New methods for estimating National Forest biomass supply and delivered cost in developing markets

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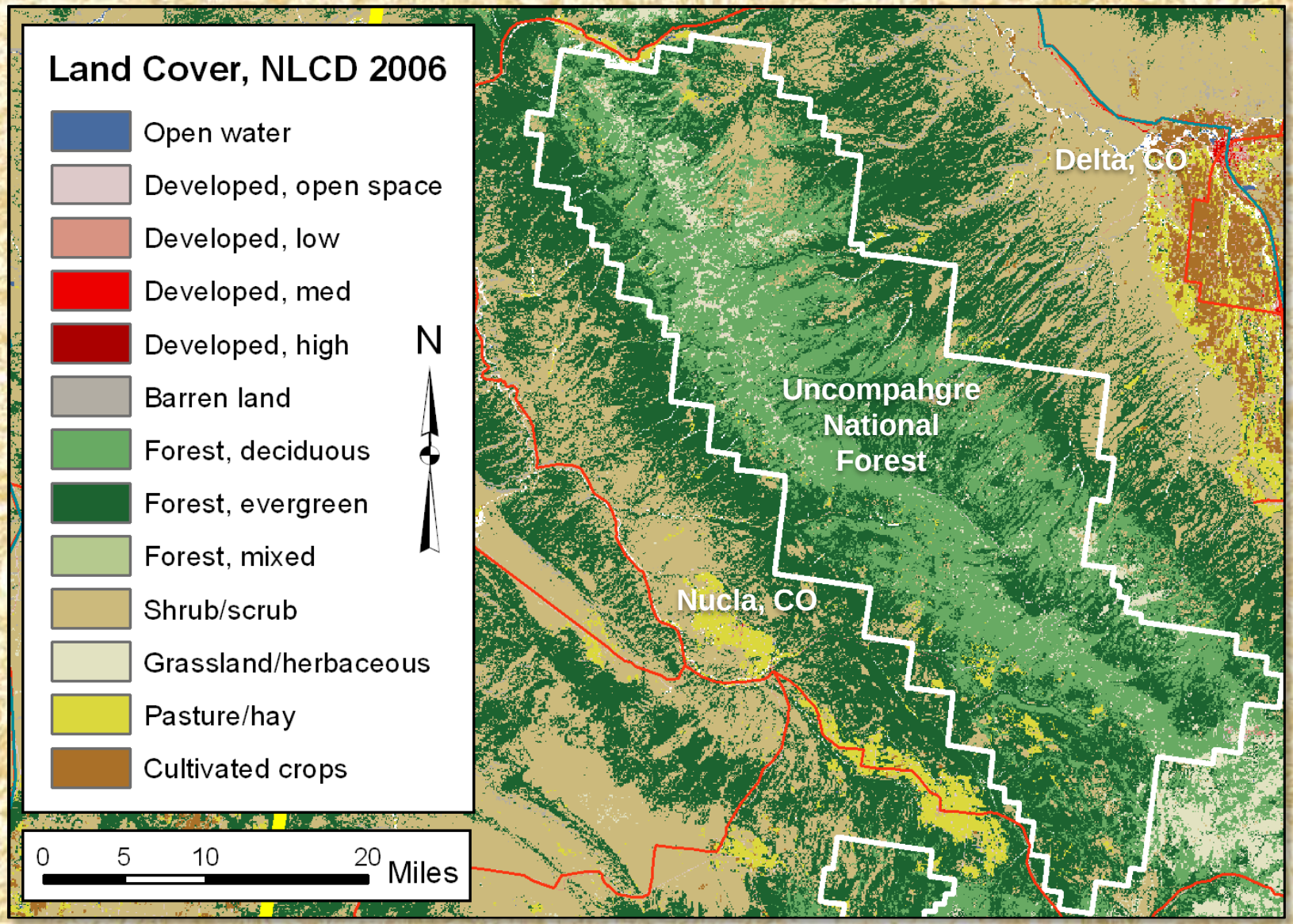
TMS, Coeur d'Alene, ID ~ April 11, 2012

What's ahead?

- Background and objectives
- Focus on three project components:
  - network analysis, delivered costs, emissions
- Synthesis and work ahead
- Questions

The Uncompahgre Plateau

The Uncompahgre Plateau



Diverse Forests

- Mixed conifer
- Aspen
- Pinyon/Juniper
- Pine forest

Active Management

- Thinning
- Aspen clearcuts
- Utility corridors
- Salvage

Biomass Byproducts

- Slash
- Roundwood
- Aspen
- Salvage

Challenges on the UP

- Need for biomass removals
- Limited markets
- Little or no transaction evidence
- High uncertainty

Advantages on the UP

- Active management with good road access
- NEPA ready projects
- CFLRP funding for treatments

Cover Type	Treatments	CFLRP Total (acres)	Annual Tx (acres)
Pinyon-Juniper	Mastication	2,500	250
Mountain shrub	Mastication, prescribed fire	7,000	700
Ponderosa pine	Mechanized commercial and non-commercial, prescribed fire	15,000	1,500
Mixed conifer	Mechanized commercial and non-commercial, broadcast burning	11,000	1,100
Aspen	Harvest, mechanical treatments, prescribed fire	11,000	1,100
Spruce-Fir	Commercial harvest	4,000	400
TOTAL	**ALL**	**50,500**	**5,050**

"Developing" markets?

- Sexy operations
  - 30MW gasification plant (TCG Global), pellets (EEP), liquid fuels, Biochar (BSI)
- Distributed heat and power
- Cofiring with coal – Tri-State, Nucla

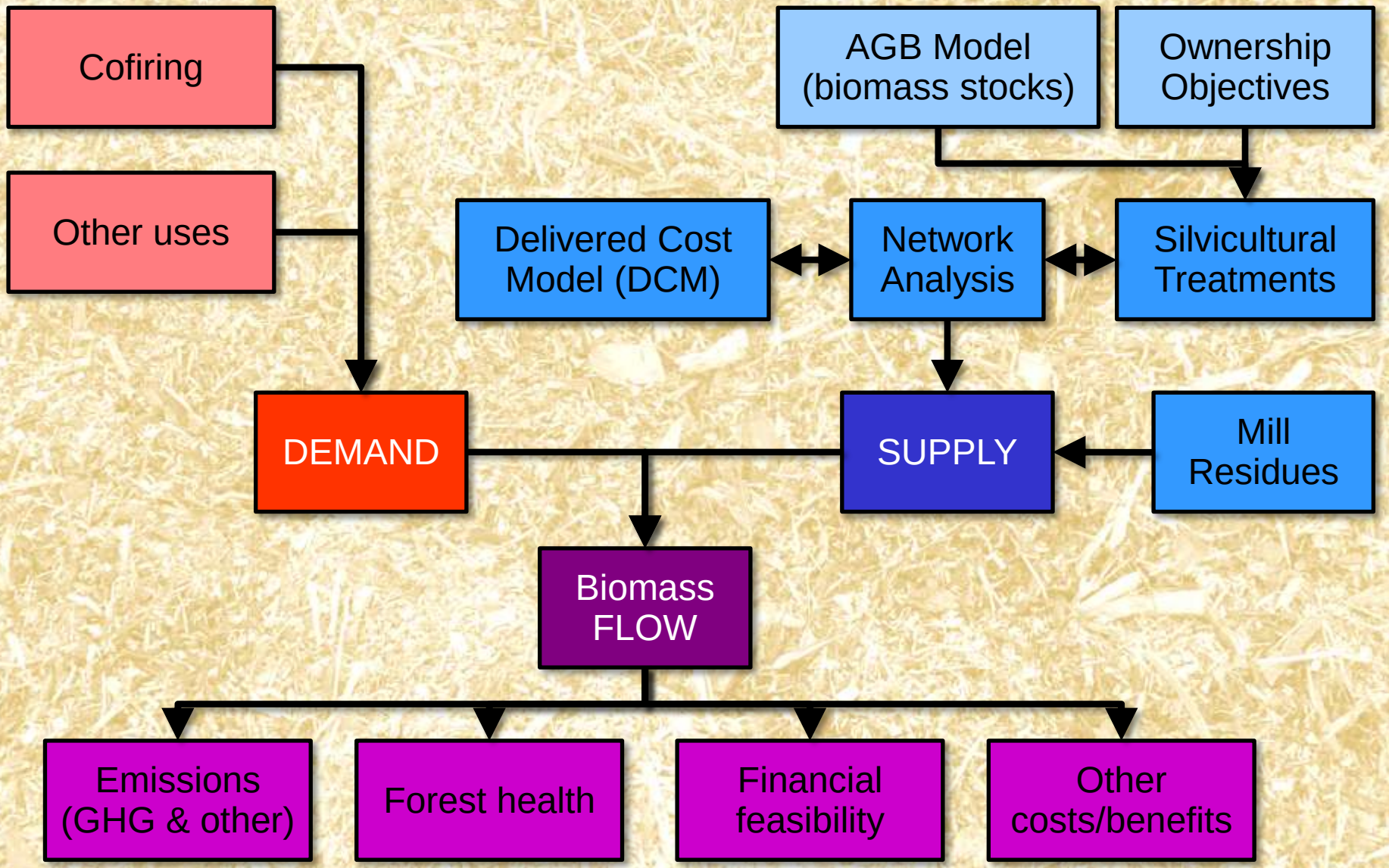
- 110 MW
- Local bituminous coal
- Circulating fluidized bed
- Renewable portfolio standard
- 8,000 hrs/yr at 55.5 MMBtu max
- Up to 250,000 green tons per year

Research Objectives

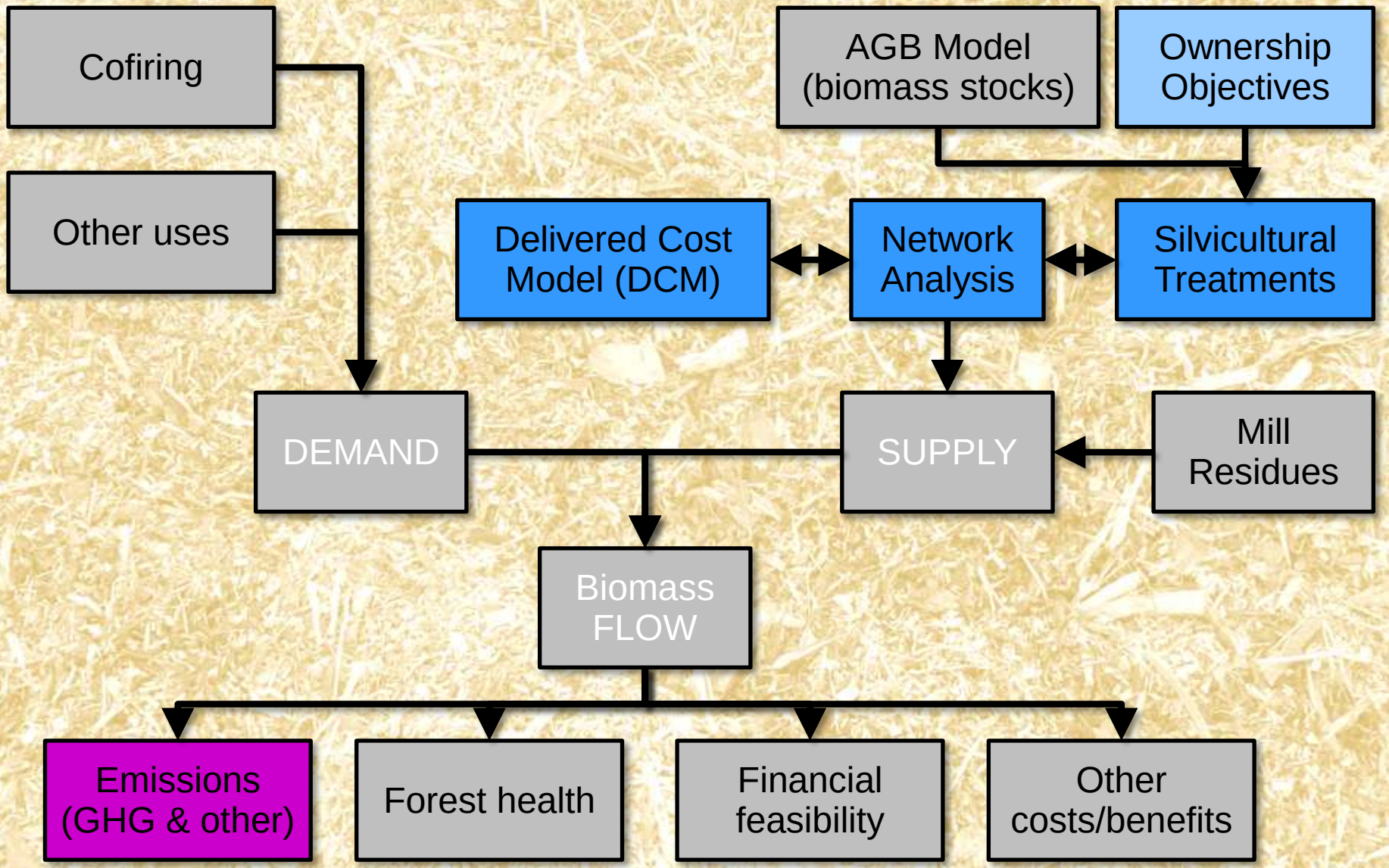
- RMRS Competitive Research Initiative (CRI)
- $160,000 over 2 years, 2011-2012
  - Map potential biomass stocks and flows
  - Quantify the benefits ($, PM10, etc.)
  - Quantify the costs ($, traffic, etc.)
  - Evaluate tradeoffs

How much biomass could be delivered to market, at what cost?

Approach


Cofiring
Other uses
AGB Model (biomass stocks)
Ownership Objectives
Delivered Cost Model (DCM)
Network Analysis
Silvicultural Treatments
DEMAND
SUPPLY
Mill Residues
Biomass FLOW
Emissions (GHG & other)
Forest health
Financial feasibility
Other costs/benefits

Approach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Other costs/benefits

Silvicultural Treatments

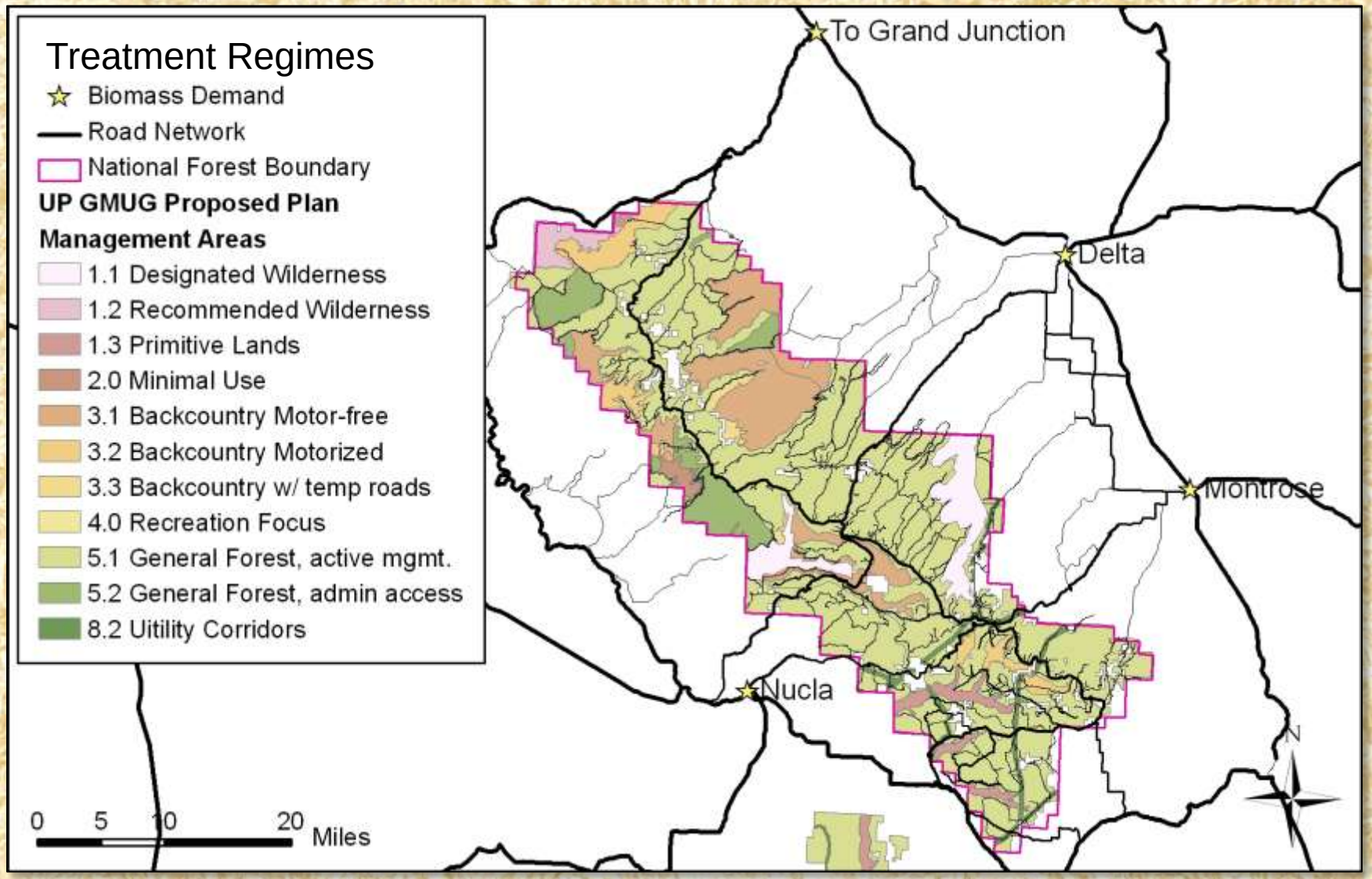
Objectives

- Understand expected treatments
- Model treatments spatially
- Link treatments to AGB, Transport and DCM

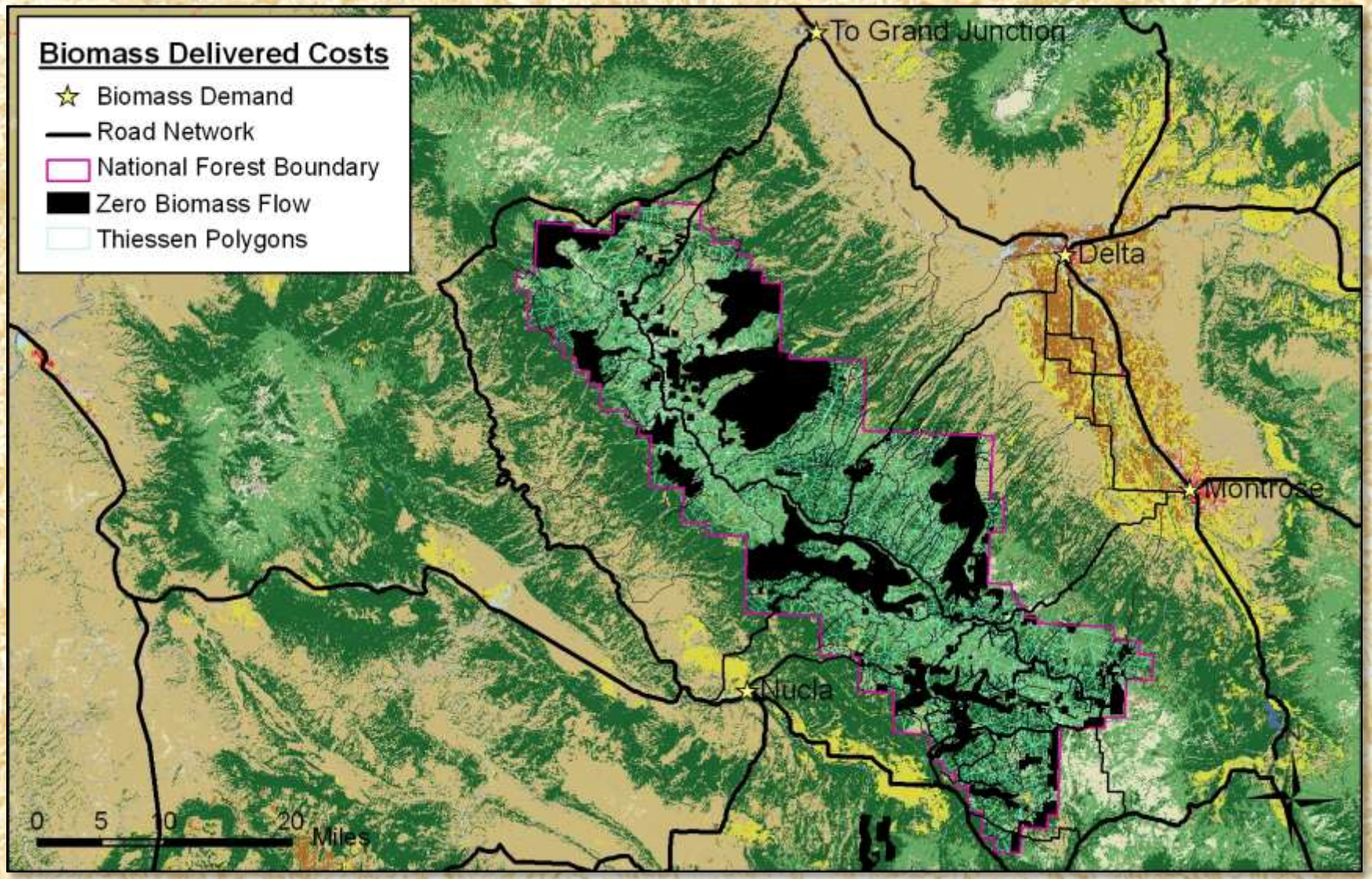
Methods

- Multiple time frames (10 yrs vs 100 yrs)
- Deterministic vs. probabilistic approaches

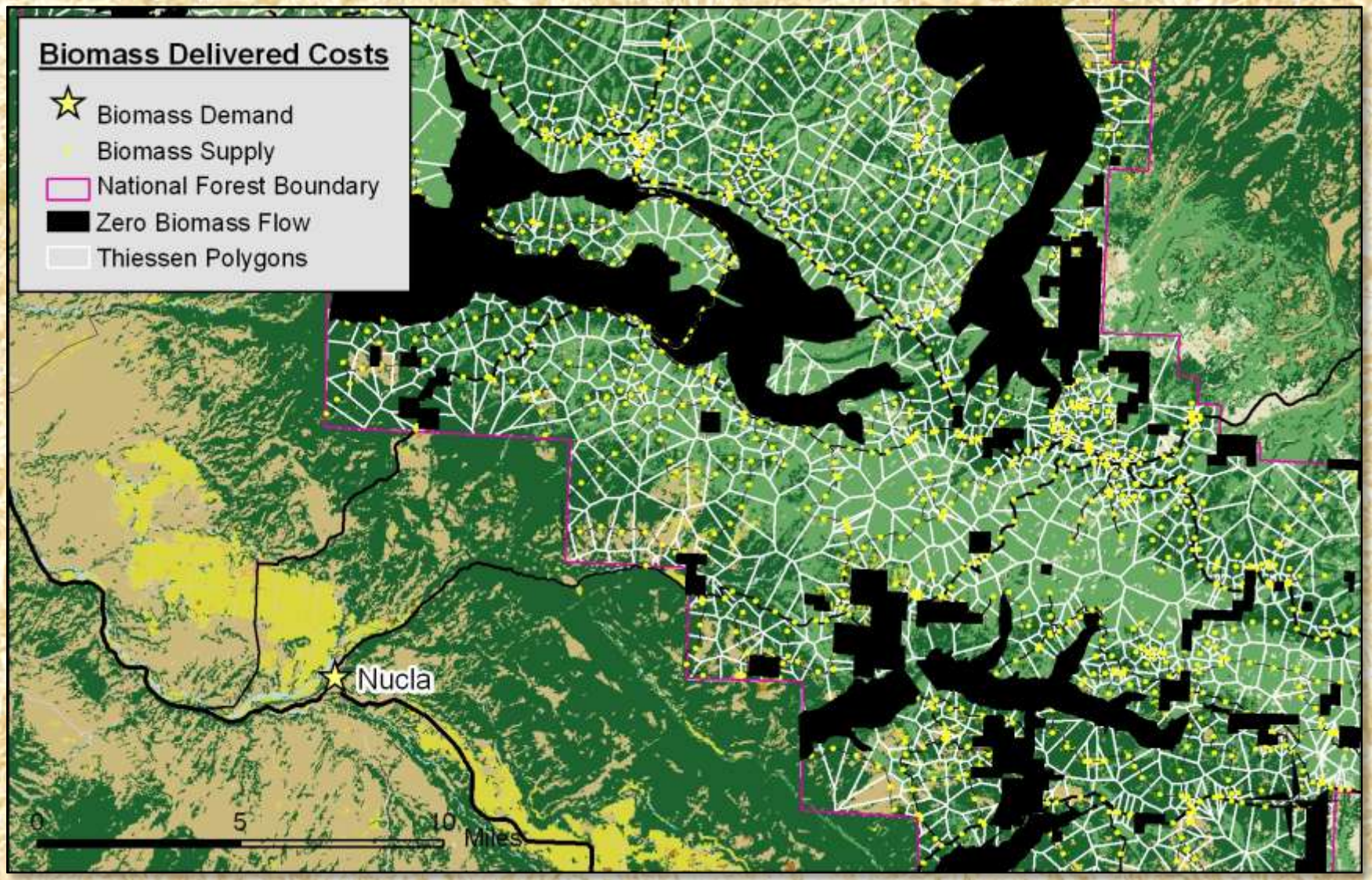
Silvicultural Treatments



Silvicultural Treatments



Silvicultural Treatments



Network Analysis

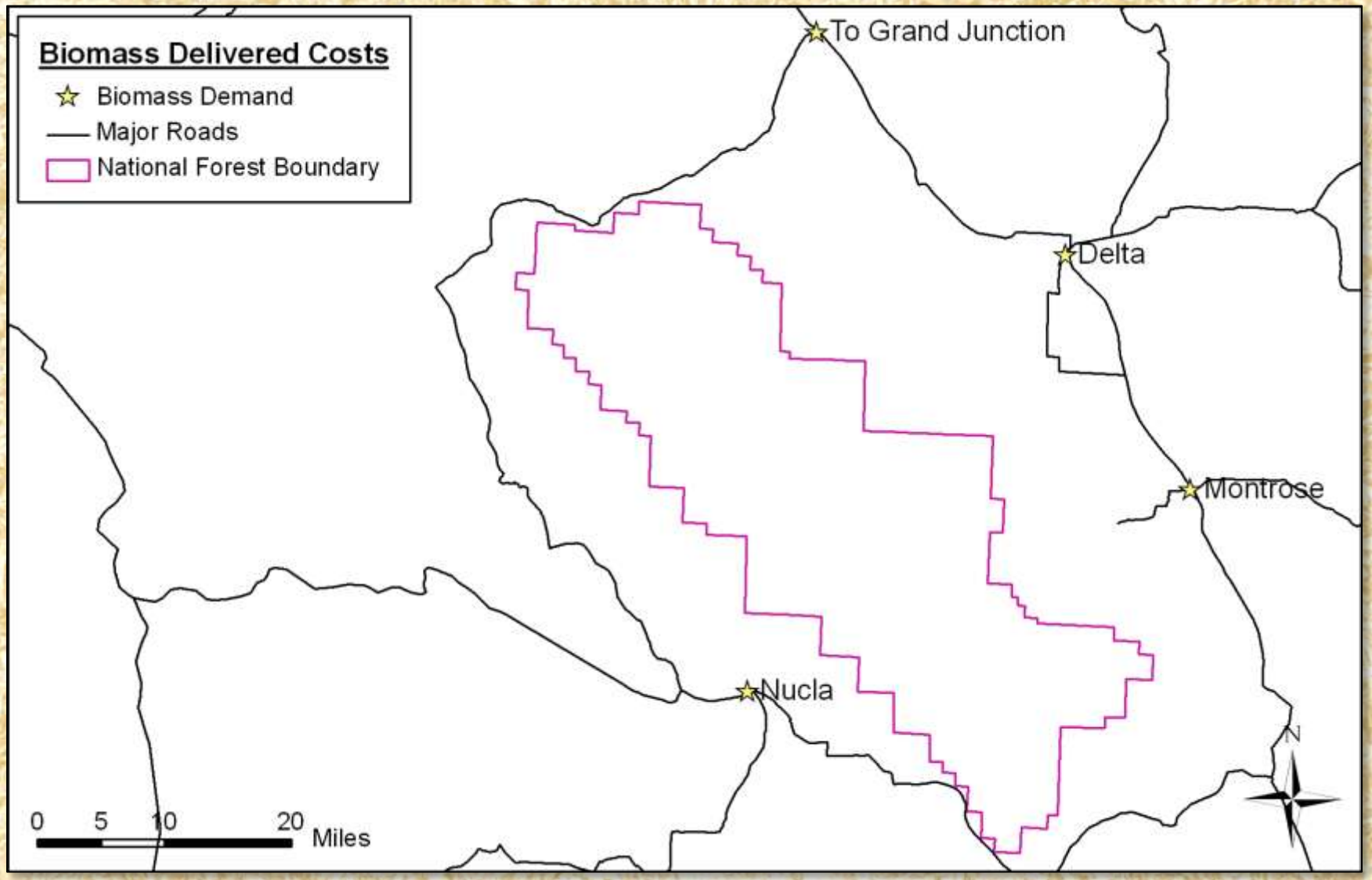
Objectives

- Model transportation costs spatially
- Build a system to link supply to demand
- Link treatments to optimized road network

Methods

- ArcGIS and heuristic algorithms
- Inform non-spatial delivered cost model
- Integrate with AGB and treatments

Network Analysis



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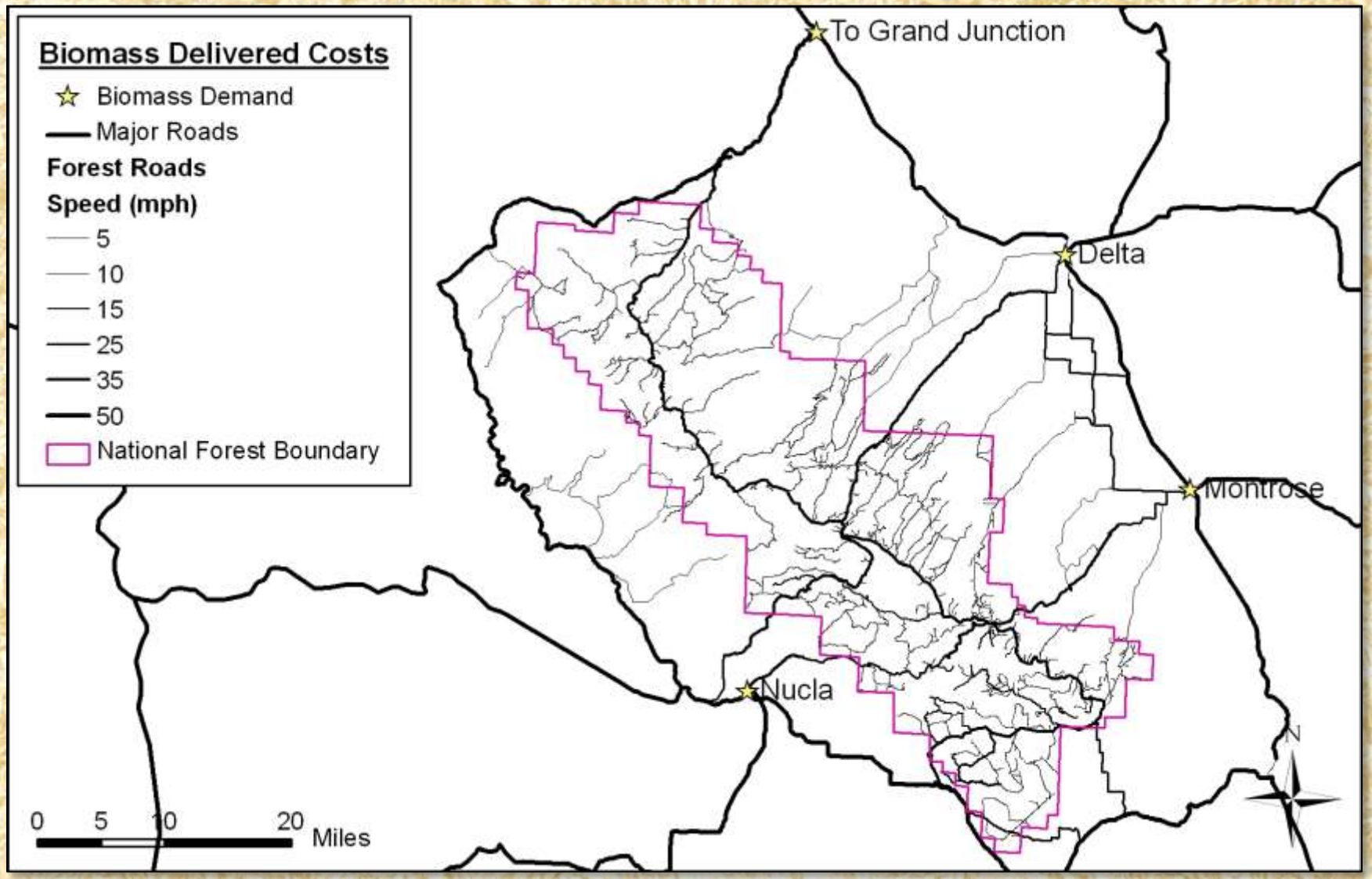

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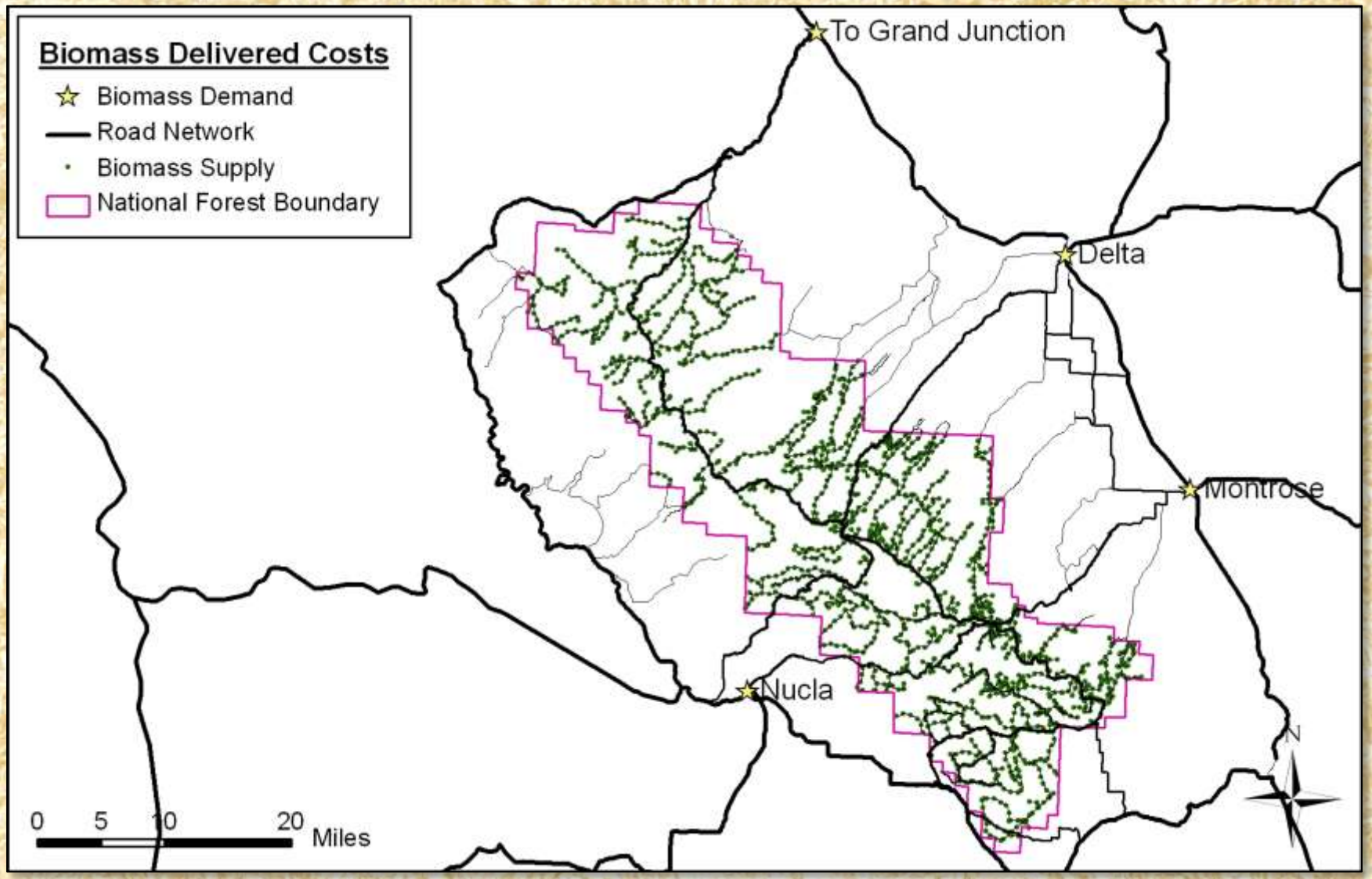

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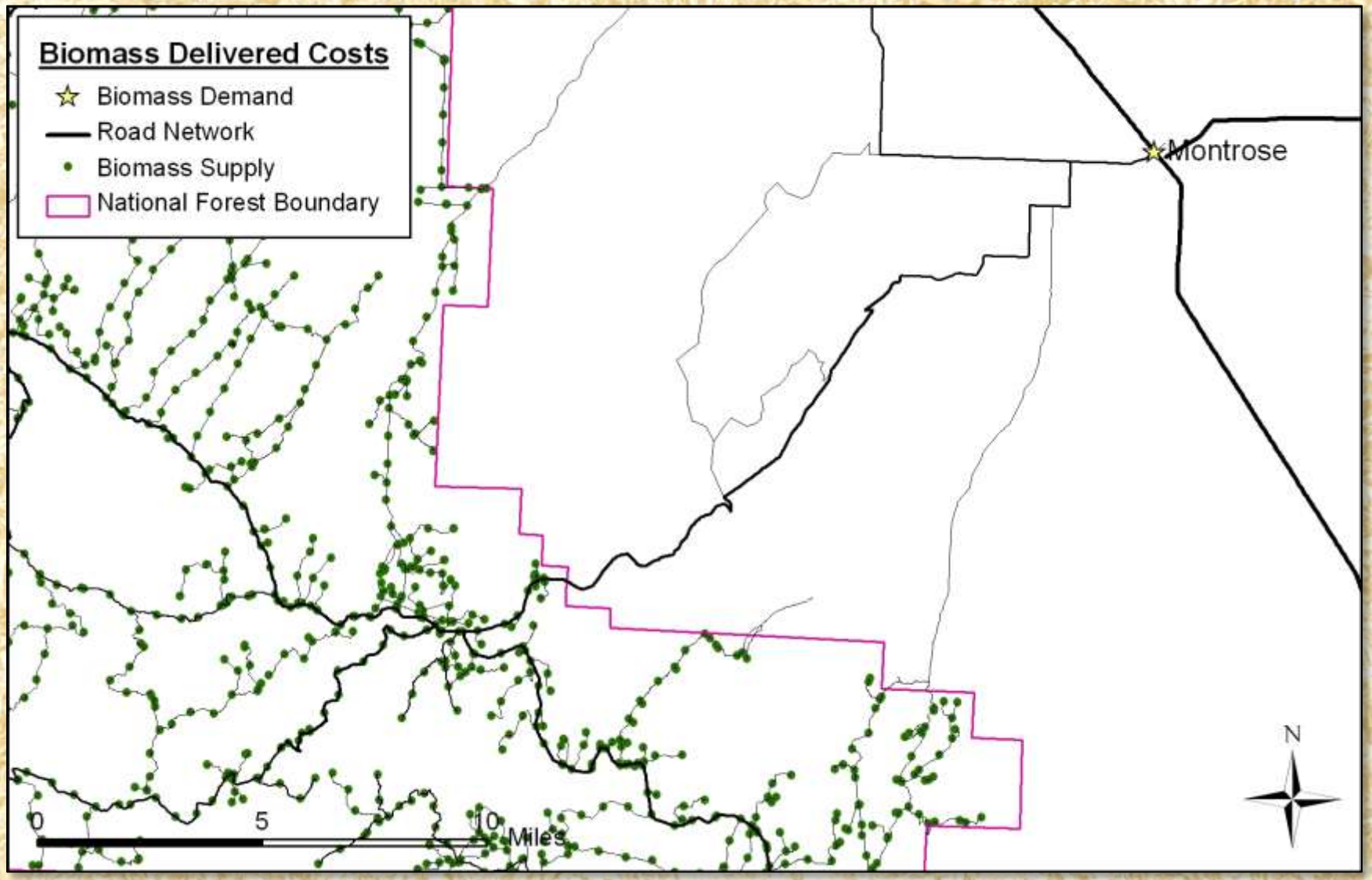

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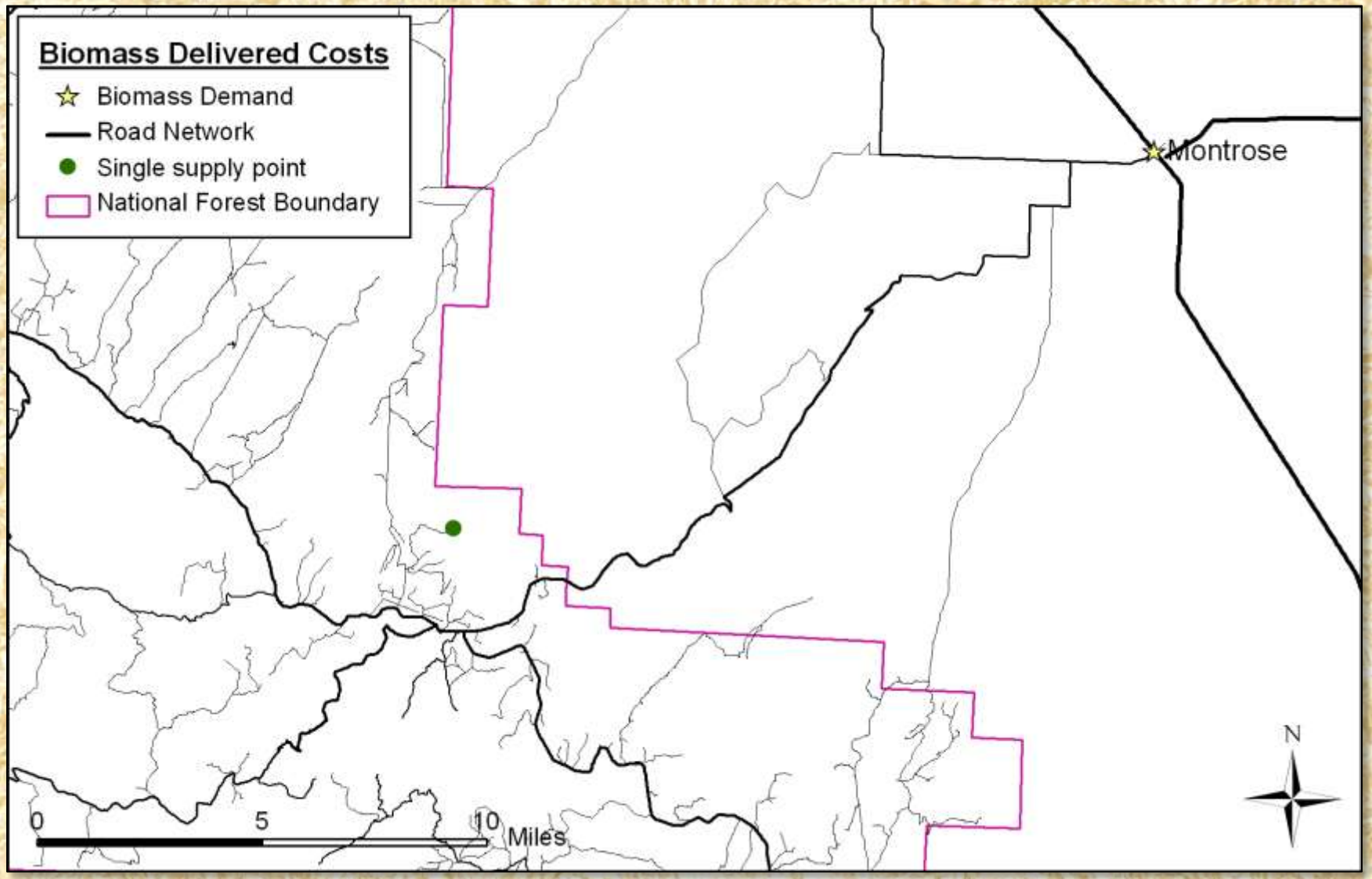

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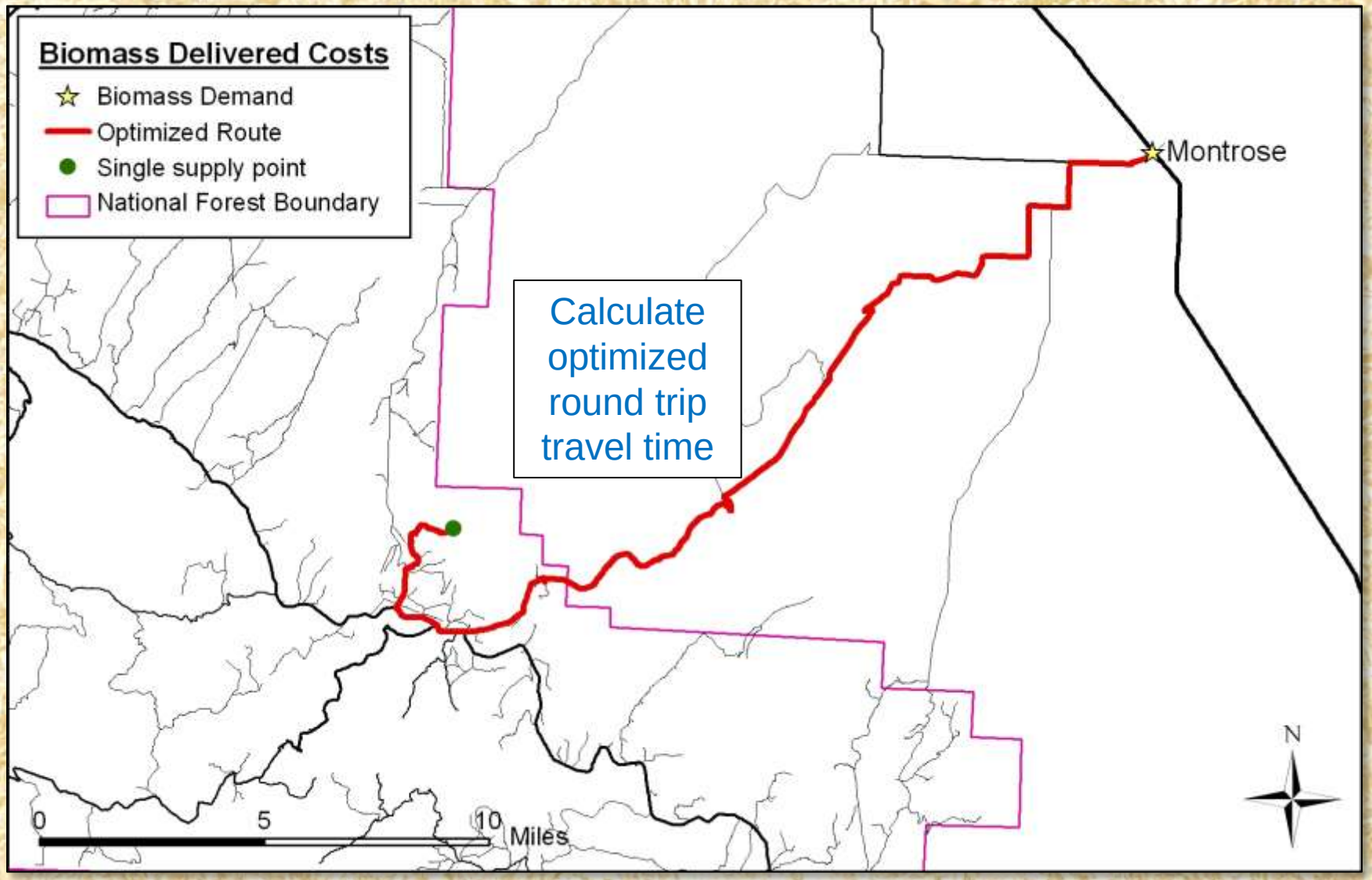

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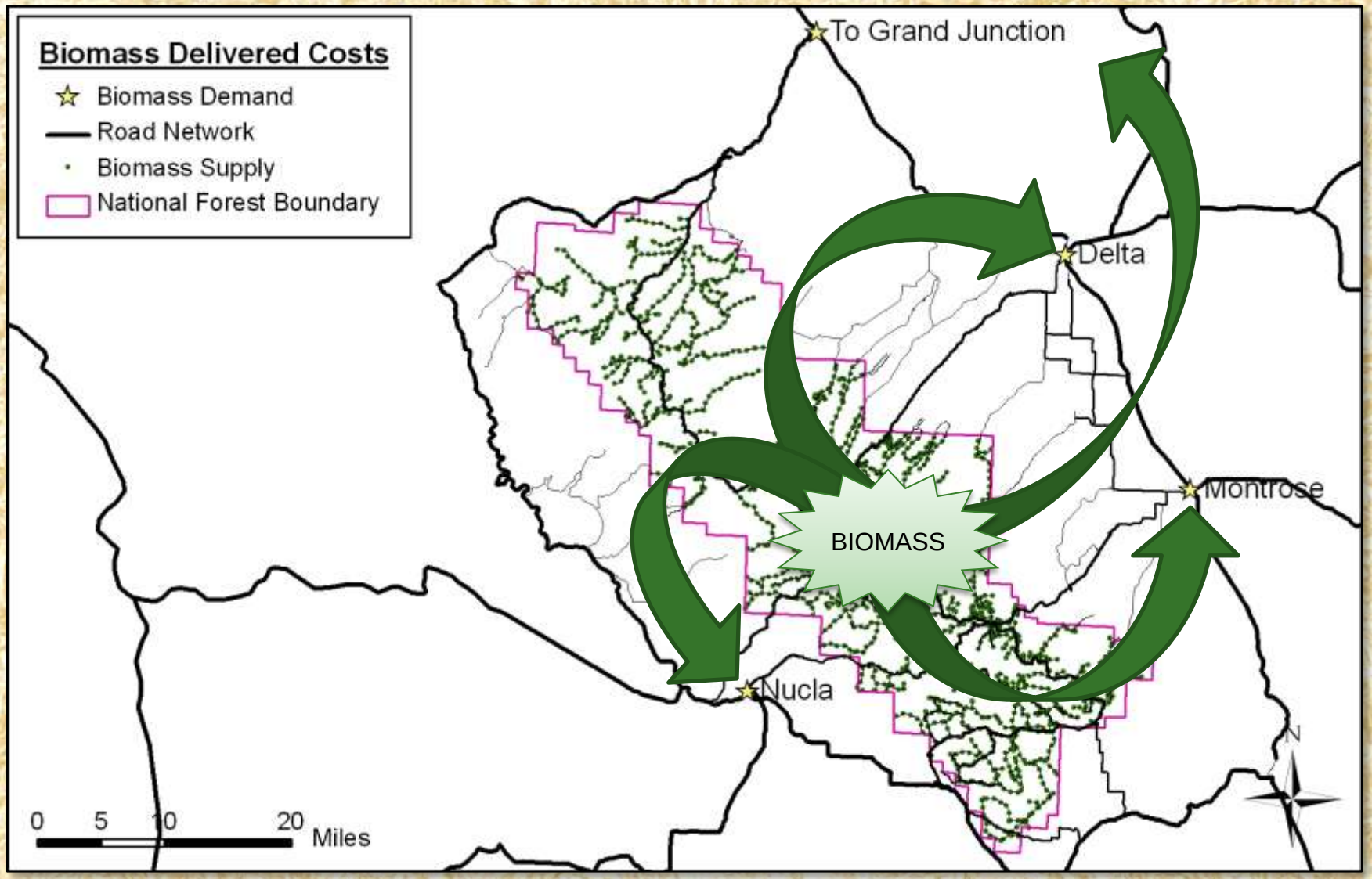

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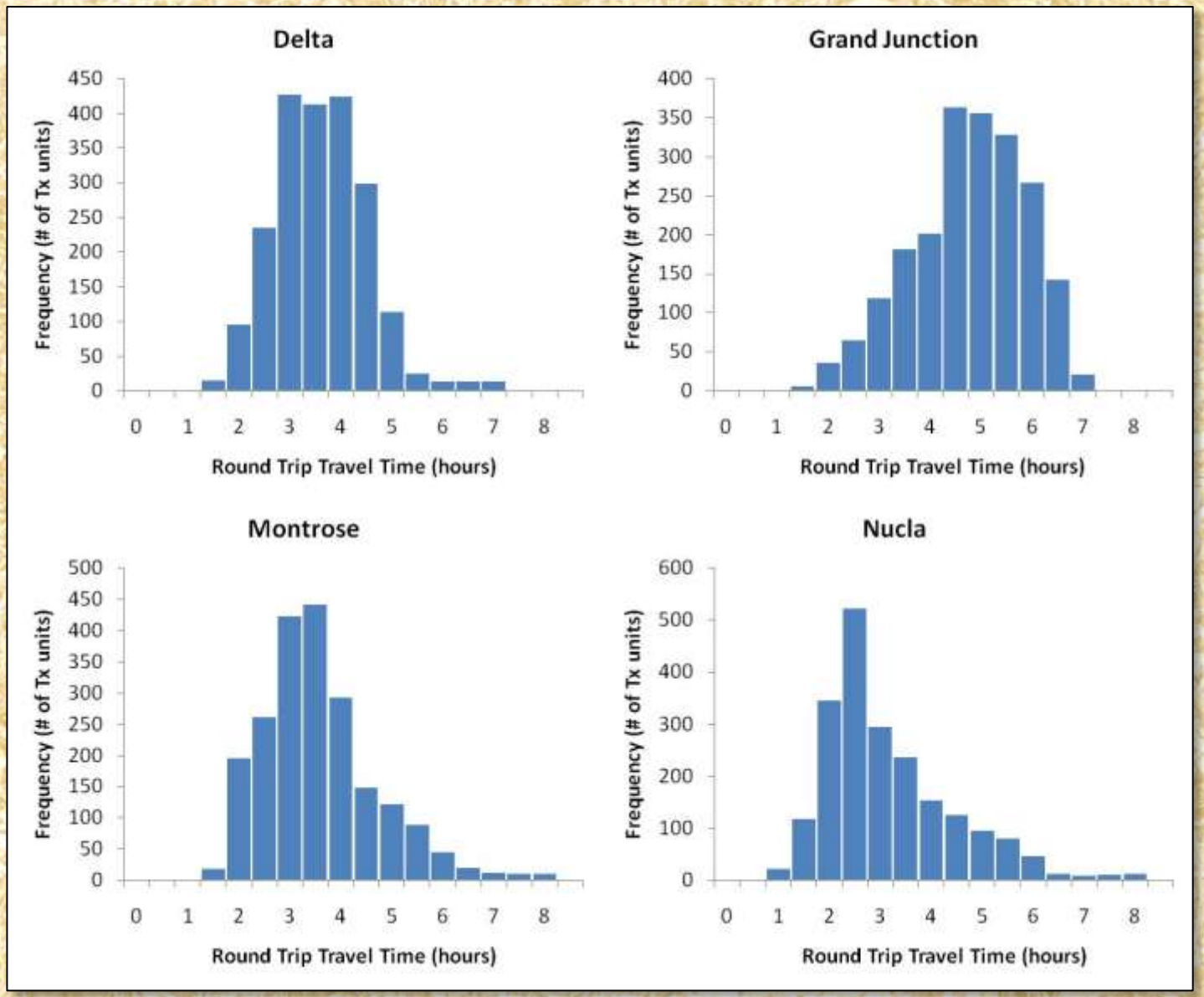

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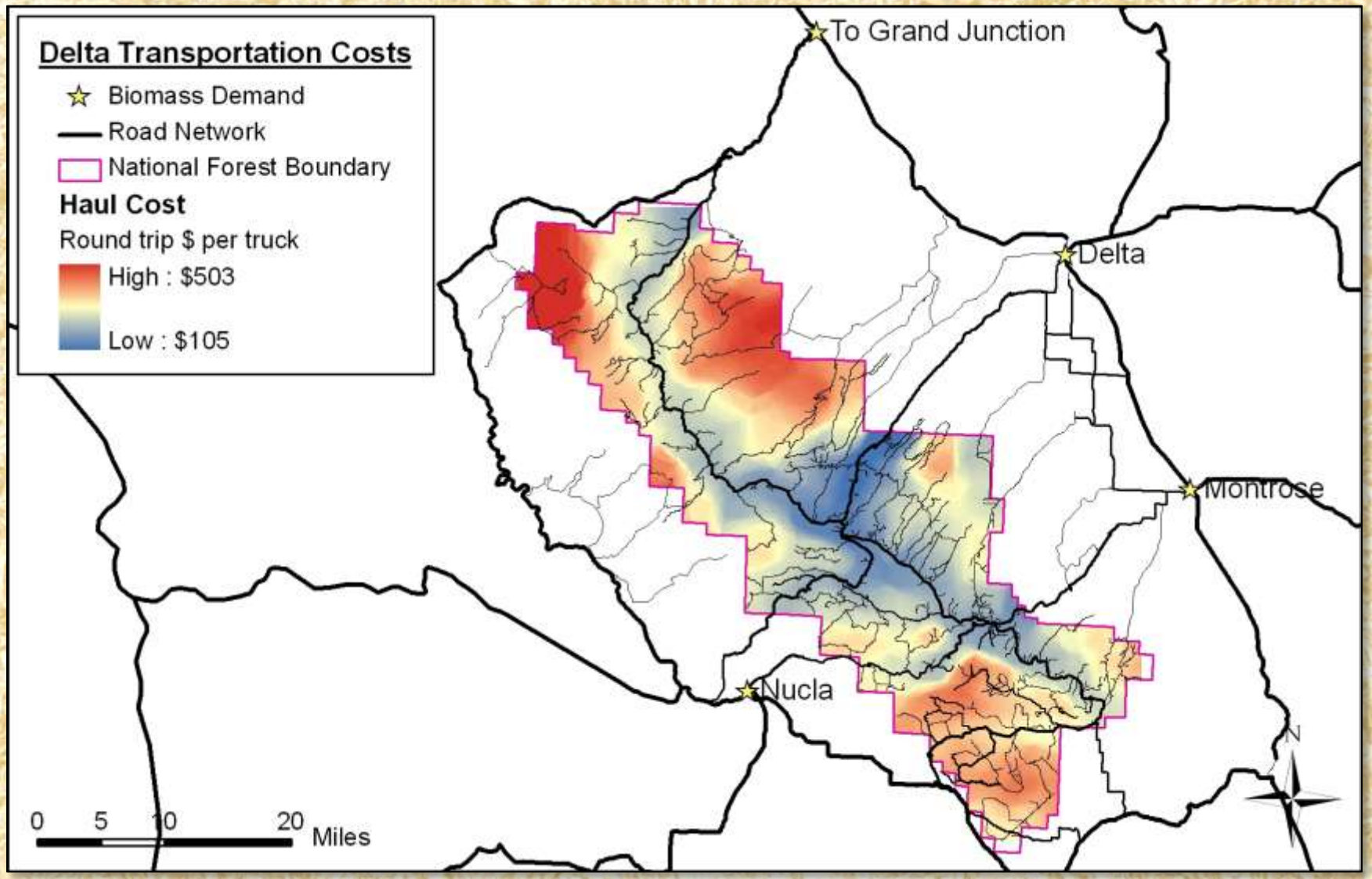

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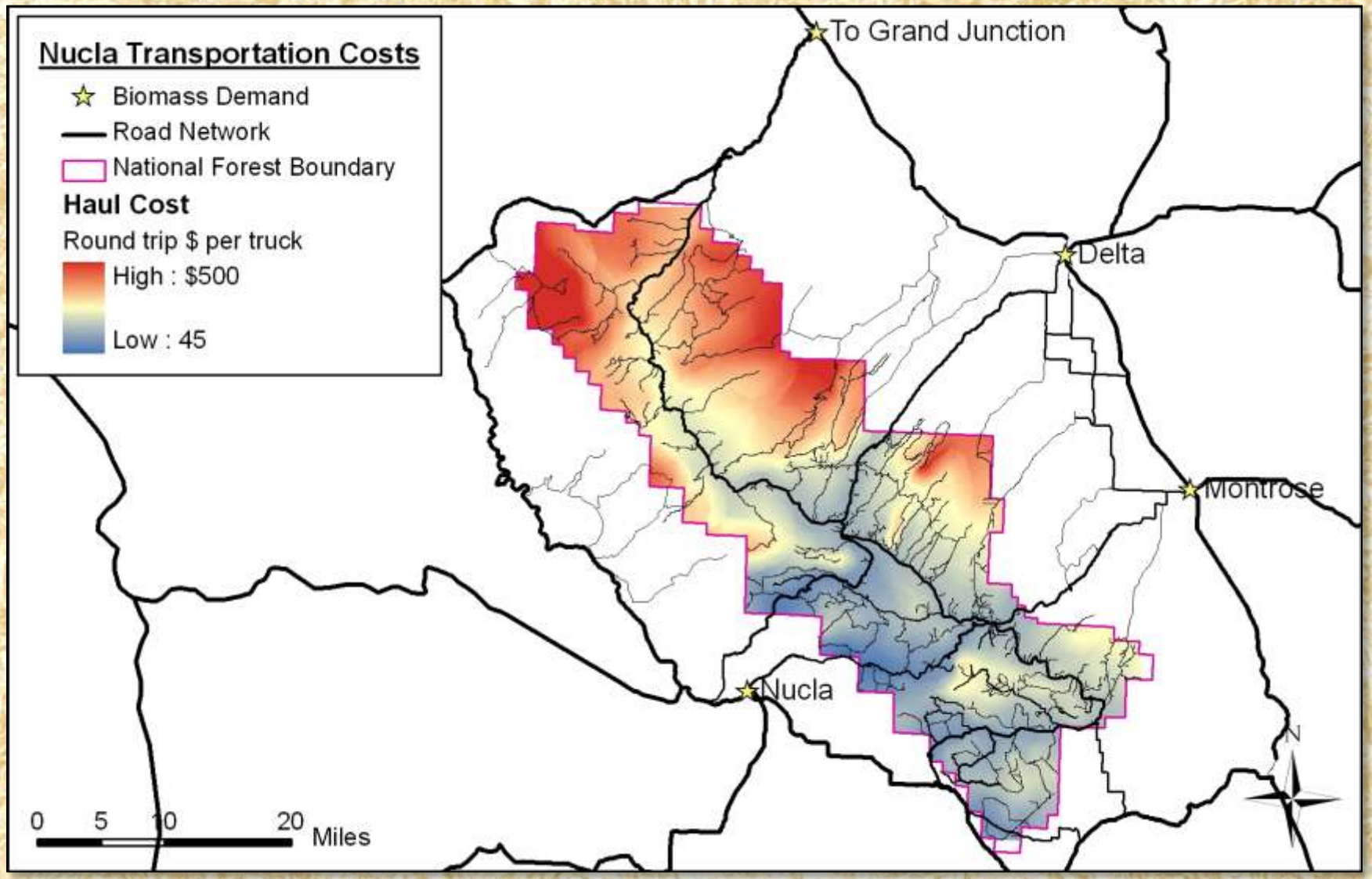


Delivered Cost Model

Objectives

- Estimate delivered cost of biomass
- Understand how uncertainty impacts cost

Methods

- Non-spatial
- Define cost and establish variable distributions
- Apply Monte Carlo simulation
  - Repeated random sampling of variables from defined distributions

DCM: Methods

- Delivered cost (C), is the sum of the costs of stumpage (S), forest operations (O), transportation (T), and additional costs (x):

$$C = O + S + T + x$$

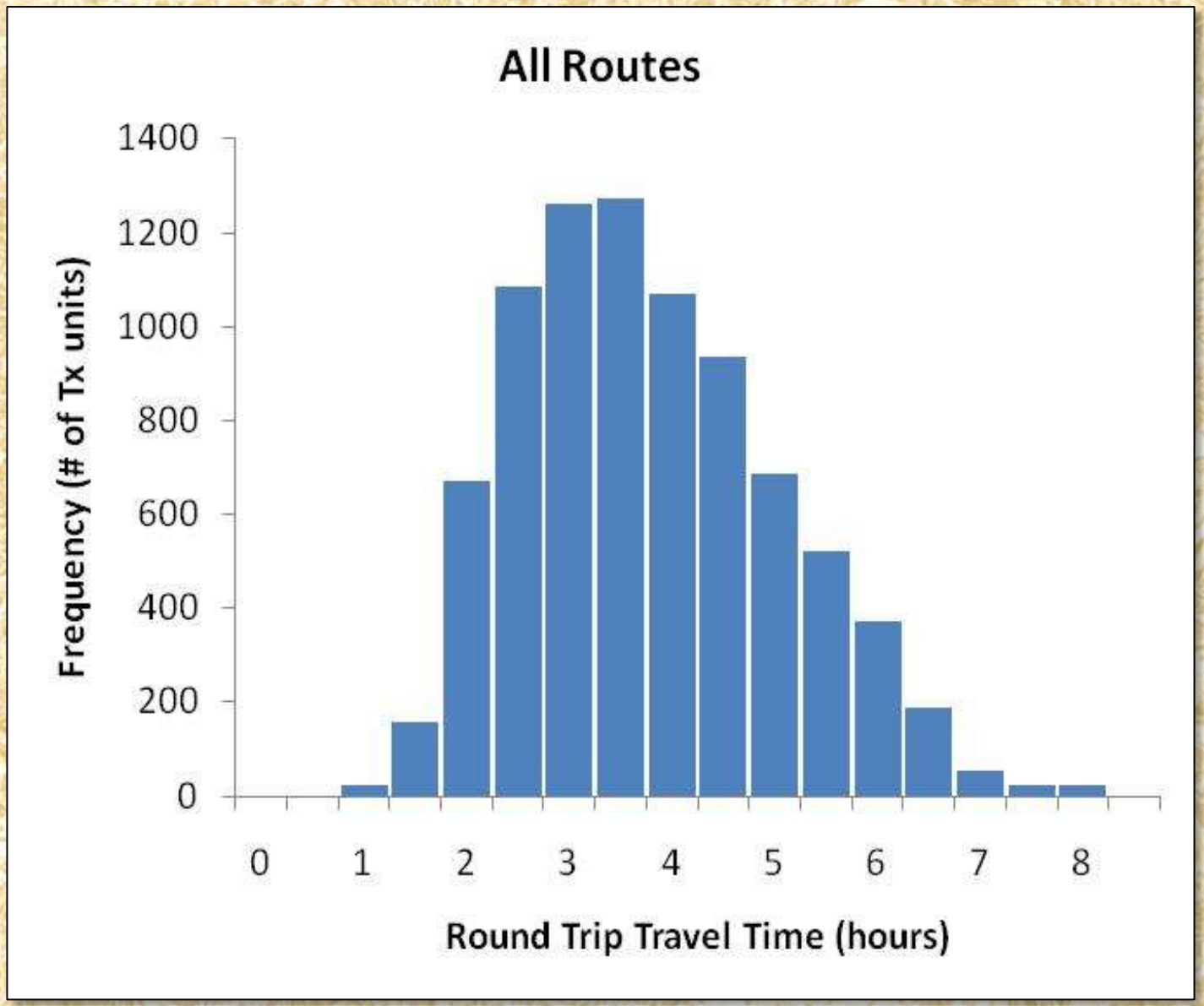
- T = RT travel time multiplied by hourly trucking cost divided by the payload.

$$T = \frac{(h + l + u) * \left(n + p + \left((d * e^{-1} * v) + a\right)\right)}{m * (1 - w)}$$

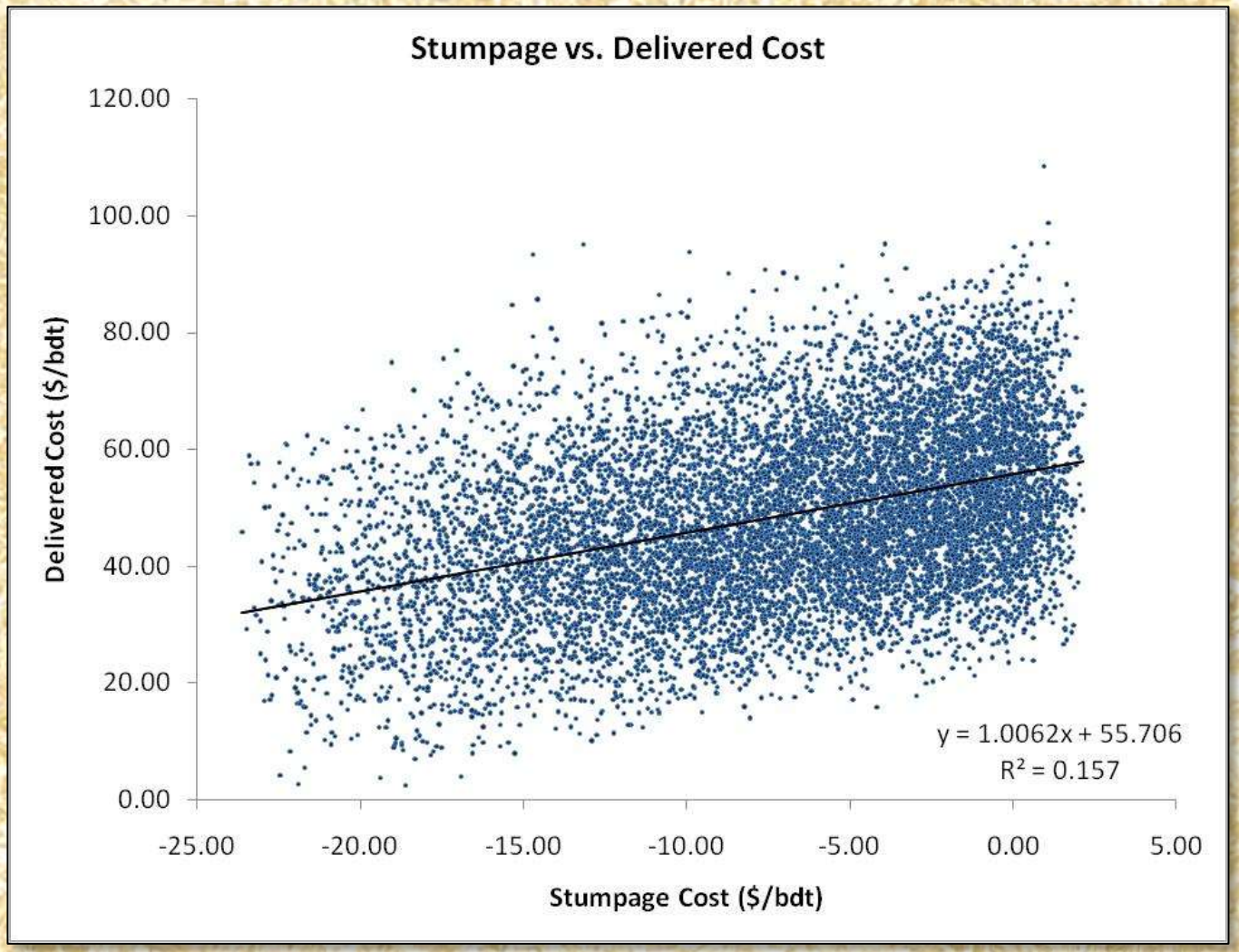
DCM: Methods

Variable	Abbrev.	Expected Value	Units	Min	Max
Forest operations	**O**	**34.33**	**$/bdt**	**9.33**	**67.5**
Stumpage cost	**S**	**0.00**	**$/bdt**	**-23.8**	**2.22**
Transportation	**T**	**18.62**	**$/bdt**	**5.47**	**45.75**
Non-fuel trucking cost	n	48.03	$/hr	38.42	57.64
Specialized trucking	p	12.00	$/hr	9.6	14.4
Diesel fuel price	d	3.17	$/gal	2.02	4.78
Lubrication cost	a	0.317	$/gal D	0.202	0.478
Average truck speed	v	20.1	mph	18.1	22.1
Average fuel economy	e	4.65	mpg	4.19	5.12
Round trip travel time	h	3.5	hr	0.58	7.82
Load wait time	l	0.5	hr	0.25	0.75
Unload wait time	u	0.5	hr	0.25	0.75
Van capacity	m	30.0	ton	25	34
Biomass moisture content	w	0.375	%	0.25	0.5
Additional costs	**x**	**0**	**$/bdt**	**0**	**0**

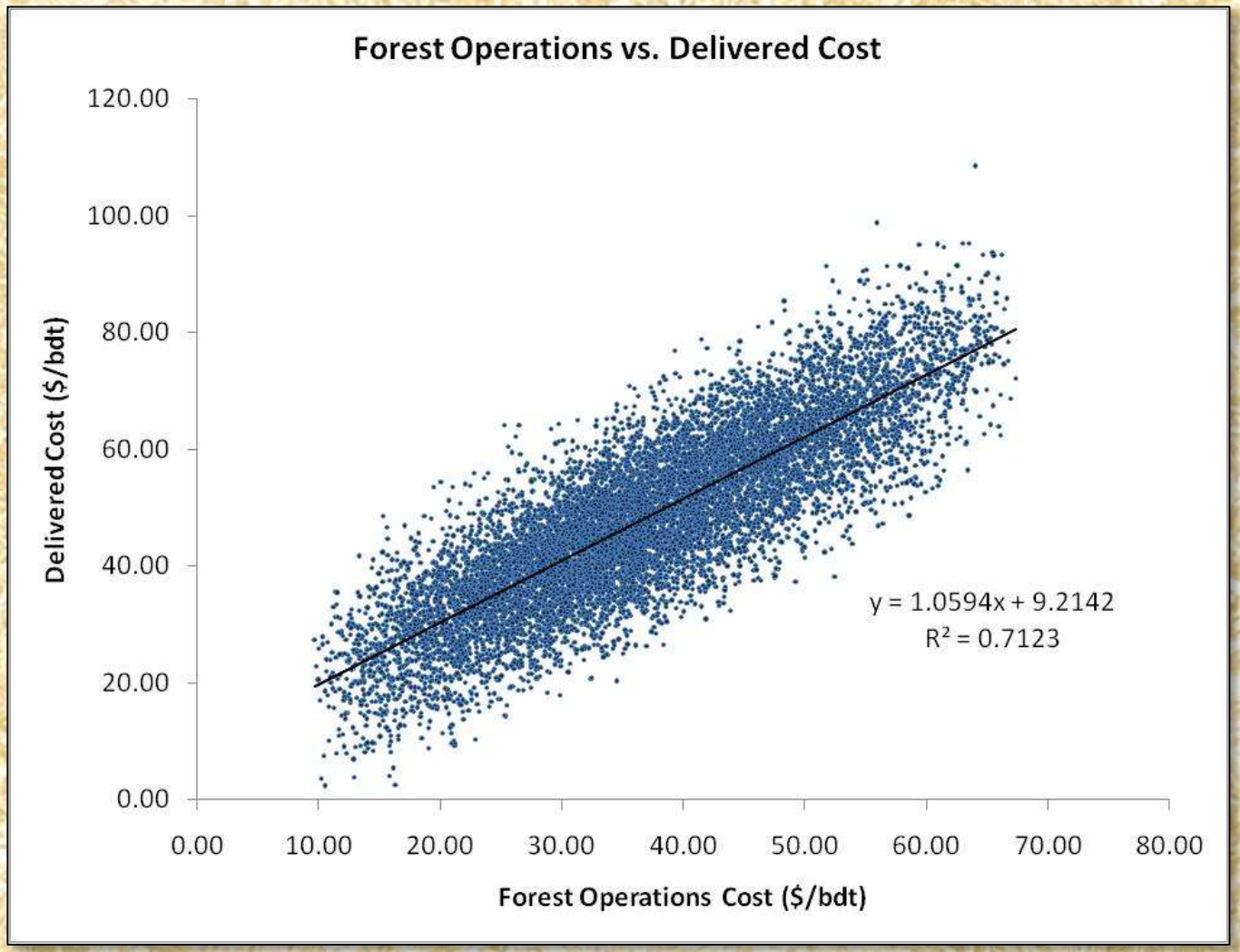
DCM: Methods


All Routes
Frequency (# of Tx units)
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
8
Round Trip Travel Time (hours)

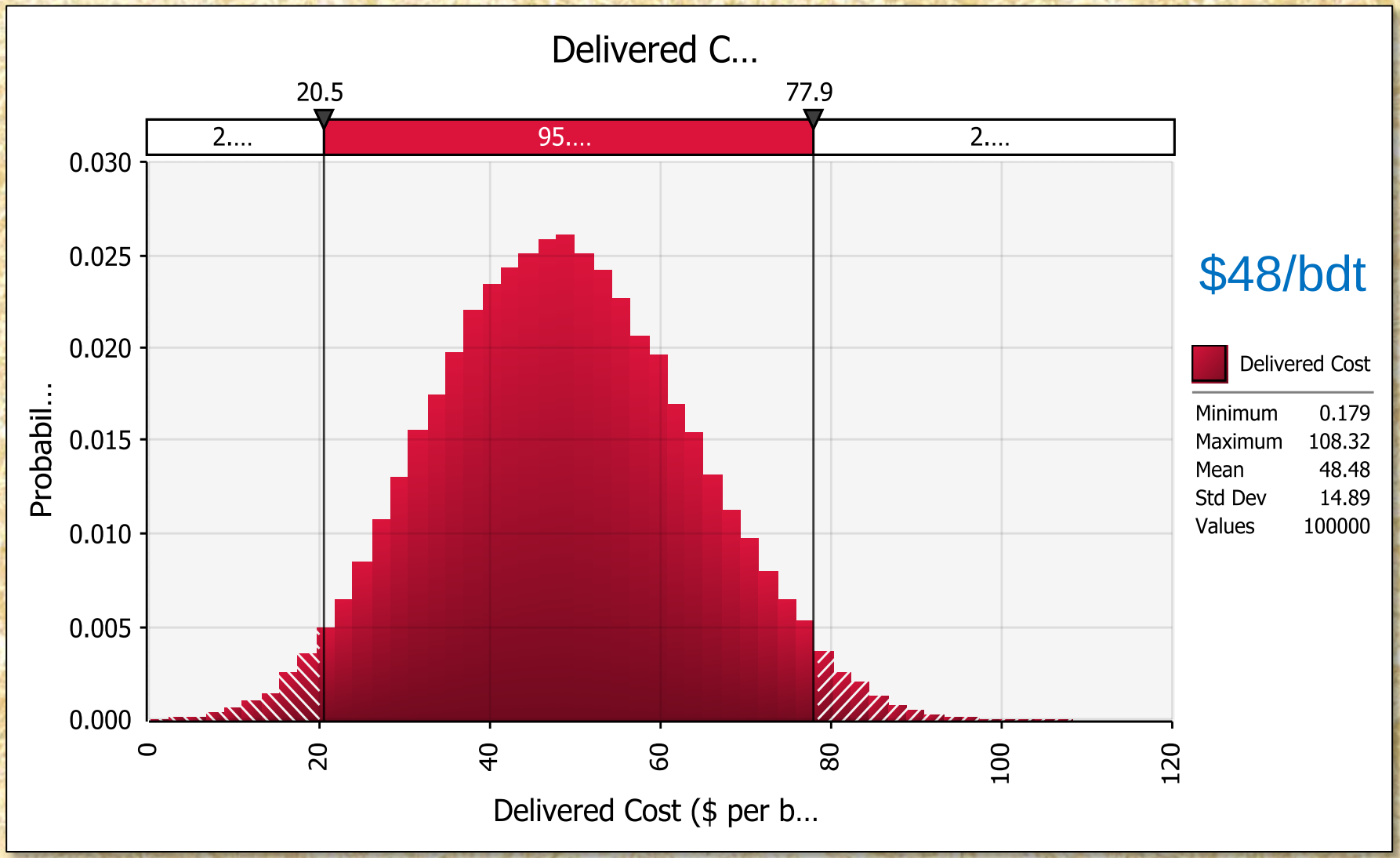
DCM: Methods


Stumpage vs. Delivered Cost
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Delivered Cost ($/bdt)
-25.00
-20.00
-15.00
-10.00
-5.00
0.00
5.00
Stumpage Cost ($/bdt)
y = 1.0062x + 55.706
R² = 0.157

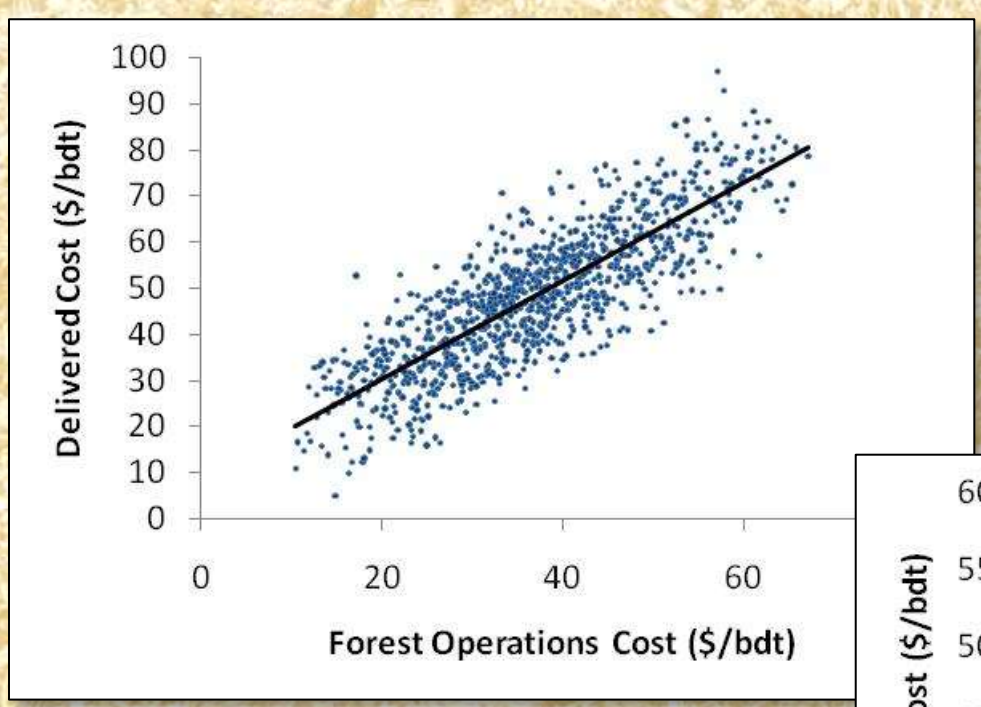
DCM: Methods

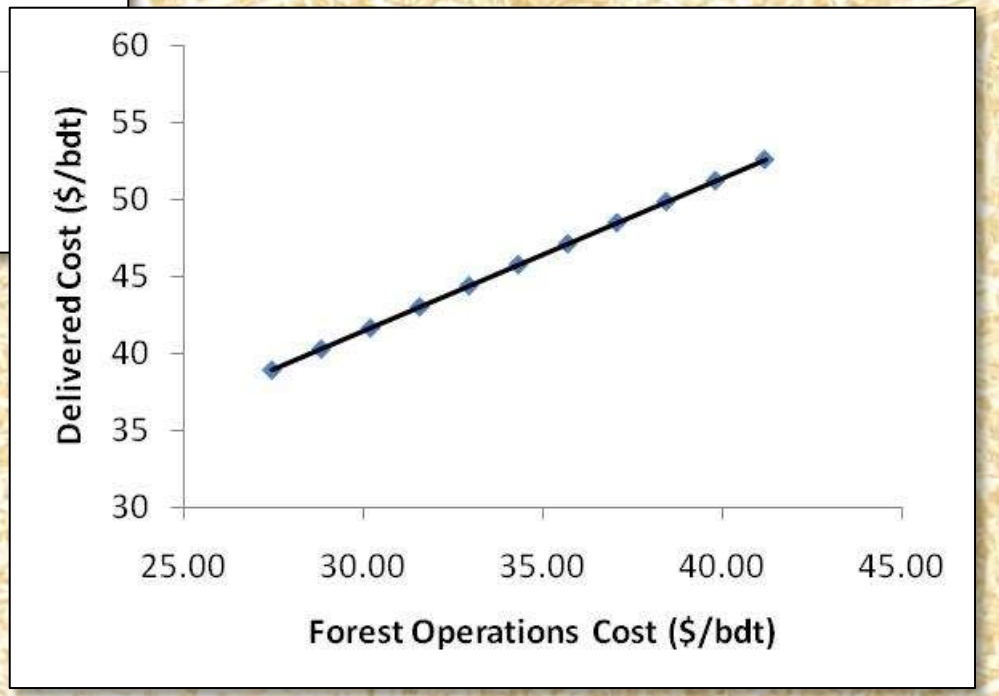

Forest Operations vs. Delivered Cost
Delivered Cost ($/bdt)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Forest Operations Cost ($/bdt)
y = 1.0594x + 9.2142
R² = 0.7123

DCM: Results


Delivered C...
20.5
77.9
2....
95....
2....
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Probabil...
0
20
40
60
80
100
120
Delivered Cost ($ per b...
$48/bdt
Delivered Cost
Minimum 0.179
Maximum 108.32
Mean 48.48
Std Dev 14.89
Values 100000

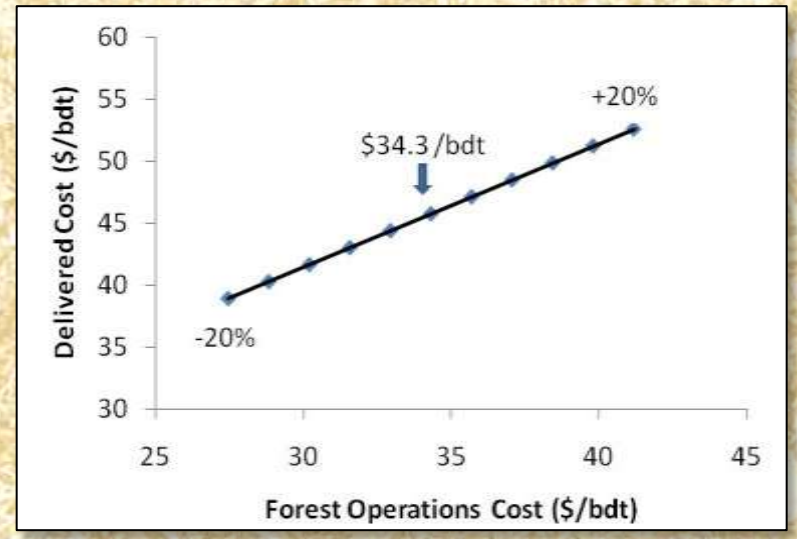
DCM: Sensitivity Analysis

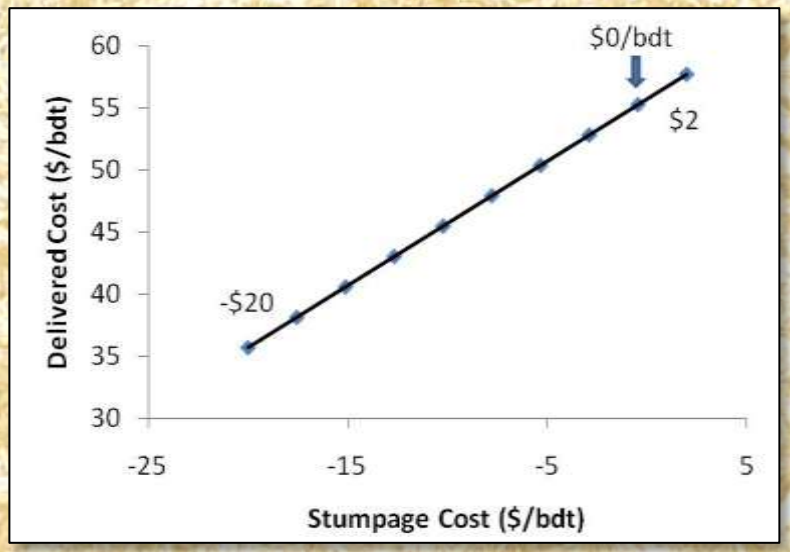


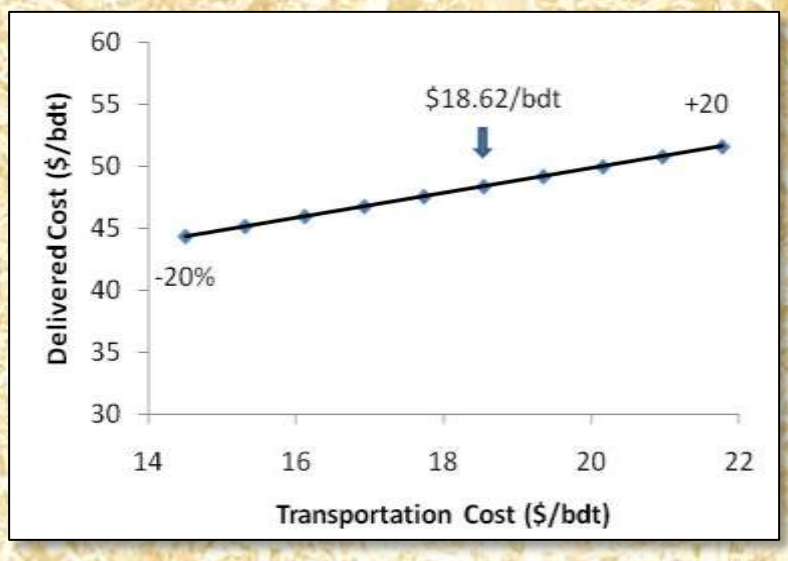


Control one variable, repeat simulation to plot average result

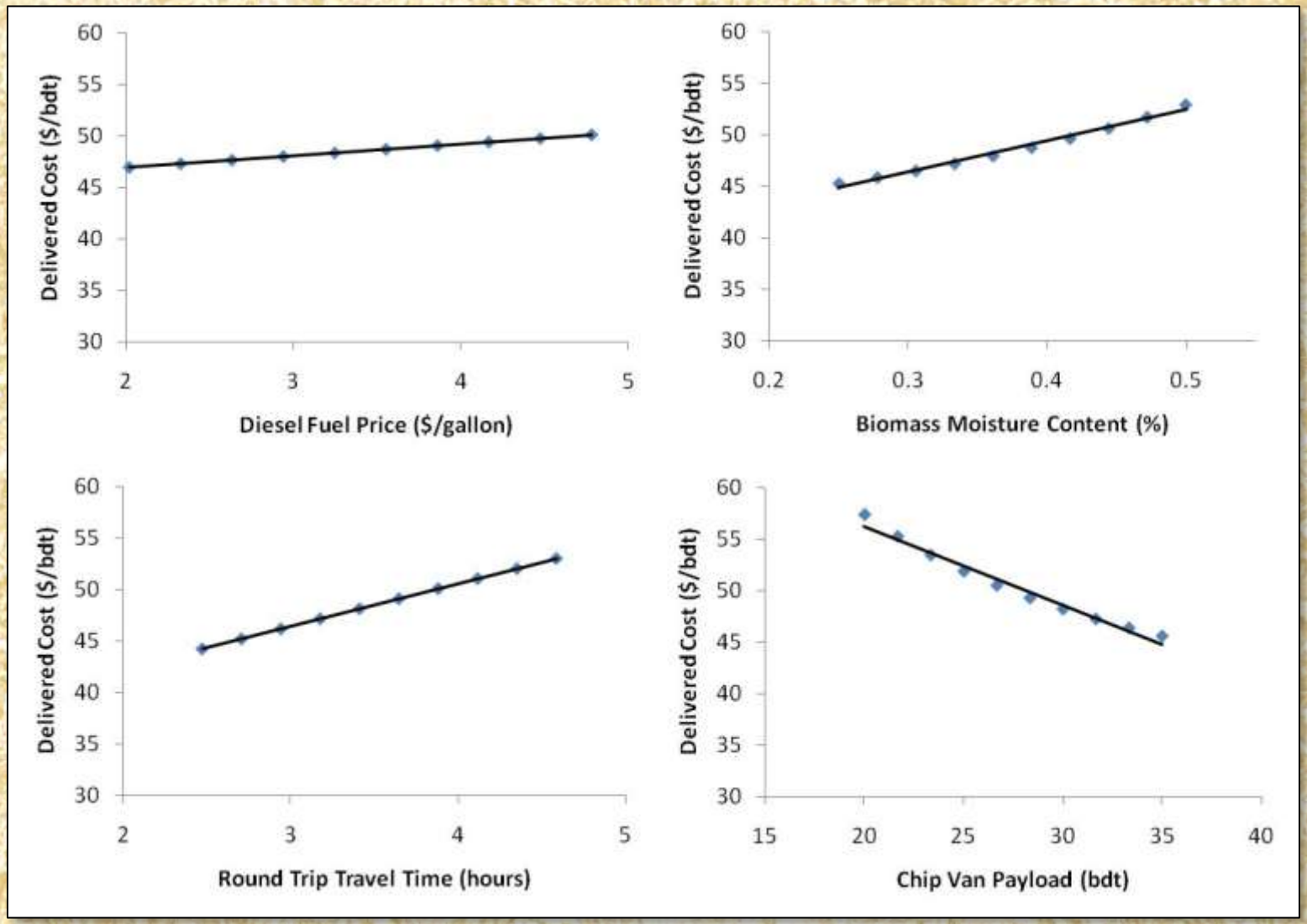
DCM: Sensitivity Analysis







DCM: Sensitivity Analysis



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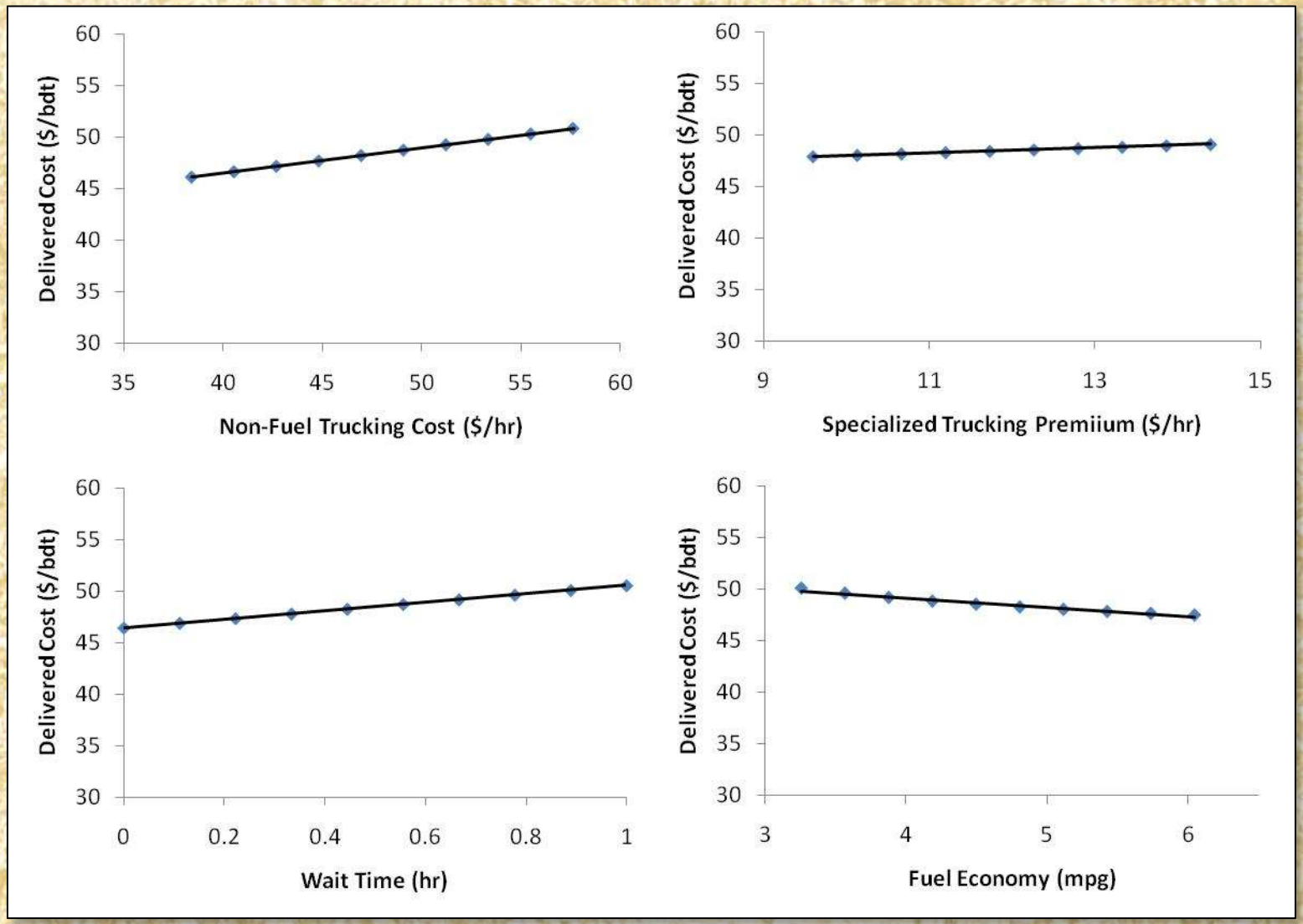


DCM: Conclusions

- $48.48 is a good place to start
- The effects of uncertainty and variation can be quantified and understood
- The current DCM should be improved

Emissions Analysis

Objectives

- Quantify emissions for utilization alternatives
- Understand tradeoffs

Methods

- CO_2, NO_x, SO_x, PM_{10}, CH_4
- Site-specific data combined with data from the EPA, EIA, scientific literature, and others
- Include all local sources (mine, transport, etc.)

Emissions: One Option

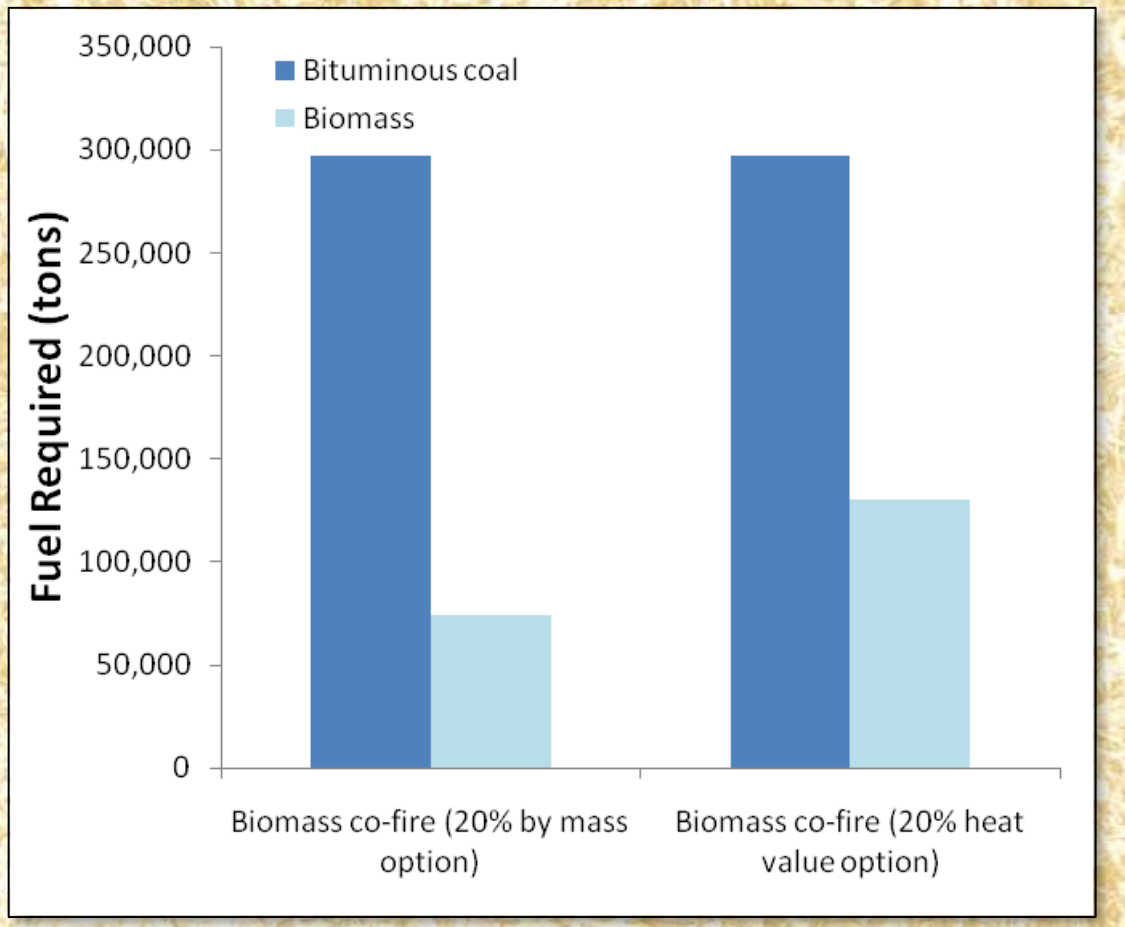
Tri-State's Nucla Power Station

- Member of Tri-State electricity cooperative
- Atmospheric circulating fluidized-bed combustion
- Bituminous coal fired – 100 MW generating capacity
- Plant operates approximately 8,000 hrs/yr with maximum heat input of 55.5 MMBtu, or about 55 tons coal/hr
- Environmental controls in place

Emissions: Methods

Two scenarios:

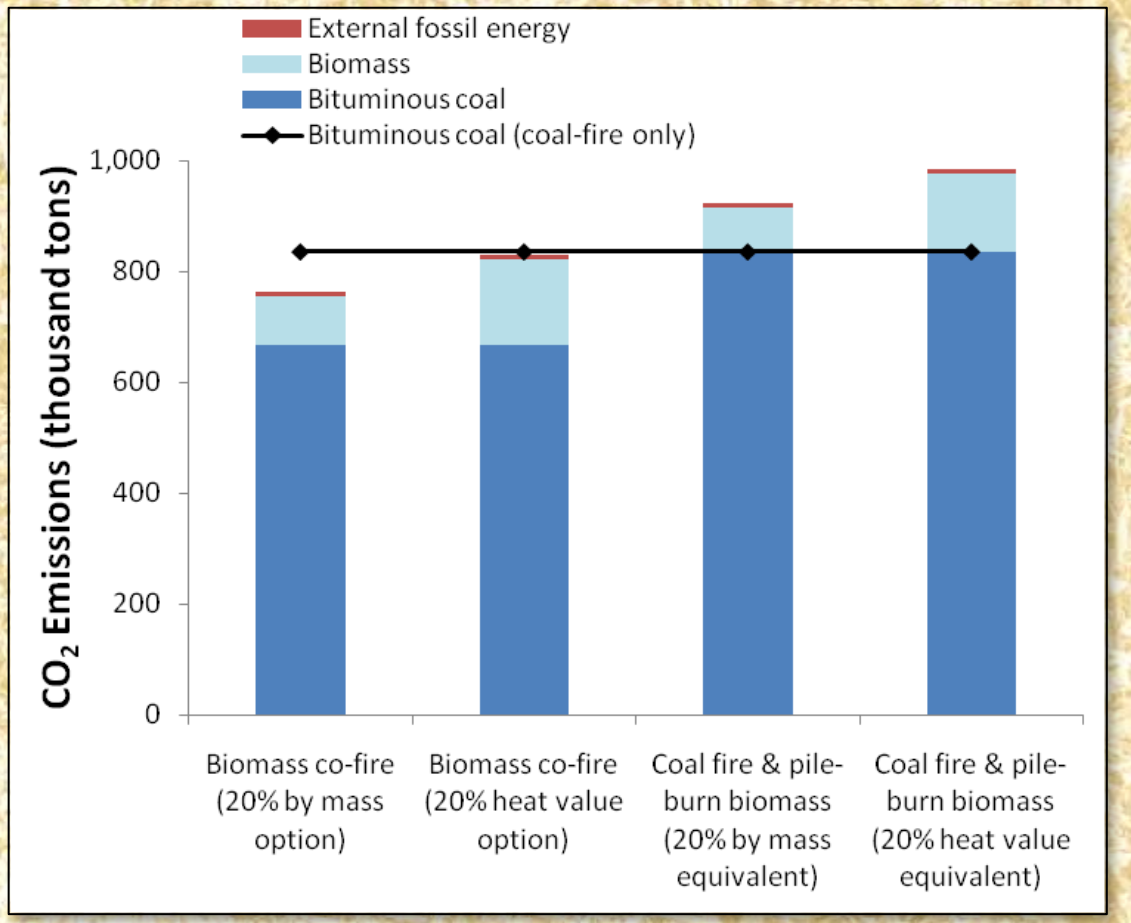
- 20% by mass
- 20% by heat



Emissions: Results

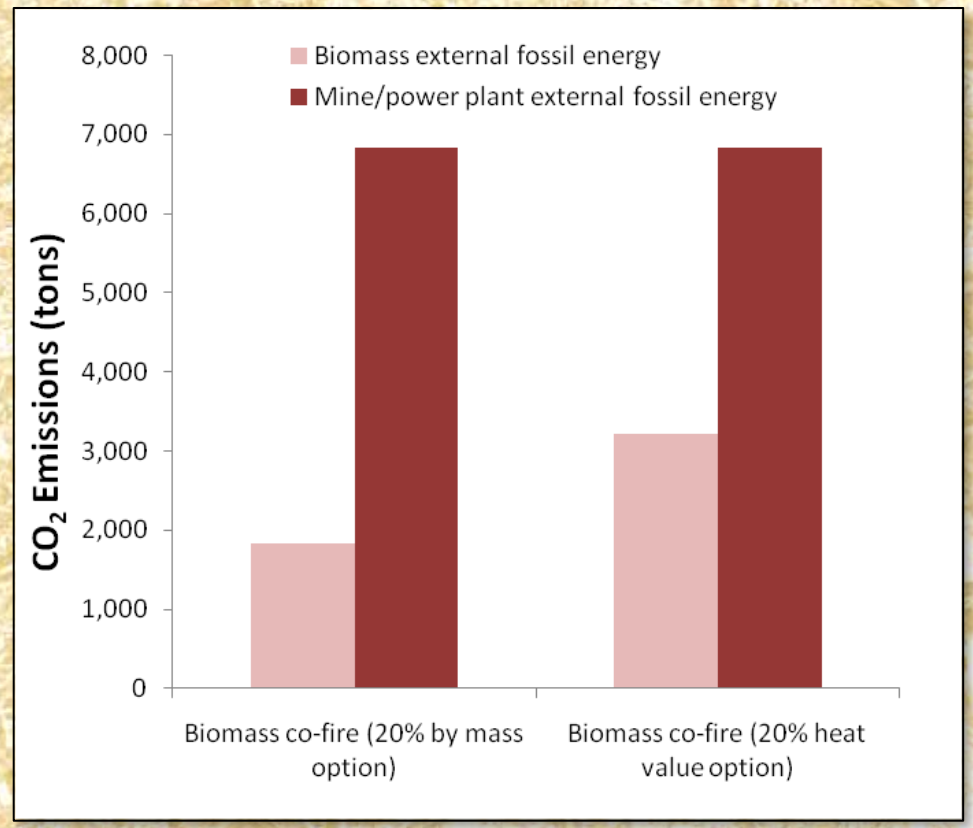
Big Fish, CO_2:

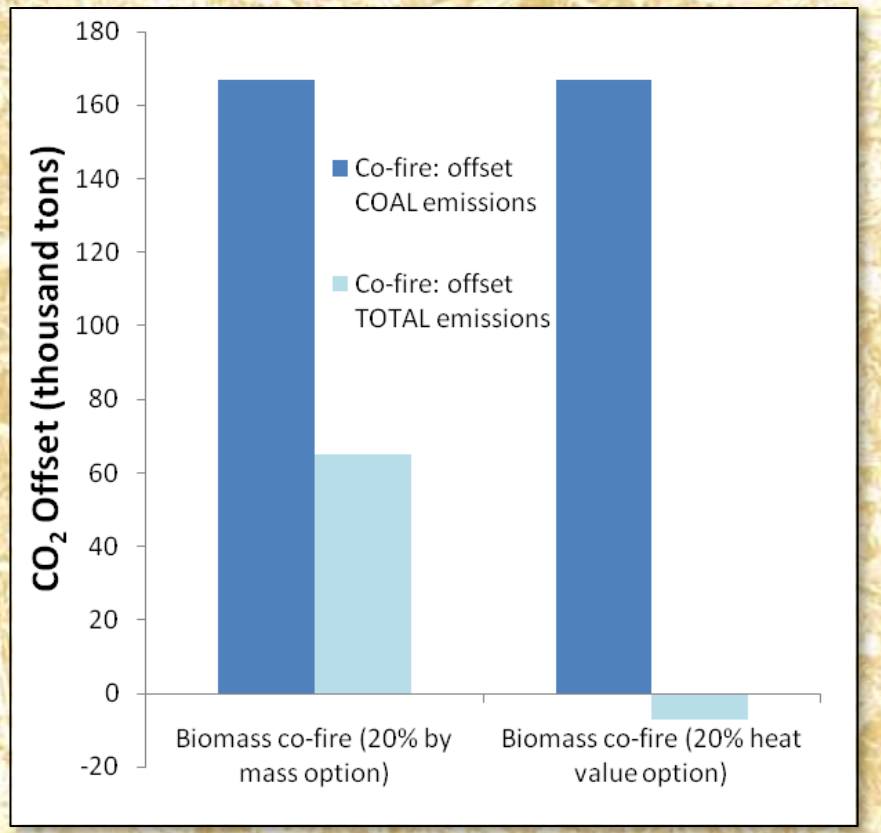
- Comparison
- Net reduction in CO_2 in both scenarios



Emissions: Results

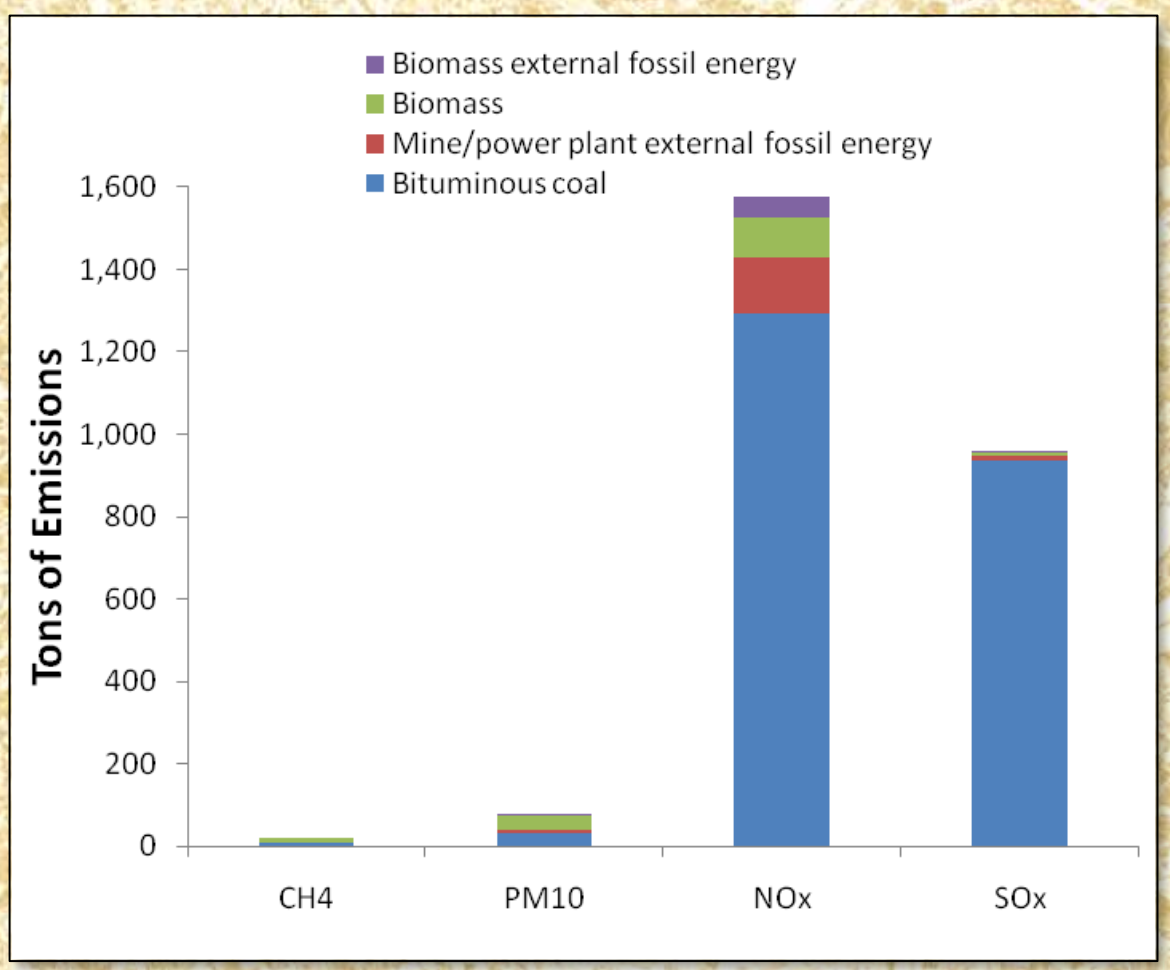
- A closer look…



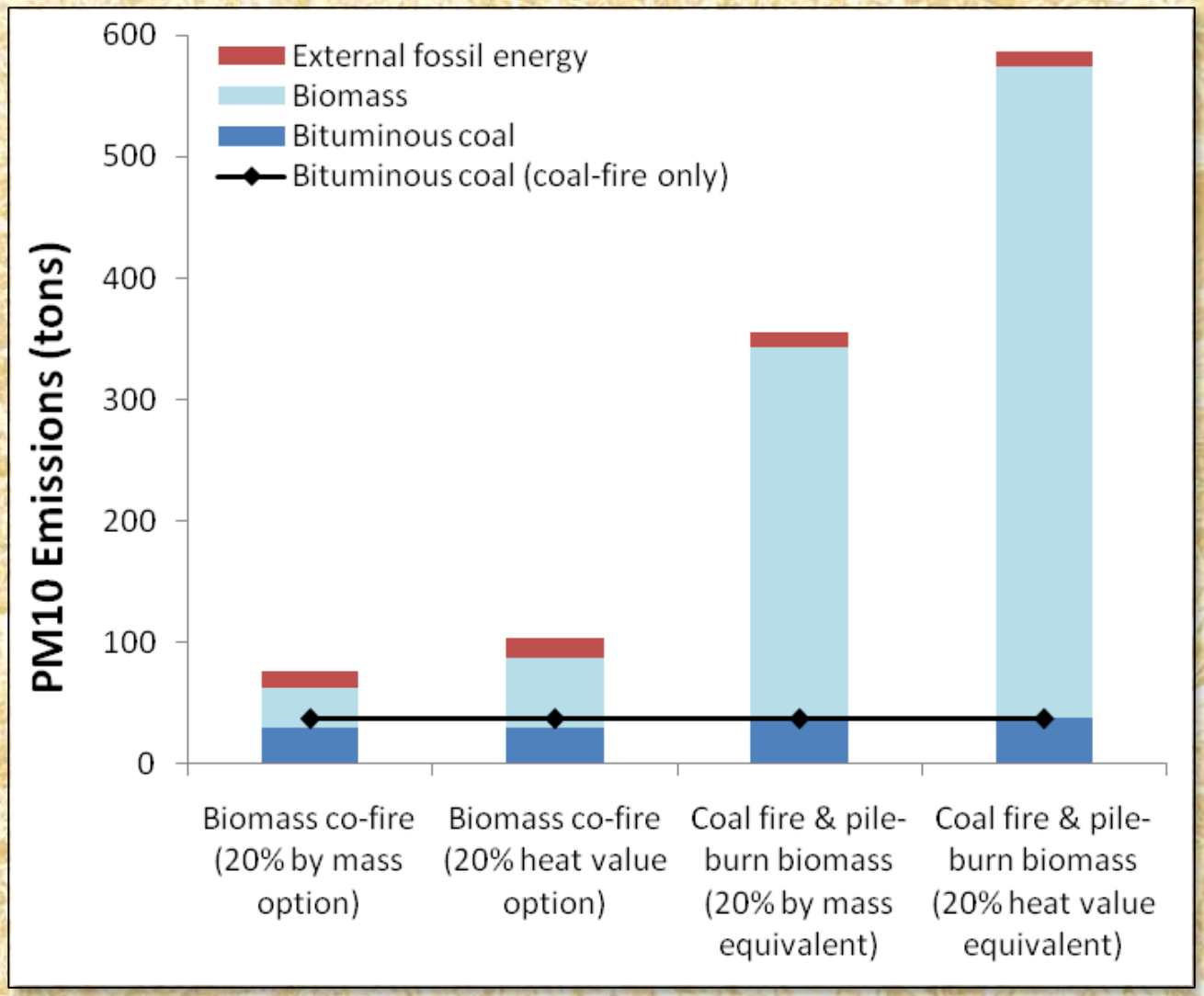


Emissions: Results

- Other emissions for 20% by mass option



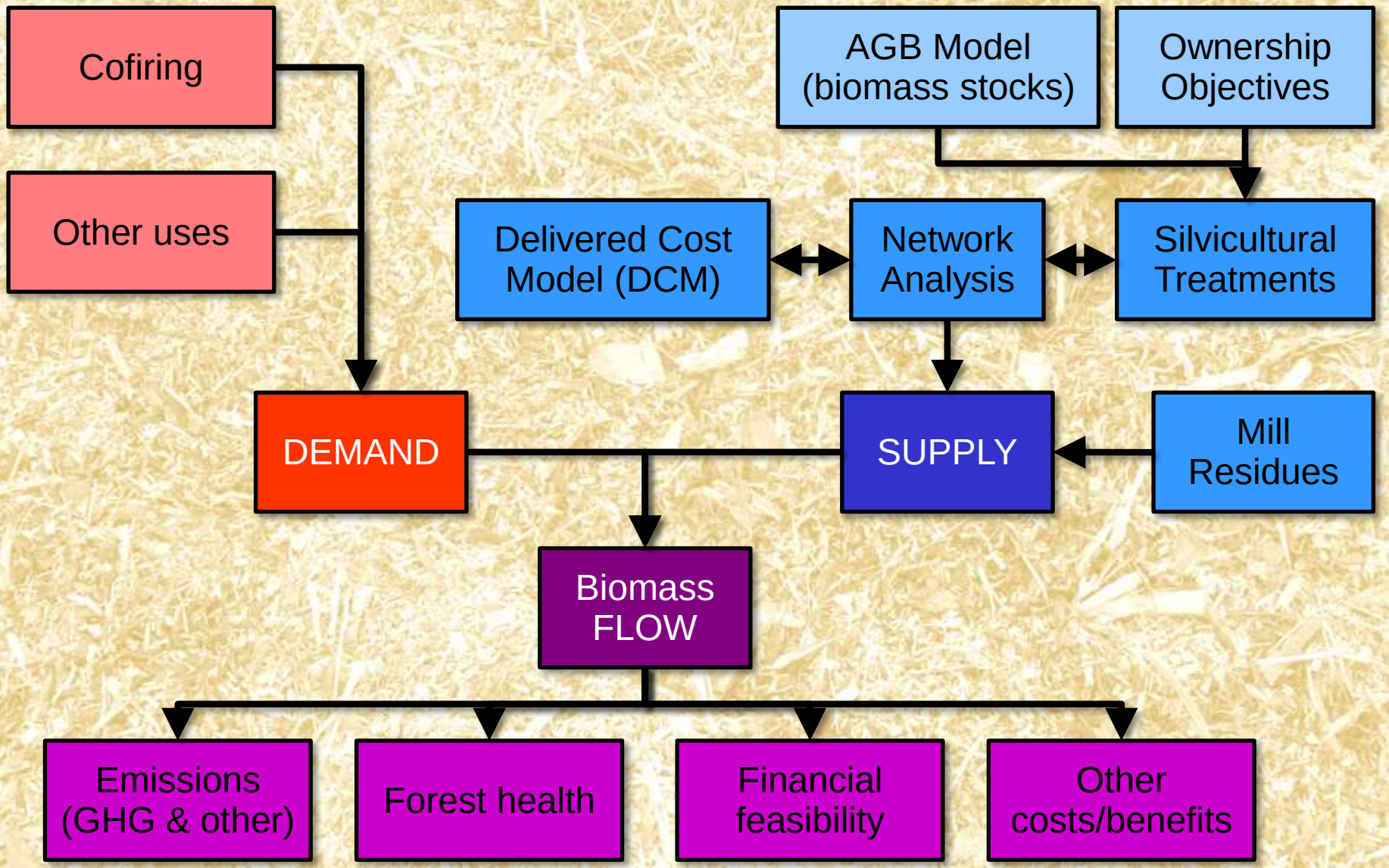
Emissions: Results



Emissions: Conclusions

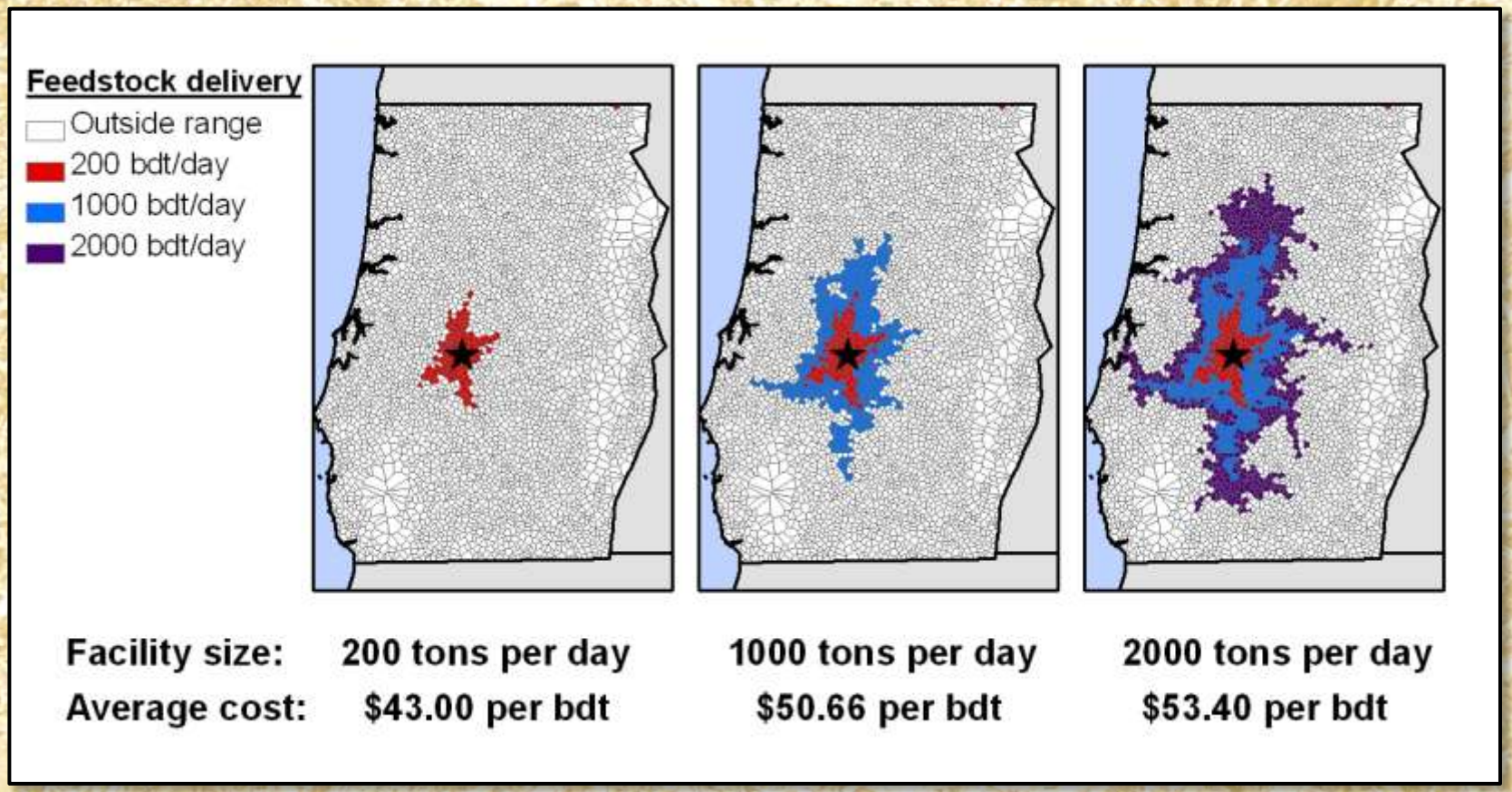
- Transportation emissions are important, but not as important as many people think
- Interpretation of results depends on:
  - Is fossil CO_2 different than biomass CO_2?
  - Are other emissions important?
  - Is open burning likely?
  - Are non-market values in play?

Synthesis and Work Ahead



Synthesis and Work Ahead

- Stocks + Logistics = Flow
- *How much <u>at what cost?</u>*



Research Personnel

Rocky Mountain Research Station

- Nate Anderson, Research Forester
- John Hogland, Biological Scientist
- Greg Jones, Research Forester

University of Montana

- Woodam Chung, Associate Professor
- Dan Loeffler, Economics Research Associate
- Edward Butler, GIS Research Associate

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  - Uncompahgre Partnership
  - Public Lands Partnership
  - CSU- CFRI
  - Intermountain Resources
  - Delta Timber
  - Tri-State and DMEA
  - Phil Seligman and other stakeholders

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