Potential dispersal of invasive aquatic plants: a model of floatplane pilot behavior

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Invasive aquatic species are an increasing threat to remote and pristine freshwater resources and the local livelihoods that depend on the ecosystem services derived from these systems. This presentation will illustrate a risk assessment of the floatplane pathway responsible for the long-distance dispersal of *Elodea* spp. across Alaska. A web-based survey was used to elicit the freshwater locations Alaska's floatplane pilots fly to. A fully hierarchical Bayesian probability model was applied to calculate a shrinkage estimator for the ratio of pilots flying to individual lakes from floatplane bases containing aquatic invasive species. Model results are consistent with known infestations and provide critical information to prioritize resource management actions. The presentation concludes with comprehensive model checking and discussion of further integration into a decision analysis.

Potential dispersal of aquatic invasive species by floatplanes

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Photograph by Heather Stewart, DNR

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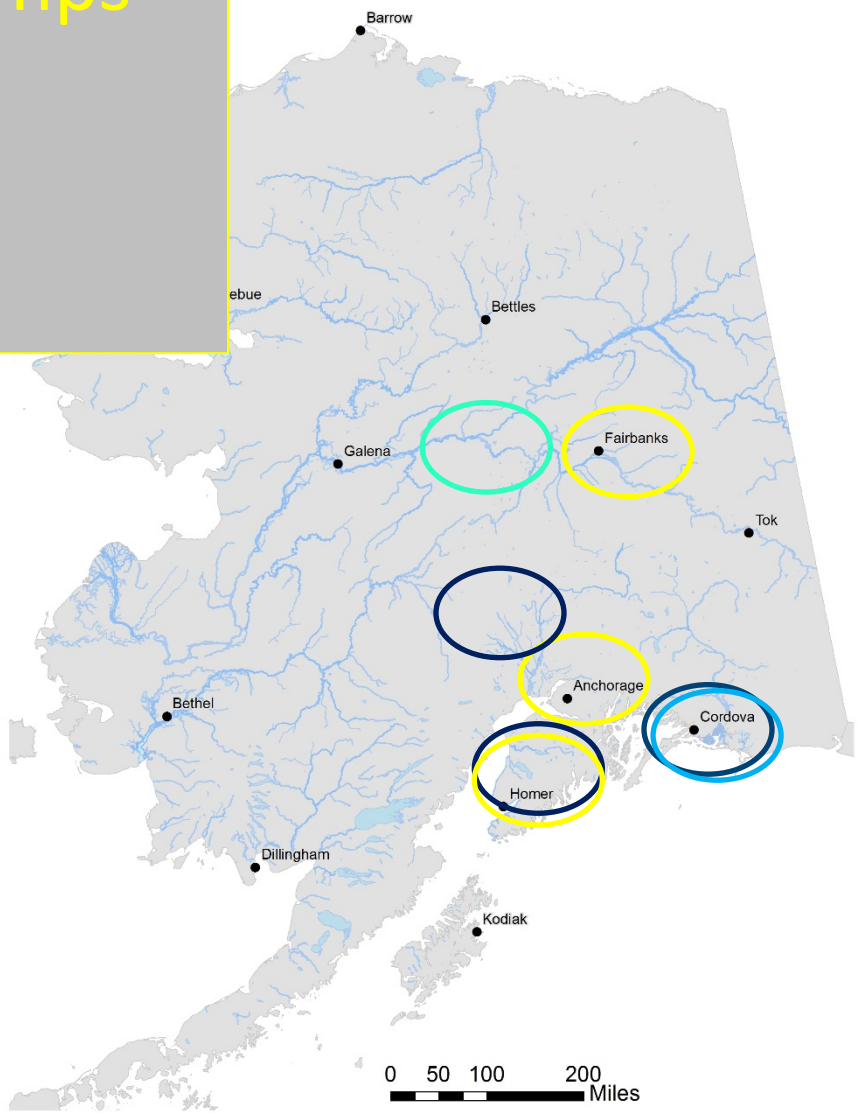
Currently "Known" Pathways

Aquarium dumps

Floatplanes

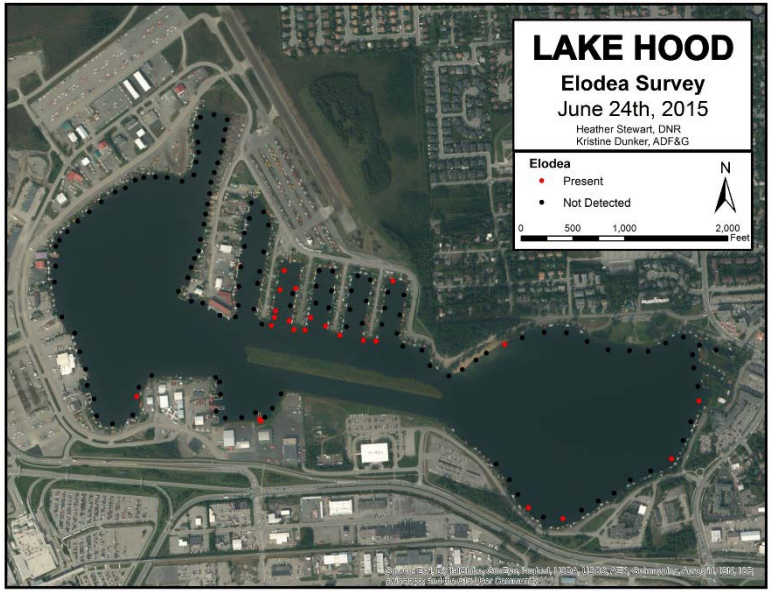
Hydrology

Boats



Elodea in Lake Hood

- Busiest seaplane base in the world
- 70,000 take-offs & landings per year on average
- Large and widespread air charter business
- 327+ slips



Understand **P**eople & **P**athway

- Survey of Alaska floatplane pilots
  - Where pilots fly - now
  - Where pilots fly - if current destination infested
  - Use (travel) costs to infer resource value, damage
  - Measure awareness
  - Get a volunteer base
- Probability of new introductions
  - Set detection/monitoring priorities
  - Quantify risk

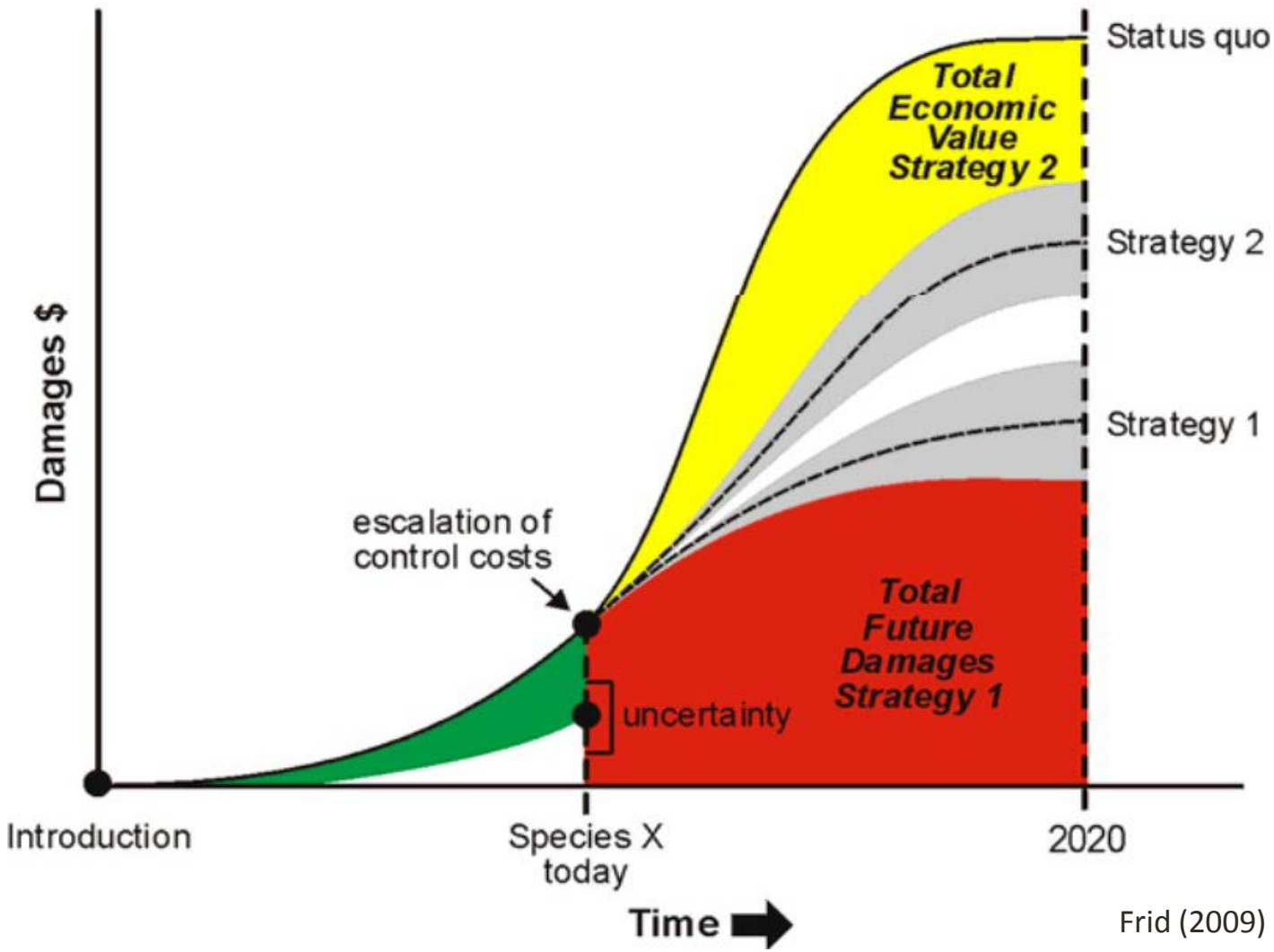
Manage Risk

Risk = probability * consequences

- Market and non-market values
  - Floatplane sector
  - Salmon fisheries
- Decision analysis
  - Evaluate set of management actions
  - Optimize - How is society best off?

    " Do nothing" vs. "action 1…n"
- Justify action

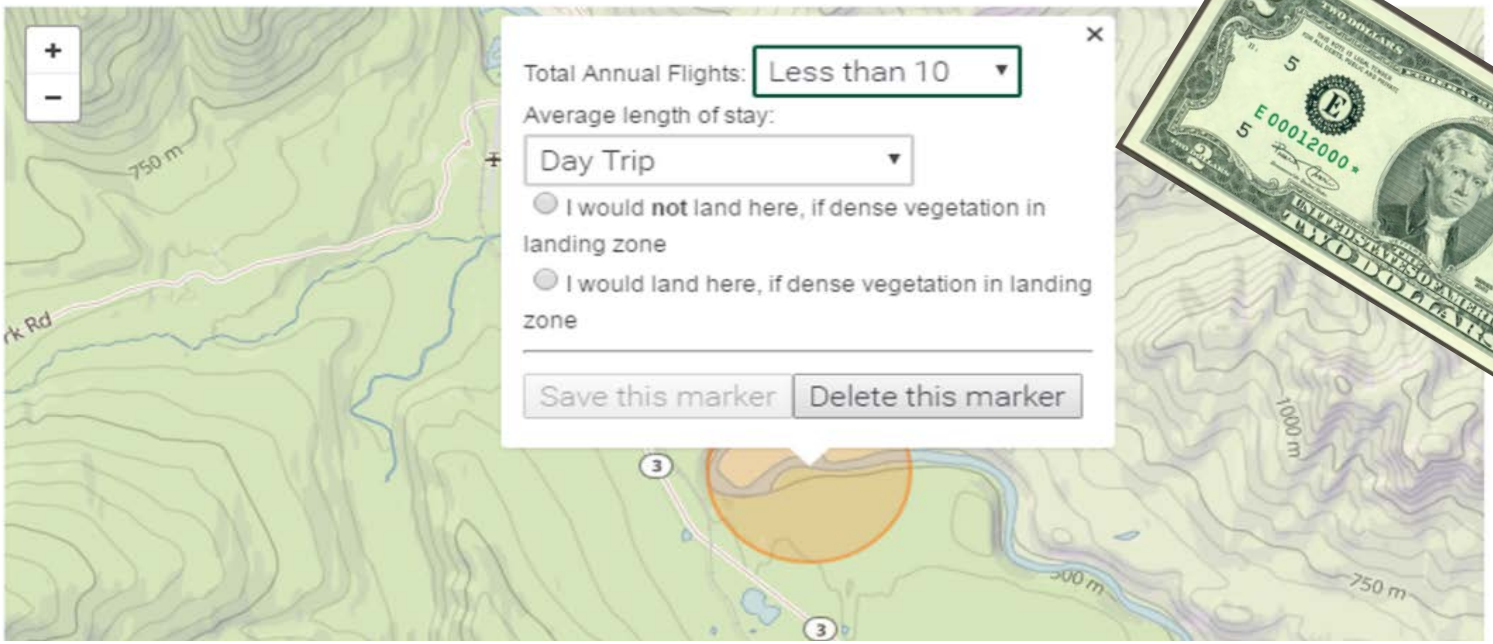
Quantify Benefits of Action



Frid (2009)

Survey with Floatplane Pilots

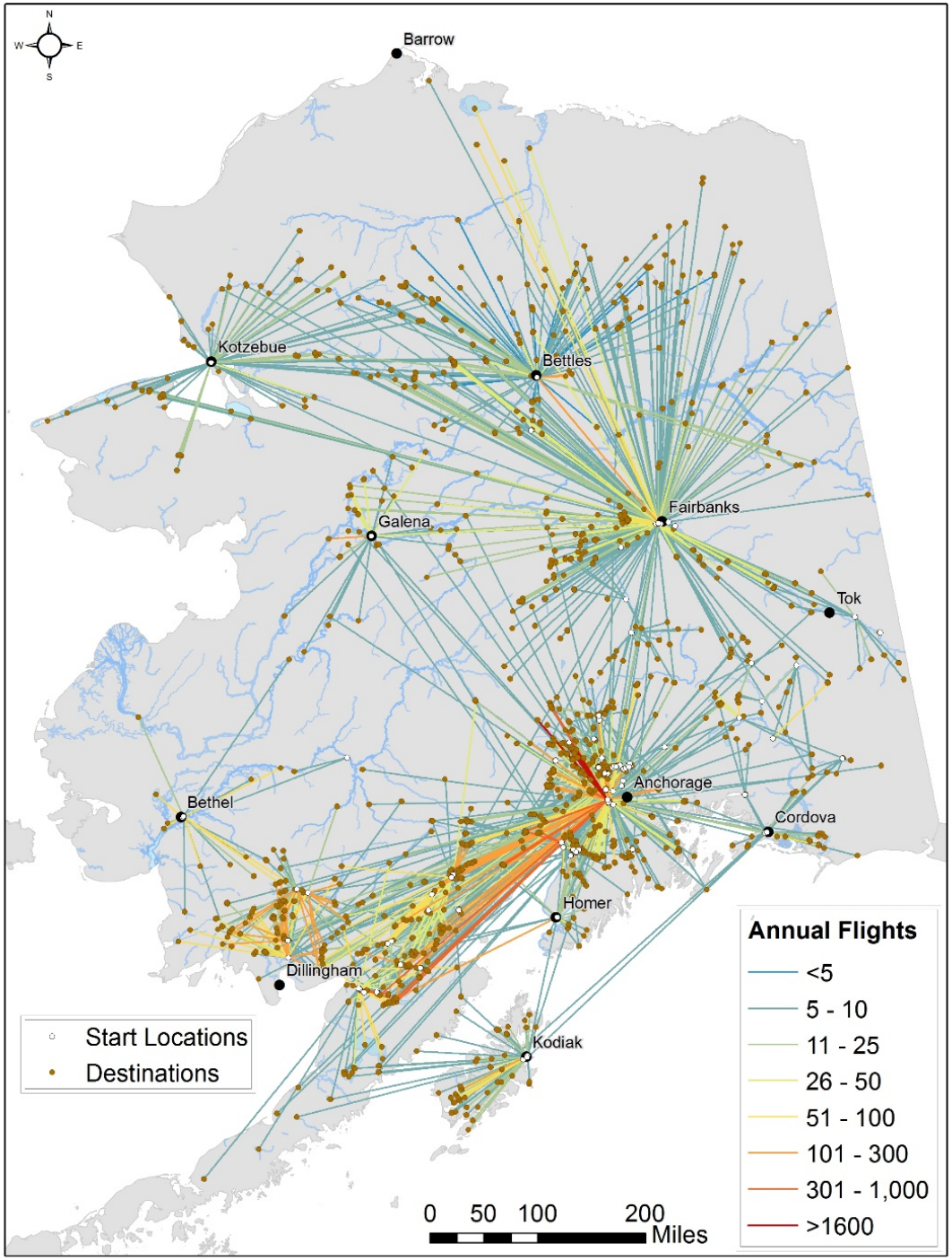
Type of flights	Type of contact	Effective sample size	Response count	Response rate
Personal	Mailed invitation	1000 a)	462 b)	46%
Commercial	Telephone	80	63	79%
Agency	Emailed invitation	64	38	59%
Overall		1147	576	50%



Flights from Known Elodea Lakes

Rk	Destination	# of flights	Rk	Destination	# of flights
1	Yentna River	**1634**	12	Lucile Lake	**170**
2	Big River Lakes	**681**	13	Nonvianuk Lake	**165**
3	Crescent Lake	**515**	14	Trinity Lake	**162**
4	Naknek Lake	**351**	15	Big Lake	**155**
5	Alexander Lake	**346**	16	Iliamna Lake	**154**
6	Chelatna Lake	**345**	17	Finger Lake	**150**
7	Figure Eight Lake	**324**	18	Lake Clark	**119**
8	Susitna River	**260**	19	Nancy Lake	**106**
9	Inner Lake George	**246**	20	Twin Island Lake	**104**
10	Beluga Lake	**212**	21	Red Shirt Lake	**103**
11	Lake Hood	**210**	22	Sevenmile Lake	**102**

N55758


N
W
E
S
Barrow
Kotzebue
Bettles
Fairbanks
Galena
Tok
Anchorage
Bethel
Cordova
Homer
Dillingham
Kodiak
Start Locations
Destinations
Annual Flights
<5
5 - 10
11 - 25
26 - 50
51 - 100
101 - 300
301 - 1,000
>1600
0 50 100 200
Miles

The Statistical Challenge

- Pilots identified 727 unique destinations
  - 89 floatplane bases
- Extremely small sample sizes
  - 58% of destinations only see a single pilot
  - Can we trust the raw counts?
  - How uncertain are estimates?
- 727 parameters to estimate

The Statistical Challenge

- What about destinations not identified in survey?
  - 208,000 possible floatplane destinations
    - Based on National Hydrography Dataset (NHD)
    - Calculated fetch for 1.1 million waterbodies
    - Survey showed min. fetch = ca. 300m
- All observations from pilots are related (similar)
  - Borrow information from all pilots to infer risk for individual waterbodies and missing observations

Bayesian Hierarchical Model

Parameters governing probability distribution for all pilots

$$\alpha, \beta$$

$$\theta_1 \quad \theta_2 \quad \theta_3 \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad \theta_{727}$$

Measure of risk

$$y_1 \quad y_2 \quad y_3 \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad y_{727}$$

Raw count observations

The Statistical Caveat

- Assumption:

  Raw observations must be independent

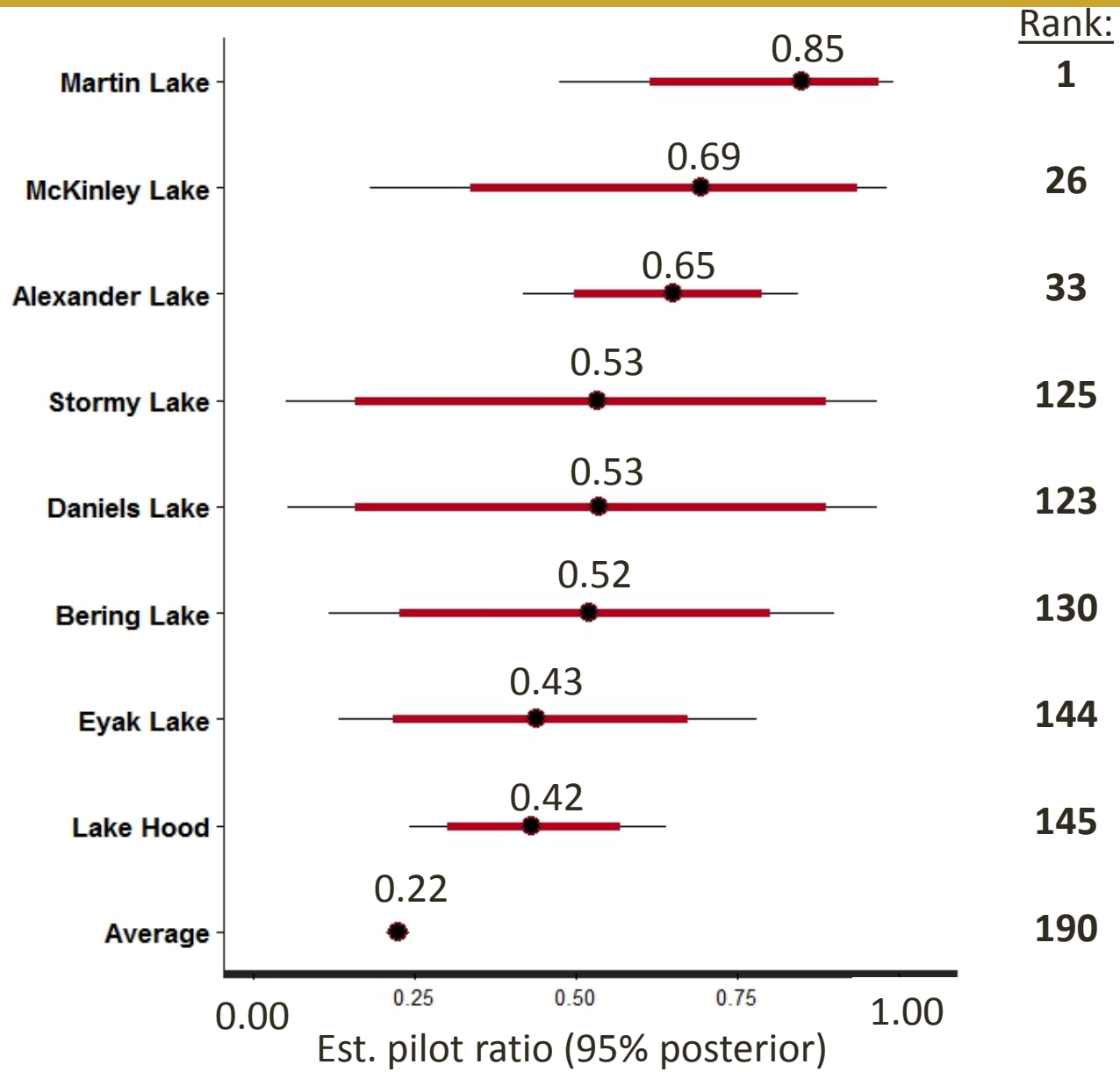
- Measure of Risk based on # of pilots

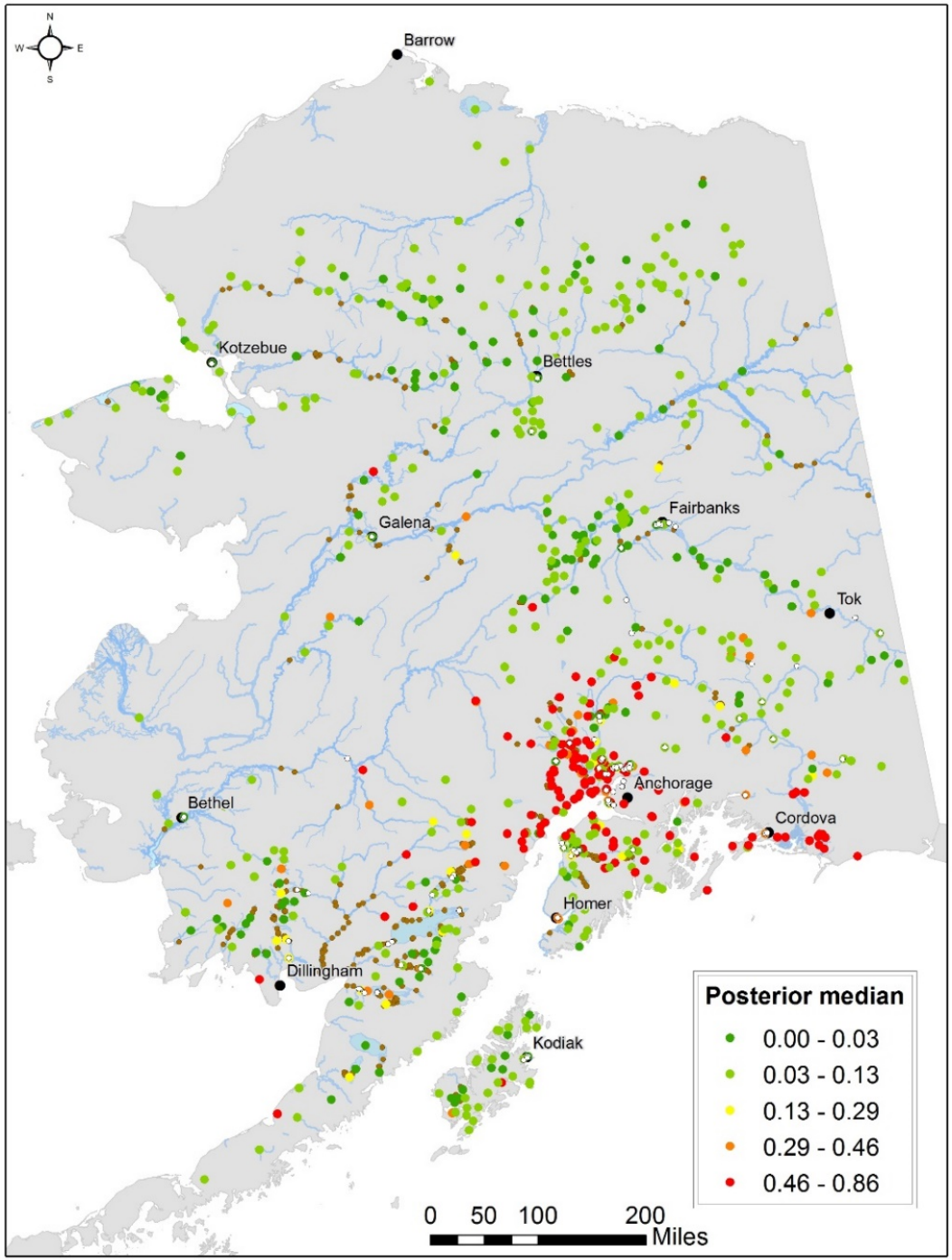
$$\frac{\text{\# pilots coming from elodea source locations}}{\text{\# all pilots to a destination}}$$

- More realistic would be # of flights

  ~ Propagule pressure

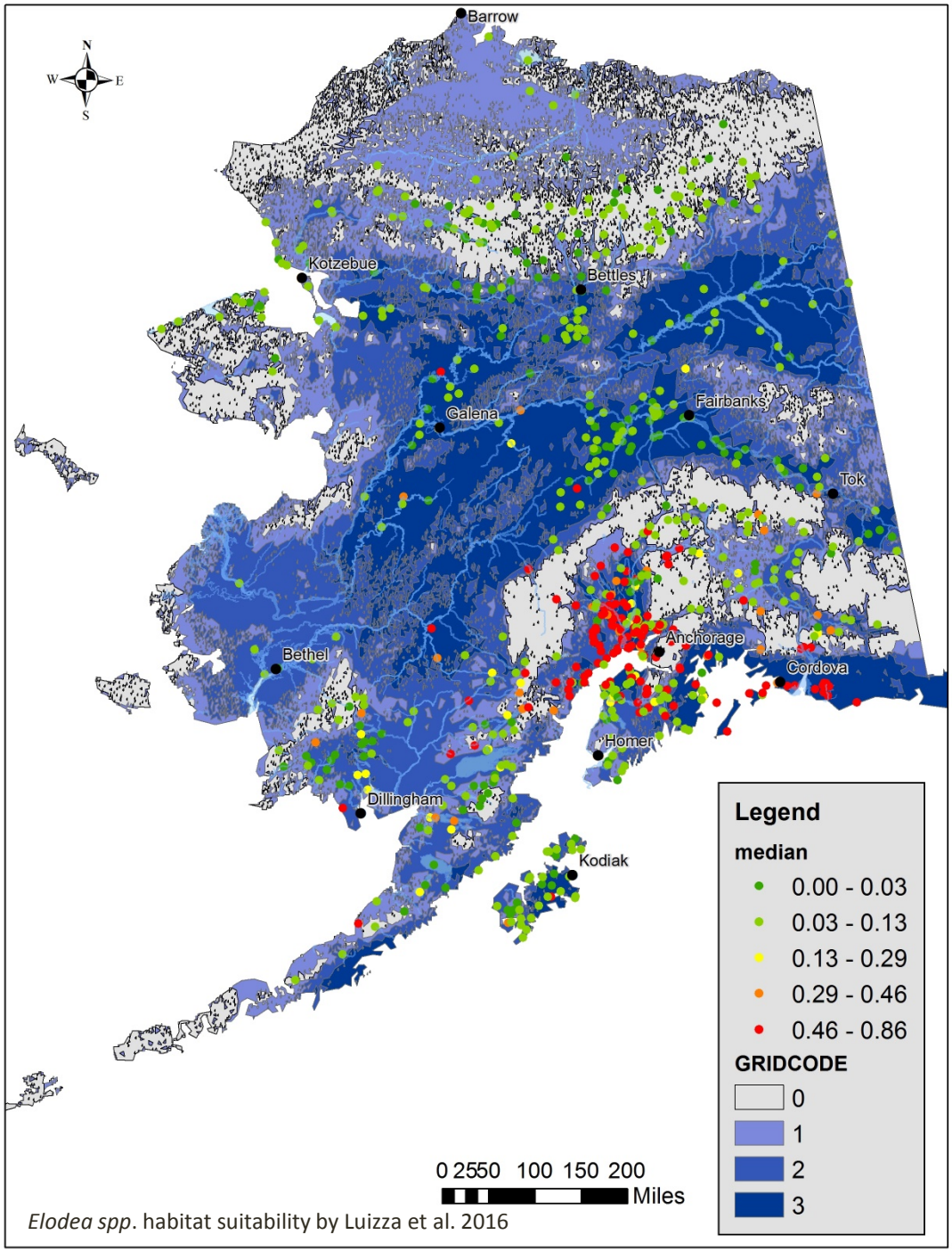
Known Elodea-infested Lakes




N
W
E
S
Barrow
Kotzebue
Bettles
Galena
Fairbanks
Tok
Anchorage
Bethel
Cordova
Homer
Dillingham
Kodiak
Posterior median
0.00 - 0.03
0.03 - 0.13
0.13 - 0.29
0.29 - 0.46
0.46 - 0.86
0 50 100 200
Miles

Uninvaded Floatplane Bases

Floatplane base	mean	SD	2.5th percentile	Median	97.5th percentile	Rank a)
Big Lake, Mat-Su	0.64	0.09	0.45	0.64	0.81	34
Red Shirt Lake, Mat-Su	0.56	0.10	0.37	0.56	0.74	48
Lake Clark, Port Alsworth	0.43	0.09	0.26	0.43	0.61	146
Campbell Lake, Anchorage	0.21	0.15	0.01	0.18	0.56	198
Shannon's Pond, Dillingham	0.18	0.13	0.01	0.15	0.50	203
Int. Floatpond, Fairbanks	0.14	0.11	0.01	0.12	0.40	207
Kenai Float Pond, Kenai	0.14	0.18	0.00	0.06	0.65	307
Chena Marina, Fairbanks	0.10	0.14	0.00	0.04	0.51	559
Alexander Lake, Galena	0.10	0.14	0.00	0.04	0.51	562
Airport Lake, Kotzebue	0.10	0.14	0.00	0.04	0.50	571
Christiansen Lake, Talkeetna	0.10	0.14	0.00	0.04	0.50	574



Elodea spp. habitat suitability by Luizza et al. 2016

Conclusions

- Prelim. results consistent with known infestations
- Good start but with limitations
  - Current approach underestimates risk to the Bristol Bay
  - Expand to a more realistic model, flight frequencies
  - Out-of-state pilots
  - Multi-leg trips
- Approach allows estimating:
  - Level of uncertainty
  - Prob. distributions related to unknown destinations
- Further integration
- Practical model for prioritization

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