System-of-systems interfacing issues:

a threat to western bioenergy availability

Jeffrey Richardson[2], Kurt Spies[1], Steve Rigdon[2], Sara York[1], Rodney Cawston[2], and Daniel Schwartz[1]

the role of life cycle assessment (LCA)

Joyce Smith Cooper[1]

Bioresource-Based Energy for Sustainable Societies Program
Colleges of [1]Engineering and [2]Forest Resources

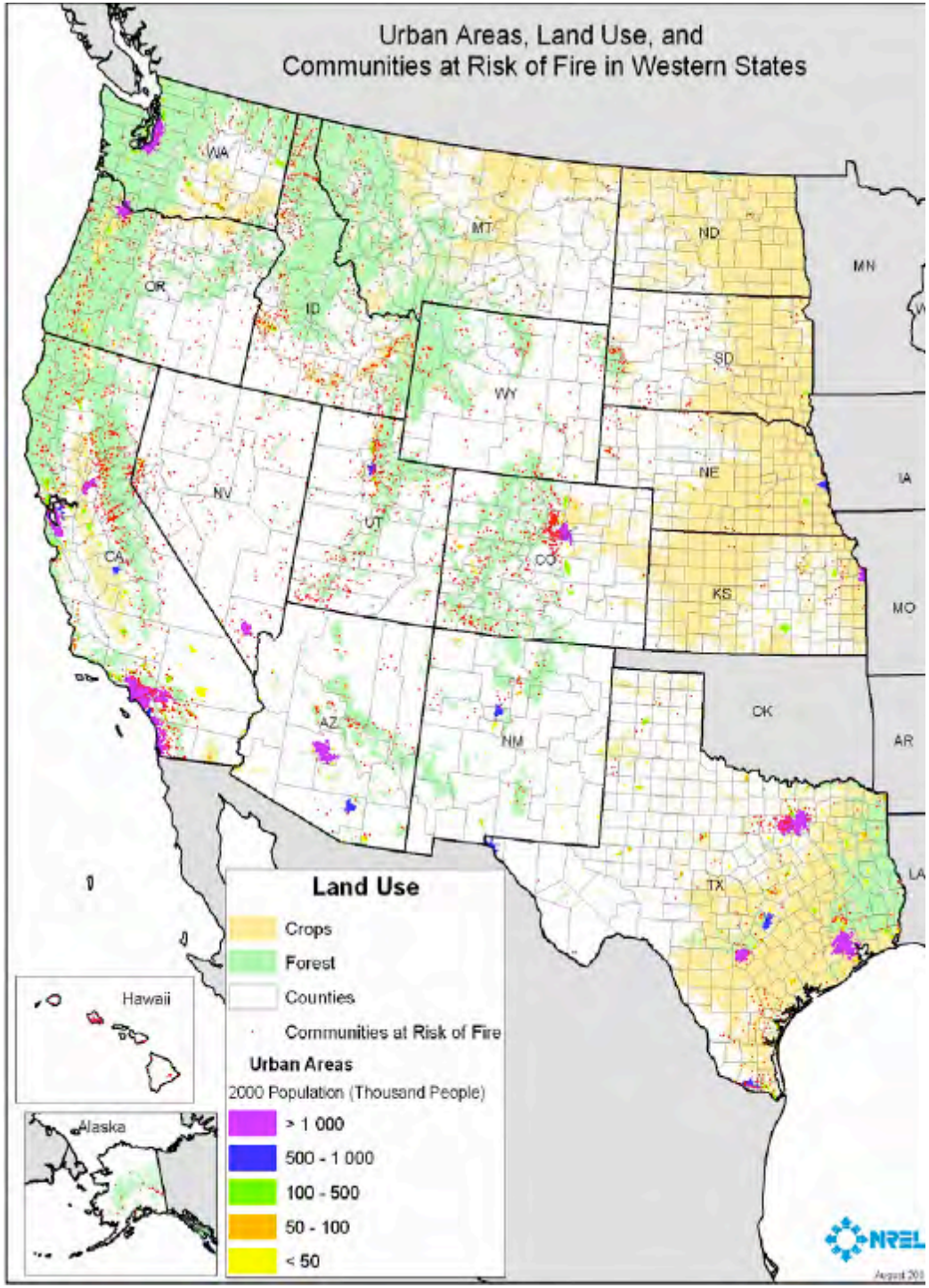
Western Governors Bioenergy Surveys

- 10 GW capacity at ¢8/kWh by 2015, if used for electricity

- Great for meeting renewable portfolio standards and renewable energy credits

- Uncompensated benefits from reduced fire risk, reduced air pollution, reduced GHG_e is worth >¢11/kWh

Biomass Task Force Report, Jan. 2006



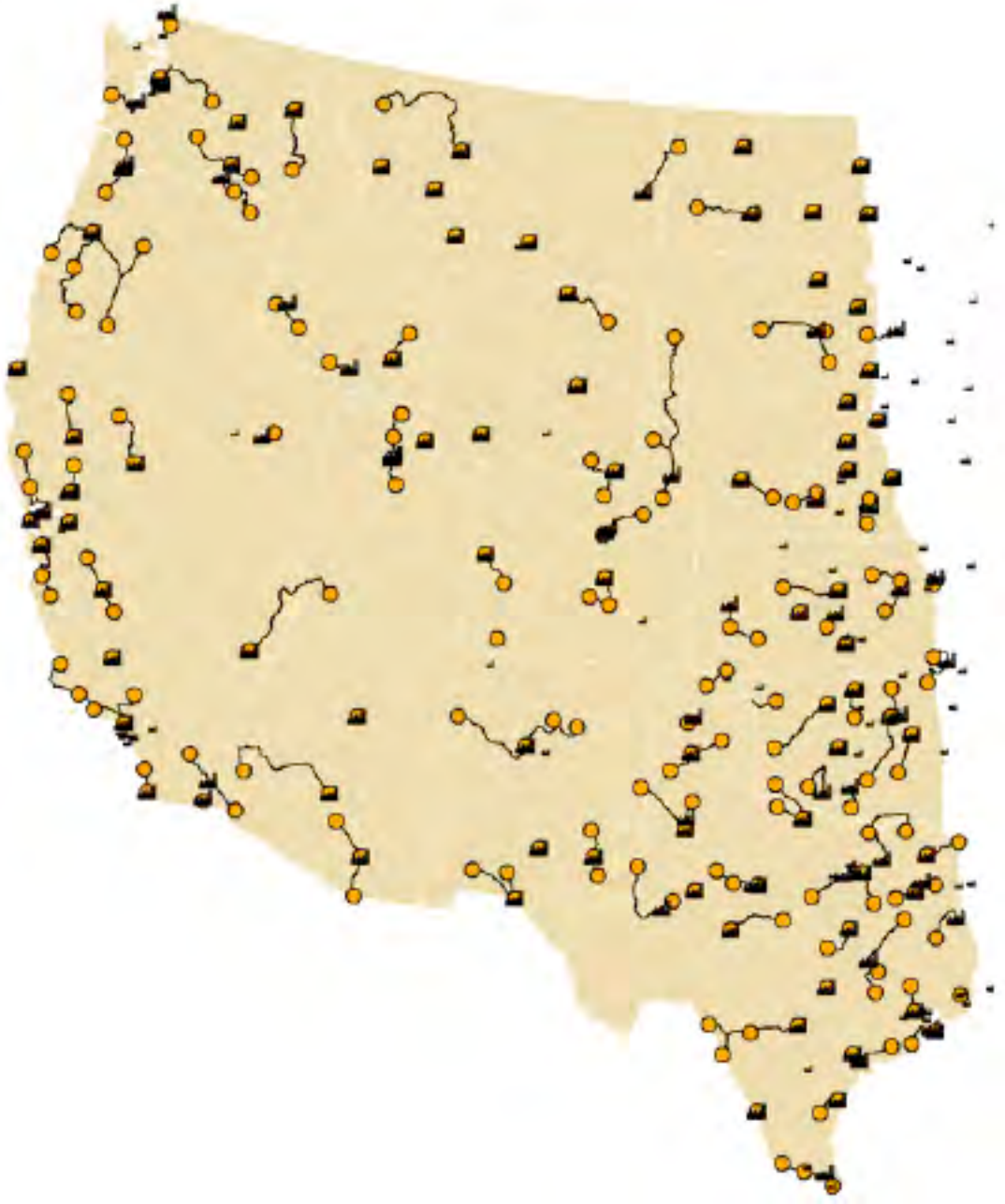
Western Governors Bioenergy Surveys

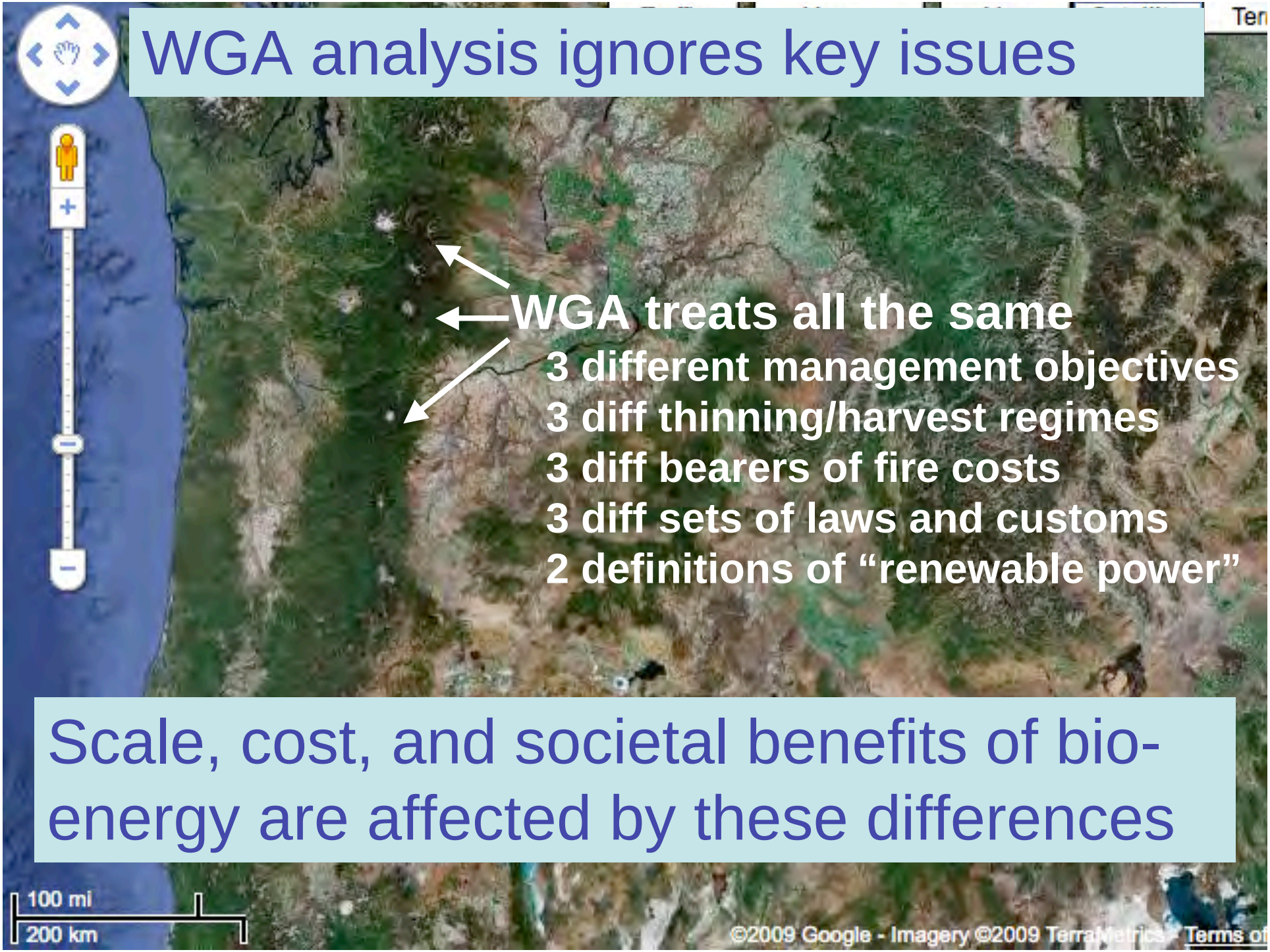
- 8.3B gallons of gas (equiv) at $2.40/gge by 2015 using different conversion methods

- Can provide 55% of the renewable fuel standard in the Energy Independence and Security Act by 2015

- Includes grains, oil seeds, and lignocellulosic biomass

Strategic assessment of bioenergy in the West, Sept. 2008




WGA analysis ignores key issues
WGA treats all the same
3 different management objectives
3 diff thinning/harvest regimes
3 diff bearers of fire costs
3 diff sets of laws and customs
2 definitions of “renewable power”
Scale, cost, and societal benefits of bio-energy are affected by these differences
100 mi
200 km
©2009 Google - Imagery ©2009 TerraMetrics - Terms of

Biomass availability is set by interactions in

- Social Systems
  - values of land owners
  - laws and policy
  - political boundaries
- Technical Systems
  - transportation logistics
  - existing infrastructure
  - process technology
- Economic Systems
  - competing markets for the biomass
  - cost vs. competing renewables (e.g., I-937 mandates)
- Environmental Systems
  - more natural fire regimes
  - more resilient to insects
  - carbon credits
  - invasives removal

Tribal energy design projects probe these interactions

Tribal energy partnership 1: Yakama Nation

Yakama Power/Yakama Forest Products/Grant Co. PUD

- Sawmill residues (negligible transportation)
- Mill kilns require heat (combined heat & power)
- Satisfy I-937 renewables (15% by 2020)
- Tax structure on tribal lands

Interfacing Issues (not resolvable at resolution of WGA)

- Biomass from off-tribal lands (USFS, State, Private…)
- Supply stability linked to size of capital investment
- Employment and capital utilization
- Reduction in GHG emissions…

How many MWs can be reliably fueled with biomass?

First Bio-Energy IGERT Cohort (January, 2008)

Sara York
Chem E

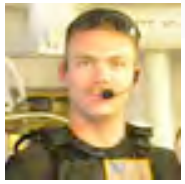
Kurt Spies
Chem E

Valerie Lieu
Chem E

Jeff Richardson
CFR

Betzaida Garcia
Mat Sci & E

Lloyd Nackley
CFR



Kenneth Faires
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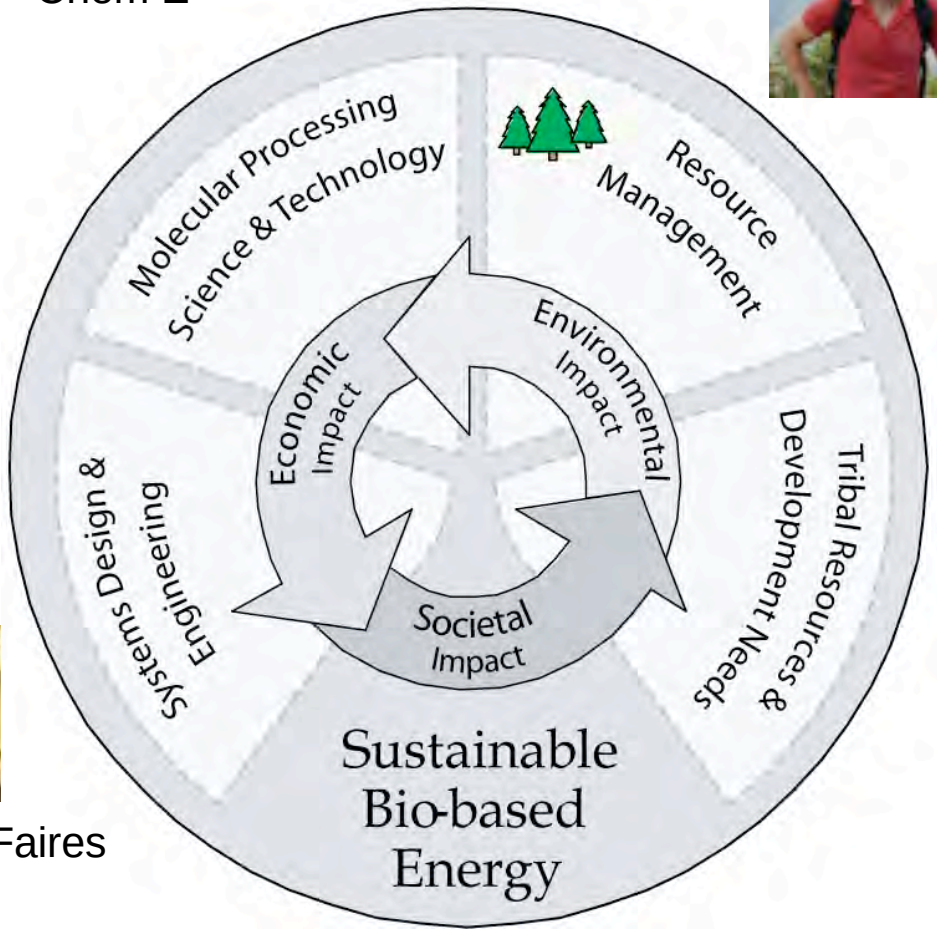
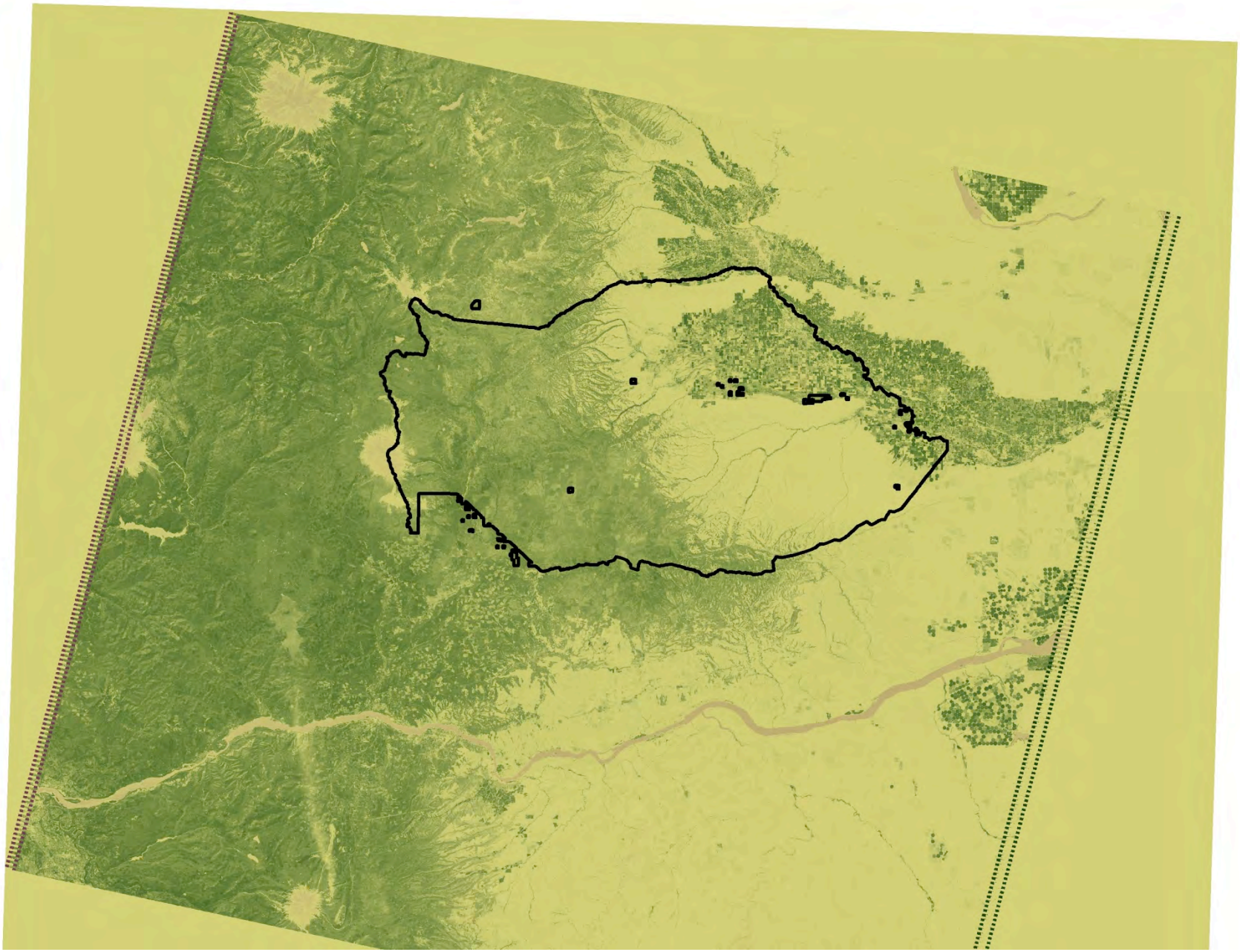
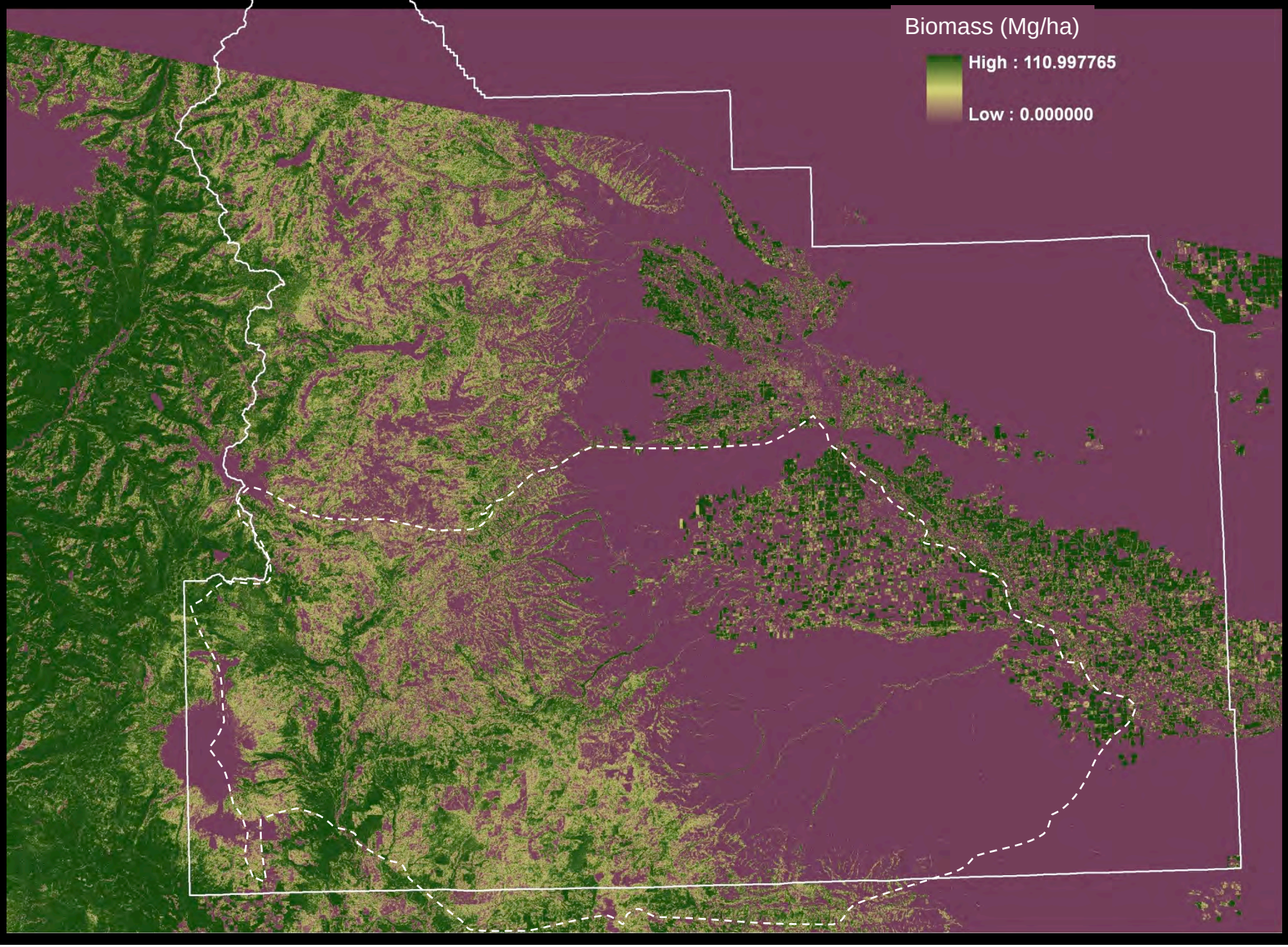


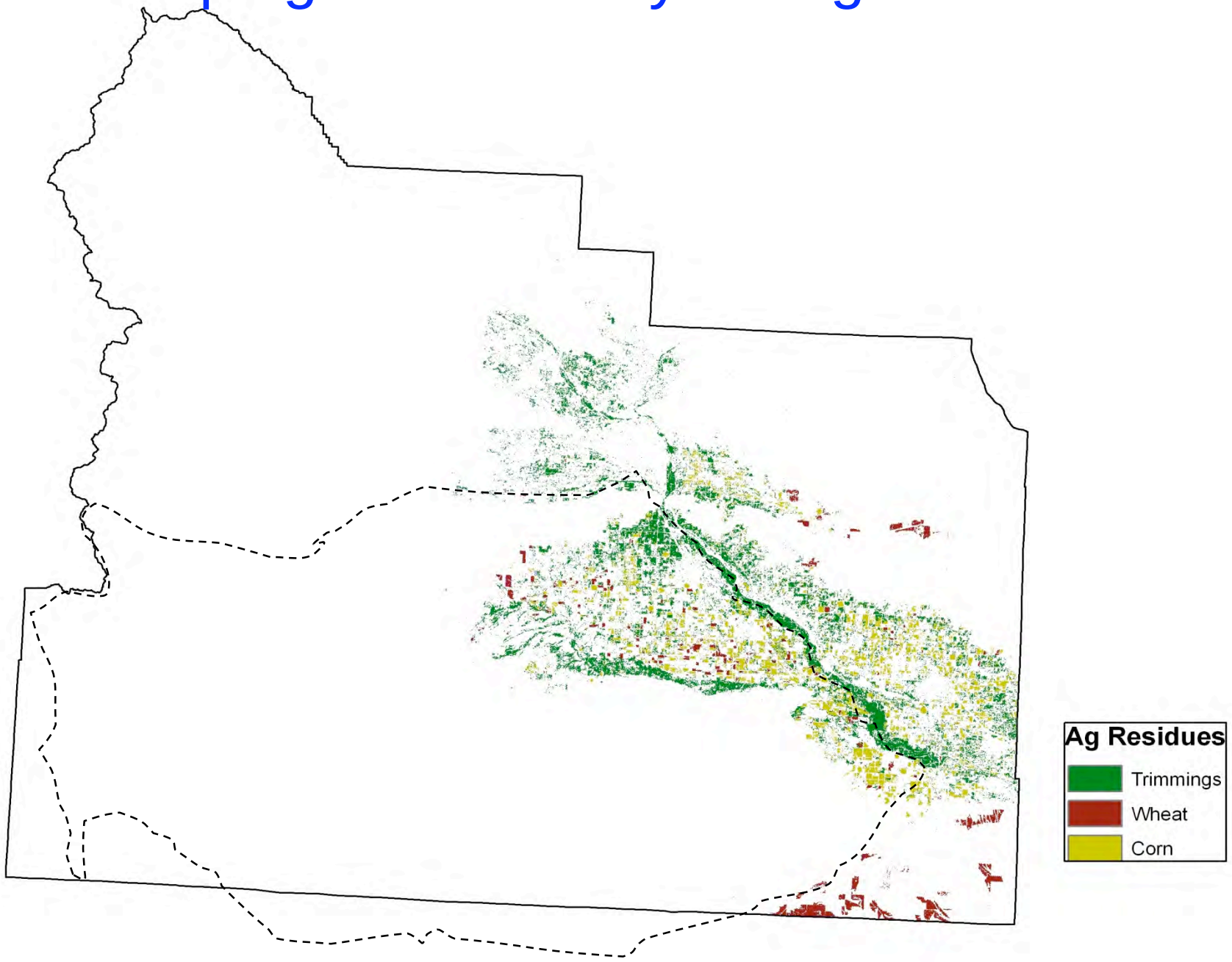
Base-case: Yakama Reservation and Yakima Co.



Developing an inventory of Forest Residues



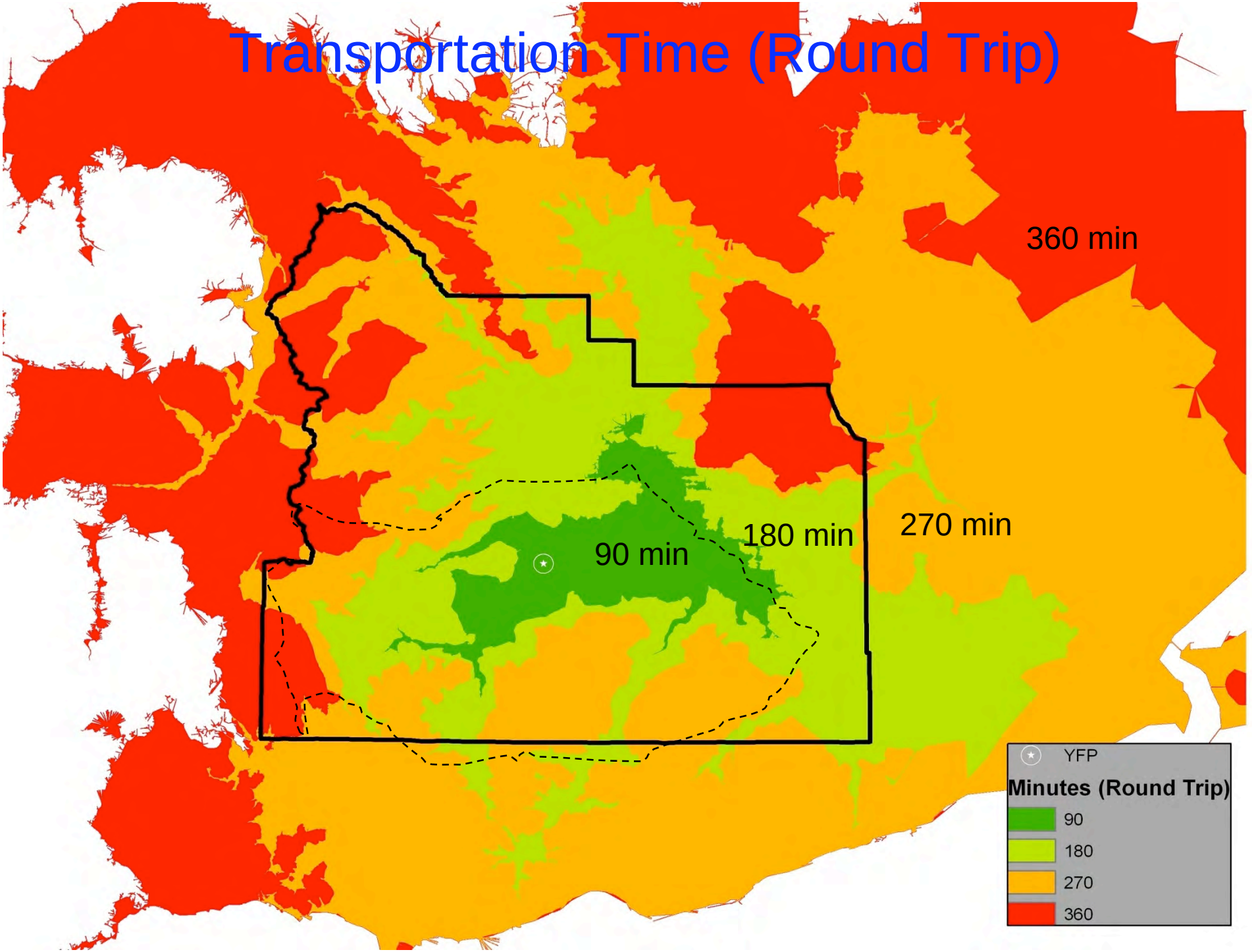
Developing an Inventory for Ag Residues



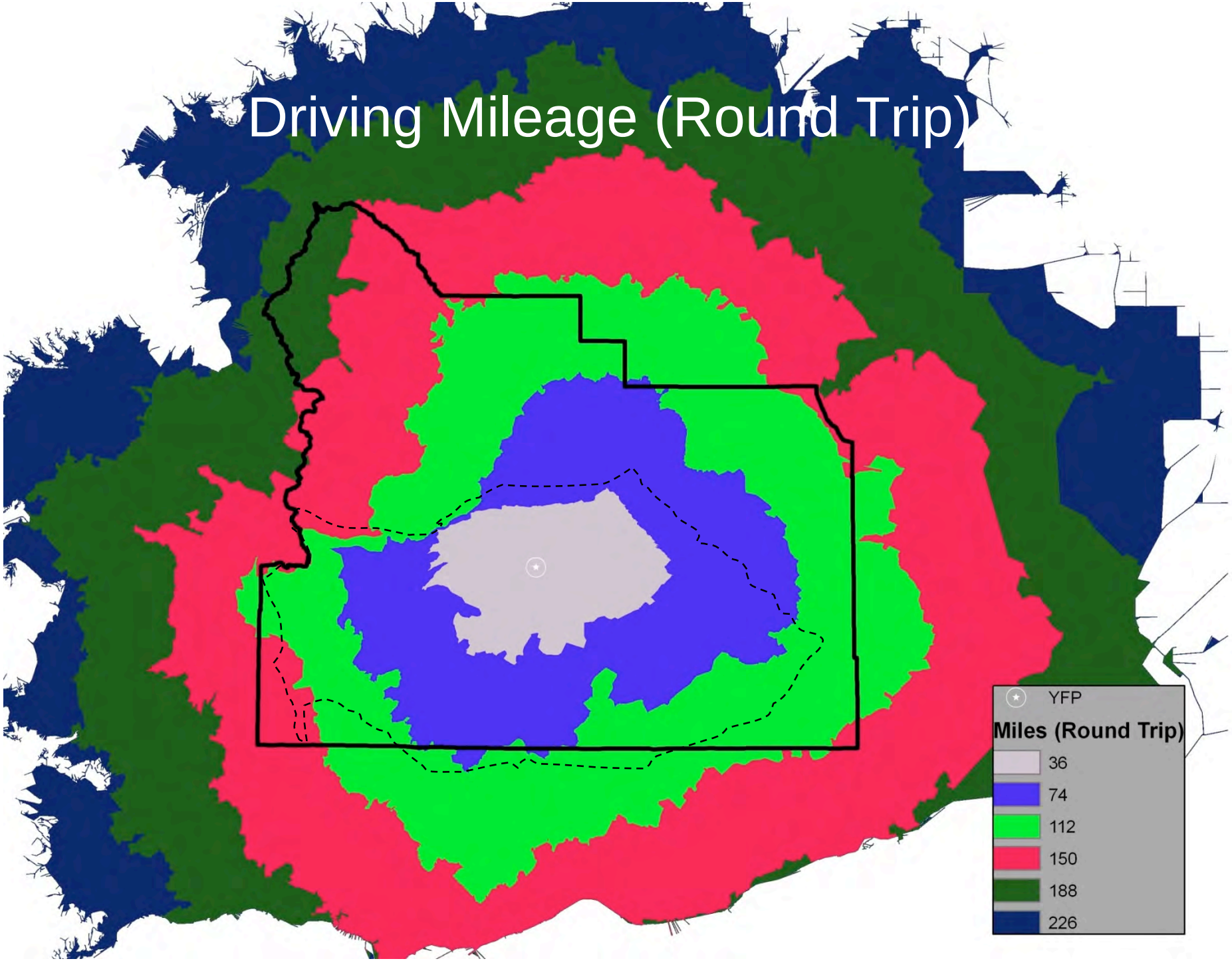
Transportation Model Overview

- Computes over the road costs on a **distance** (mainly fuel and equipment costs) and **time** (mainly labor costs)basis.
- Roads are classified into four categories to determine time
- ArcGIS Network Analysis is used to compute distances and times
- Other costs and limits are mostly derived from Polagye, et al. (2007), and Western Governors reports (2006, 2008).

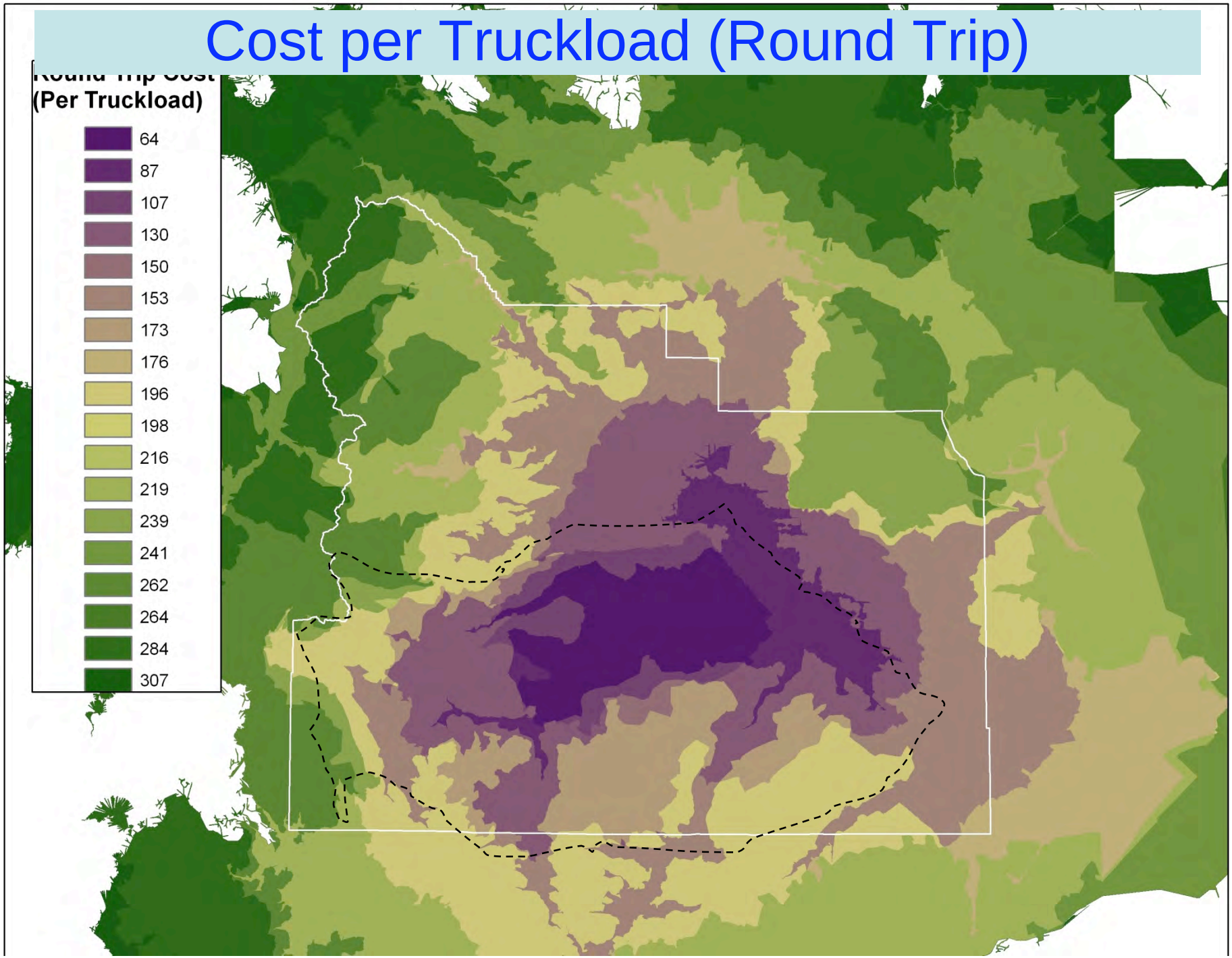
Transportation Time (Round Trip)



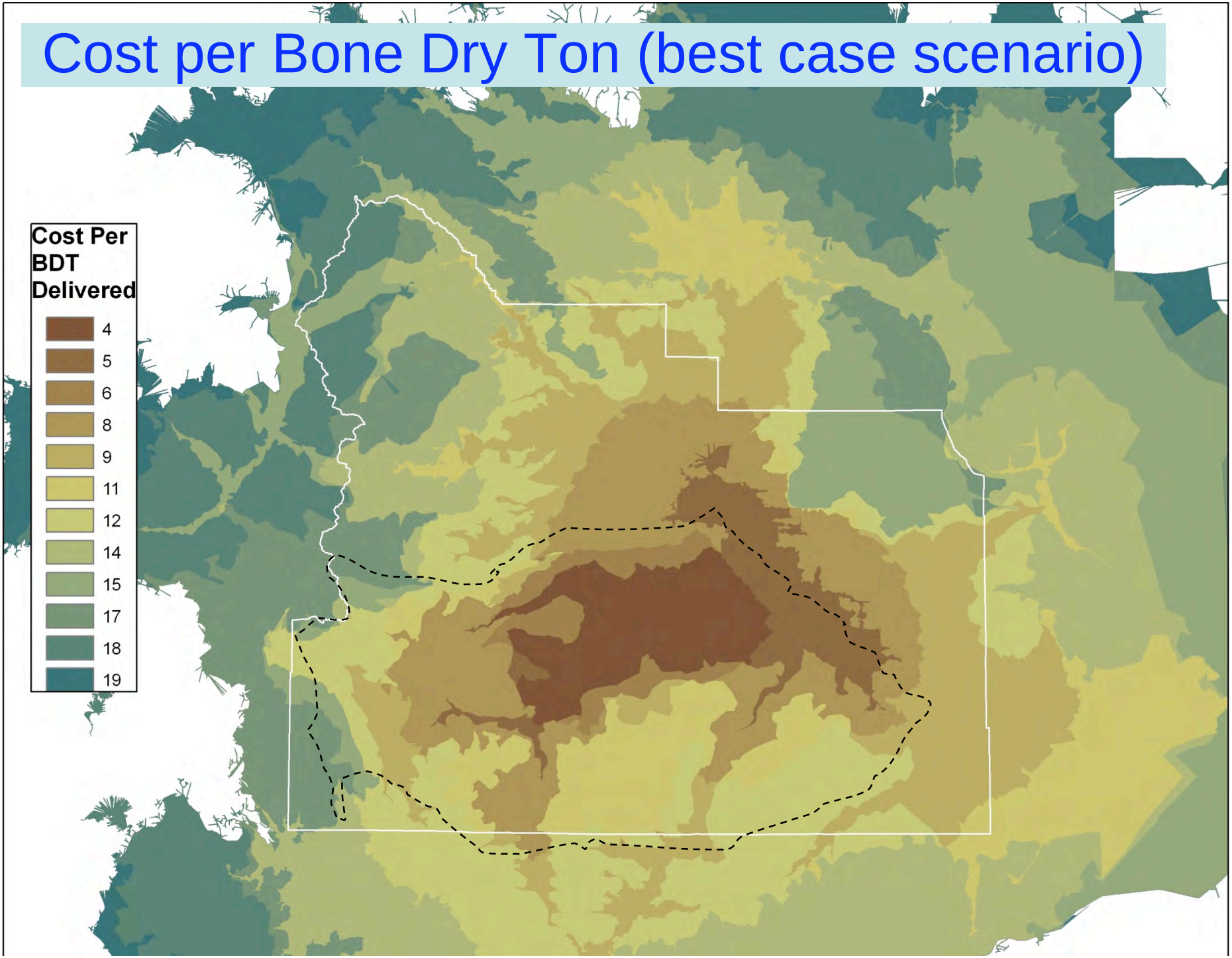
Driving Mileage (Round Trip)



Cost per Truckload (Round Trip)



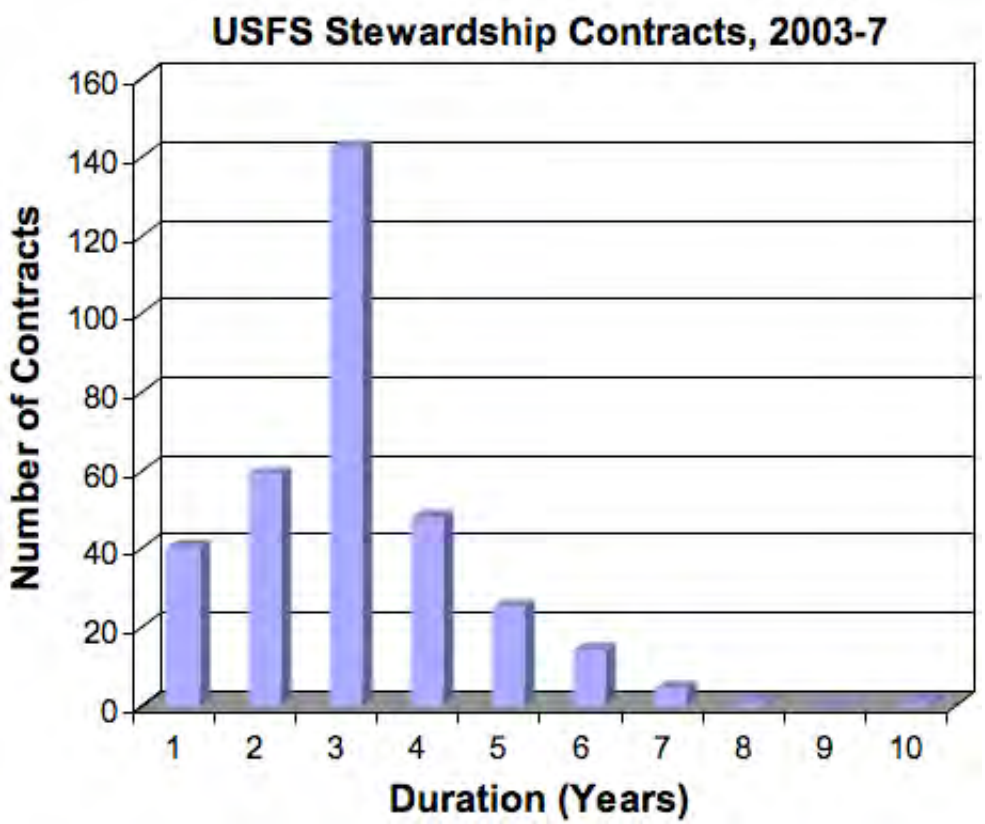
Cost per Bone Dry Ton (best case scenario)



Beyond base-case: Interfacing

- Off reservation biomass has many implications

  - Federal forests are unhealthy (need thinning for fire, bugs)
  - Urban residues must comply with I-937
  - Extra employment opportunities (~4.9 jobs/MW)



Beyond base-case: Interfacing

- Off reservation biomass has many implications
  - Federal forests are unhealthy (need thinning for fire, bugs)
  - Urban residues must comply with I-937
  - Extra employment opportunities (~4.9 jobs/MW)
- Life Cycle Assessment (Joyce Cooper)
  - Contributions to climate change
  - Effects of land/water use change
  - Energy return on energy invested
  - Employment shifts
  - Possible impact of technology innovations