Expert probability elicitation through adaptive choice:

The risk of *Elodea spp. to salmonid persistence in Alaska*

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At risk?
Not at risk?

Outline

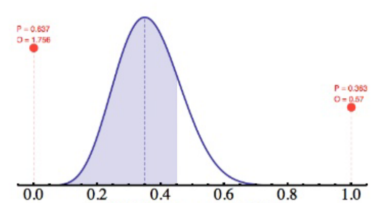
1. How we deal with uncertainty
2. Defining risk
3. Formalizing decisions
4. Measuring expert opinion & estimating probabilities
5. Advantages & limitations

Ways of dealing with uncertainty

- Arbitrarily → use arbitrary safety factors (engineering)
- Status quo → don't change course without proof (ADFG)
- Optimistically → use best case (Alaska Legislature)
- Avoid it → act as if best guess were true (assign one invasiveness score)
- Pessimistically → follow precautionary principle, use worst case (*Elodea*, Kenai)
- Quantitatively → conduct formal decision analysis

potential damages to ecosystem services

$$Risk = probability \cdot consequence$$



Knight (1921), Sirling and Gee (2003), Avon (2011)

Decision analysis considers both components of risk

		Action 1	Action 2	Action 3
H1: ***E. spp affects salmon persistence***	Probability that H1 is true	Consequence of Action 1 given H1	… Action 2 given H1	… Action 3 given H1
H2: **No effect**	Probability that H2 is true	… Action 1 given H2	… Action 2 given H2	… Action 3 given H2
"Risk" = Expected Value		E(Action1)	E(Action2)	E(Action3)

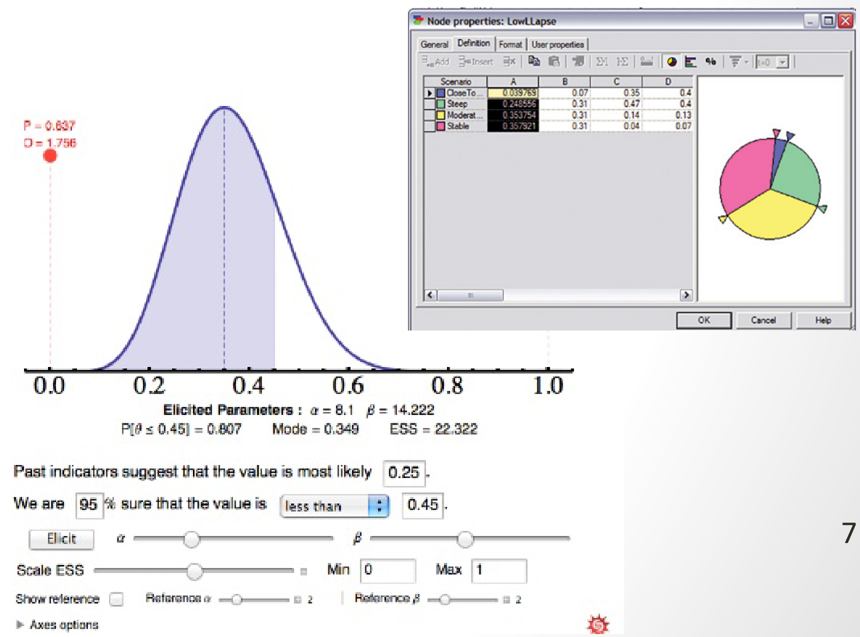
How to get the probabilities?

objective

subjective

Experiments

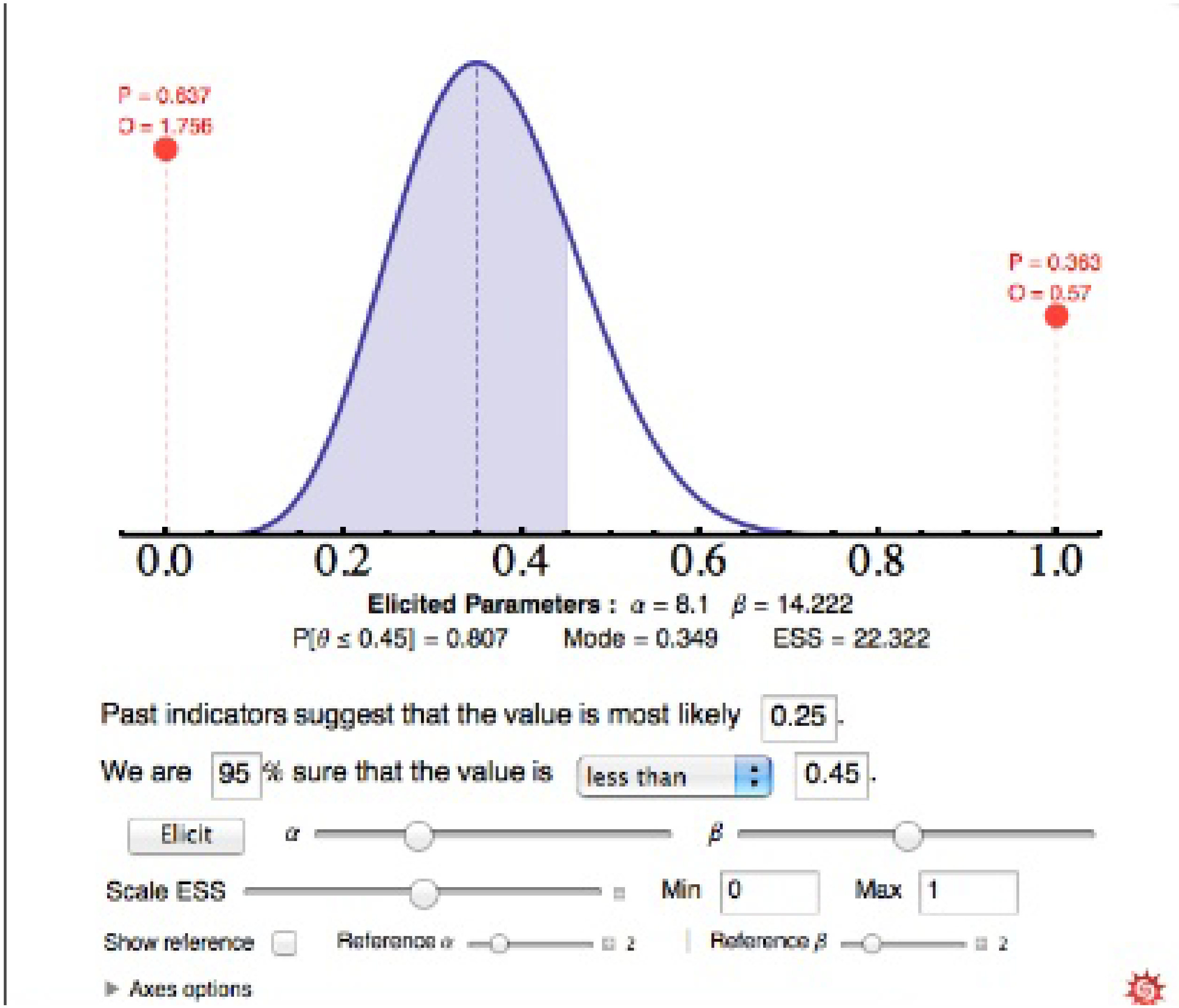
Experts



Expert sample (N=110, n=56)

aquatic plants & fish	invasive aquatic plants	salmon	other fish	% of sample (n-56)
X				11%
X		X		29%
X			X	9%
	X			16%
		X		54%

Common direct probability elicitation



An <u>**in**</u>direct method

- A Model of human choices / behavior
- Applications:
  - Marketing, transport, non-market valuation, etc.
- Foundation:
  - discrete choice models, random utility theory
- Assumes people are rational

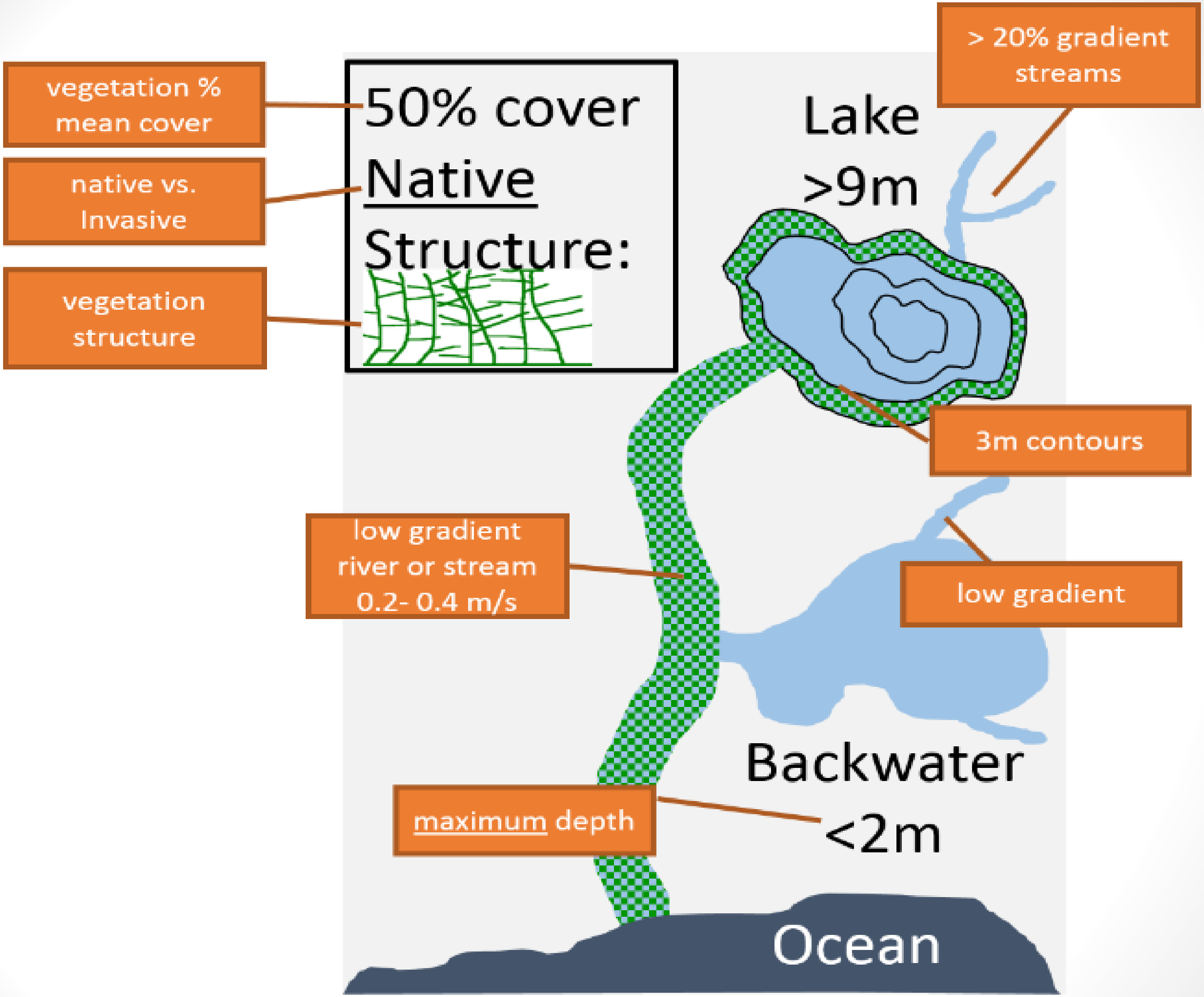
McFadden (1973)

Aggregated among all experts

$$U_{nj} = V_{nj} + \varepsilon_{nj}$$

$$V_j = \beta_{0j} + \beta_{1j} f(X_{1j}) + \beta_{2j} f(X_{2j}) + ... + \beta_{kj} f(X_{kj})$$

- Utility estimation using hierachical Bayes
- Humans are similar but not identical
- Ideally used in situations of high uncertainty


vegetation % mean cover
native vs. Invasive
vegetation structure
50% cover
Native
Structure:
> 20% gradient streams
Lake
>9m
3m contours
low gradient river or stream 0.2- 0.4 m/s
low gradient
Backwater
maximum depth
<2m
Ocean

Scenario characteristics

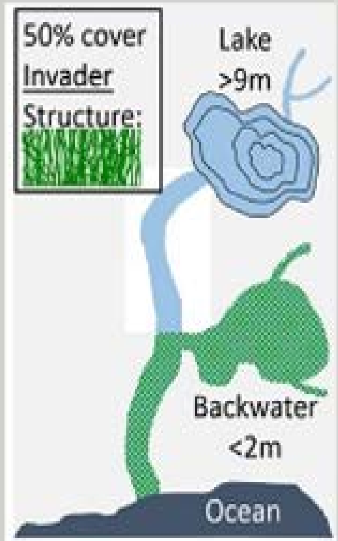
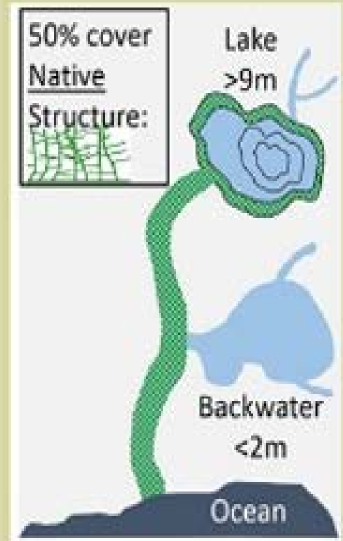
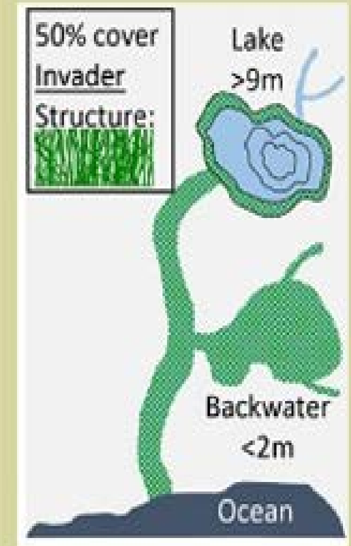
	Un-invaded habitat Level 1	Un-invaded habitat Level 2	Invaded habitat Level 1	Invaded habitat Level 2
Vegetation cover (%)	**0%**	**50%**	**50%**	**100%**
Dissolved oxygen (mg/l)*	**5.5**	**10.5**	**0.5**	**5.5**
Prey abundance (mg/m^2)*	**400**	**600**	**30**	**3000**
Piscivorous fish (#/acre)*	**5**	**20**	**20**	**35**

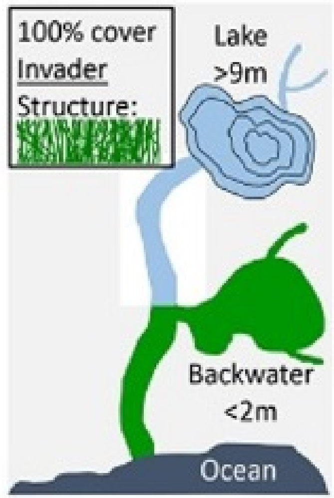
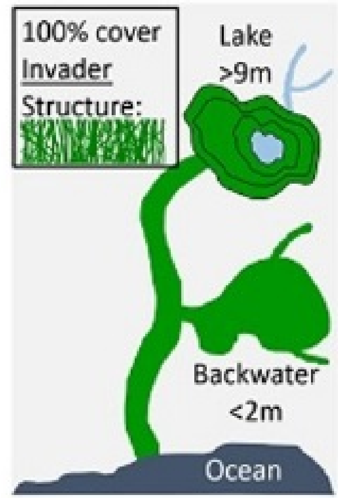
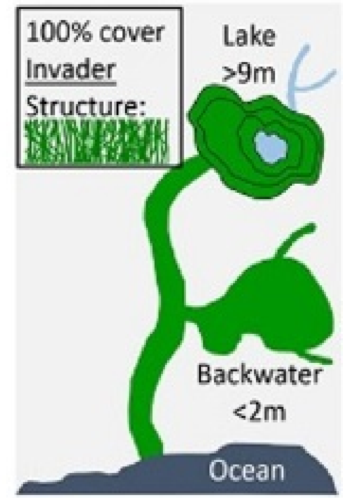
Expert survey

Background

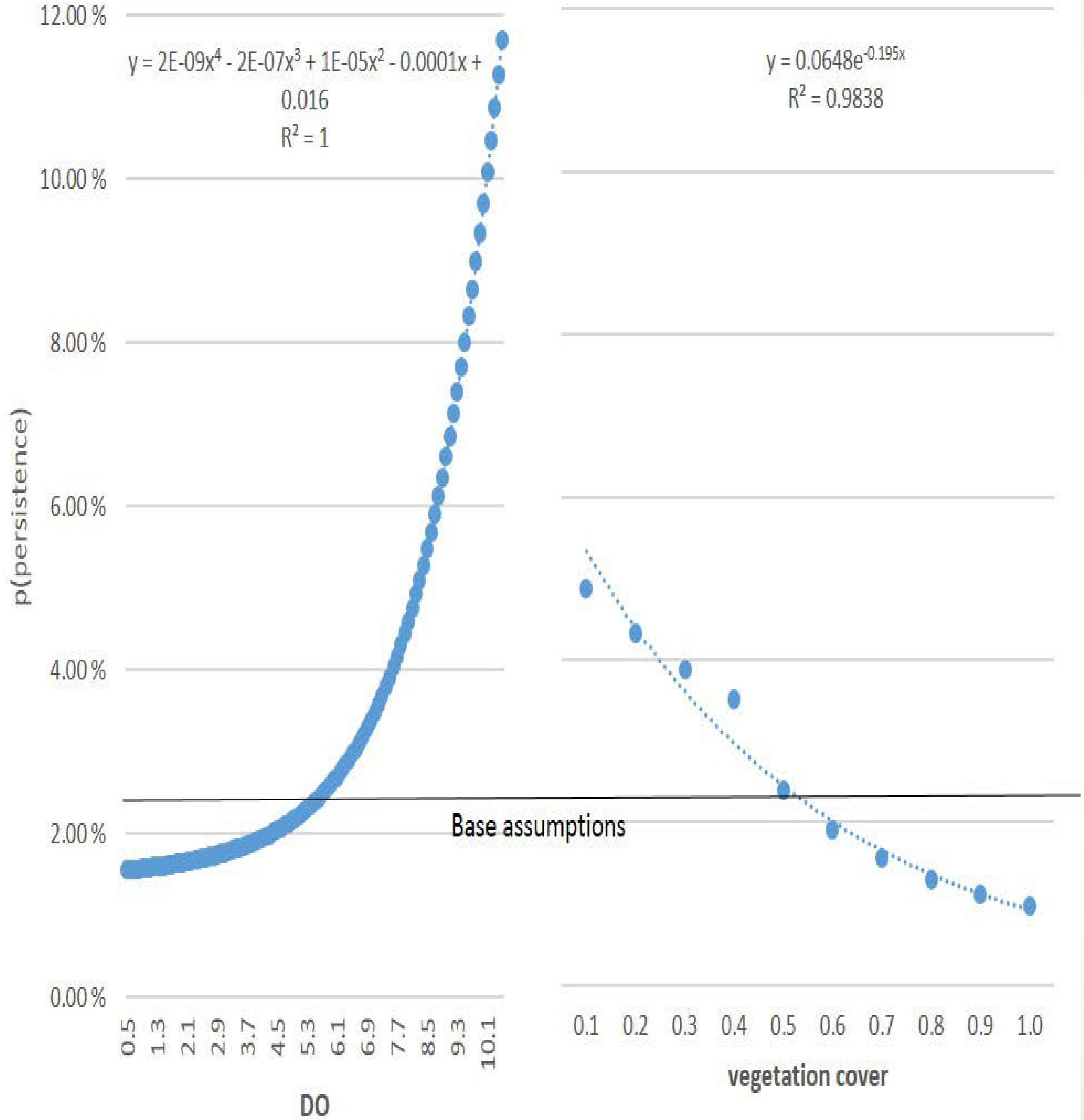
This information is intended to provide you with a basic overview of *Elodea*'s habitat suitability, long-distance dispersal, and ecological impact. Below, we also describe the task and define the habitat characteristics. This information is by no means complete in describing the complexity and potential alterations of ecosystem processes affected by *Elodea*. Instead, we aim at a broad overview of ecological effects that could be related to the viability of salmonid populations in Alaska. We also realize that scientific evidence from outside Alaska limits transferability to Alaska locations and environmental conditions. However, we believe that in data limited situations such as this, non-site-specific literature is essential in establishing a baseline from which to start the discussion.

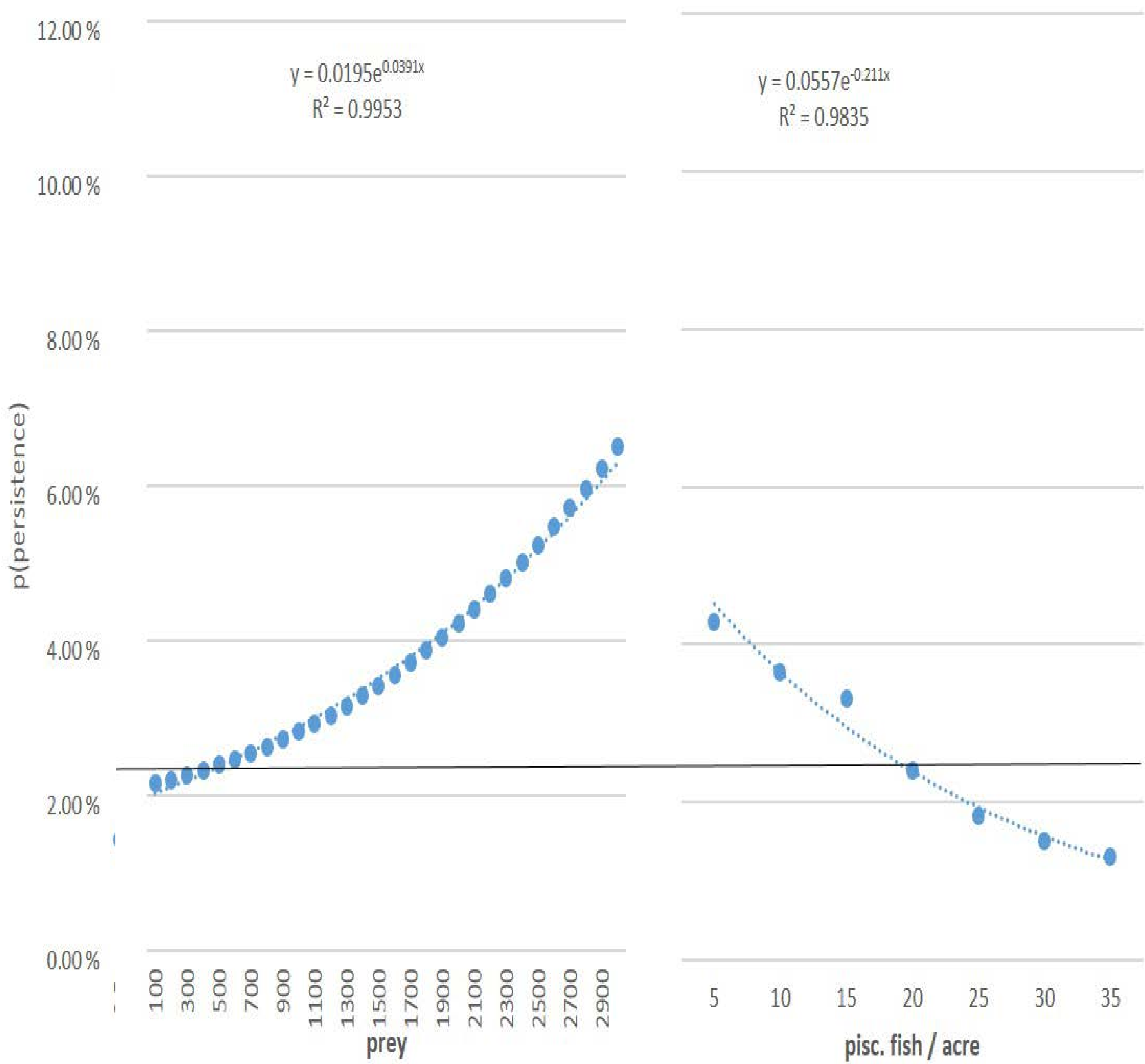
Content:

Species utilizing habitat	Chinook	Sockeye	Sockeye	Humpback whitefish
Habitat map				
Habitat state	invaded	not invaded	not invaded	invaded
Dissolved oxygen (mg/l at 10°C)	10.5	5.5	10.5	0.5
Prey abundance	30 indiv./m² macroinvertebrates	600 mg dry/m² zooplankton	400 mg dry/m² zooplankton	3000 indiv./m² macroinvertebrates
Predators/acre	35	5	5	20
	○ Likely persist ○ Possibly extirpated	○ Likely persist ○ Possibly extirpated	○ Likely persist ○ Possibly extirpated	○ Likely persist ○ Possibly extirpated

Species using habitat	Humpback Whitefish	Dolly Varden	Sockeye
Habitat map			
State of habitat	invaded by *Elodea*	invaded by *Elodea*	invaded by *Elodea*
Dissolved oxygen (mg/l at 10°C)	10.5	0.5	10.5
Prey abundance	30 indiv./m^2 macroinvertebrates	3000 indiv./m^2 macroinvertebrates	3000 mg dry/m^2 zooplankton
Piscivorous fish/acre	35	35	35
	○	○	○

Some results from 56 experts





12.00 %
10.00 %
8.00 %
6.00 %
4.00 %
2.00 %
0.00 %
p(persistence)
y = 0.0195e^0.0391x
R² = 0.9953
100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300 2500 2700 2900
prey
y = 0.0557e^-0.211x
R² = 0.9835
5 10 15 20 25 30 35
pisc. fish / acre

Advantages and limitations of choice-based method to elicit probabilities

- Advantages:
  - Ideal for rapid response
  - Expert panel follows literature review that's part of IPM
  - Tailored to local conditions
  - No need for experts to state probabilities
  - Structured, transparent, repeatable
  - Transparent aggregation technique across expert pool

- Limitations:
  - "Black box"
  - No substitute for physical experimentation

Thank you funders and collaborators!

Sea Grant Alaska

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