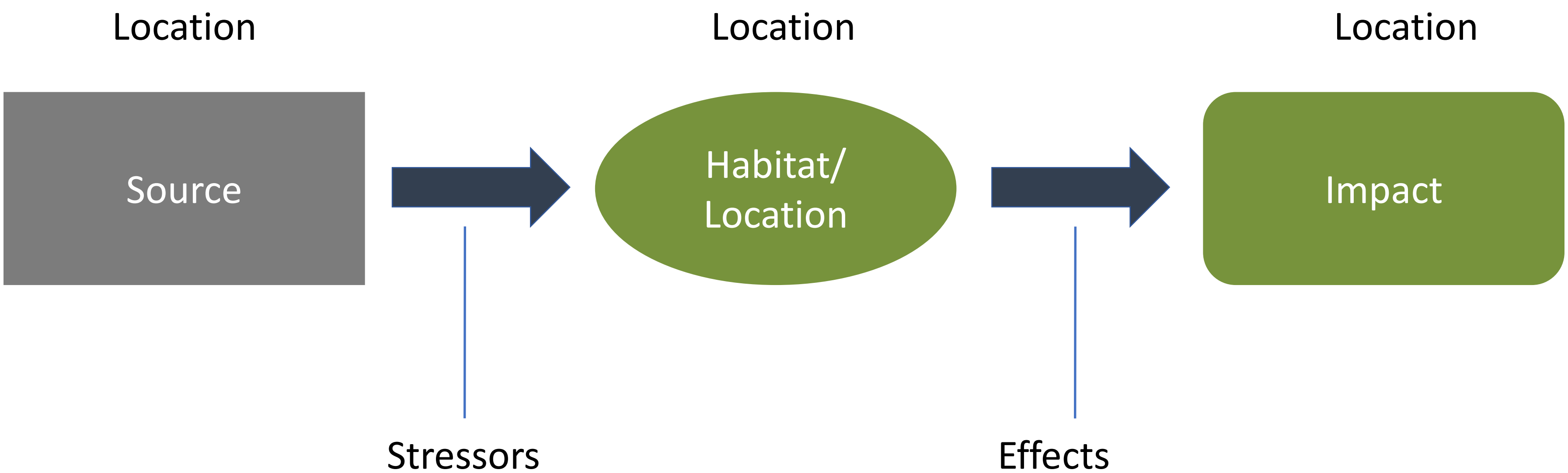
At a Regional Scale there are multiple stressors and multiple receptors unevenly distributed over a landscape.

The World is lumpy—spatially explicit

Padilla Bay, Washington

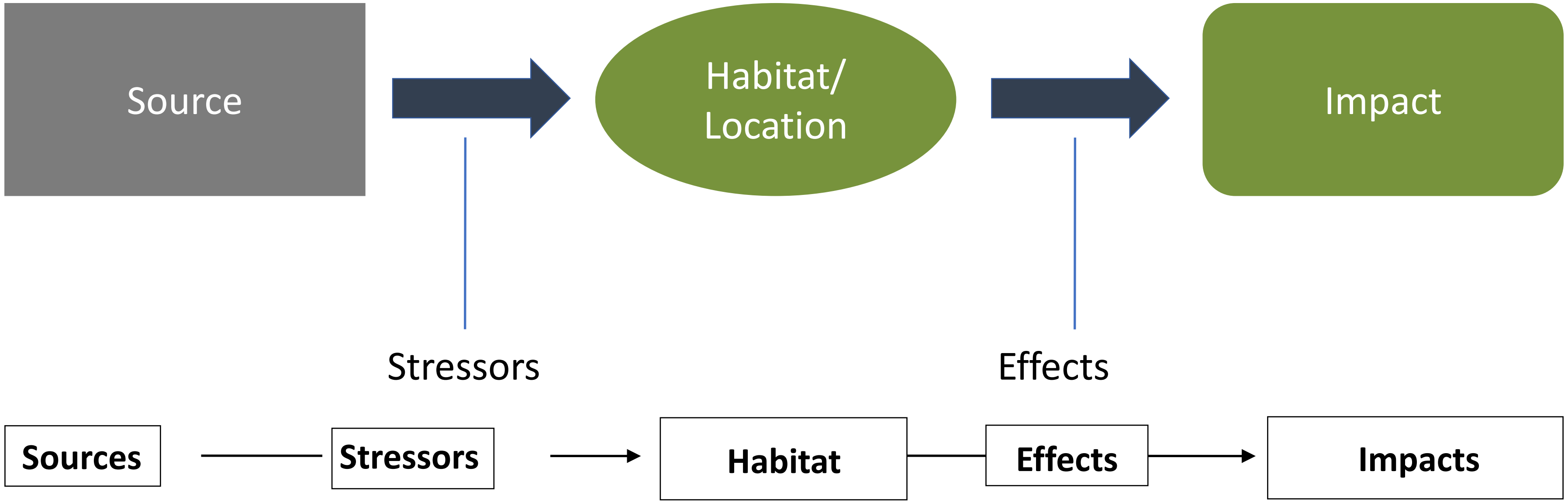


Relative Risk Model-the basics



The values at each step and the interactions are ranked—as in discrete values.

Conceptual Model is also configured with this pattern



The Relative Risk Model.

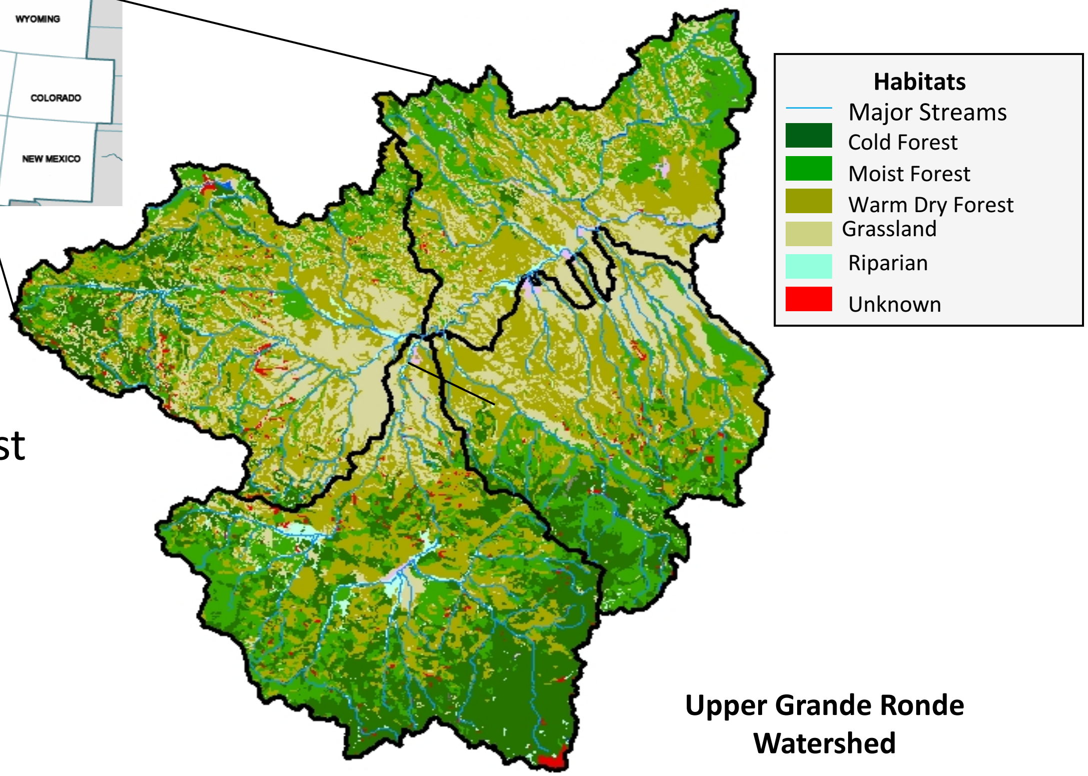
Why Ranks????

Combining different effects with different stressors, all with different metrics.

It's like counting apples and oranges.

Bayesian Network for the Upper Grande Ronde Watershed of INLAS-K. Ayre based on work by S. Anderson.

INLAS Study Area
Wallowa-Whitman National Forest



Upper Grande Ronde Watershed

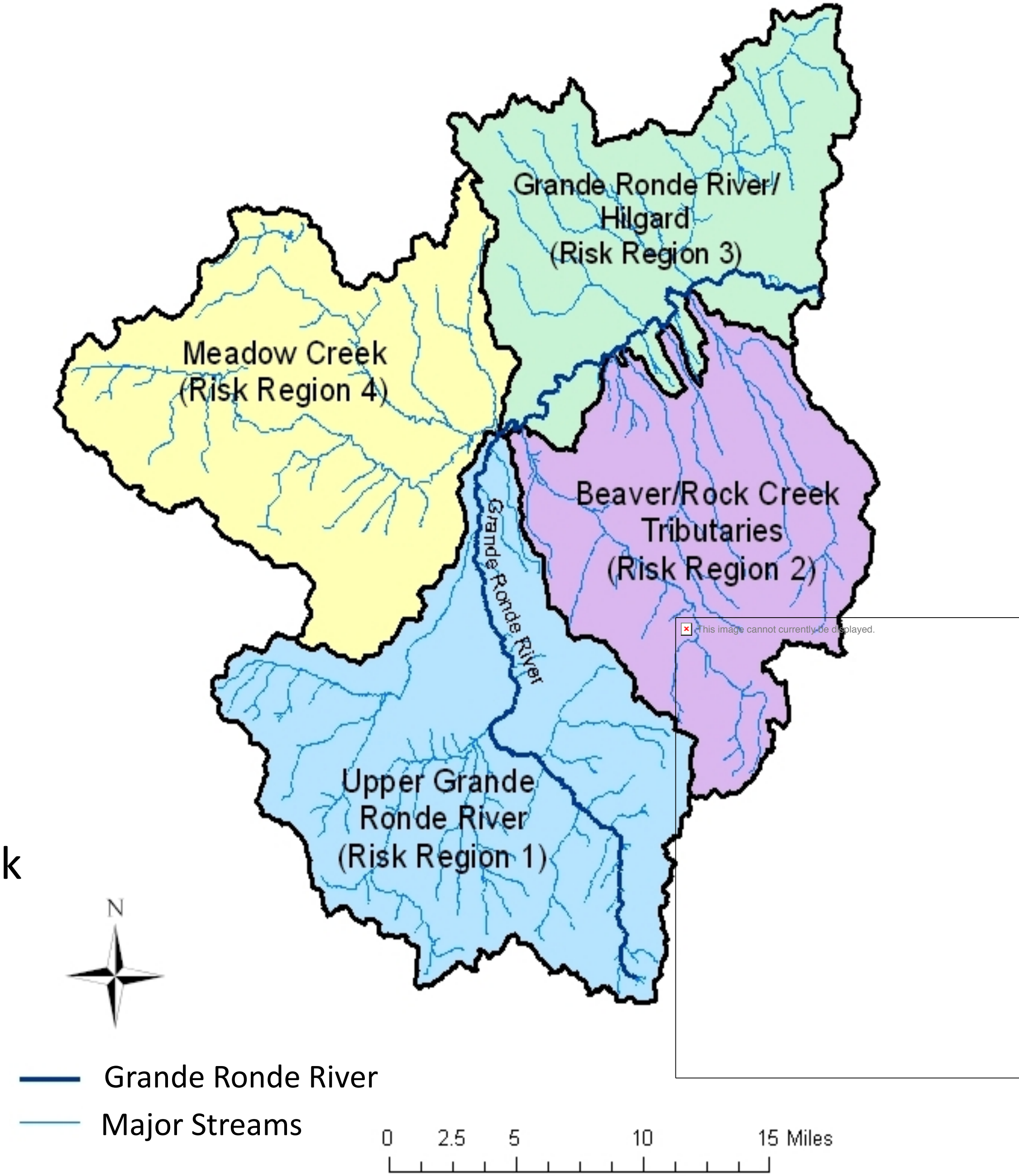
Funded by the US Forest Service

Multiple sources, stressors, habitats and management goals

Study Area

In the RRM approach the first item to to make a map of the region with the locations of where various management activities occur, disturbances, and for what regions are being managed for what goals.

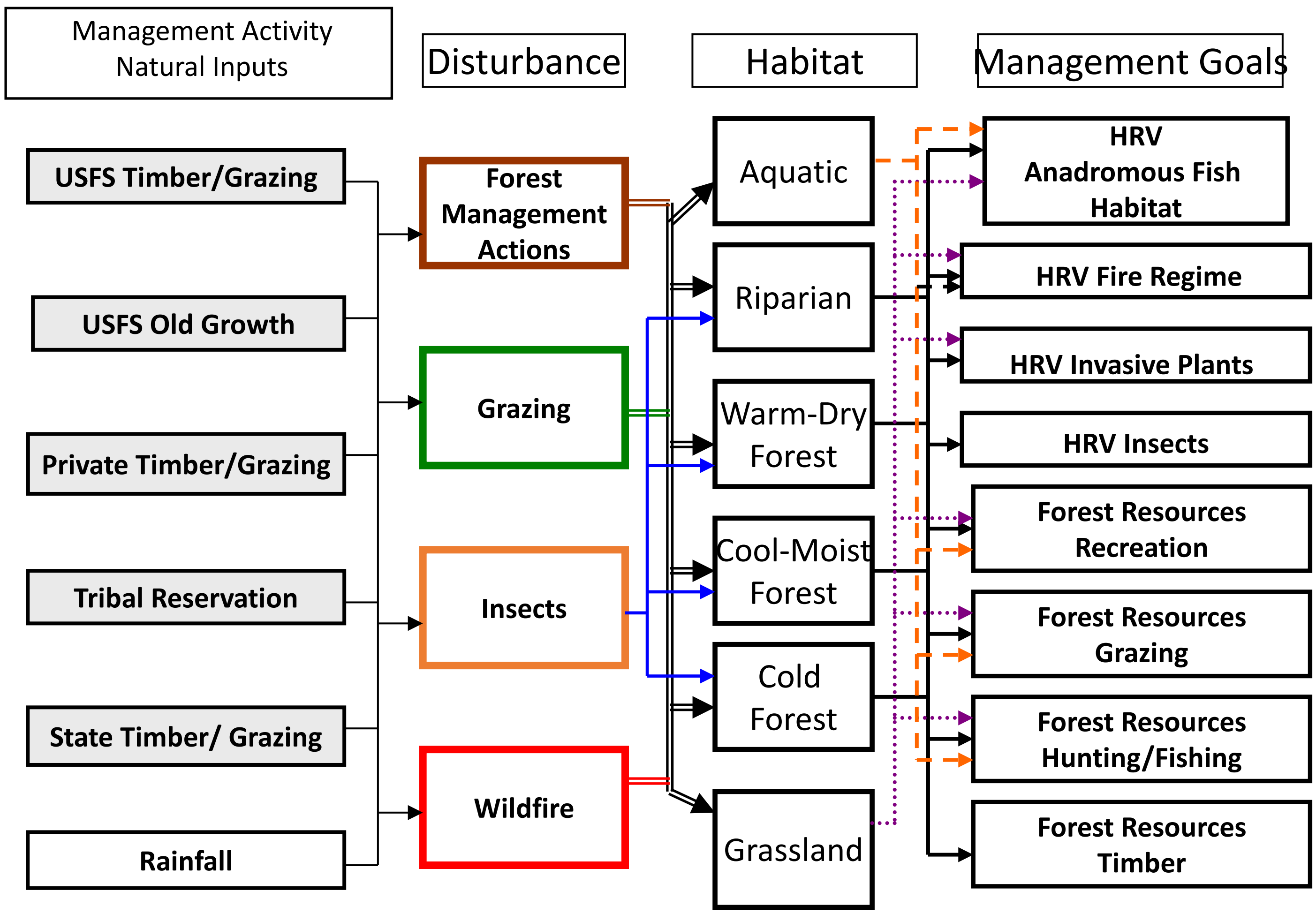
INLAS was divided into four risk regions to characterize the relative risks in the region.



Development of Conceptual Model

- What management activities, natural inputs, disturbances and habitats are present within the study area?
- With what management goals are the public and land managers concerned?
- How are these connected in causal pathways?

The original INLAS model

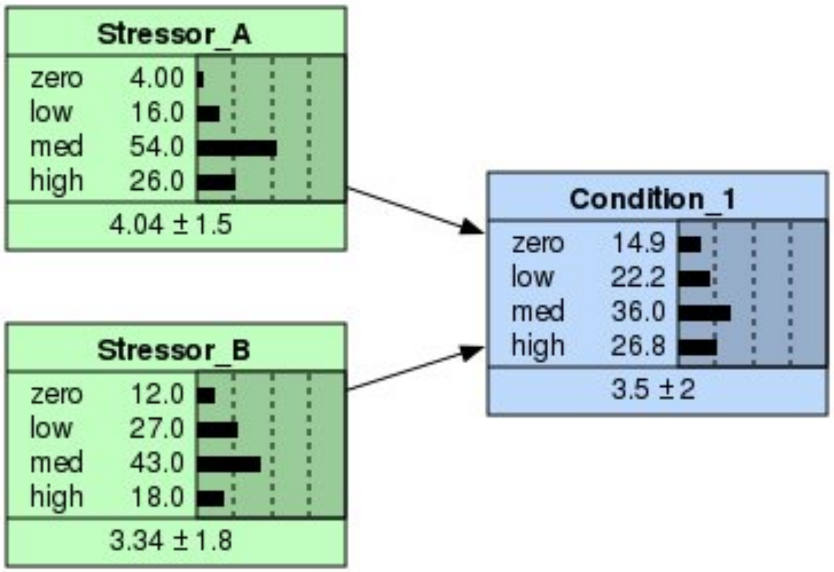


Addressing challenges using Bayesian network modeling

- Bayesian networks (BN) can be based on a broad-array of data types
- Model structure displayed with a graphic interface
- Incorporate uncertainty
- Model outcome displayed with the same graphic interface

How about an example?

BN Model Structure



1. Consists of nodes (boxes) and linkages (arrows)
2. Each node has 4 potential states
3. Likelihood of each state for input nodes determined from spatial analysis data
4. Conditional probability tables established for all other nodes

Conditional Probability Tables

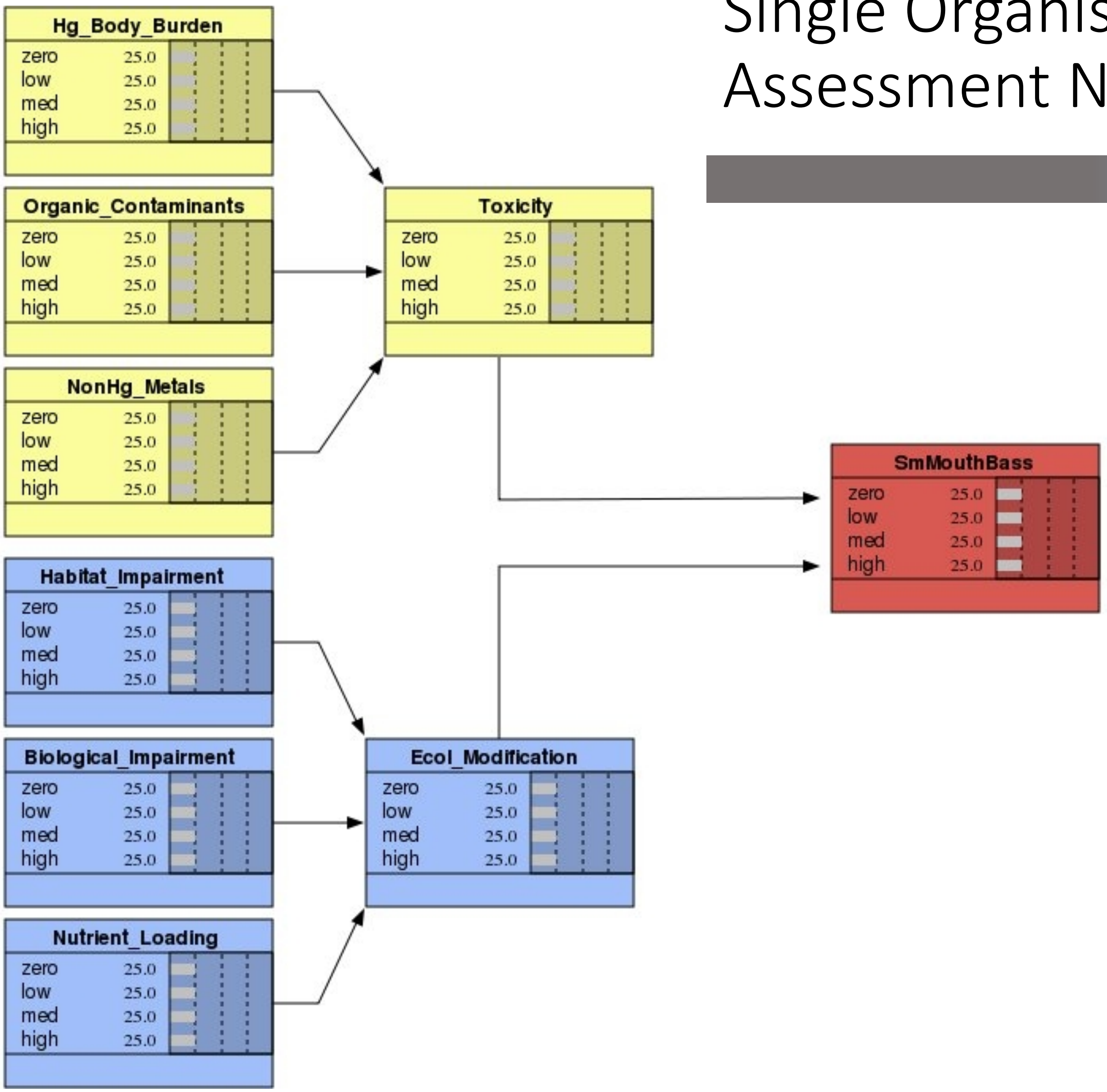
Stressor_A	Stressor_B	zero	low	med	high
zero	zero	100.00	0.000	0.000	0.000
zero	low	90.000	8.000	1.500	0.500
zero	med	75.000	20.000	4.000	1.000
zero	high	60.000	25.000	10.000	5.000
low	zero	75.000	20.000	4.000	1.000
low	low	50.000	35.000	10.000	5.000
low	med	25.000	35.000	30.000	10.000
low	high	10.000	30.000	45.000	15.000
med	zero	25.000	35.000	30.000	10.000
med	low	10.000	30.000	45.000	15.000
med	med	5.000	25.000	50.000	20.000
med	high	1.000	9.000	40.000	50.000
high	zero	15.000	25.000	40.000	20.000
high	low	10.000	15.000	35.000	40.000
high	med	5.000	10.000	30.000	55.000
high	high	1.000	4.000	20.000	75.000

- Probability distribution for all combinations of input node states

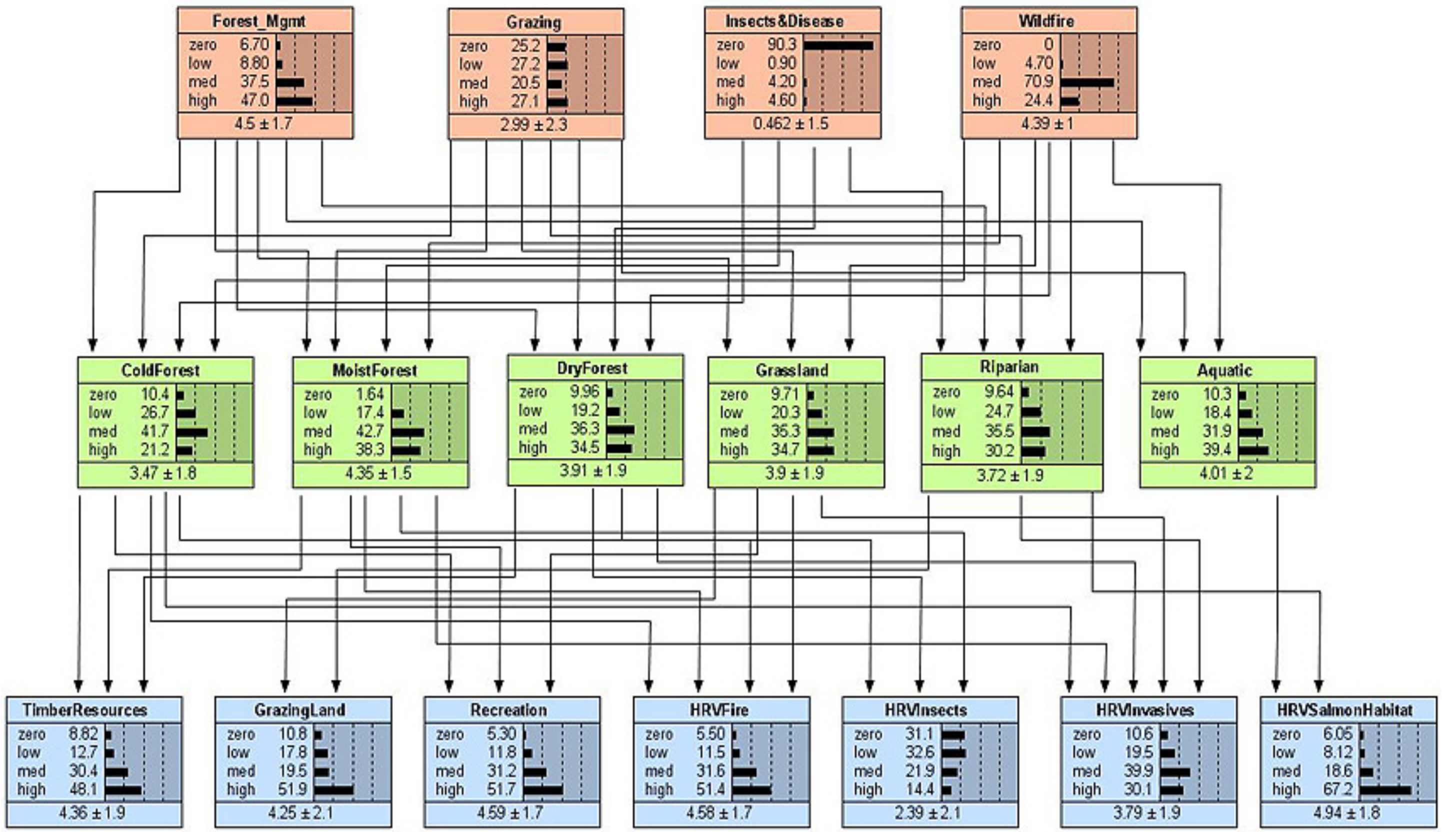
Procedure:

1. Assign the most probable outcome a probability
2. Assign remaining probabilities for a reasonable distribution, given the information available

Single Organism Risk Assessment Network



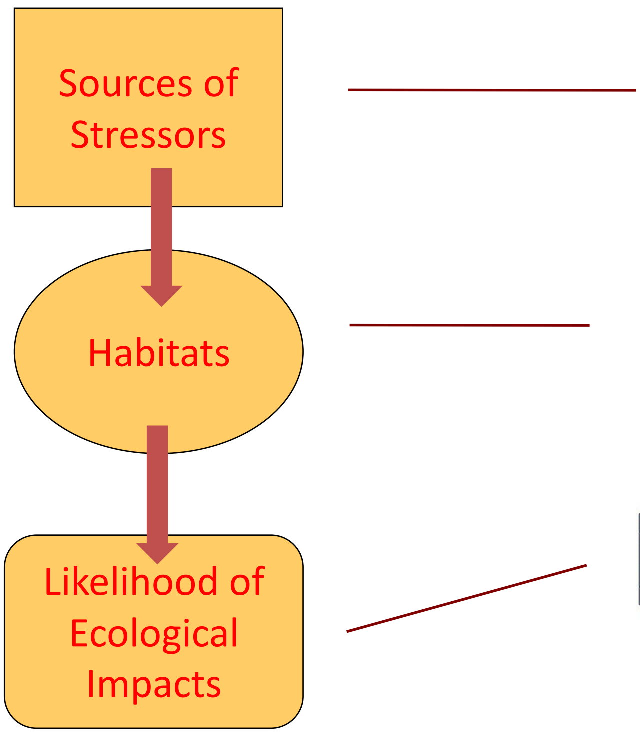
Final BN for the Grande Ronde of INLAS

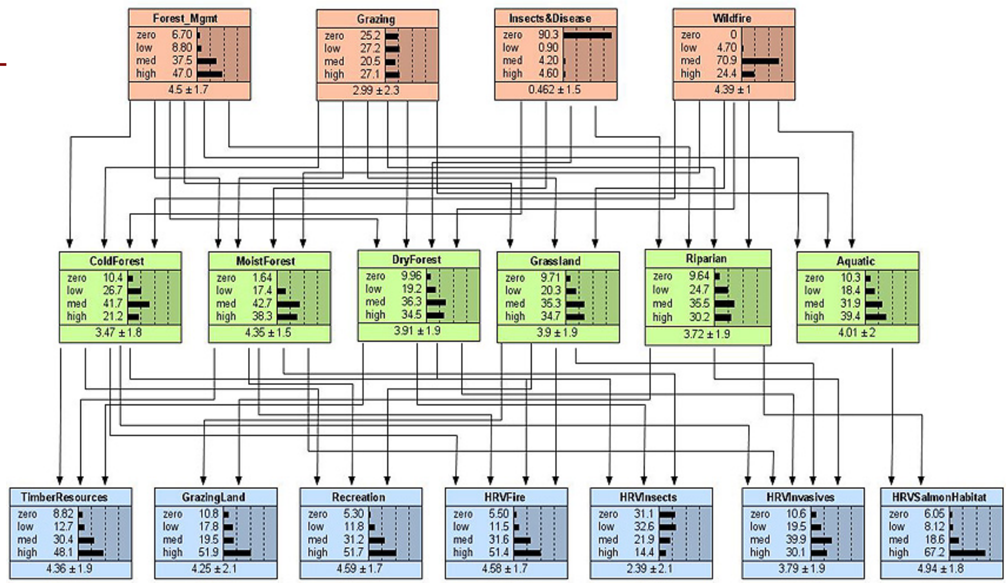


Netica software

--Now we need to focus on each layer

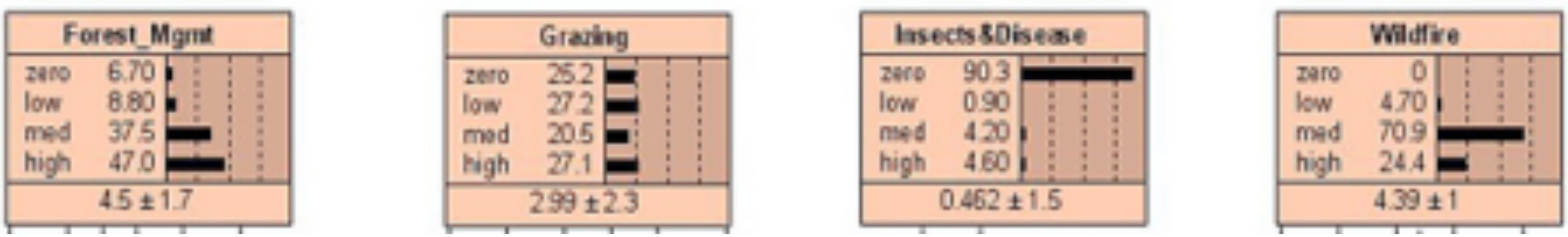
BN Models Corresponds to our risk assessment framework





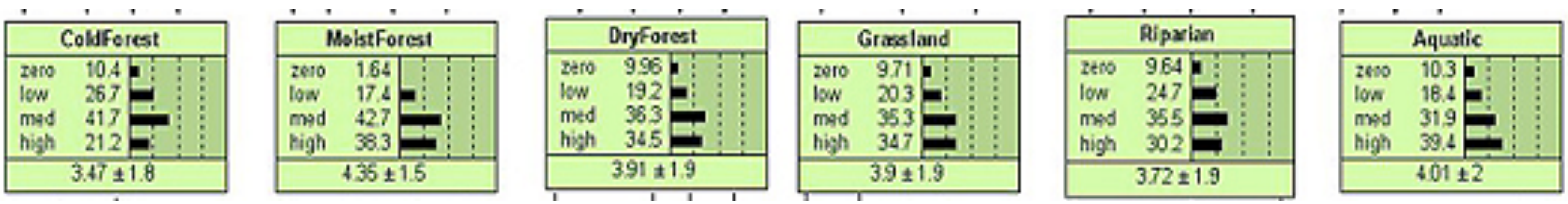
INLAS BN

Focus on Each Layer-Management



Each of these parent nodes are used to describe a particular kind of management action for a variety of habitats. These management actions are in part a decision based on current policy and the state of the practice.

Focus on Each Layer-
Habitat Type and Amount

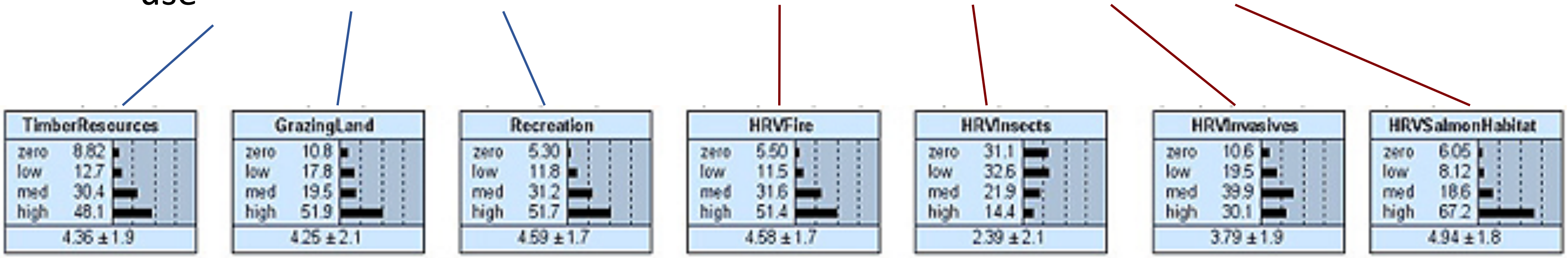


These daughter nodes describe the type of habitat to be managed and the relative amount of each. The bars describe the exposure of the UGR from the stressors to each of the habitats.

Focus on Each Layer-
Impacts to Ecological Resources

Specifications for harvest or use

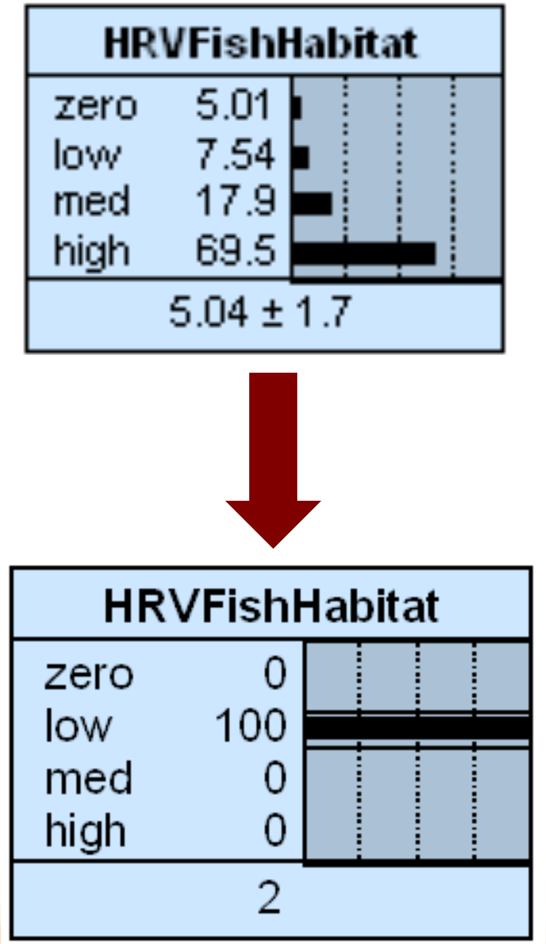
HRV=Historical Range of Variability before European Settlement



These daughter nodes the impacts to each of the resources that are being managed for the area.

These endpoints are social-cultural choices.

Now to run some scenarios and focus on the outcomes-1



Management goal is to lower the risk to HRV Fish Habitat to a low risk scenario.

Now what are are the management changes that would have to be made?

Now to run some scenarios and focus on the outcomes-2

Baseline

Forest_Mgmt	
zero	0.10
low	2.40
med	37.8
high	59.7
5.14 ± 1.1	

Grazing	
zero	5.00
low	25.0
med	35.0
high	35.0
4 ± 1.8	

Insects	
zero	90.3
low	0.90
med	4.20
high	4.60
0.462 ± 1.5	

Wildfire	
zero	0
low	0.46
med	94.4
high	5.14
4.09 ± 0.46	

Low fish risk

Forest_Mgmt	
zero	0.10
low	3.27
med	49.7
high	46.9
4.87 ± 1.1	

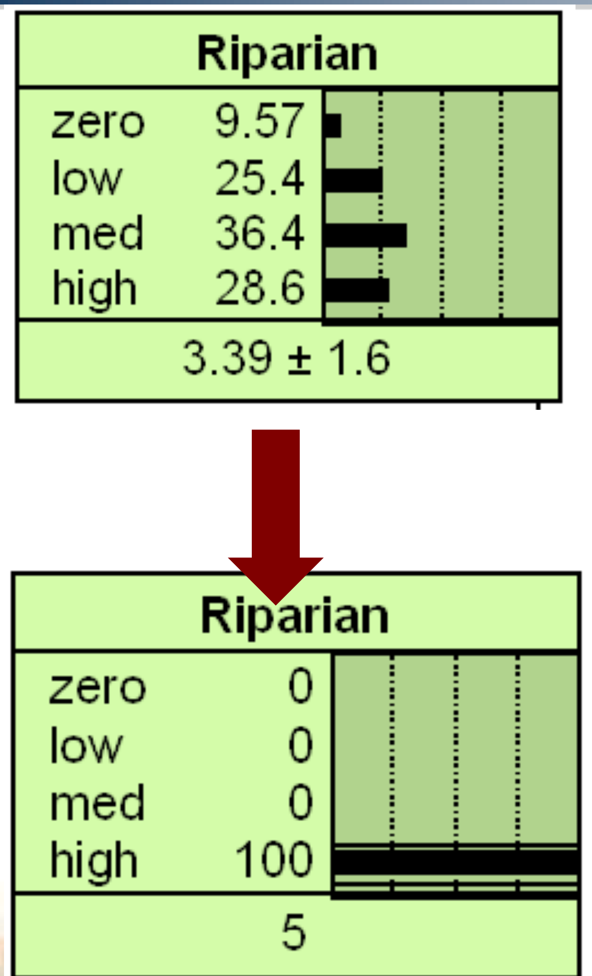
Grazing	
zero	7.78
low	36.2
med	35.2
high	20.8
3.38 ± 1.8	

Insects	
zero	92.0
low	0.84
med	3.67
high	3.46
0.371 ± 1.3	

Wildfire	
zero	0
low	0.80
med	96.5
high	2.74
4.04 ± 0.37	

Small changes in management make a big difference

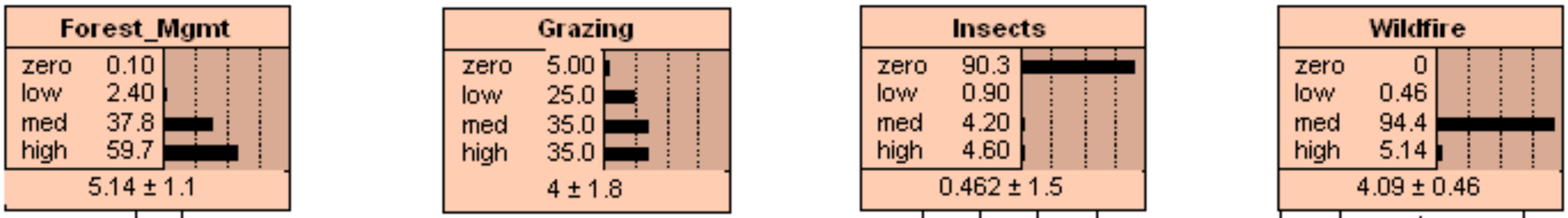
Now to run some scenarios and focus on the outcomes-3



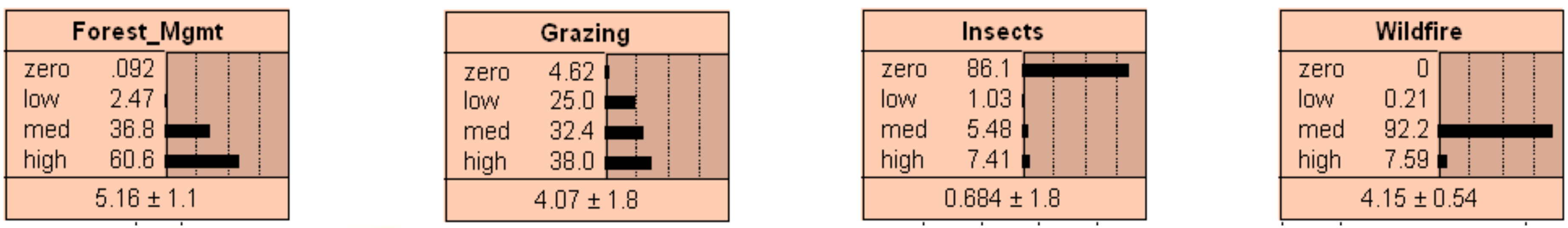
So let us see what changes in management are necessary to put the riparian zone at high risk and then check on the risk to the fish habitat.

Now to run some scenarios and focus on the outcomes-4

Baseline Management



Recalculated **Riparian** high risk Management, slightly higher management intensity



Small changes in management create a big change in the **Riparian** exposure

Uncertainty……..

Uncertainty and Sensitivity Analysis is essential

Kinds of uncertainty (Regan, Colyvan and Burgman (2002).

Epistemic-

Linguistic

Epistemic

Uncertainty and Sensitivity Analysis is essential

Measurement error

Systematic error

Natural variation

Inherent randomness

Model uncertainty

Subjective judgment

Linguistic

Numeric vagueness

Nonnumeric vagueness

Context dependence

Ambiguity

Indeterminacy in theoretical terms

Under-specificity

The greenhouse at Down House, Downe England