SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

Biodiesel Supply Chain Optimization

in the northern Great Plains region

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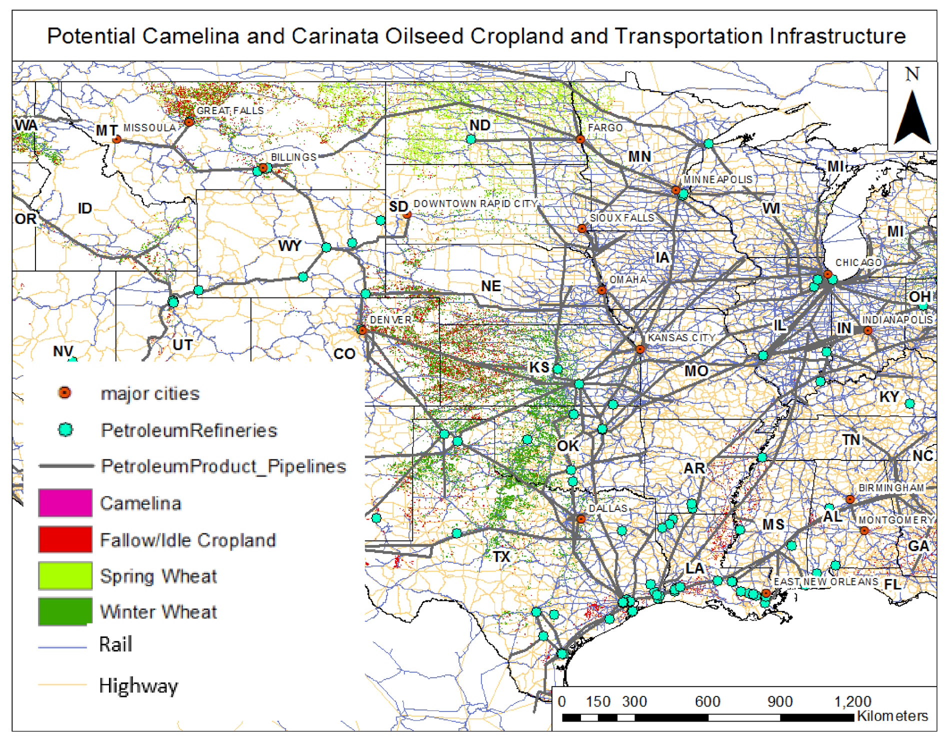
BACKGROUND

OILSEED CROP

Camelina sativa *Brassica carinata*

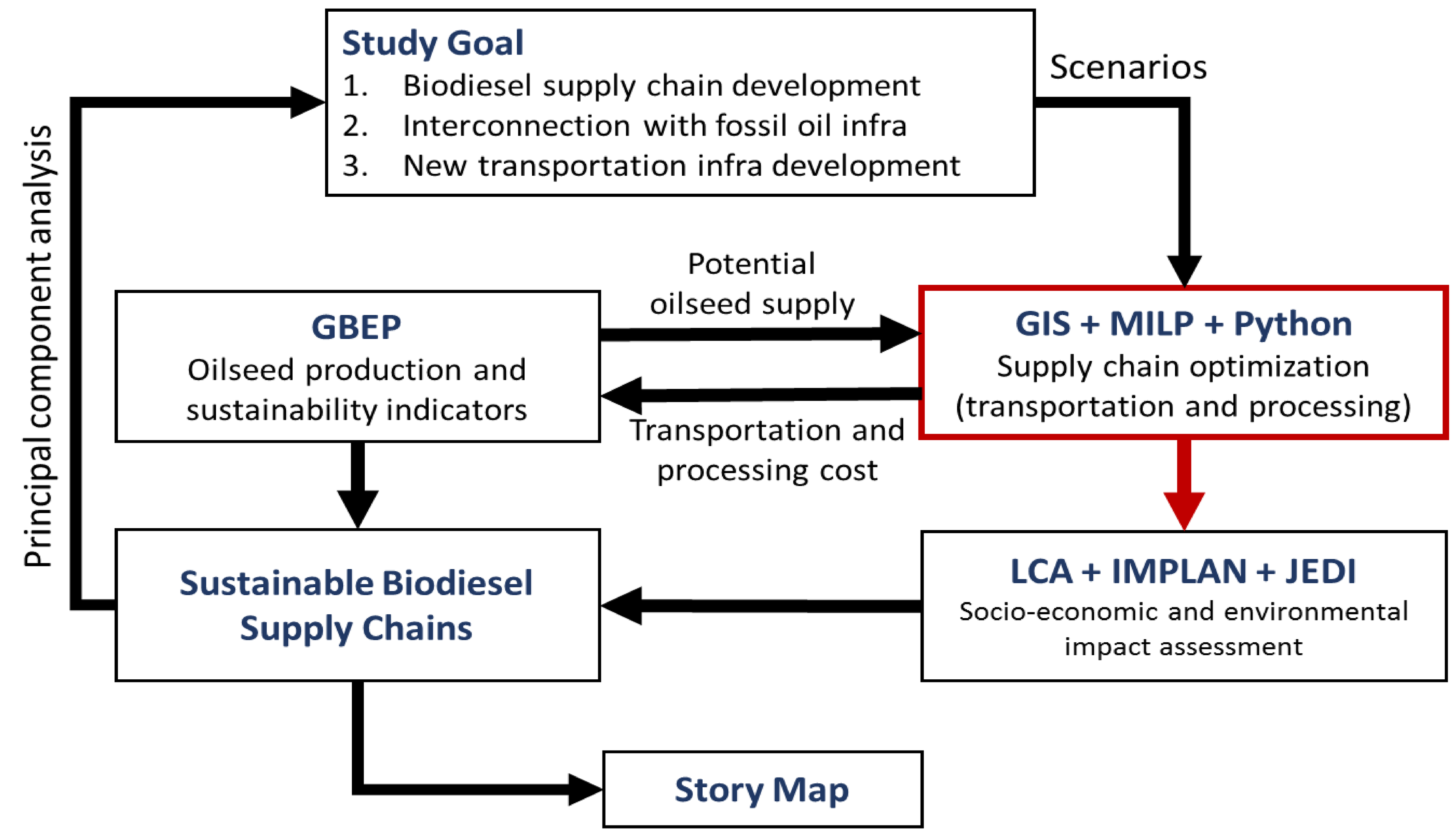
- Non-food crop
- Low water and fertilizer use
- Increasing organic carbon content in soil
- Feasible for double cropping with wheat in western South and North Dakota and eastern Montana and Wyoming

INFRASTRUCTURE



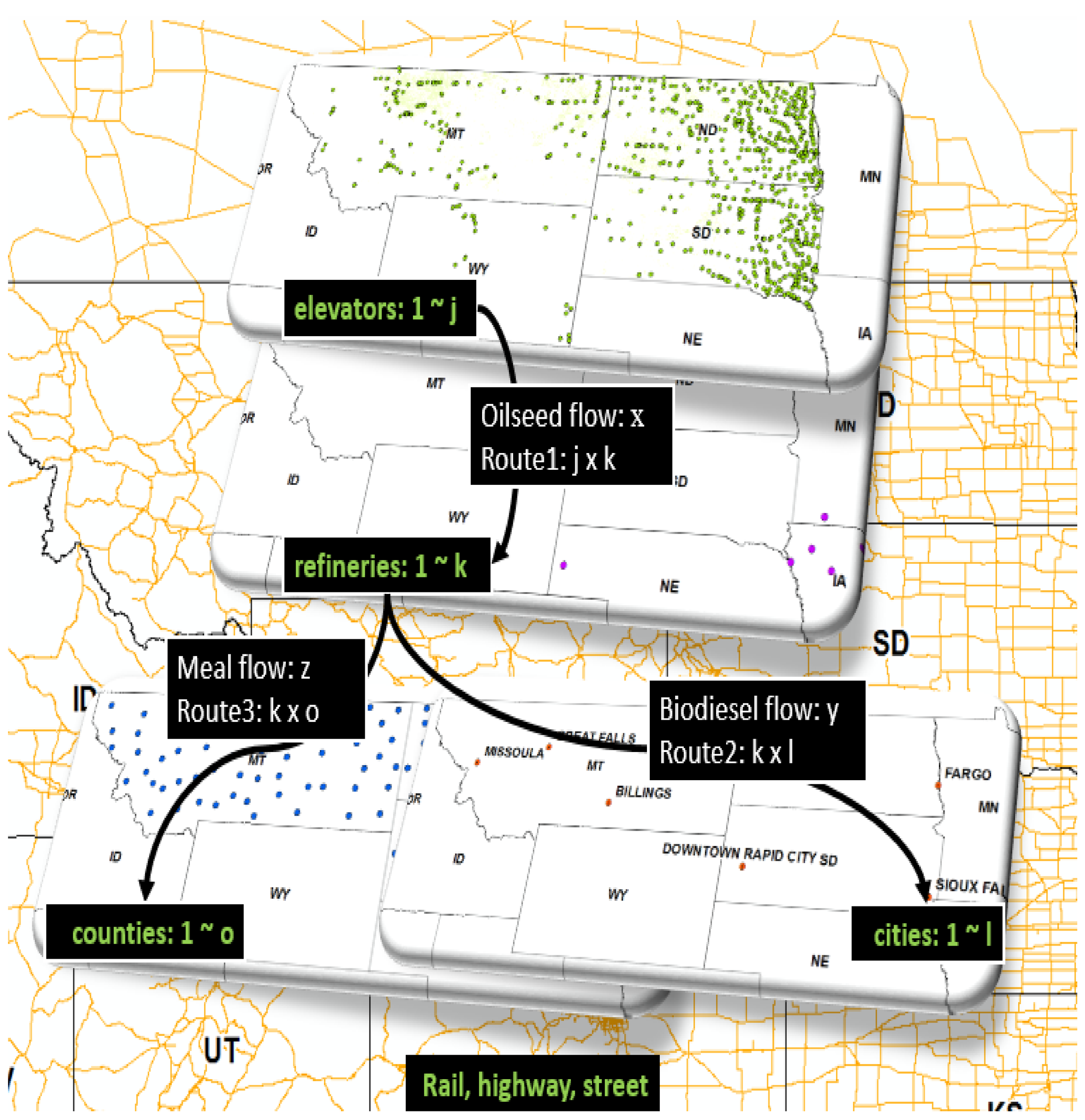
- Low infrastructure density
- Fossil oil facility and infrastructure
- Oilseed meal use for livestock

STUDY APPROACH



OPTIMIZATION PROCESS

GIS DATA and NETWORK ANALYSIS



MIXED INTEGER LINEAR PROGRAMMING

Assignment of oilseed, biodiesel, and oilseed meal loads to routes for Min. transportation cost

$$Min\ C_T = Min\left(\sum_j \sum_k T_{jk}^s x_{jk}^s + \sum_k \sum_l T_{kl}^d y_{kl}^d + \sum_k \sum_m T_{km}^m z_{km}^m\right)$$

The minimum transportation cost is computed according to the following constraints.

Objective constraint

For cities l = n,

$$\sum_k y_{kn}^d = D_n^d$$

Mass balance constraints

For refineries k = n,

$$\sum_j x_{jn}^s \times f_{sd} = \sum_j y_{nl}^d$$

$$\sum_j x_{jn}^s \times f_{sm} = \sum_j z_{no}^m$$

Capacity constraints

For elevators j = n,

$$\sum_k x_{nk}^s \le E_n$$

For refineries k = n,

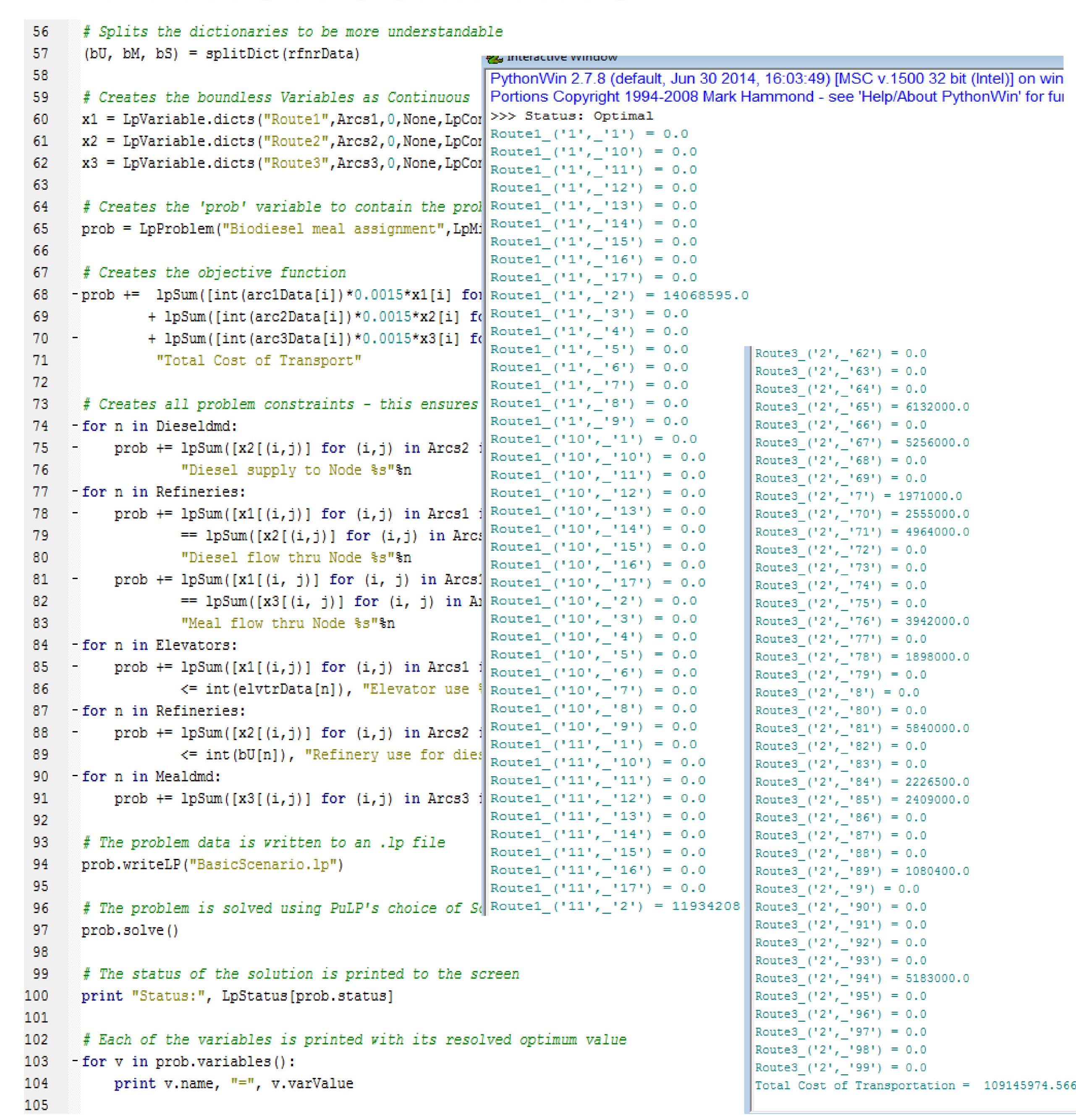
$$\sum_l y_{nl}^d \le R_n$$

For counties o = n,

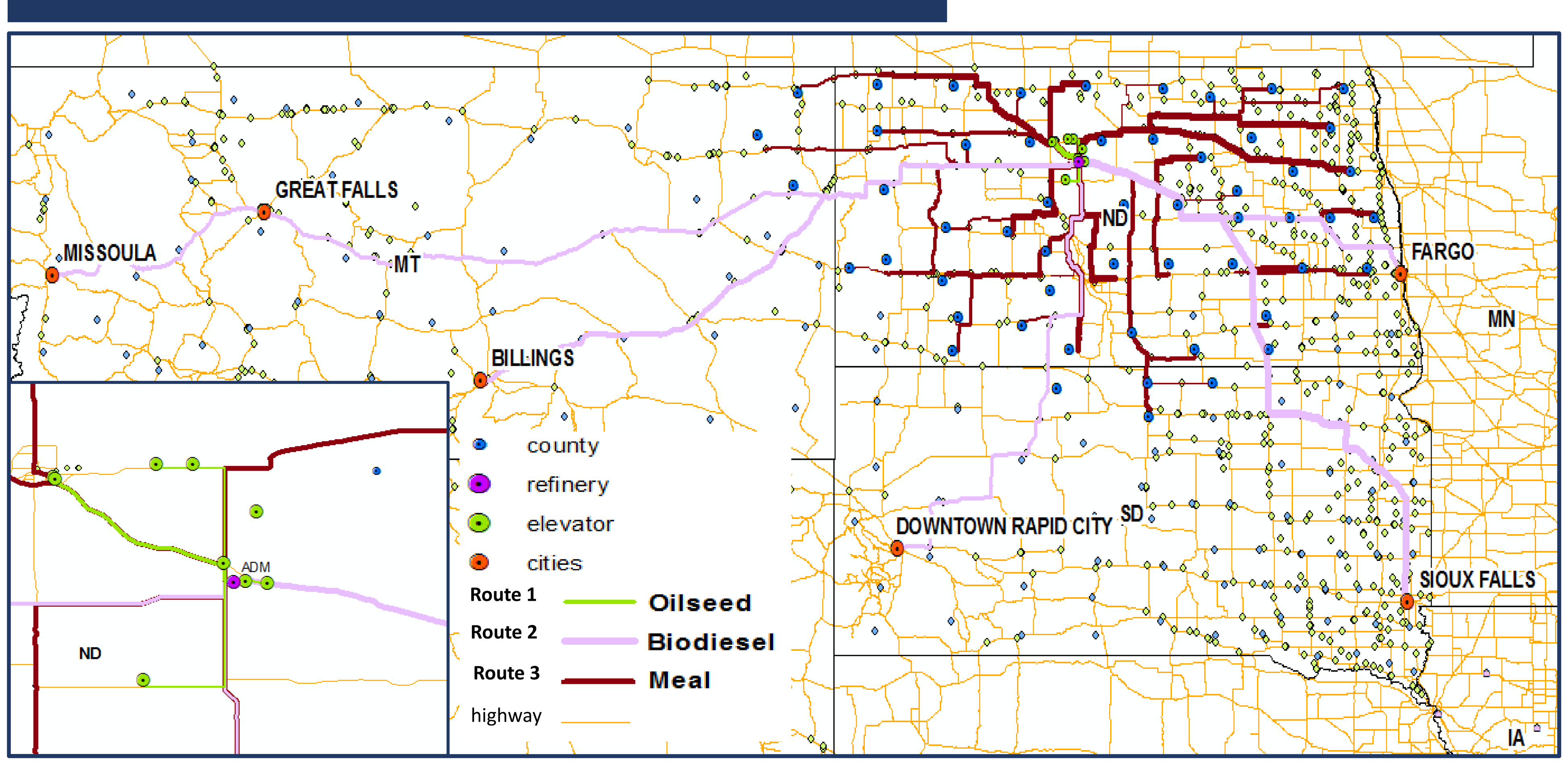
$$\sum_l z_{kn}^m \le L_n$$

Variables	x_{jk}^s	Flow of oilseed s from elevators j to refineries k
	y_{kl}^d	Flow of biodiesel d from refineries k to cities l
	z_{ko}^m	Flow of livestock meal m from refineries k to counties o
Parameters and factors	E_j	Oilseed collection and storage capacities of elevators j
	R_k	Biodiesel production capacities of refineries k
	L_o	Oilseed meal demand of counties o
	T_{jk}^s	Transportation cost per unit amount of oilseed s from elevators j to refineries k, $/kg
	T_{kl}^d	Transportation cost per unit amount of biodiesel d from refineries k to cities l, $/kg
	T_{ko}^z	Transportation cost per unit amount of livestock meal m from refineries k to counties o, $/kg
	D_l^d	Demand of biodiesel d in cities l
	D_o^m	Demand of oilseed meal m in counties o
	f_{sd}	Conversion factor from oilseed s to biodiesel d, 0.316
	f_{sm}	Conversion factor from oilseed s to oilseed meal m, 0.6

PYTHON SCRIPTING



PRELIMINARY RESULT



Target:
20% replacement of diesel use in 6 cities

5% of potential oilseed production
6% of total meal demand
32% of total oilseed meal demand

Transportation cost:
$110 million/yr (highway)

- 4%: oilseed (0.013 $/kg)
- 61%: biodiesel (0.591 $/l)
- 35%: oilseed meal (0.215 $/kg)

RESEARCH DIRECTIONS

- Use advanced transportation network
- Consider new refinery construction
- Add processing cost
- Integrate existing fossil-oil refineries and transportation modes
- Design new infrastructure development
- Match transportation and processing cost with oilseed production potential
- Integrate environmental and socio-economic impacts

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