Econometric Cost Models for Restoration Planning: An Application to Fish Passage Barriers in the Pacific Northwest

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Learn more:
- Email Braeden Van Deynze vandeynz@uw.edu with questions or comments
- Download this poster as a PDF at vandeynze.github.io/salmon_culverts/poster.pdf
- View the source code at github.com/vandeynze/salmon_culverts

POSTER PDF

SOURCE CODE

Theoretical Motivation:

1. Resource managers frequently rely on *prioritization systems* to select among alternative restoration projects when funding is constrained
2. Systems that favor **benefits** (most habitat first) vs. **costs** (least expensive first) will select different projects
3. Which is closer to **optimal** (full information) depends on relative **variability**
   - High variability means identifying outliers is more important
   - Ideally would implement cost screening in areas where costs are highly variable

Challenge: Lack of consistent *ex ante* cost information on projects makes identifying where costs are highly variable

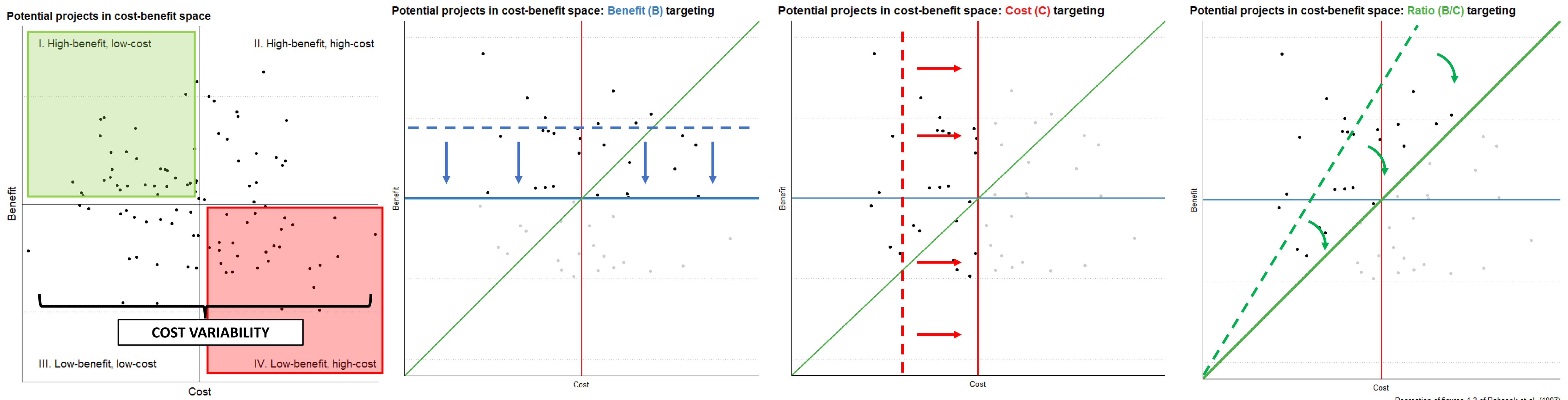


Figure Captions: Graphical representation of theoretical model

Project Goals & Requirements:

Develop methods to…
1. Identify landscape-level and project-level **drivers** of restoration costs
2. Identify **where** incorporating improved cost information into prioritization will have the biggest payoff

Methods should…
1. Represent true underlying variability in cost levels
2. Have consistent predictive power over space
   - At least in relative terms i.e., assign quantiles
3. Require minimal *ex ante* data
   - Achievable with spatial data layers

Case study: Salmon Passage Barriers

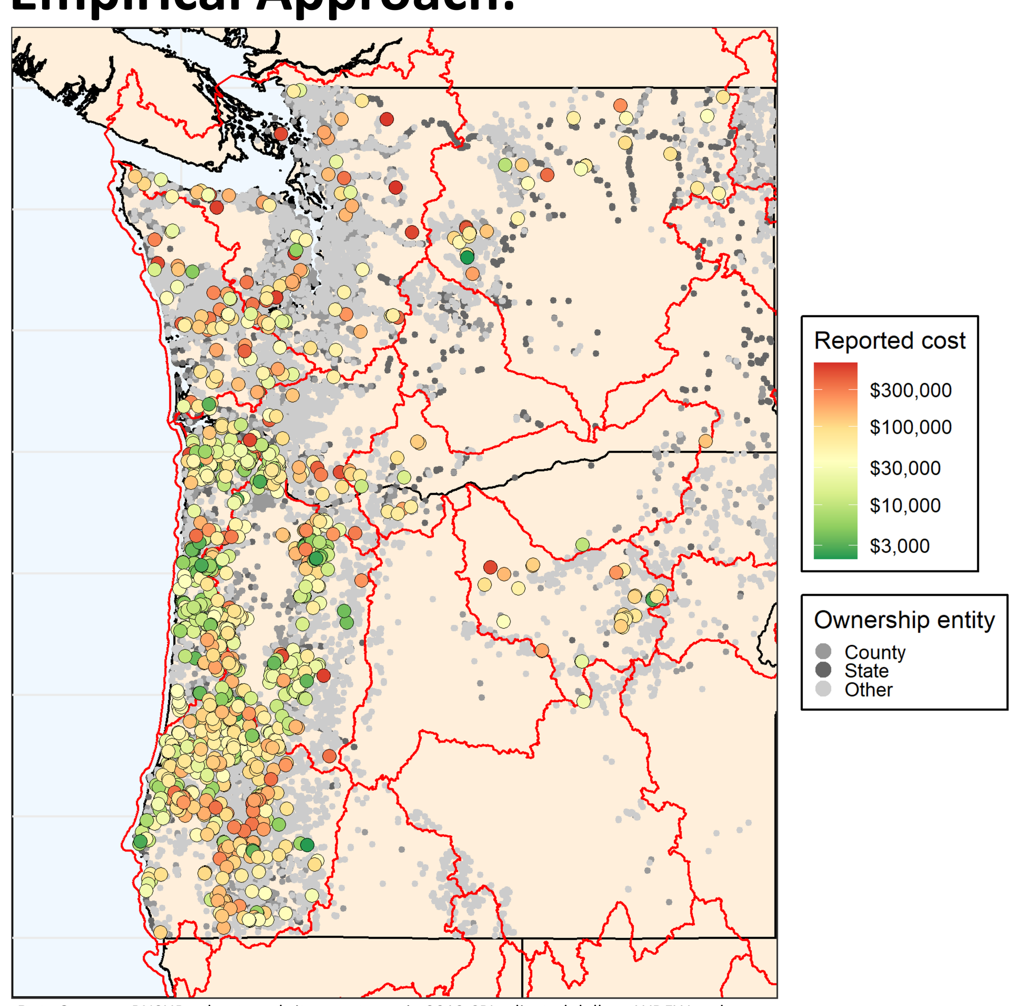
Road Crossings Restrict Habitat Access

- **Culverts,** pipes or other structures that carry water under roads, block access to hundreds of miles of habitat
- **Washington State** ordered by federal court to replace hundreds of culvert barriers under tribal fishing rights violations
- Other entities (counties, cities, private forests) own thousands more across Northwest, often on same streams
- Over **27,000** culvert fish passage barriers across Pacific Northwest
- Funding for culvert improvements is limited but **growing**
  - WA increasing state funding 5-fold to **>$1.1bill** in coming biennium
  - Other owners rely on grant, private, or user-fee funds
  - Several counties wrapping up inventory efforts

Challenge: Which culverts to improve first with limited funds?

Figure Captions: Examples of barrier culvert blocking fish passage and example of an improved barrier culvert

Empirical Approach:



Data Sources: PNSHP culvert worksites; costs are in 2019 CPI-adjusted dollars; WDFW and ODFW Fish Passage Barrier Inventories; points represent all points marked as culverts with < 100% passability

Data from PNSHP

(Pacific Northwest Salmonid Habitat Project database)
- NWFSC-maintained clearinghouse for salmon habitat restoration projects
- 15 years of data (\`01-\`15)
- Lots of observations (N = 1,236)

Two modeling approaches

1. ***Drivers:*** multiple linear regression
   - Easily interpretable
   - Good for hypothesis testing
   - Fixed effects for basin, year, reporting source
2. ***Predictions:*** boosted regression trees
   - Improved accuracy of > 10% vs. OLS
   - Incorporates information from 243 explanatory variables

Additional data gathered via spatial matching

Stream features: channel slope, bankfull width *(NHDPlus)*

Road features: road material, speed limit class *(DHS HIFLD HERE)*

Terrain features: terrain slope, elevation, land cover (baseline: forest) *(NHDPlus Selected Attributes, NLCD)*

Property rights: catchment housing density, distance to urban area, ownership of surrounding property (public/private/industrial; baseline: public land) *(BLM Surface Jurisdiction, US Census)*

Supplies & labor: county-level construction/forestry employment, distance to material/equipment suppliers *(US Census, DHS HIFLD NAICS)*

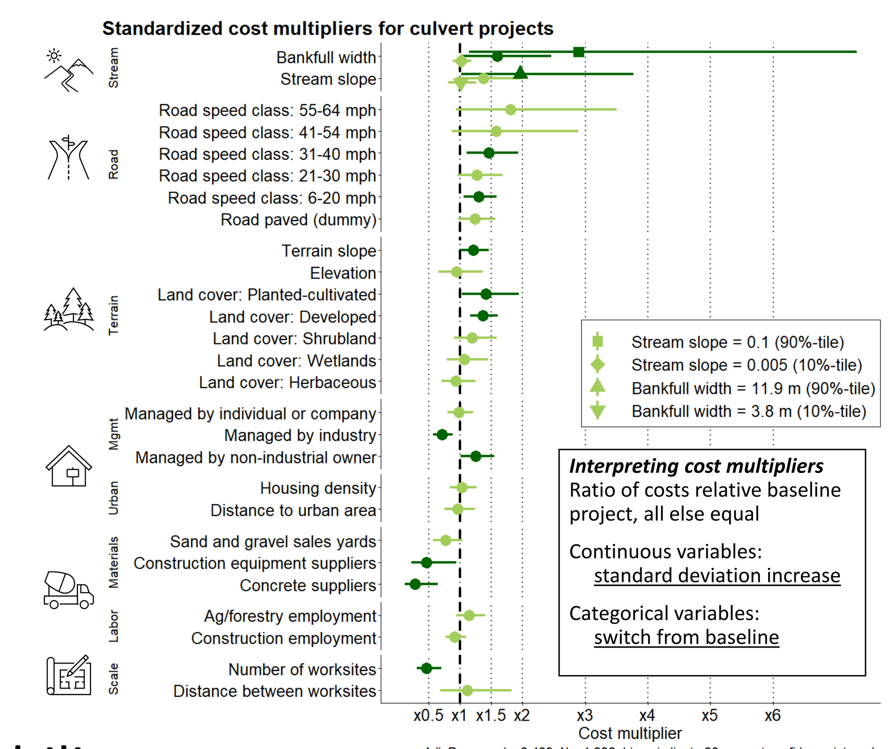
Project scale: # of worksites, distance between worksites

Results I: Cost Drivers

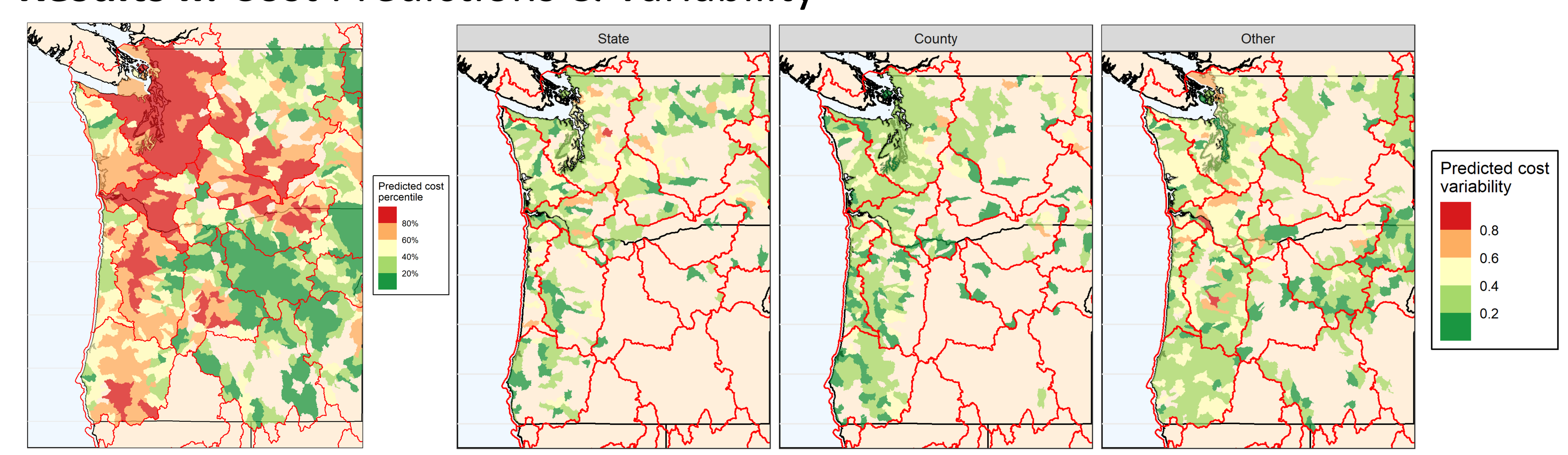
Expensive projects
- Steeper & wider streams
- Larger, paved roads
- Surrounded by development, cropland
- Worksites further apart (complexity)

Cheap projects
- Surrounded by private forest
- Close to construction equipment & concrete suppliers
- More worksites (scale economies)

Can be used to inform valid cost metrics & proxies



Results II: Cost Predictions & Variability



Puget Sound, Lower Columbia, Upper Willamette expensive
- Relatively high development
- Larger roads along major interstate corridor

Washington Coastal, Northern Oregon Costal and Eastern Oregon cheaper
- Forest land cover more frequent
- Barriers tend to be on smaller, private roads

Measuring Cost Variability:
- Barriers grouped at watershed (HUC10) level
- *Coefficient of variation* computed (σ/μ)

Higher variability in Western Washington
- Transition between urbanized and rural
- Most variability in Cowlitz River, Middle Green River watersheds

Lowest variability across Eastern Oregon
- Relatively consistent stream morphology
- Low barrier density to begin with

Different variabilities across ownership → Different importance of including costs in prioritization