Evolving Supply Chains & Local Freight Flows:

A GIS Analysis of Minnesota Cereal Grain Movement

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TPEC TRANSPORTATION POLICY AND ECONOMIC COMPETITIVENESS

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Grain and the Minnesota Economy

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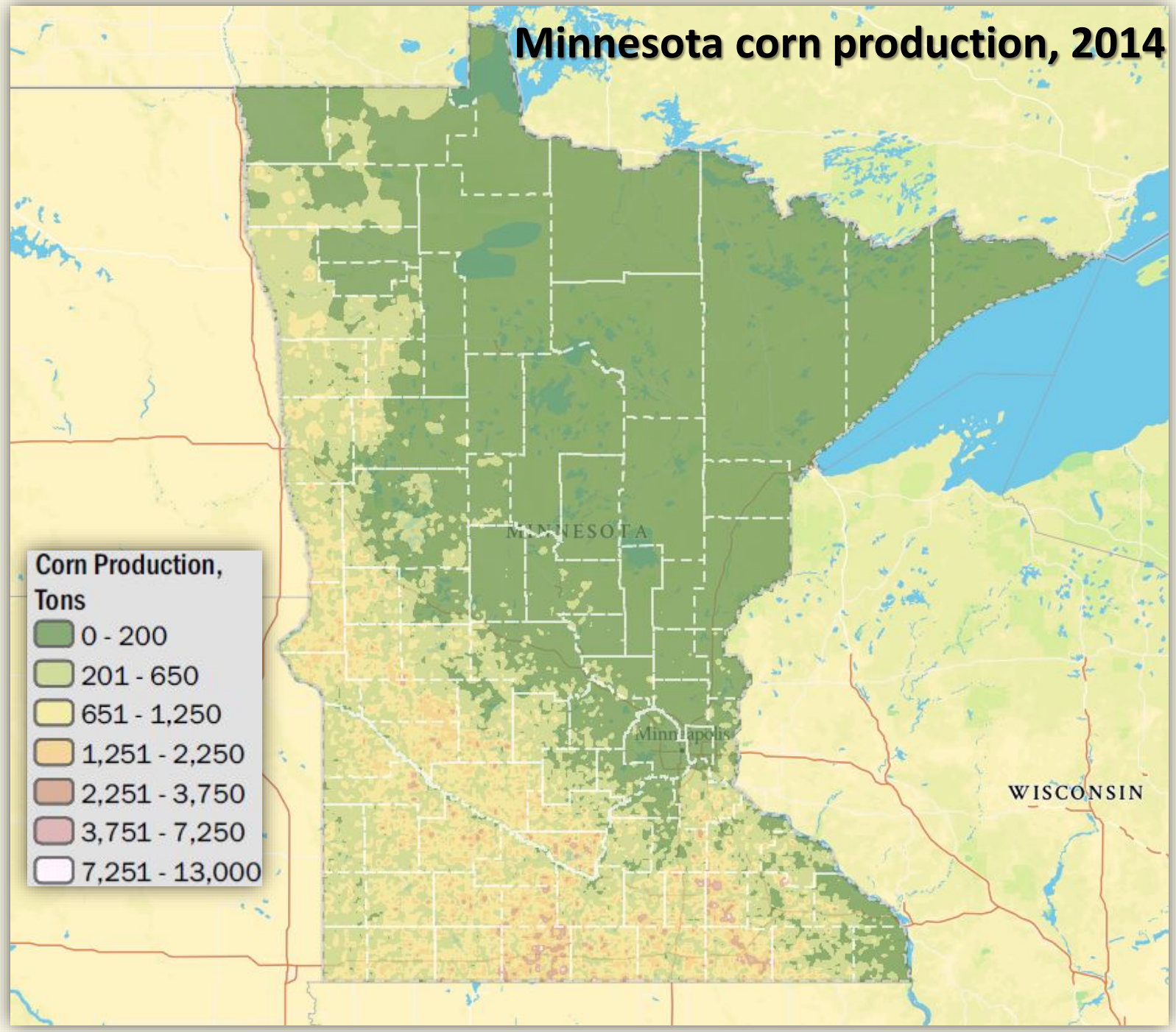
Quick MN grain facts

- 340,000 state residents work in Minnesota's agriculture sector
- 28 percent of all freight on state roadways is grain-related
- Produced 43.2 million tons in corn, 11.7 million in soybeans
- $5 billion in corn sales

Minnesota corn production, 2014



MNDOT looks to improving freight network

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[There is a] need to recognize and adapt to evolving supply chain operations. Changing definitions of "value" have led modern supply chains to operate on a just-in-time schedule... This has changed the nature of the freight transportation system, increasing the need for resiliency and redundancy across all transportation modes and along the supply chain

(MnDOT 2016: pg. 51)

So where does all that grain go?

- Overview of the evolving grain supply chain
  - A focus on roads
- GIS and grain flow modeling
  - Commodity-based approach
    - Visualizing disaggregated CFS data
    - Simulating county-level, producer behavior
- Informing strategic freight network investment decisions
  - Value-added, grain-derived markets
  - Multi-modal carriers (i.e., rail, barge)
  - Load-weight restrictions
- Learn more at freighteconomyatlas.org!

An evolving grain supply chain

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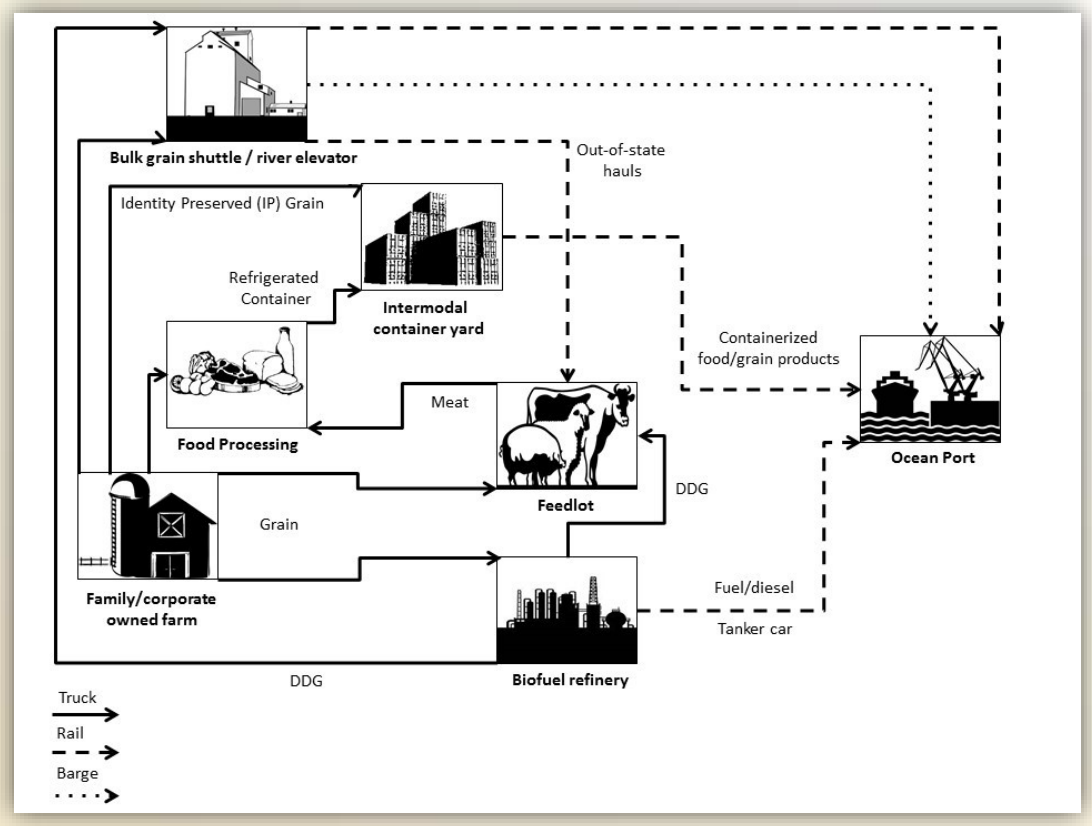
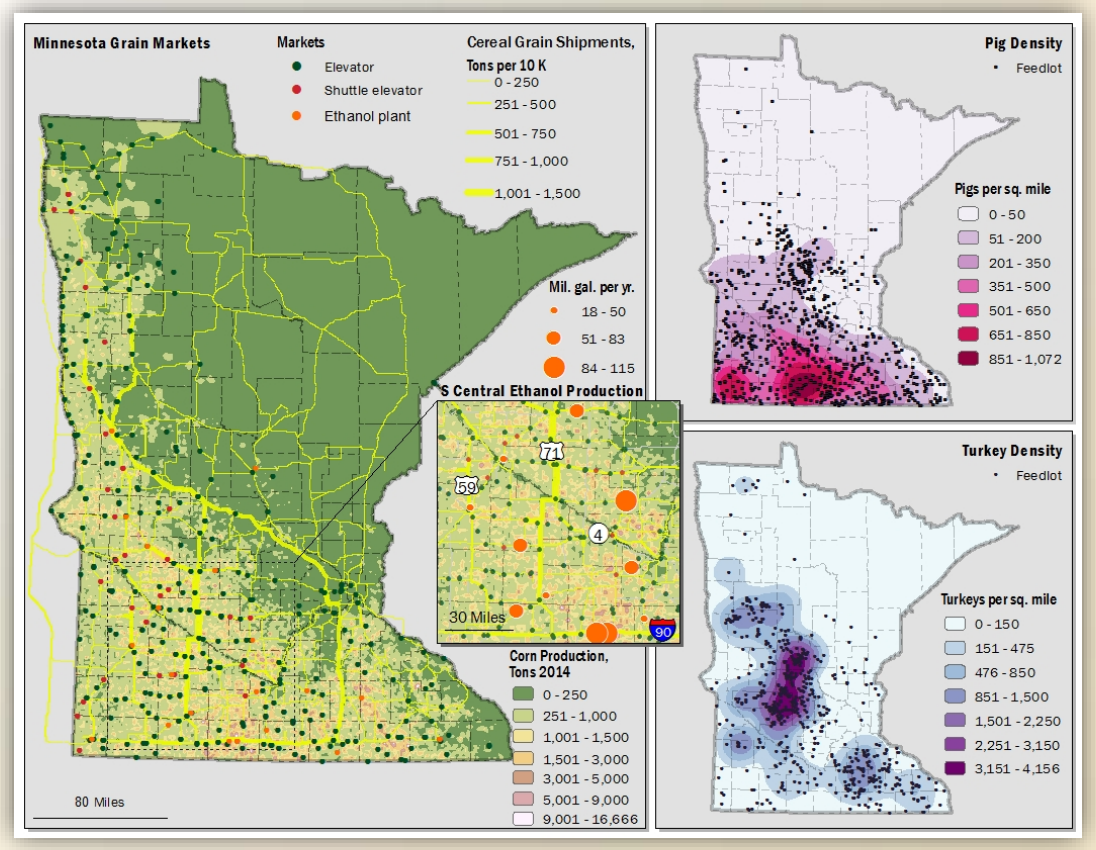
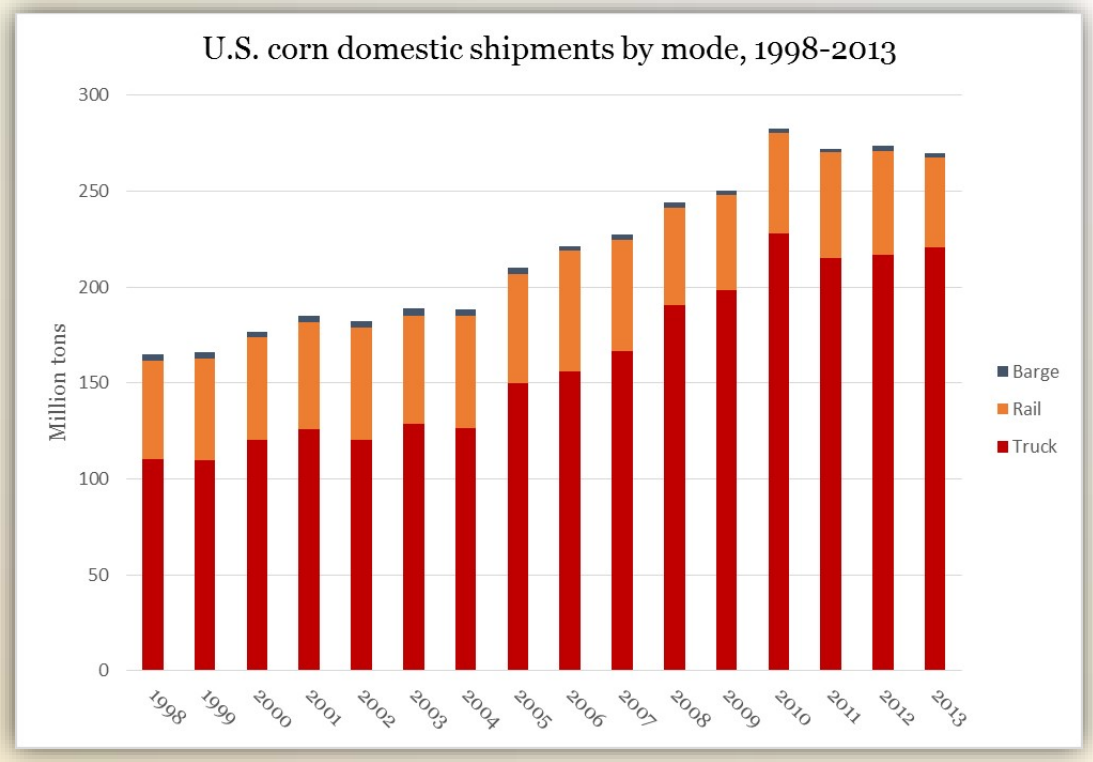
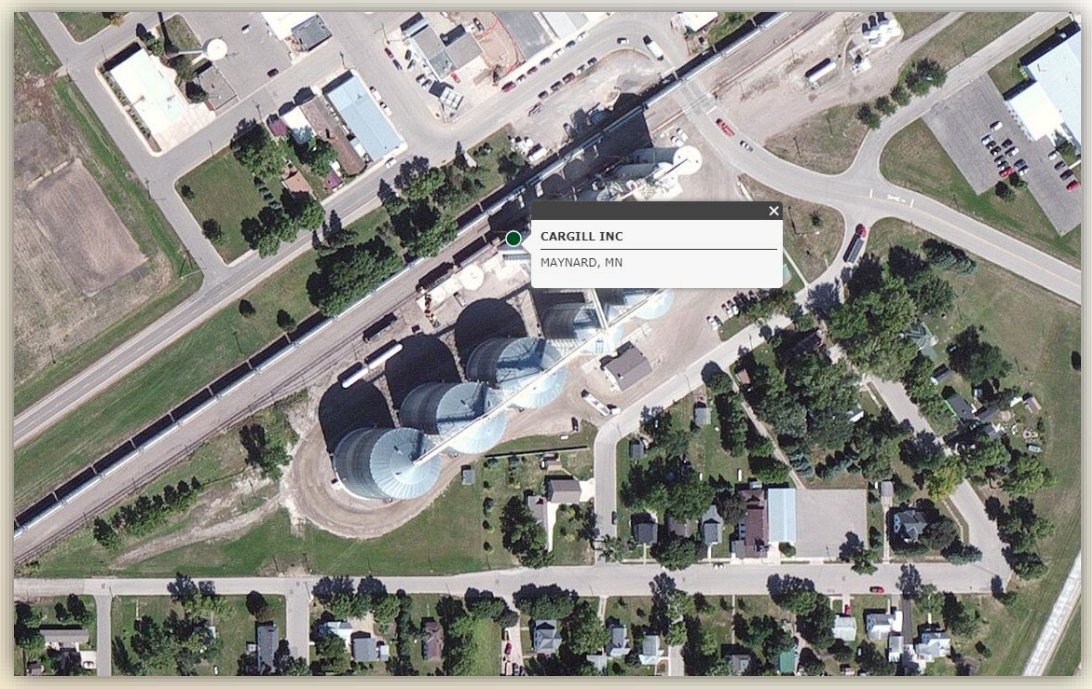


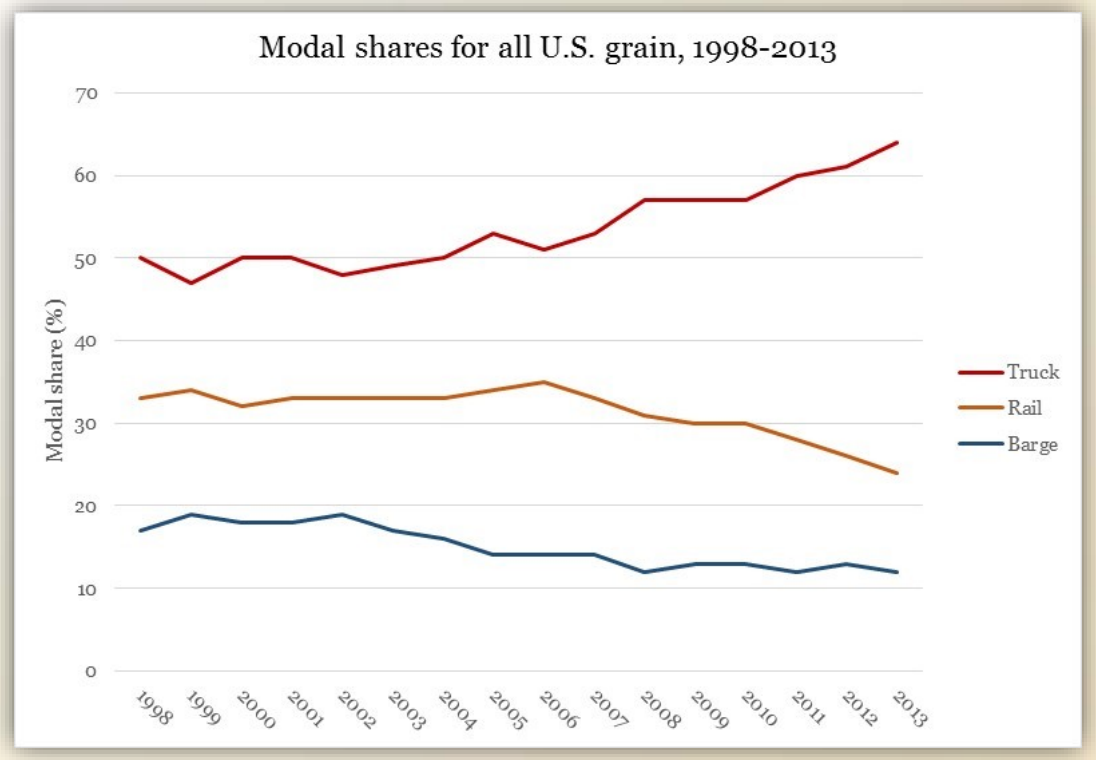


Industry focus—Ethanol



Industry focus—Railroads





"In Minnesota and elsewhere, farmers are [trucking] more outputs over longer distances compared to the previous pattern where farmers would focus on short moves to local consolidation points and rail terminals"

(MnDOT 2016)

Mapping grain flow—CFS Analysis

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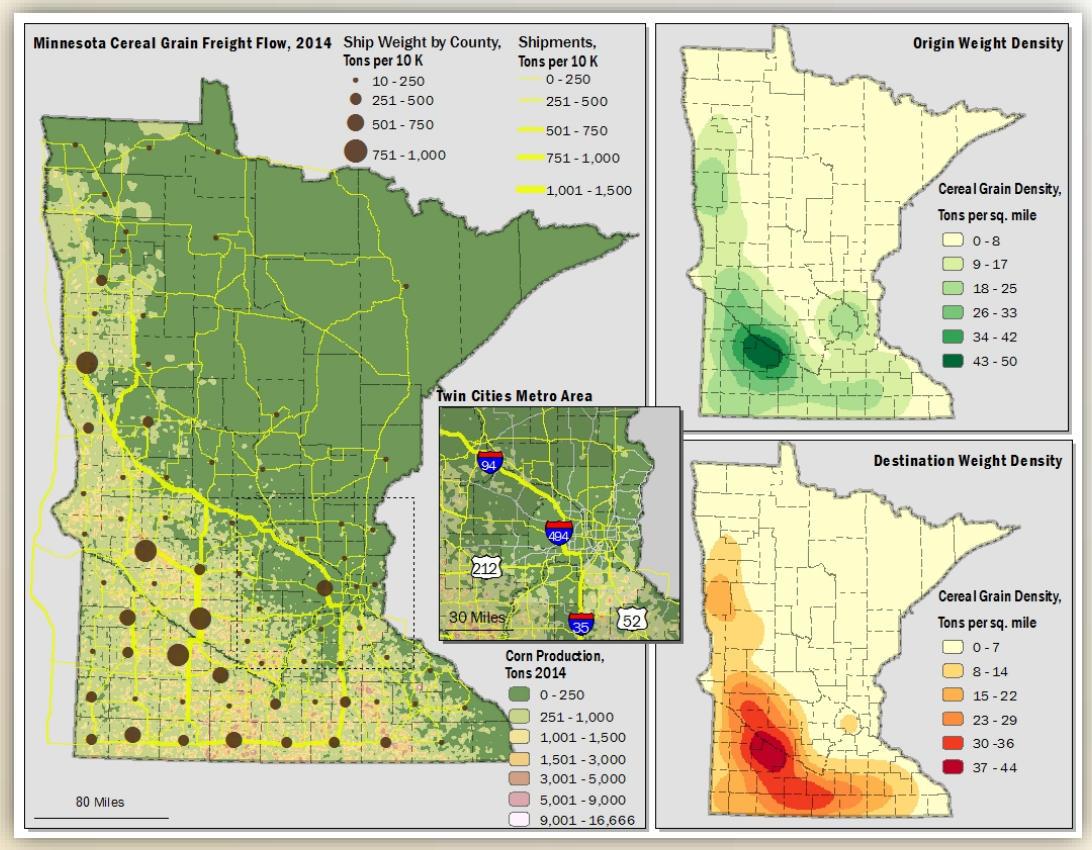

U.S. Department of Transportation
Federal Highway Administration

USDA NASS
National Agricultural Statistics Service

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Minnesota Geospatial Commons

Identifying grain related bottlenecks

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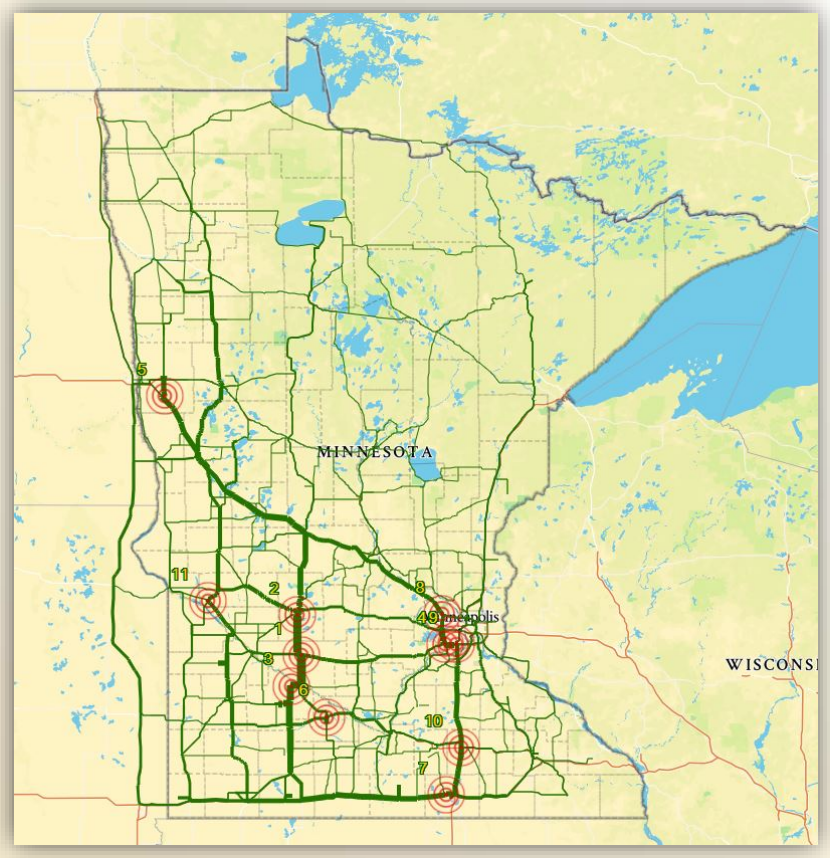

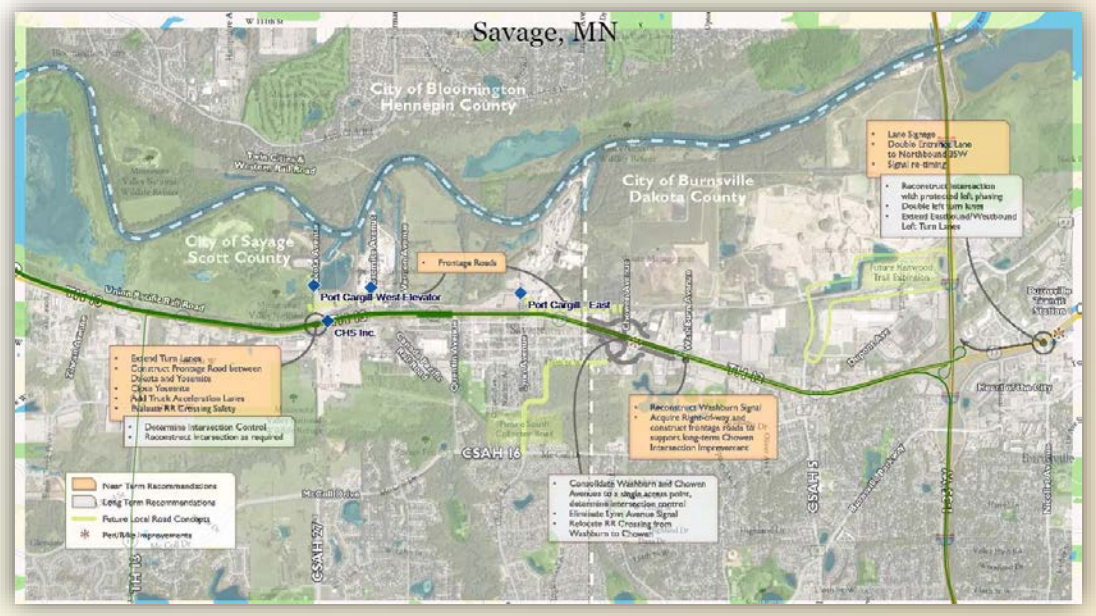

Mapping grain-flow— a micro-level, optimized approach

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- Grain flow impact from Snake River Drawdown, East Washington
  - E. Jessup & J. Ellis (1990)
- Upper Great Plain's Transportation Institute (UGPTI) studies on North Dakota grain markets
- Canadian grain handling models
  - S. Gleim & J. Nolan (2015)
  - R. Lawrence, J. Nolan & R. Schoney (2016)

TRUCK TYPE	PROPORTION USED (%)	COST (PER TON-MILE)	PAYLOAD CAP. (TONS)	TARE WEIGHT (TONS)
TWO-AXLE SINGLE UNIT	9	0.052	11.25	4.75
THREE-AXLE SINGLE UNIT	34	0.041	14.80	8.20
FOUR-AXLE SINGLE UNIT	14	0.029	21.25	8.75
FIVE-AXLE SEMI	43	0.029	26.6	13.40

$$\sum_{t=1}^{t} Expense_{o,d} = \frac{\left(x_{o,d} * Cost_t * (W_o^m + N_t * Tare_t)\right) + \left(x_{o,d} * Cost_t * N_t * Tare_t\right)}{Proportion_t}$$

$$Optimized\ profit_o^m = MAX\left(Income_{o,d}^m - Expense_{o,d}\ \forall\, d\right)$$

where:

t = truck type

W = origin corn weight (tons)

N = tot. number of trucks$_t$ *= INT (*$(W_o^m/payload_t) + 1$*)*

$$Income_o^{m=apr.} = W_o^{m=apr} * Price_d^{per\ ton}$$

$$Income_o^{m=oct.} = W_o^{m=oct} * \left(Price_d^{per\ ton} - Basis_d^{m=oct}\right)$$

Modeling producer behavior

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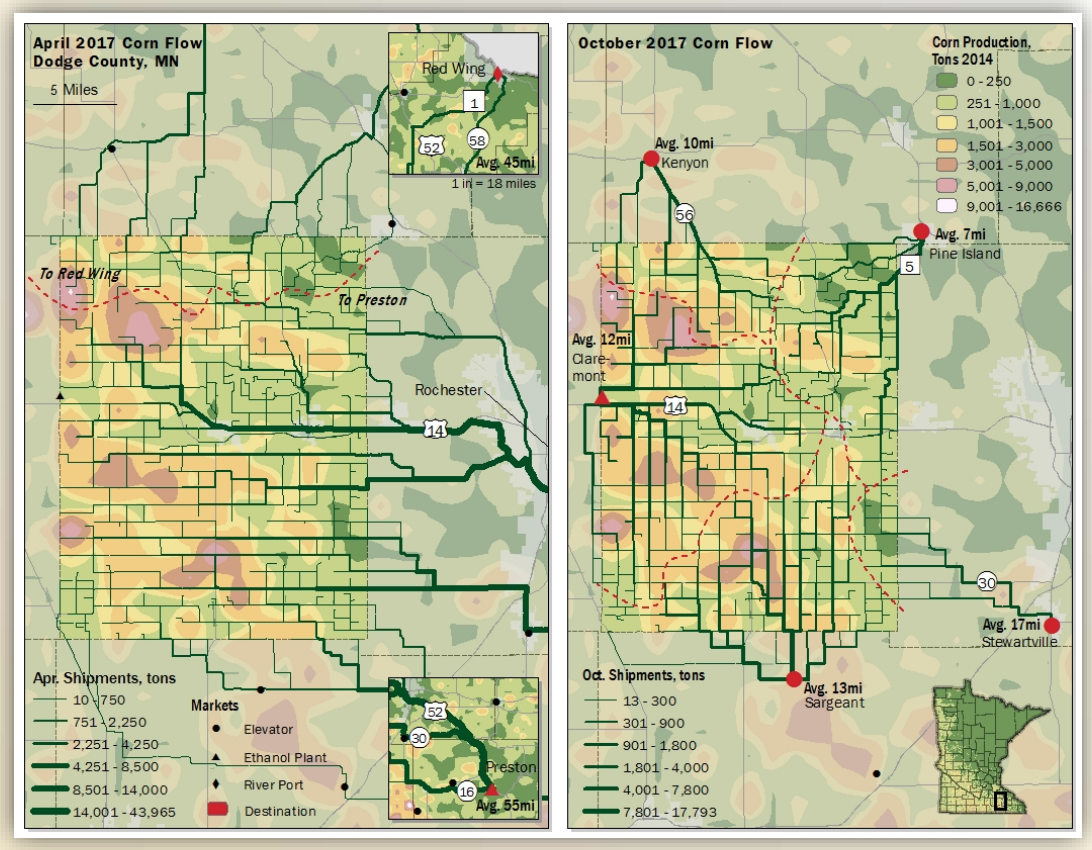

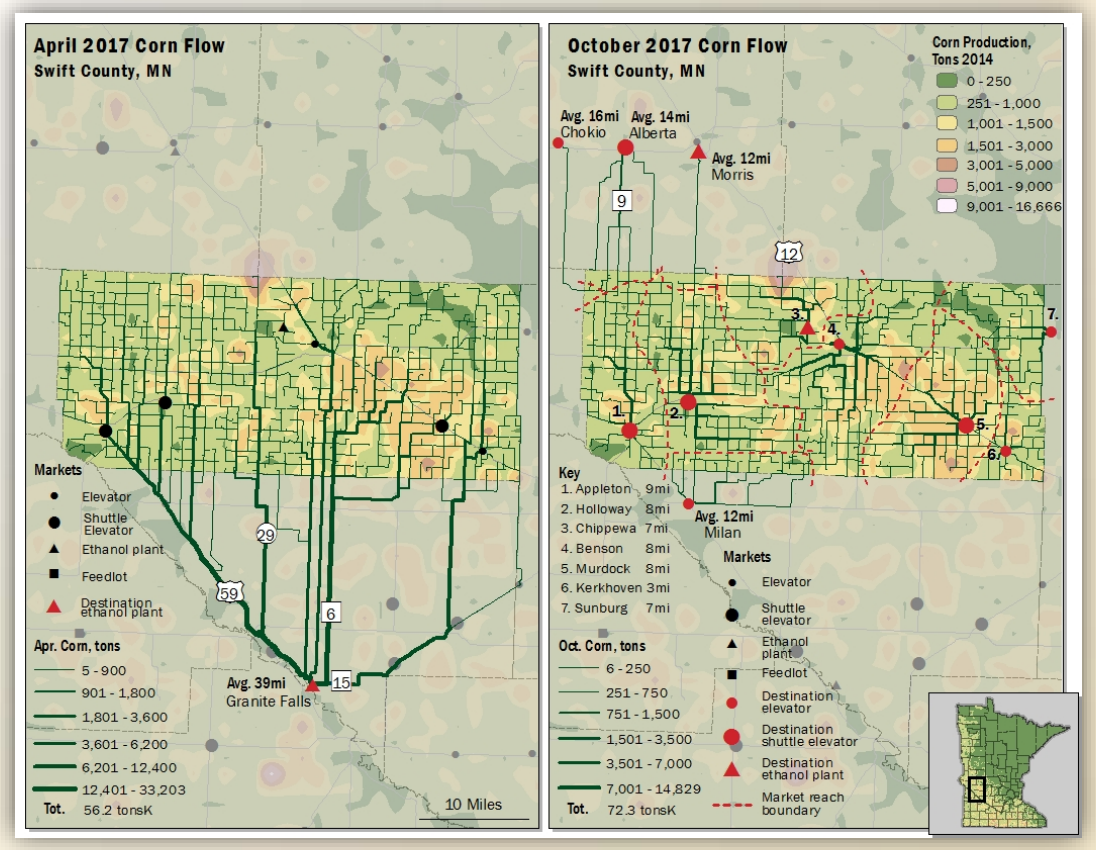

Toward a more strategic freight network

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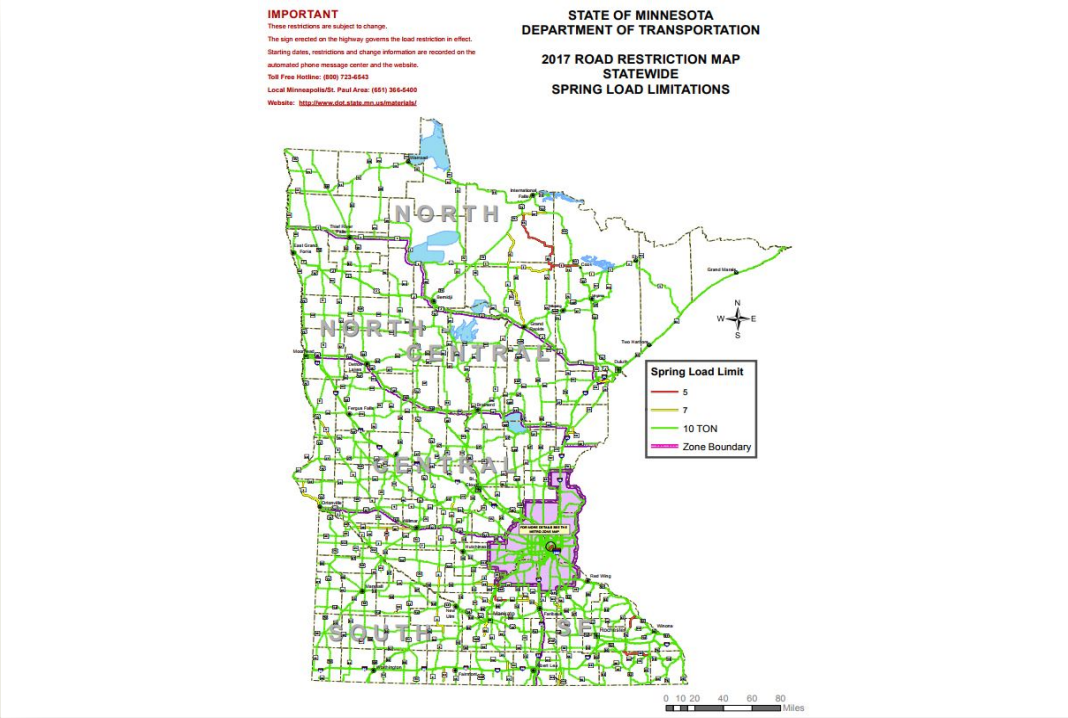
- A focus on grain-derived, value-added supply chains
- Expanding multimodal services
- Revisiting load-weight restrictions




What next?