Mari Reeves, and I am brand new to the Pacific Islands Field Office Strategic Habitat Conservation Team, where I'm really excited to be working with Steve Miller and other colleagues there Though I'm new to Region 1, I am midway through the process of moving down to Hawaii from Alaska, where I've worked with the FWS for the last 15 years. I have a PhD in Ecology, with emphasis in Biogeochemistry, Community Ecology, and Toxicology---I was in the contaminants program for a long time, so can provide assistance with those types of questions. I've also done a lot of work with amphibians.

My talk today is titled To Pave or not to Pave, and frankly, that WAS the question, when I wrote the abstract for this meeting so I left it. That said, with the help of my new colleagues in PIFWO, we ended up taking it much farther than that… not just answer that question but build from it a regional scale predictive model that can help guide people with road maintenance responsibilities to make decisions in a way that prioritizes roads for maintenance by their environmental risk.

I am going to talk about roads. Gravel roads, like we might have on or near our wildlife refuges, or paved roads that we're all familiar with, but on the lower end of the traffic spectrum.

More specifically, I am going to talk about road-based pollutants in the context of their environmental impacts to adjacent areas, and how far that impact extends from the road, based on a three year field study in the Kenai Peninsula of Alaska.

And maybe you're here because it's not happy hour yet, or wait, I'm sorry, because you have to do a NEPA analysis for a new road crossing federal land, or because you're managing listed species and want to understand how far out harm or "take" may extend from roads to the plants or animals or habitats you manage..

Either way, my presentation is meant to be an example of how we might take a reasonably cheap field study and add those data to other landscape scale or remotely sensed information to then predict the probability of deleterious effects (the risk) across this landscape

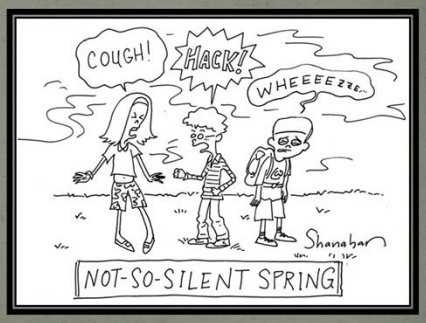
I did a lot of analyses to support what I'm sharing today – but with 15 minutes can't get into all the nuts and bolts of the analyses. So if you're interested, it will be happy hour soon, and I will be happy to talk more there about what I did to support what I'm saying. For now, I have 23 slides and 15 minutes, so if you can hold your questions till the end, I'd appreciate it.

Road Pollution and Particulate Matter

Health Risks

- Cardiopulmonary function

- Toxicity of trace element constituents



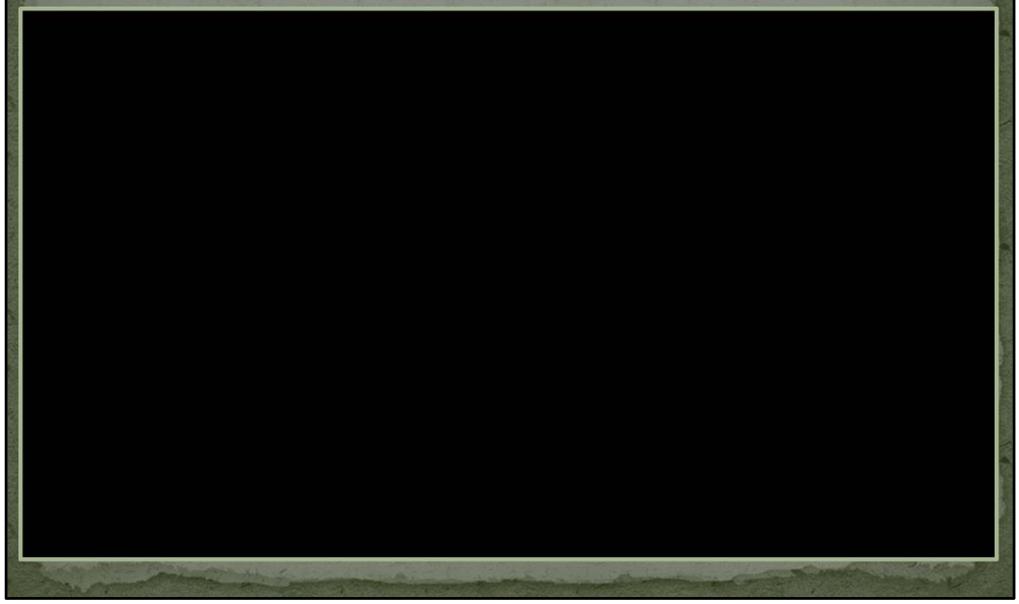
https://www.epa.gov/mobile-source-pollution/how-mobile-source-pollution-affects-your-health#particle

Like lead, nickel, iron, chromium, and copper.

Biological Effects of Trace Elements

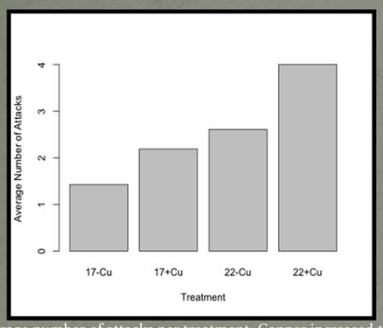
- Aquatic pollution
- Changes in salmonid olfaction and behavior
- Toxicity to plants

Ecological Community Effects



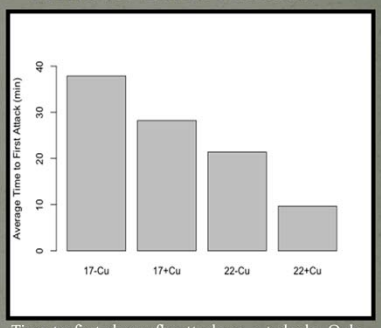
Changes to ecological communities…

Number of Attacks



Average number of attacks per treatment. Copper increased the number of attacks ($p < 0.001$), temperature warmer temperature increased the number of attacks ($p < 0.001$), and larger dragonfly size increased number of attacks ($p < 0.001$).

Time to First Attack

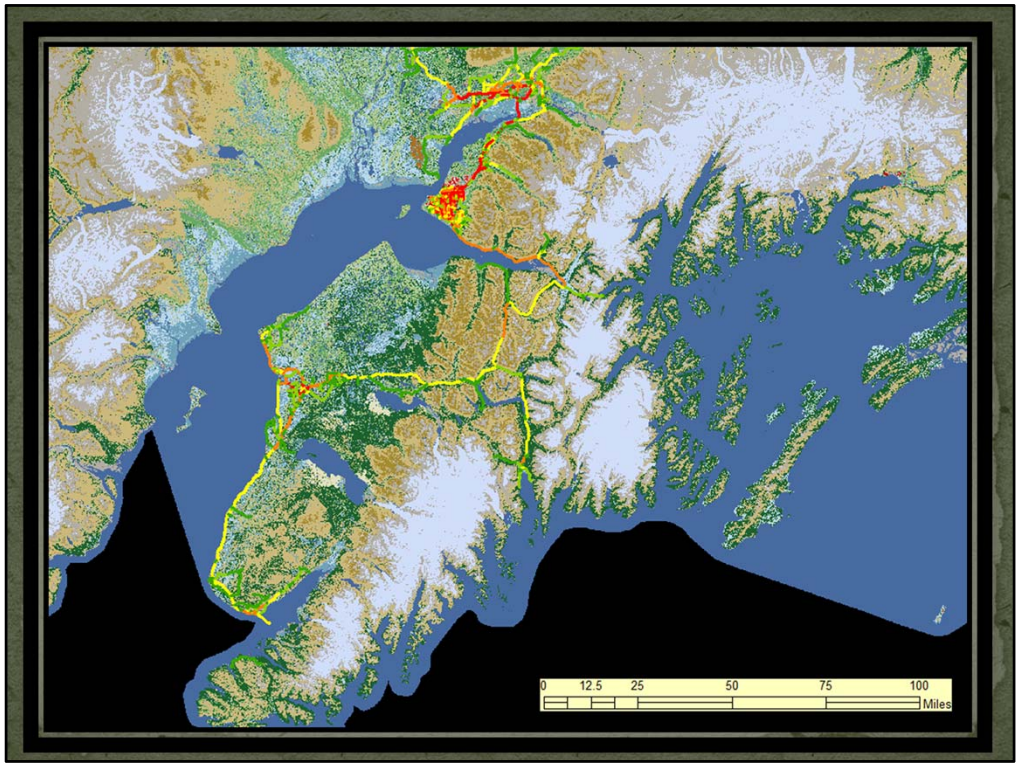


Time to first dragonfly attack on a tadpole. Only tanks with an attack ($n = 28$) are represented. Elevated temperature decreases time to first attack ($p = 0.02$).

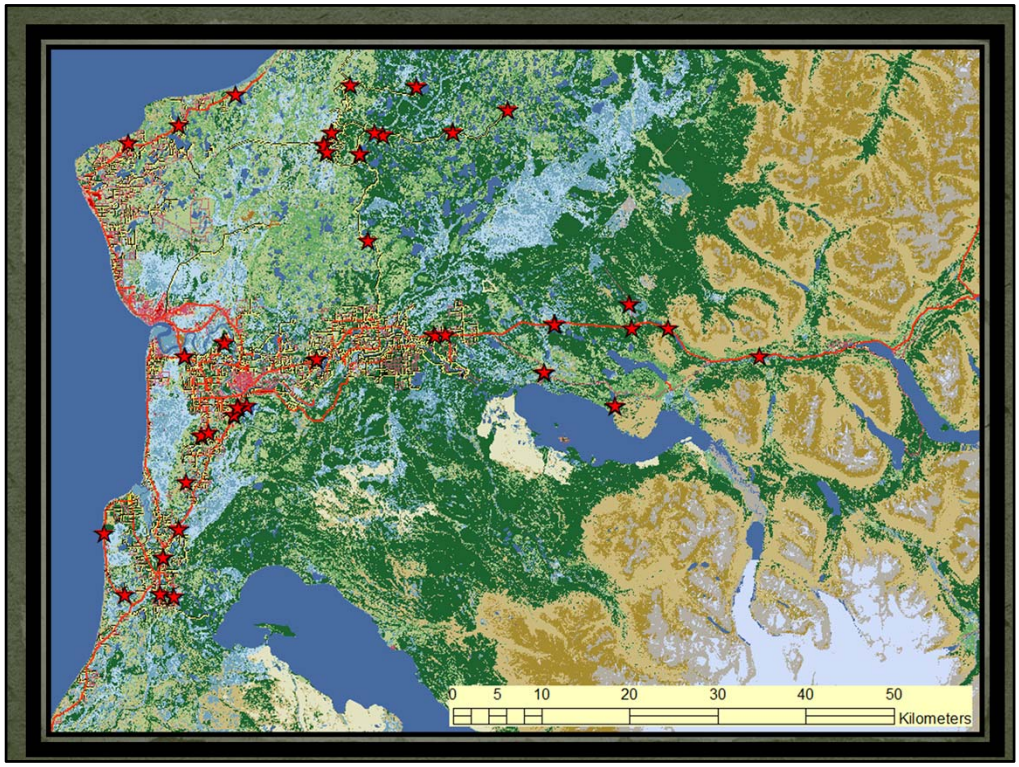
Hayden et al. 2015, Ecosphere, Thrice as easy to catch! …Volume 6, Issue 4, pages 1-17, 17 APR 2015 DOI: 10.1890/ES14-00461.1

Watch our video on Hayden et al. 2015 paper here! https://www.youtube.com/watch?v=IMoKIL_FkJA


0 62.5 125 250 375 500
Miles



The **Kenai National Wildlife Refuge** is a 1.92-million-acre (7,770 km^2) wildlife preserve located on the Kenai Peninsula of Alaska, United States. The refuge was created in 1941 as the **Kenai National Moose Range**, but in 1980 it was changed to its present status by the Alaska National Interest Lands Conservation Act. The refuge is administered from offices in Soldotna.



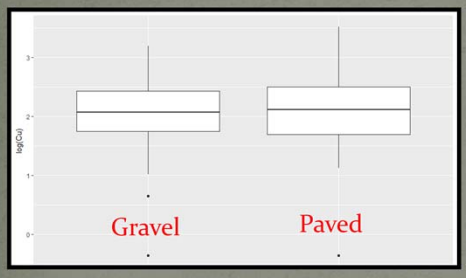
Randomly picked 36 study sites stratified by road surface (paved and gravel), relative traffic, and spatial location (also by wetlands, but we're not talking about that today).

The Questions

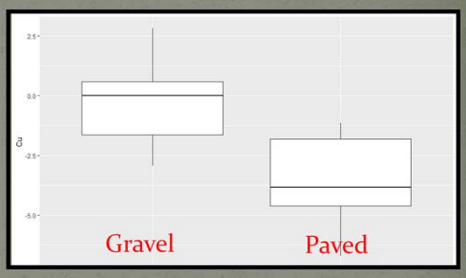
- **What contaminants are associated with roads?**
  - Lead, Iron, Manganese, Copper, Chromium, Vanadium, Nickel, Zinc
    - Exhaust, brake and tire wear
  - Calcium & Magnesium
    - Dust Suppression
  - Sodium
    - Road Salt
  - Barium
    - Local oil and gas or glacial source
- **Rural setting…how bad are they, really?**
  - Few sites at state cleanup standards for soil, most well below these thresholds
  - Most sites above the lowest toxicology based thresholds for the most sensitive organisms
    - listed spp.
- **Are Paved or Gravel Roads "Worse"?**
  - It depends
- **How far do trace element pollutants travel from the roadside?**
  - It depends
- **Can we predict road pollution risk using models derived from our data?**
  - YES!

To Pave or Not to Pave?

Raw Data

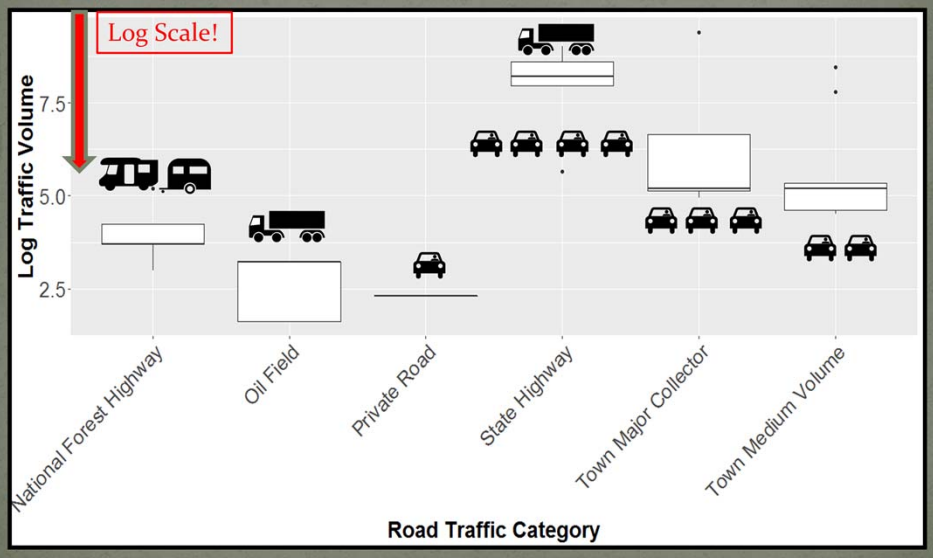


Adjusted for Traffic



Per vehicle, gravel roads are worse…

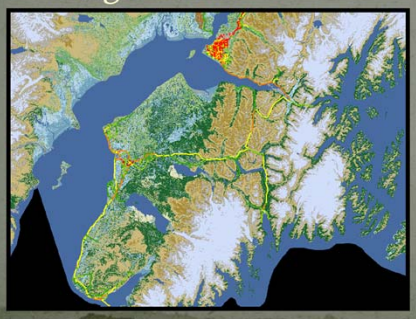
But…Paved Roads Have More Traffic



So how do we tease this out…

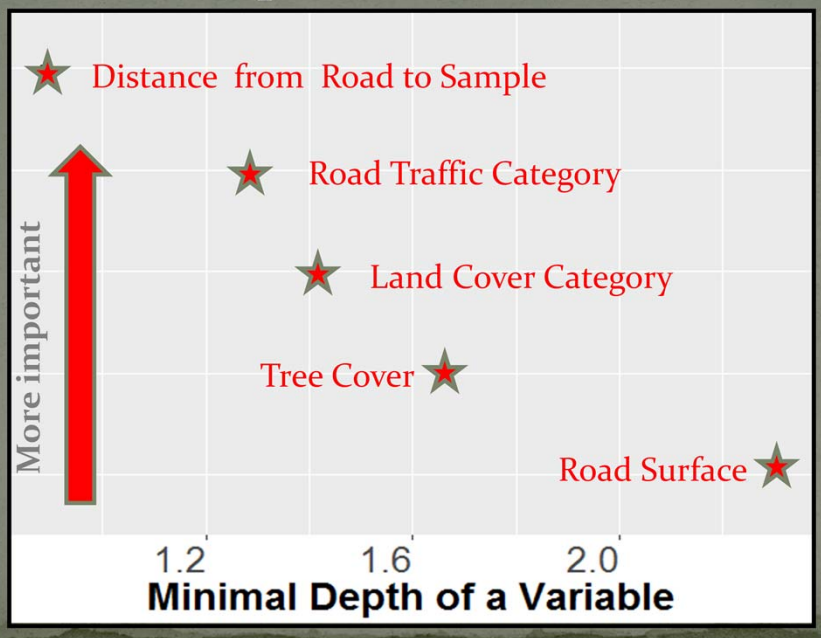
MODELS!

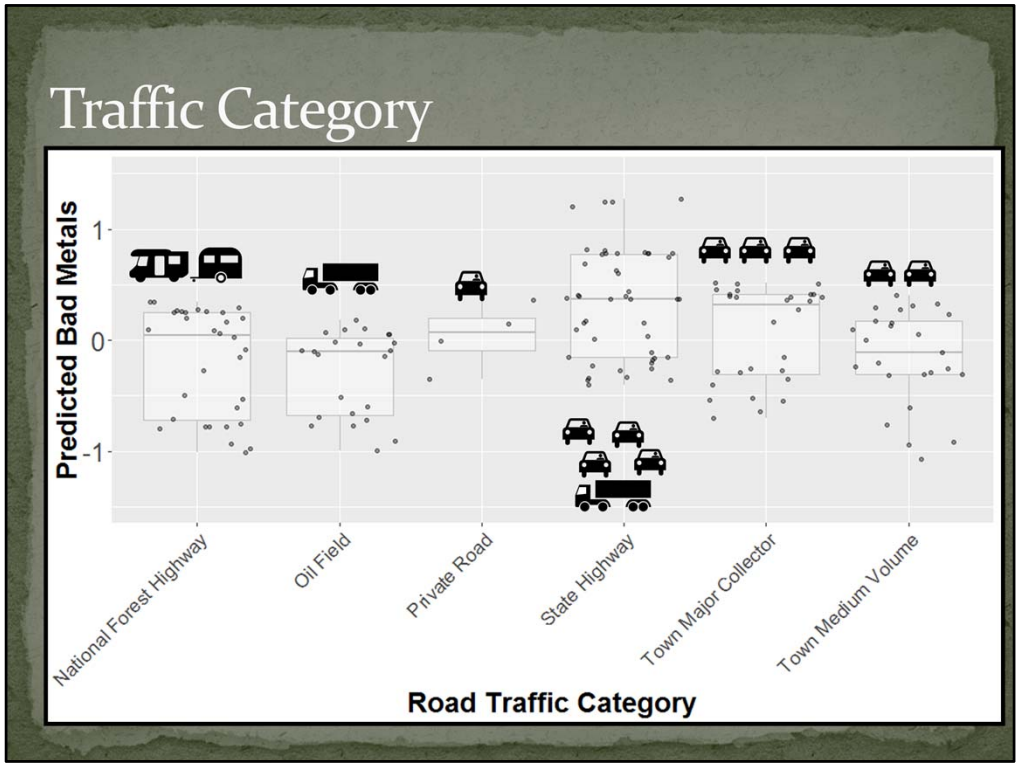
- Model Frameworks
  - Random Forests
  - Mixed Effects Regression



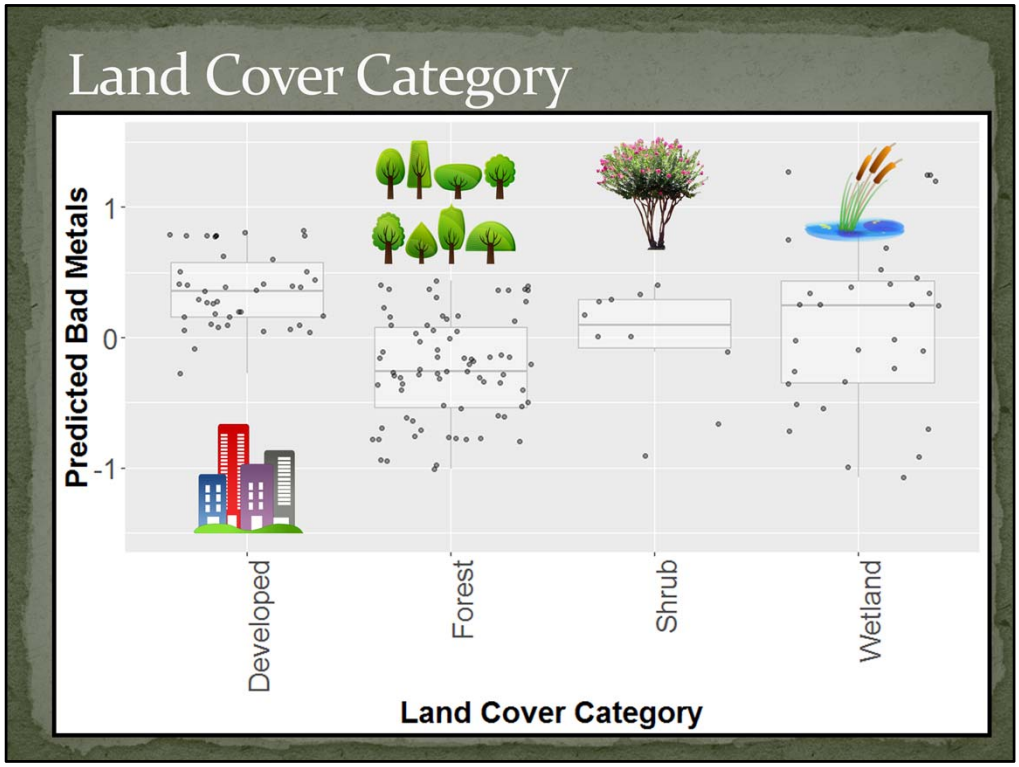
- Predictors
  - Land cover
  - Tree cover
  - Relative Traffic
  - Road Surface
  - Distance to Road
- Response
  - Bad Metals

Variable Importance

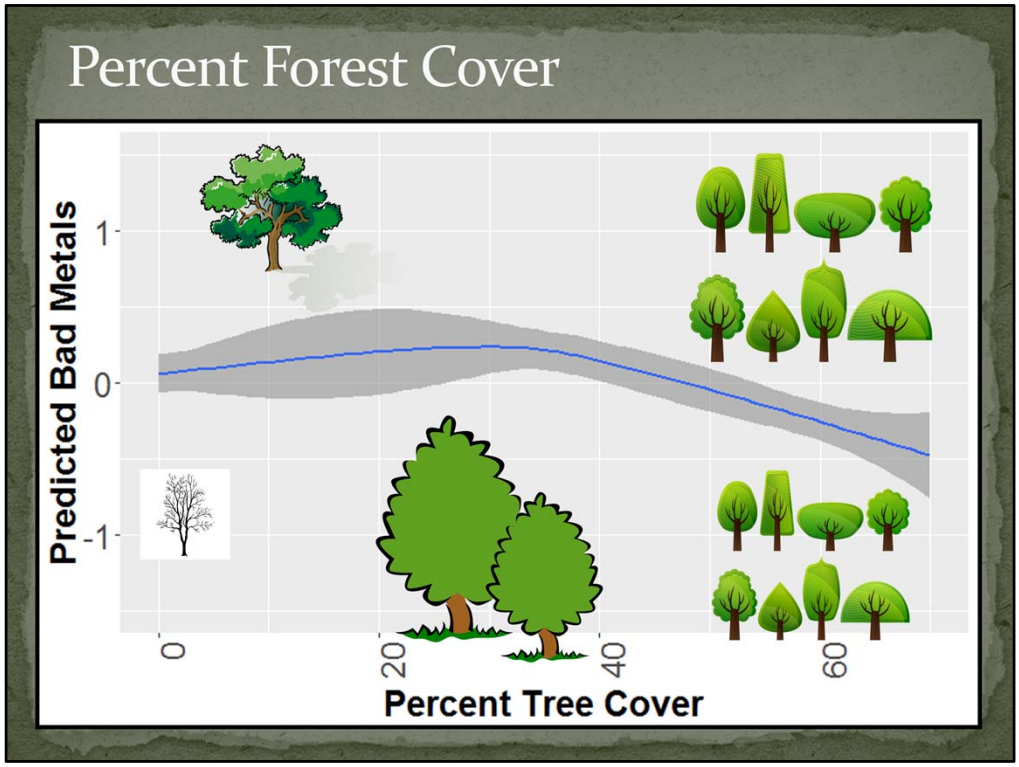




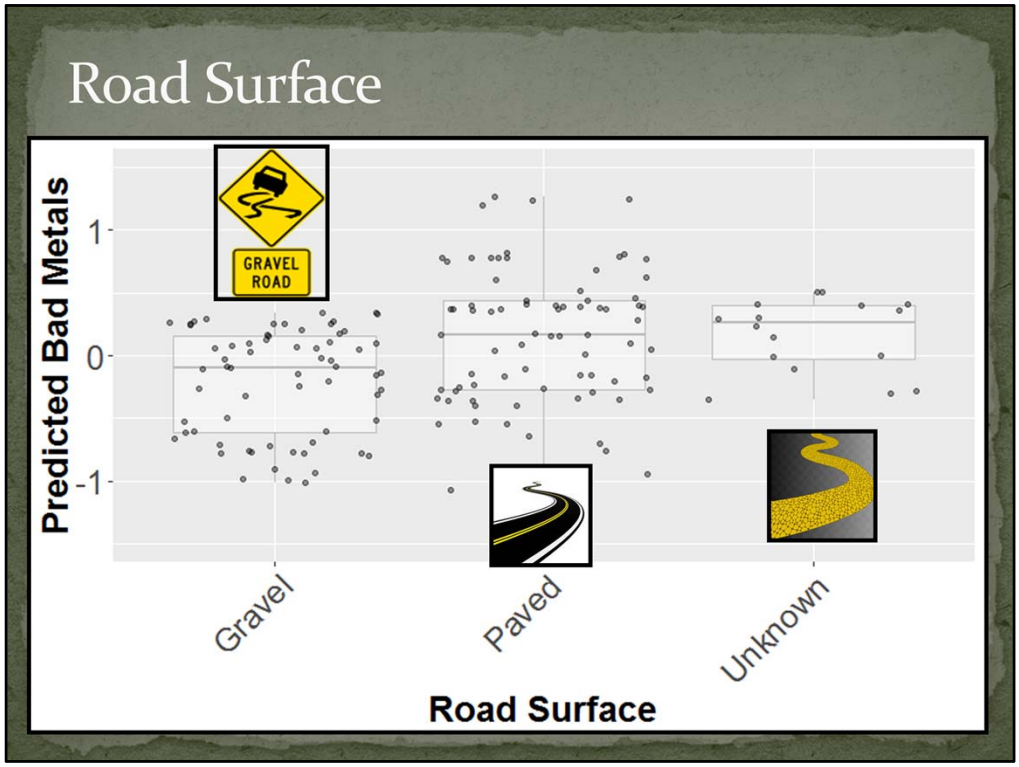
Trucks are on the bottom because the data are on the top. State Highways had more contamination.



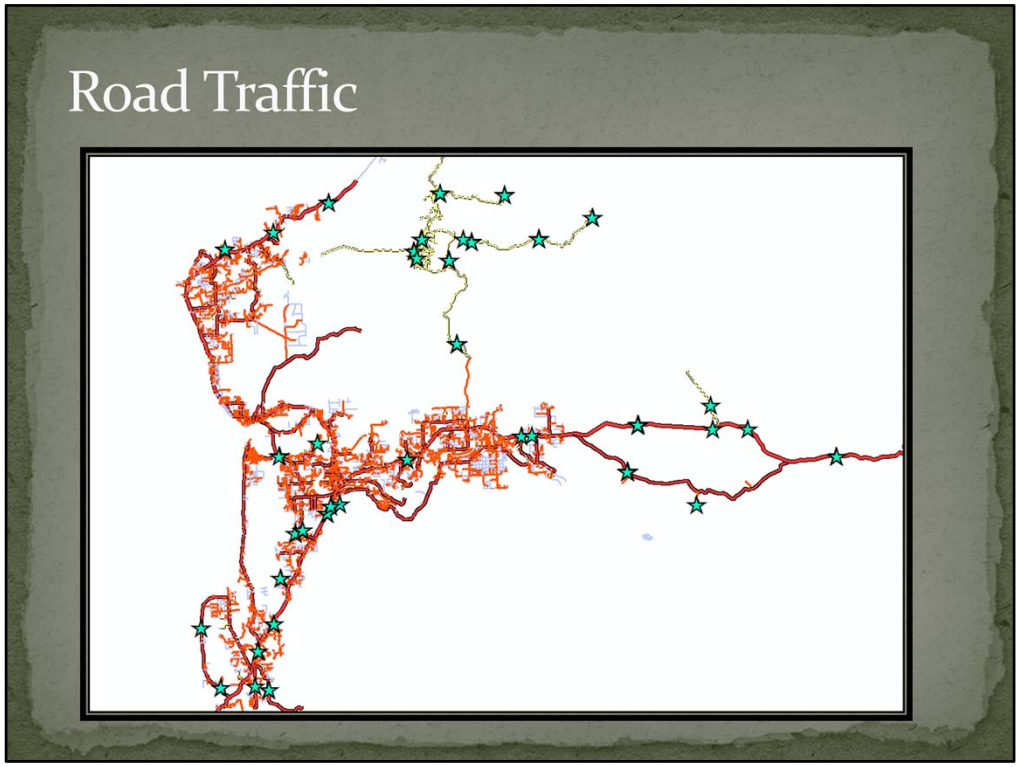
Buildings are on the bottom because the data are on the top. Developed areas had more contamination.



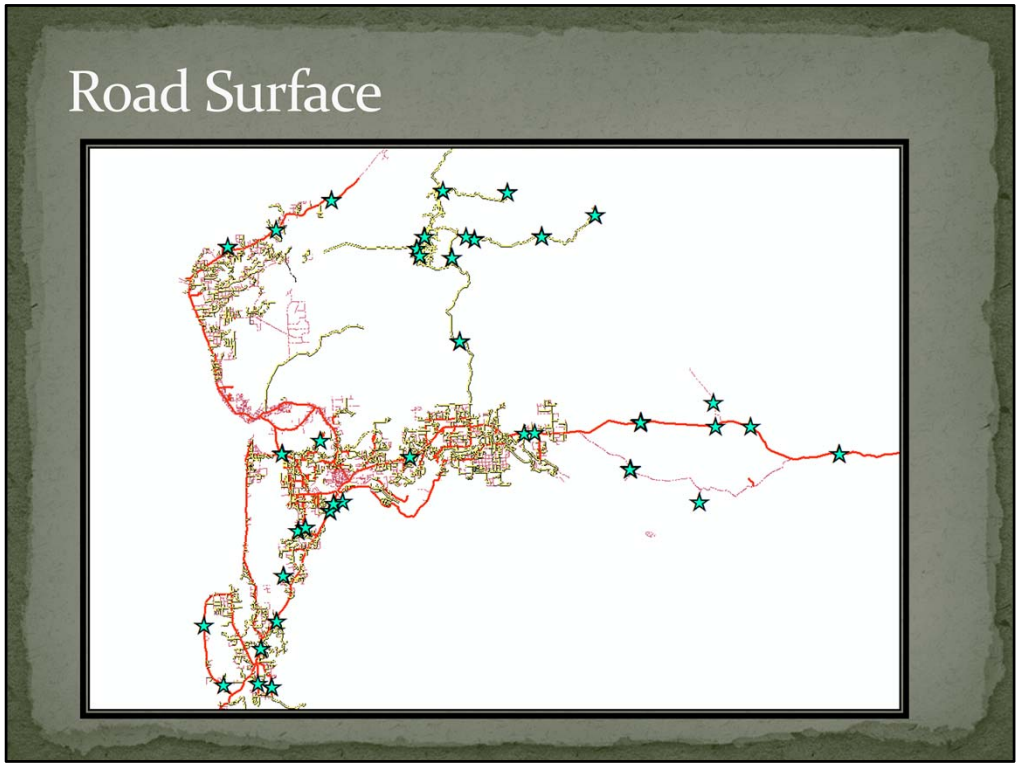
Pollution dropped off with forest cover, after about 35% cover, pollution showed a linear decrease, suggesting the trees are acting as a filter, which is great if your house is behind a forest and perhaps not so great if you are a tree.



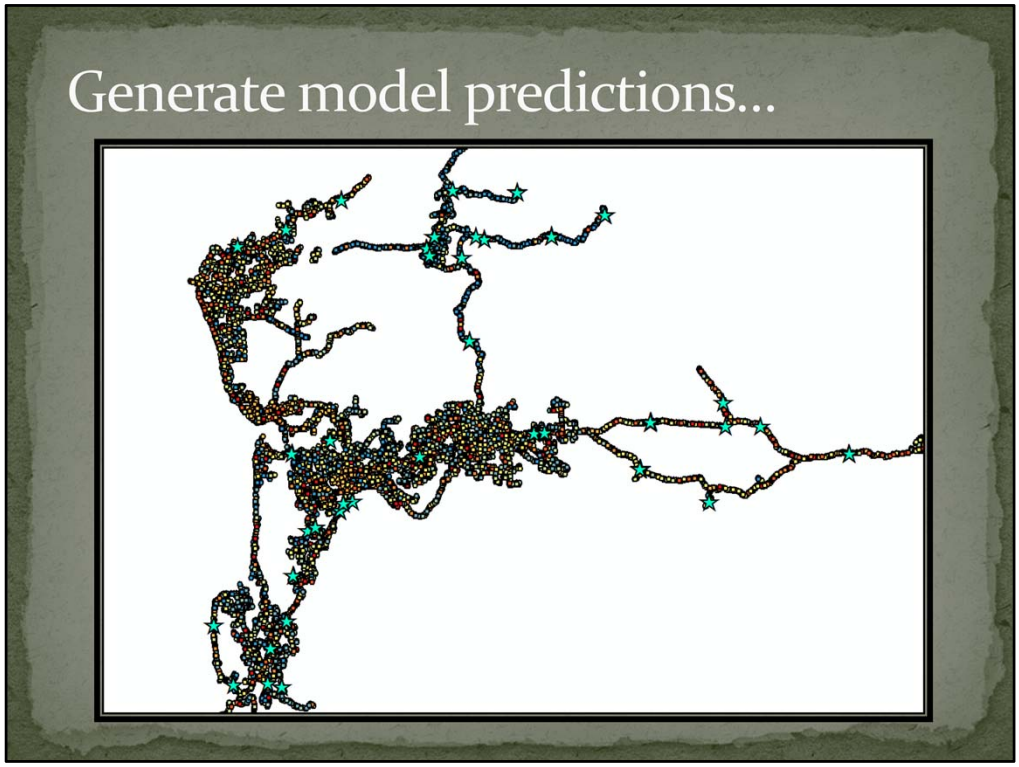
These are the model predictions, so differ from the raw data. Paved roads had more contamination. Unknown road surfaces (the yellow brick road) had the most. This is interesting because if the borough doesn't maintain the road enough to know what it is made of, there may be some opportunity for more road maintenance on these road types.



This is just the Kenai Borough Road Classification from their streets layer (I digitized the oil field roads myself, added it to this layer, and assigned them to a low traffic category).



Paved and Gravel Roads – also from the Kenai Borough Streets layer.

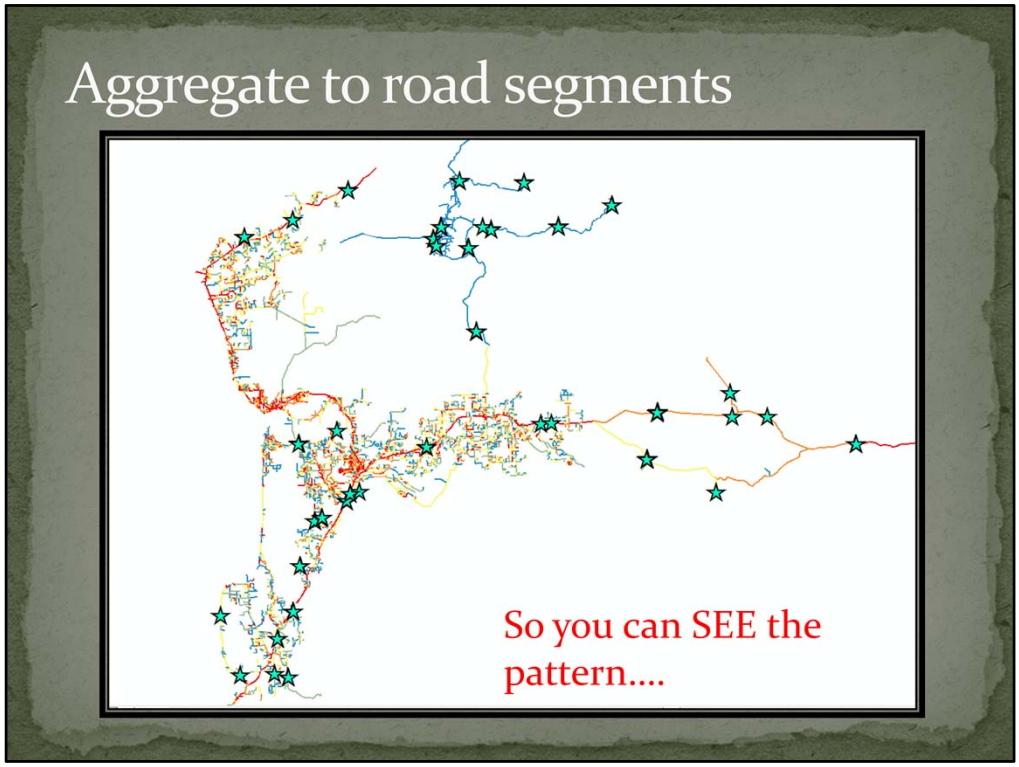


Now, how do we take this model and its predictions and get them BACK onto the landscape (because this is how we then use this information to prioritize management actions)?

We take our borough roads layer, buffer it by our area of inference (up to 80 m from the road) and generate random points.

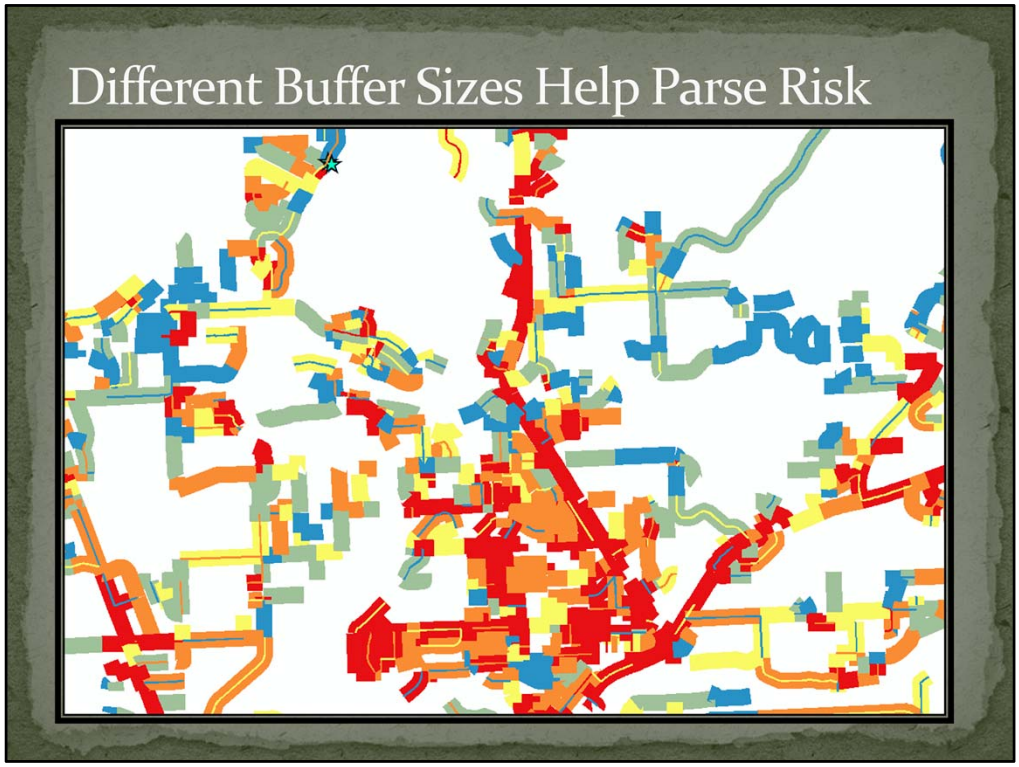
1 M, 250K, oh wait, 50 K…

Based on our 36 sample locations (transects) and 158 samples, and other data, we now have a predicted surface for 80 m out from the sides of each road in the Kenai Peninsula borough.



Warmer areas are higher risk of road based soil pollution, based on a random forest model using road category, road surface, land cover, tree cover, and sample location to predict the concentration of “bad metals” on the landscape (and index I created from 9 traffic associated metals).

Warmer areas are higher risk and cooler areas are lower risk.



To divide the data into the 80 meter buffer and a 10 meter buffer, can show not just where you need maintenance, but why? Is the risk due to traffic and road type, or due to habitat factors allowing the contaminants to move further. (I would refine the model personally before I relied too heavily on this, but it shows a proof of concept anyway).

Acknowledgements….

- Funding provided by the USFWS Division of Environmental Quality
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- PIFWO SHC Team: F. Amidon, S. Miller, A. Vorsino
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