SAND2012-3395C

The Office of Infrastructure Protection

National Protection and Programs Directorate
Department of Homeland Security

National Infrastructure Simulation and Analysis Center:

Trade Disruption Scenario Analysis

April 26, 2012

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Overview of Supply Chain Analysis

- Scenario: An initiating incident results in a closure of borders and trade in and out of the United States
- NISAC assessed the impacts to the United States under the scenario focusing on a few U.S. critical infrastructure sector supply chains including:
  - Agriculture and food,
  - Crude oil, and
  - Medical isotopes and antibiotics

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Supply Chain Analysis: Food and Agriculture

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Food and Agriculture: Key Questions

- What are the likely impacts of a trade disruption to:
  - Seeds,
  - Bees,
  - Fertilizers,
  - Grains,
  - Intermediate foods (e.g., soybean oil), and
  - Final foods?
- If the United States is a net importer:
  - Does the United States we currently have the capacity to self-supply?
  - How long would it take to self supply?
  - If too long, what are the supply chain and food insecurity effects?
- If the United States is a net exporter
  - Are there cascading disruptions that might limit our ability to distribute these goods within the United States?

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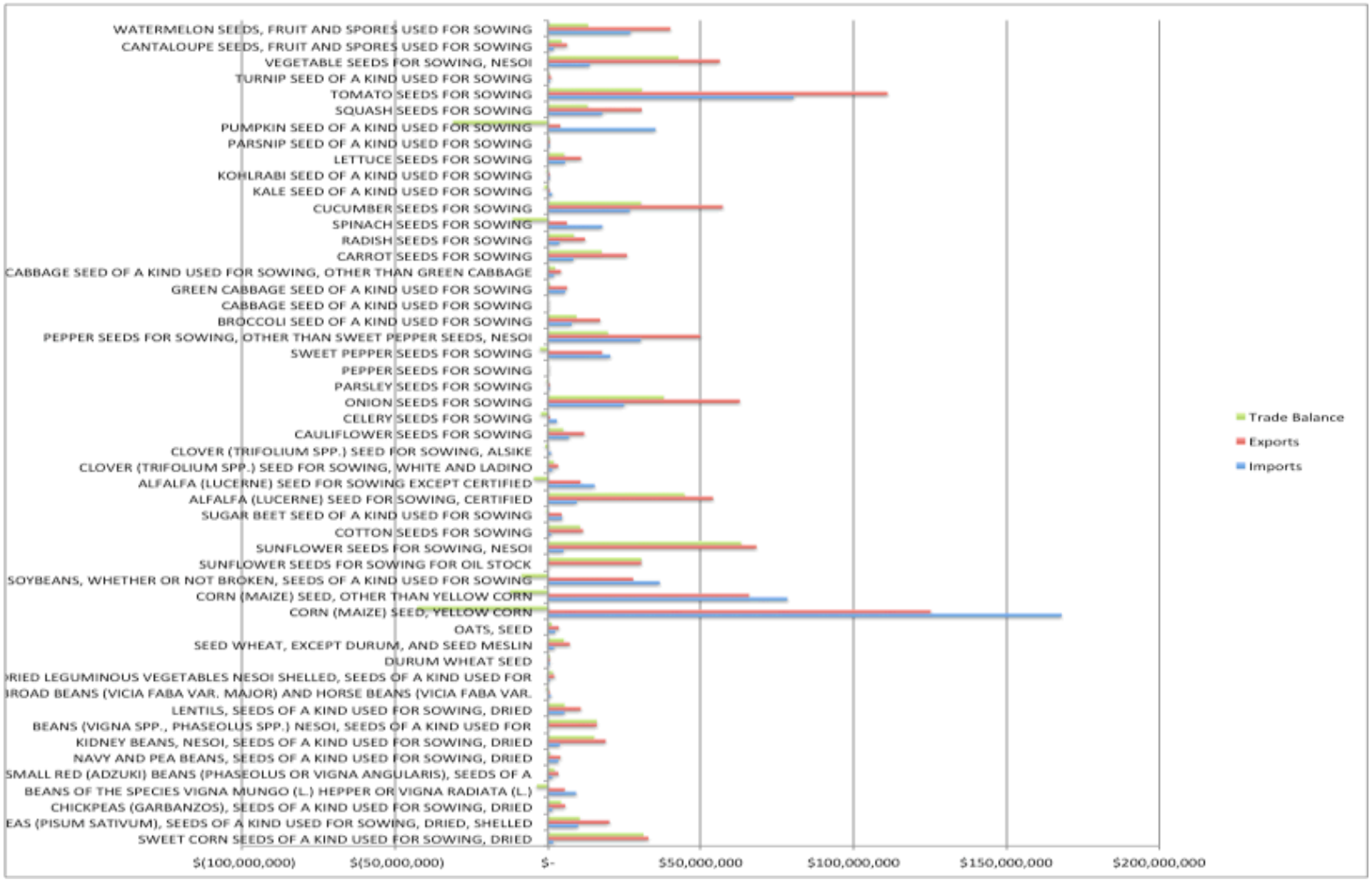
Seeds: The United States is a Net Exporter of Seeds Except for Yellow Corn (Units $000's)



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Honeybees: United States Imports 5% of Bees, Absent Widespread Colony Collapse, Impacts to Crops from Trade Disruption via Bees is Minimal

- Bees pollinate approximately 71% of humans' food crop species
  - Fruits, nuts, vegetables, soybeans, and alfalfa are completely dependent upon insect and animal pollinators
  - Corn, wheat, and rice do not need animal or insect pollination
- Fewer than 5% of United States managed bees are imported
- The 700,000-acre California almond crop, the state's biggest agricultural export, is completely dependent on managed honeybee populations for pollination
- Managed U.S. bee populations dropped from 5.5M in 1950s to 2.5M today, due to various causes
- A sudden collapse of honeybees will not lead to shortages in food, just a shortage in variety of food
- Absent widespread colony collapse (or other diseases), impacts to crops should be minimal due to bees during a trade disruption

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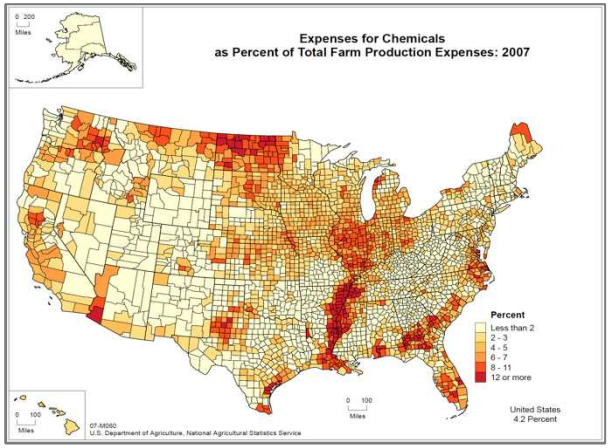
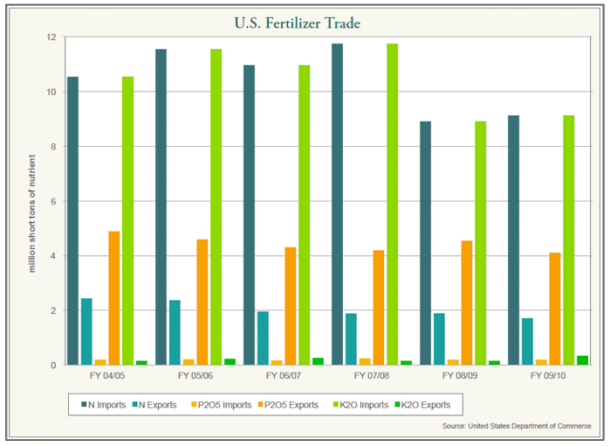
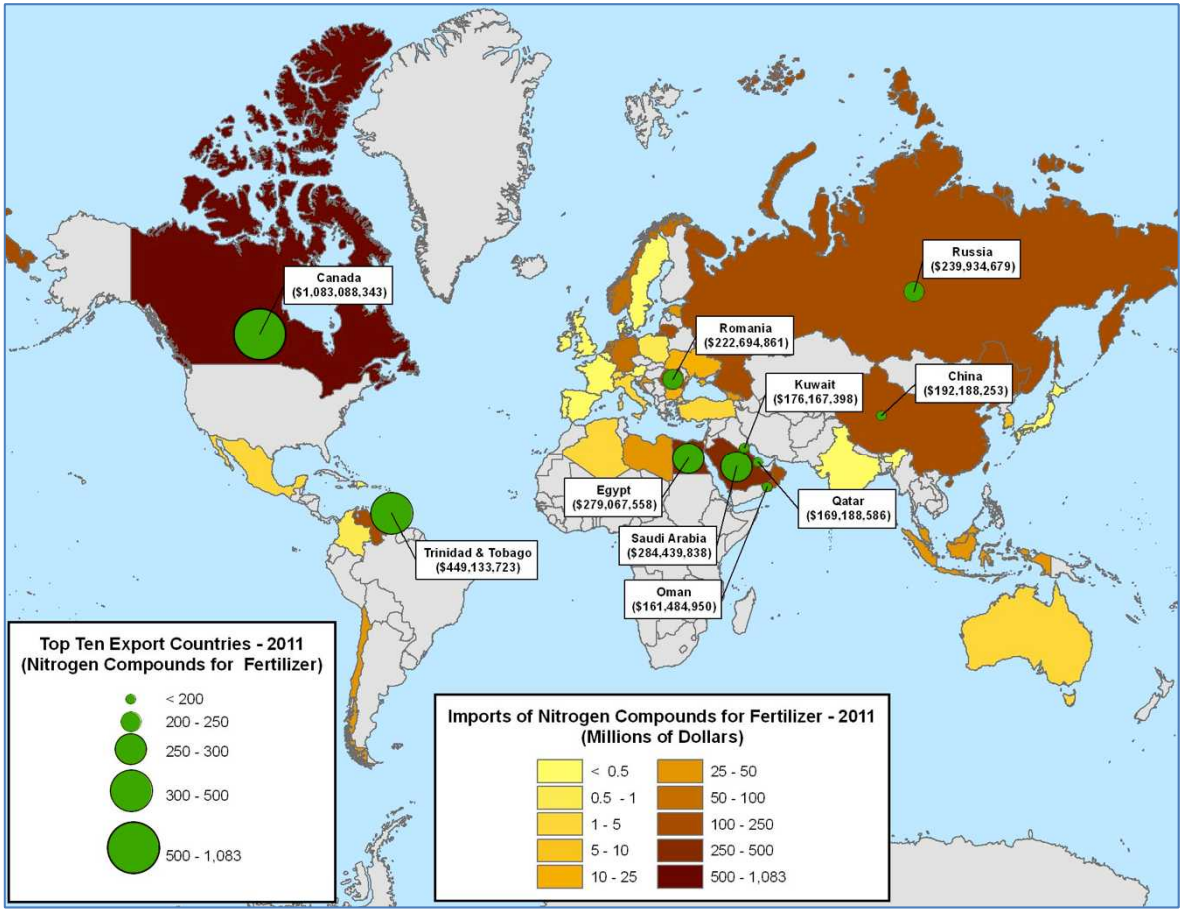
Fertilizers: The United States is a Net Importer of Nitrogenous Fertilizer (Due to a History of High Gas Prices U.S. Production Capacity was Idled)







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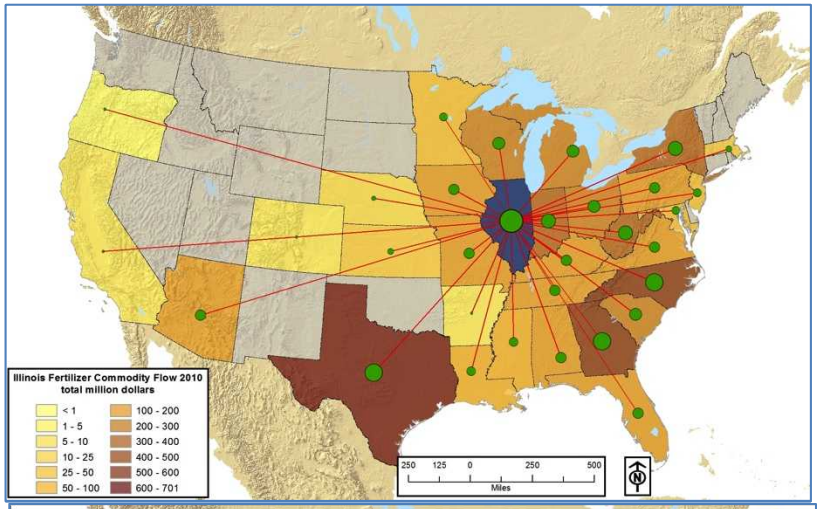
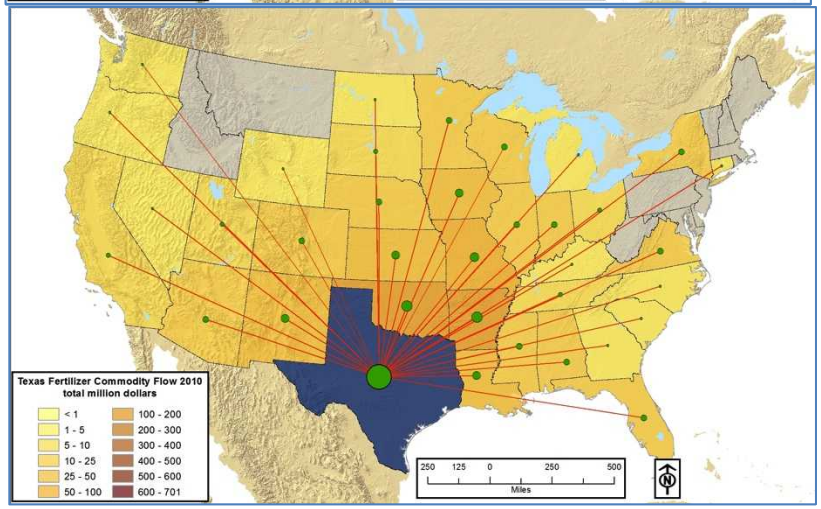
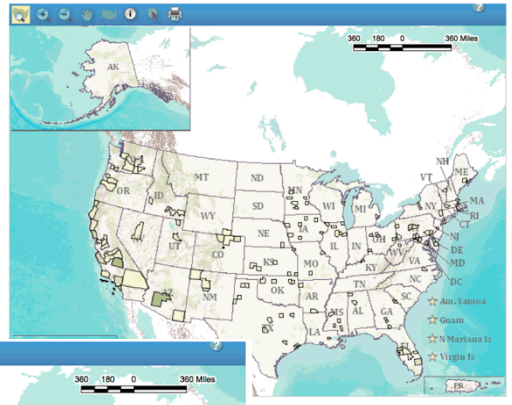
Fertilizers: Majority of Fertilizer that is Consumed in a State is Produced in that Same State

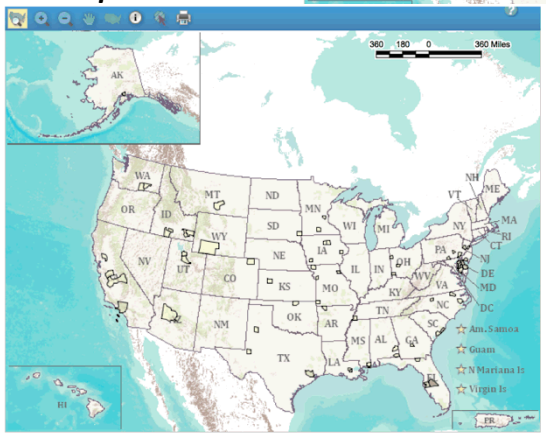




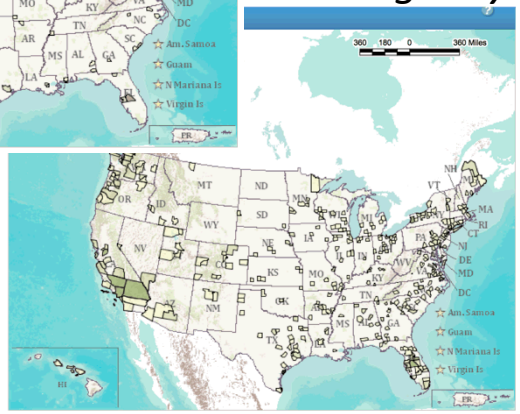
Nitrogenous



Phosphatic



Mixing only



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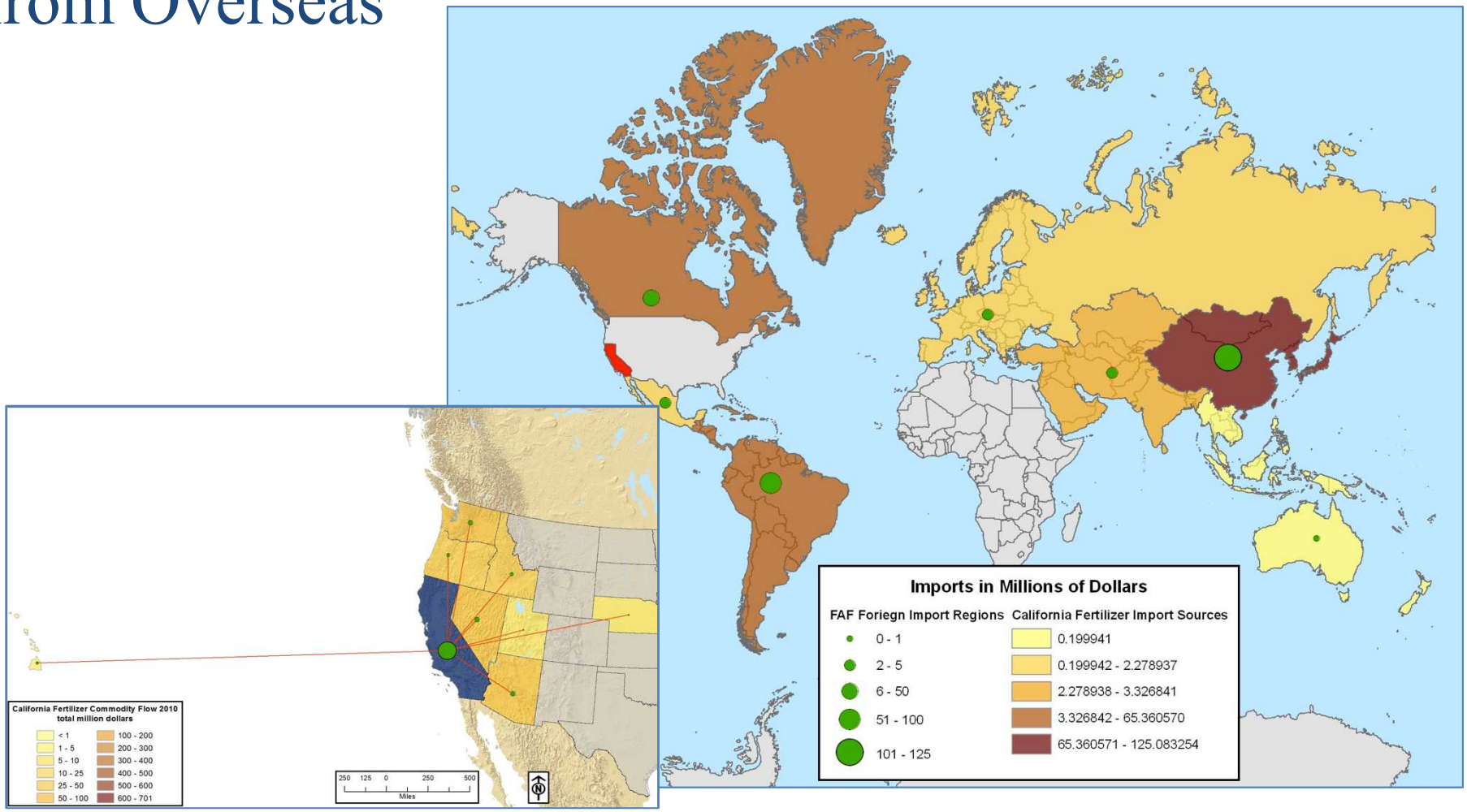
Fertilizer: Of the Fertilizer California Consumes, Most of it is Produced in State, but also Imports from Overseas



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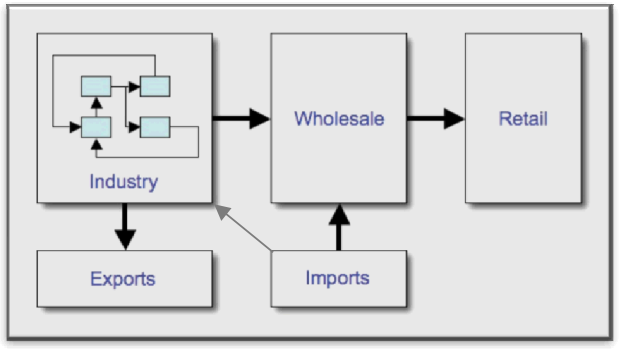
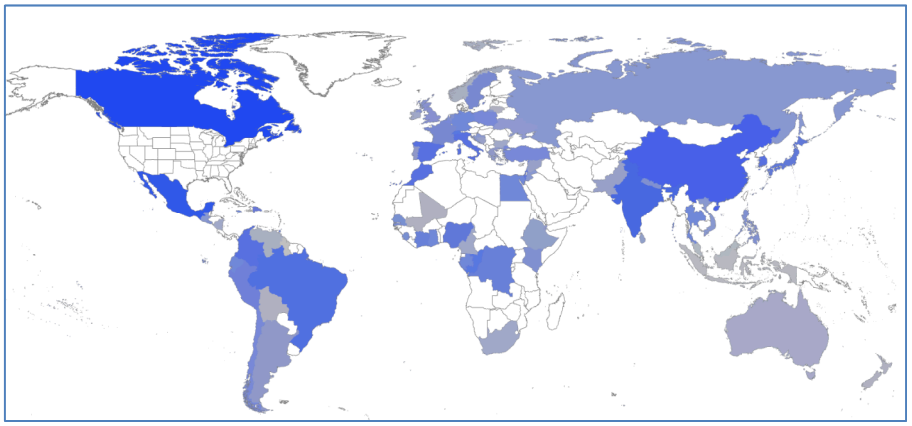
U.S. Food Supply Chain: While there are some Imports, Most of the Food Consumed in the United States is made in the United States, including inputs



NAICS codes (Census URL)

- **AGRICULTURE:** 11 – includes Agriculture
  - 111 – **Crop** Production
  - 112 – **Animal** Production
  - 1151 – Support Activities for Crop Production
  - 1152 – Support Activities for Animal Production
- **PROCESSERS:** 31 – includes Food Production
  - 311 – **Food** Production
  - 312 – **Beverage and Tobacco** Product Production
- **DISTRIBUTION:** 42 – Wholesale Trade
  - 4244 – **Grocery** and Related Product Merchant Wholesalers
  - 4245 - Farm Product Raw Material Merchant Wholesalers
  - 4248 - **Beer, Wine, and Distilled Alcoholic Beverage** Merchant Wholesalers
  - 42491 - **Farm Supplies** Merchant Wholesalers
  - 42494 **Tobacco** and Tobacco Product Merchant Wholesalers
- **RETAIL:** 44 – Retail Trade
  - 445 – Food and Beverage Stores
- **RETAIL:** 72 – Accommodation and Food Services
  - 722 – Food Service and Drinking Places



Flour Millings (NAICS 311211) U.S. Imports, by Country of Origin: 2010

Soybean Processing (NAICS 311222) U.S. Imports, by Country of Origin: 2010

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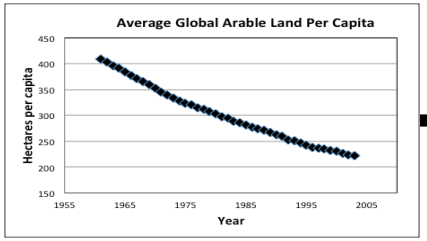
The Long View: Regardless of Acute Disruptions the Long-term Global Food Picture Looks Bleak

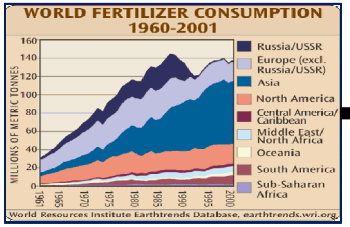
Arable land

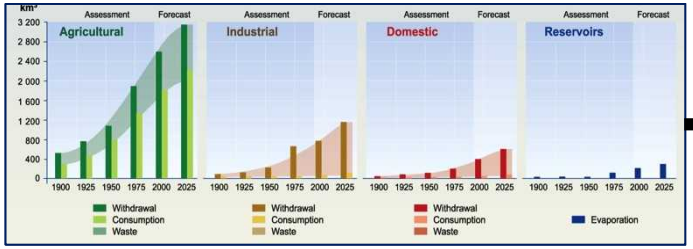
Key inputs

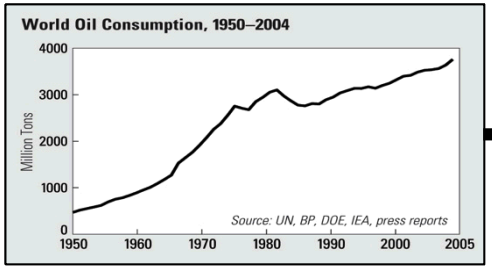
Water

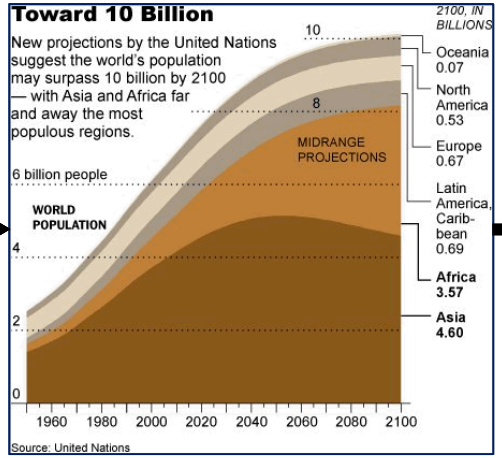
Transportation



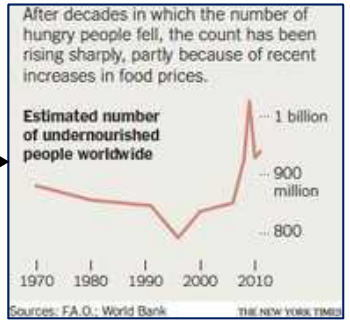








Population



World Hunger

Almost every element of the global food supply chain is under increasing stress

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Key Threats to the Domestic Food Supply Chain

- Threats caused by long-term global food stressors:
  - High and/or highly variable fossil fuel prices – diesel fuel price and availability factors heavily into farm operations (tractors, combines), shipments (trucking, rail, shipping)
  - Disease spread through animals, people, and/or crops
  - Food defense and food safety issues
  - World migration/U.S. immigration, due to failed nation states
  - World financial/trade instabilities affect world currencies, exchange rates, ability to afford and to trade food
- These threats could lead to trade closures!

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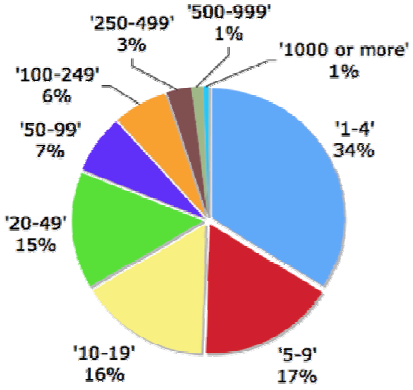
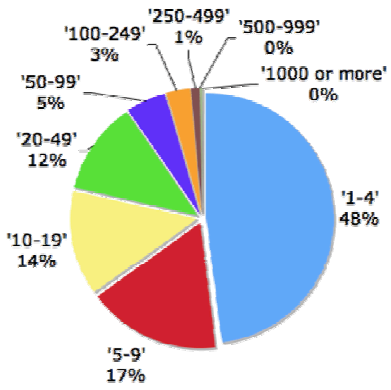
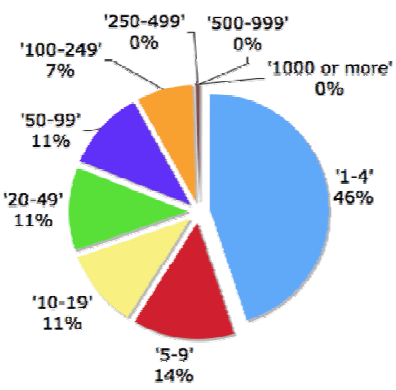
Food Supply Chain: Unclear if the U.S. Firms can Adjust to this Scenario Quickly Enough to Keep Food on the Table



Food (NAICS 311)



Wholesale (NAICS 4244)



Retail (NAICS 4451)

- Food Industry
  - Composed mainly of small- to medium- sized firms, most of which do not have business continuity plans if not resources
  - These firms would likely see widespread, scattered shutdown of various parts of the food supply chain, due to lack of material inputs, transportation, cash flow, etc.
- Consumers
  - Highly susceptible to food hoarding, runs on supermarkets and other food suppliers
  - Food-insecure populations and areas likely to increase greatly due to increased food prices (due to scarcity, fuel costs)

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Agriculture Supply Chain Analysis Conclusions

- Fertilizer shortages could be major risk to the system:
  - Large amounts certain fertilizers are imported into the U.S.
  - U.S. fertilizer capacity could be brought back
- Other than fertilizer the data does not seem to show any major issues with agricultural macro flow to the United States
  - U.S. is a major seed exporter
  - Only 5% of managed bees imported
  - U.S. is a net exporter of food
- There are still many unknowns:
  - The survivability of firms through the prescribed scenario is in question
  - The inability to transport food due to fuel issues is a major issue that we have not reviewed in the agriculture section
  - The effects of consumer hoarding and other consumer behaviors are largely unknown
  - Time to reorganize and transition in the long term is a major unknown
  - Availability of other key inputs impact the system
- The long-term global food picture looks bleak irrespective of acute disruptions

Agriculture: Unanswered Questions

- How long would it take the food supply chain to reconfigure itself domestically?
- By how much would the “food insecure” increase over this period?
- Could the federal government (DHS, USDA) maintain “situational awareness” over the numbers of food insecure, regional inventory levels, and other critical food resources? What critical food supplies might need to be rationed?
- How long a disruption would national/regional government and private industry long-term inventory tolerate?
- Would the federal government need to intervene in bulk agriculture markets (price supports, price controls, supply rationing) to smooth out regional distributions? Does it have enough information to do so in time?
- What are potential impacts of retail hoarding on regional wholesale locations? Would city-level rationing be required? If regional food availability is a problem, who would maintain societal order?

Supply Chain Analysis: Crude Oil

Petroleum: Scope

- Obtain an overview of crude oil and refined product capacities under a border closure
- Obtain a general understanding of the regions that could be impacted

Production: The U.S. Produces Only 38% of the Crude it Consumes

- 60% of crude oil consumption is produced in North America
- Despite large reserves SPR has a maximum drawdown capacity of 4,400 kbbl/day (49% total imports) (Department of Energy, 2012)
- SPR drawdown decreases as oil is extracted
- More than enough refining capacity exists in the U.S. the major limiter is the amount of crude available

U.S. Crude Oil Statistics	000's bbl/day
Consumption	14,883
Domestic Production	5,659
Canadian Imports	2,207
Mexican Imports	1,100
Total North American Imports	3,349
Other Imports	5,572
Total Imports	8,921
Strategic Petroleum Reserve (SPR)	750,000

Source: Annualized daily averages from the U.S. Energy Information Administration, 2011

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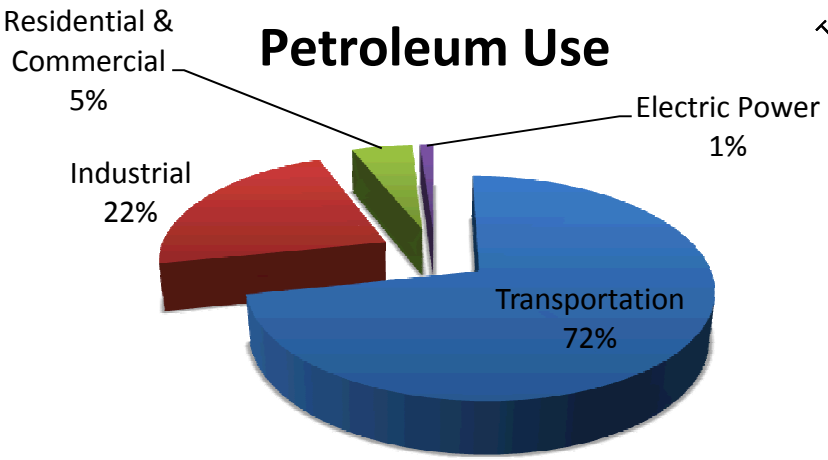
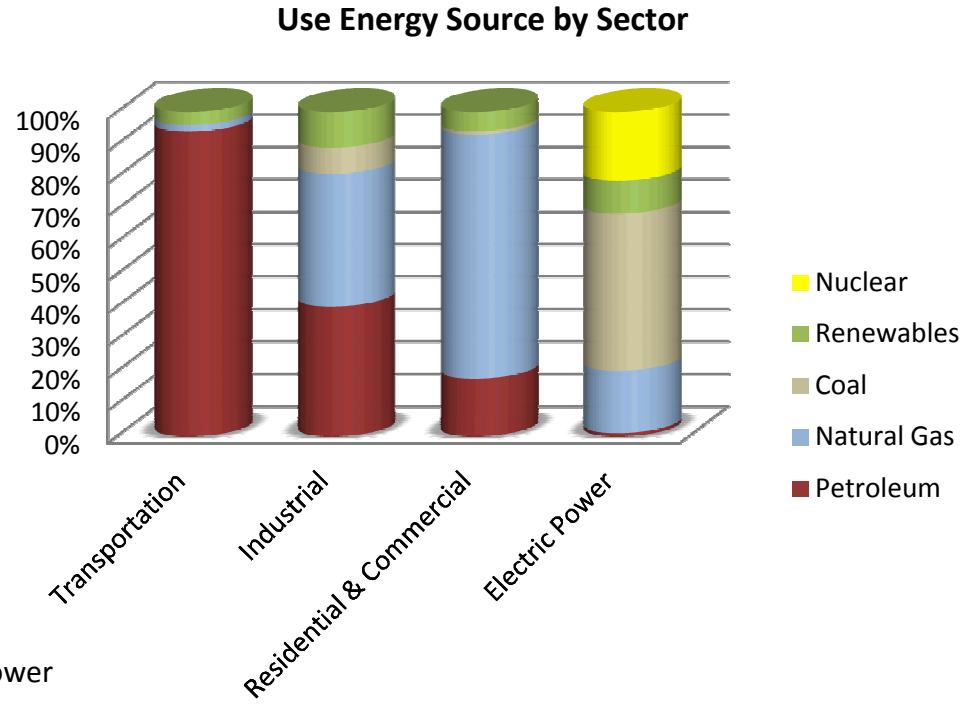
Consumption: Transportation is the Largest Consumer of Fuel and Would Suffer the Most as a Result of Shortages

- 94% of all energy used in transportation is via petroleum
- While residential and commercial use of petroleum is relatively small (18%) much of this could be due to heating oil which is critical in northeastern winters





- Adaptation for shortages would require significant curtailment of transportation fuels as well as reduction in use by industrial and electric power generation consumers

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SPR: Provides Cushion Only if the U.S. is Able to Continue Imports from Mexico / Canada

Number of Days of Consumption using the SPR		
Percent Curtailed	**U.S. Only Production**	**North American Production**
0%	Not possible	Not Possible
10%	Not possible	170
20%	Not possible	258
30%	Not possible	531
40%	174	Sustainable
50%	312	Sustainable

** Assumes constant drawdown at maximum rate;*
Does not include bulk storage throughout the system.

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Overview: National Petroleum Model

- Model includes:
  - Crude production and Refining nodes
  - Pipeline linkages
  - Terminals
  - Ports
- Model does not distinguish between foreign and domestic crude within ports
- Model does not include the SPR
- Model scenario: All shipping terminals and international pipelines disrupted into the U.S.

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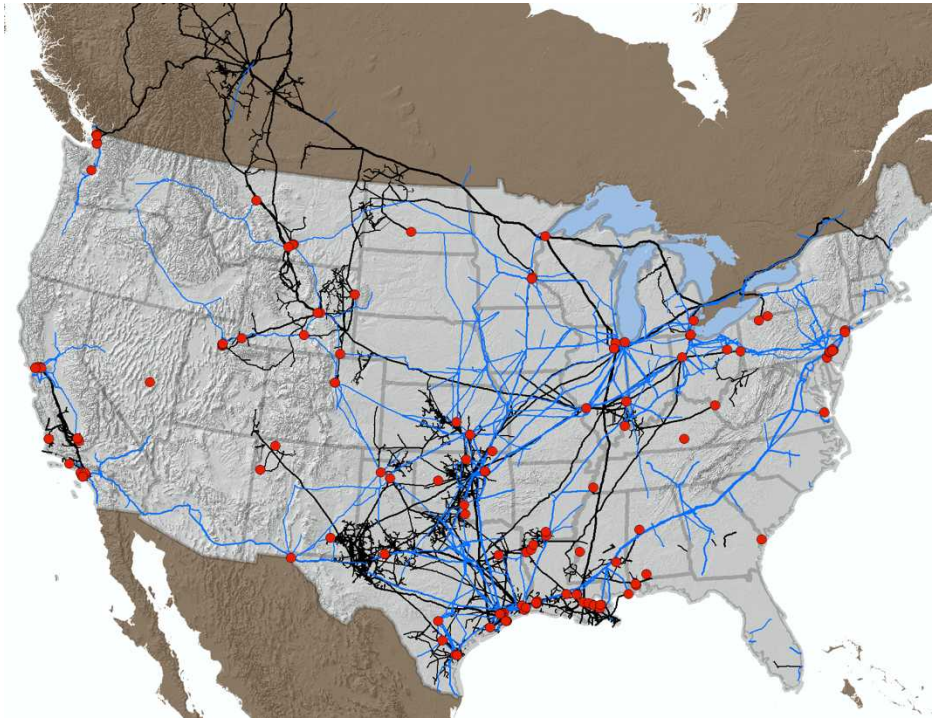
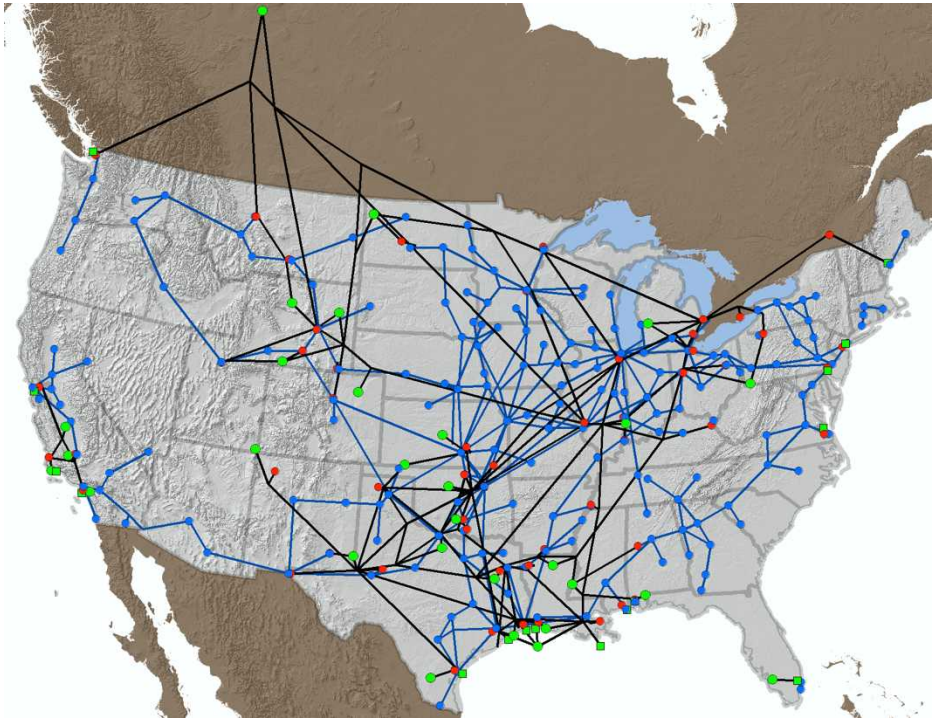
NISAC Petroleum Model: Real System vs. Modeled

Real System: Platts Dataset



NISAC Model of System



Blue links = Product Pipelines
Black links = Crude Pipelines

Red Circle = Refinery
Blue Circle = Fuel Terminal

Green Circle = Production Area
Green Square = Port

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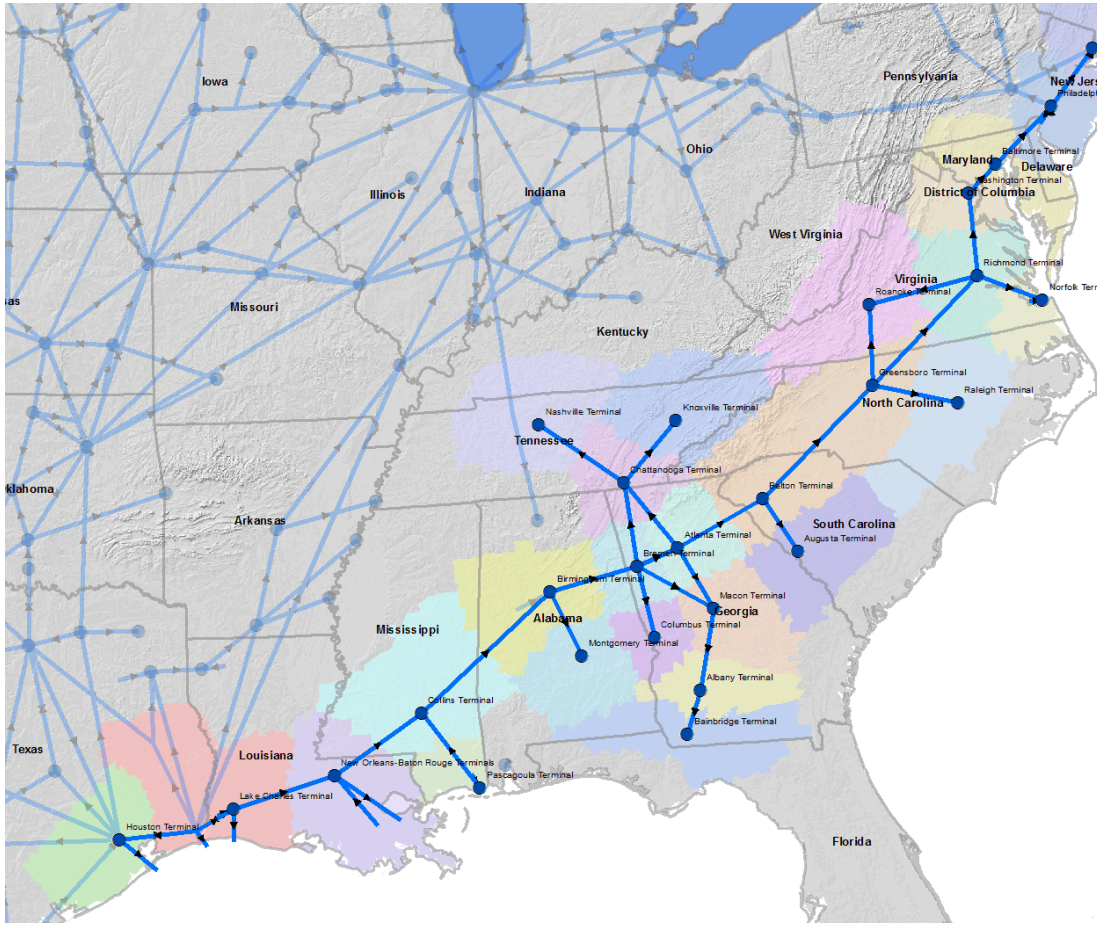
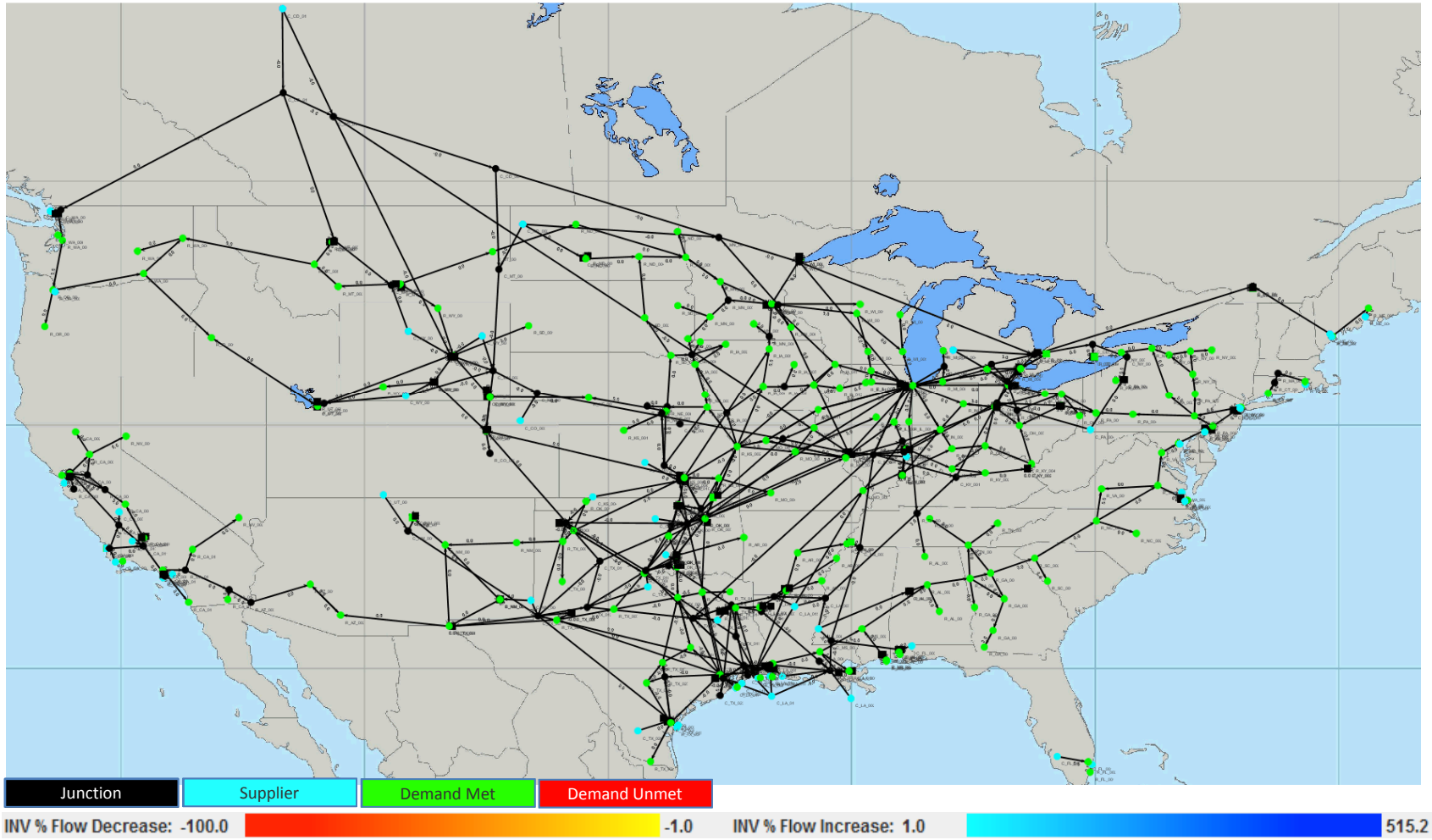
NISAC Petroleum Model: Network Modeling Approach

- System is represented in links and nodes
- Nodes represent interfaces in the system for product / crude consumption or ingress
- Disruption modeled by “breaking” a node or link
- Links represent physical pipelines
- Links are unidirectional (see arrow), for multidirectional pipelines, two links are made



Simulation: Before Disruption



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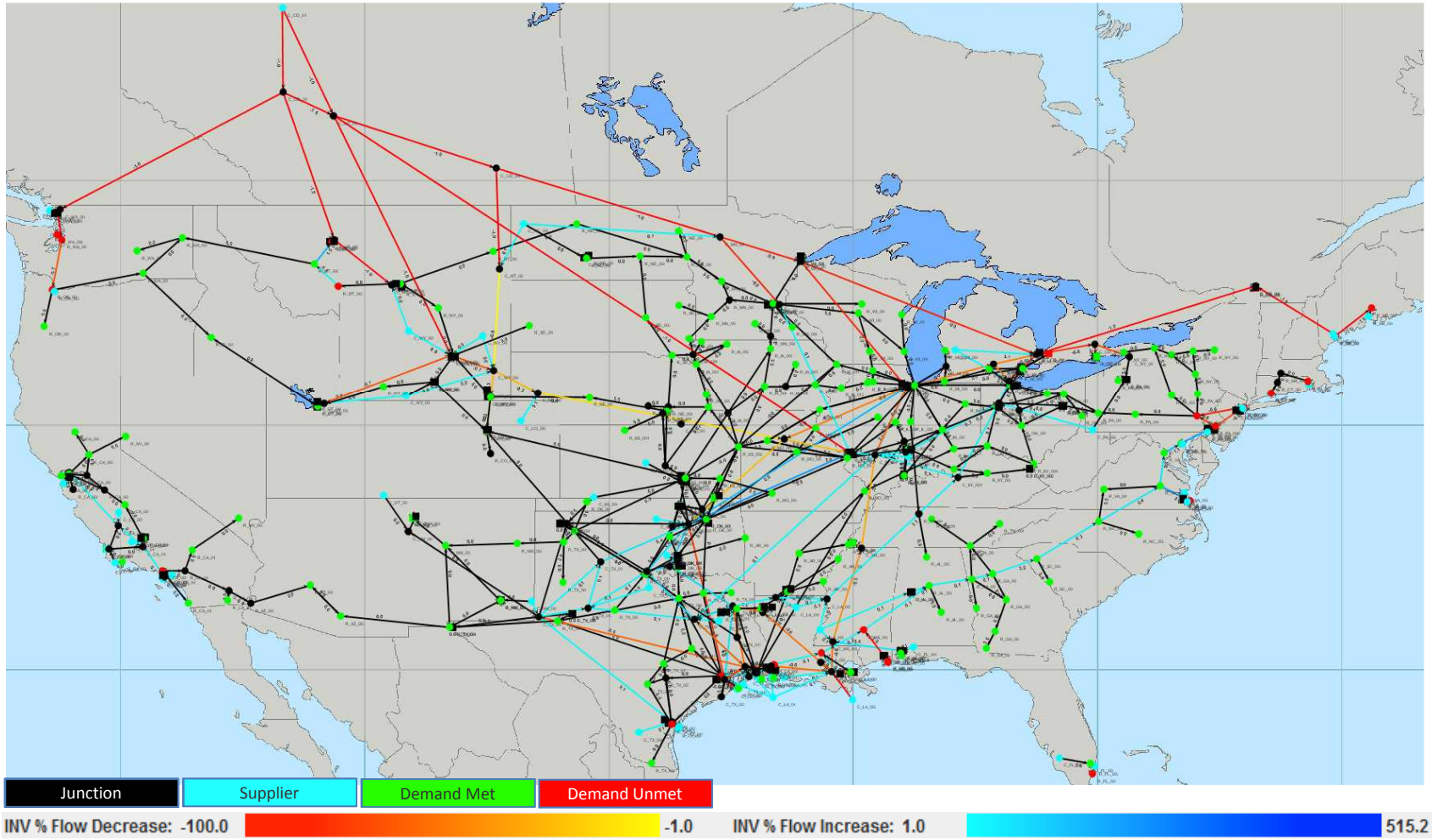
Simulation: Disruption Day 30



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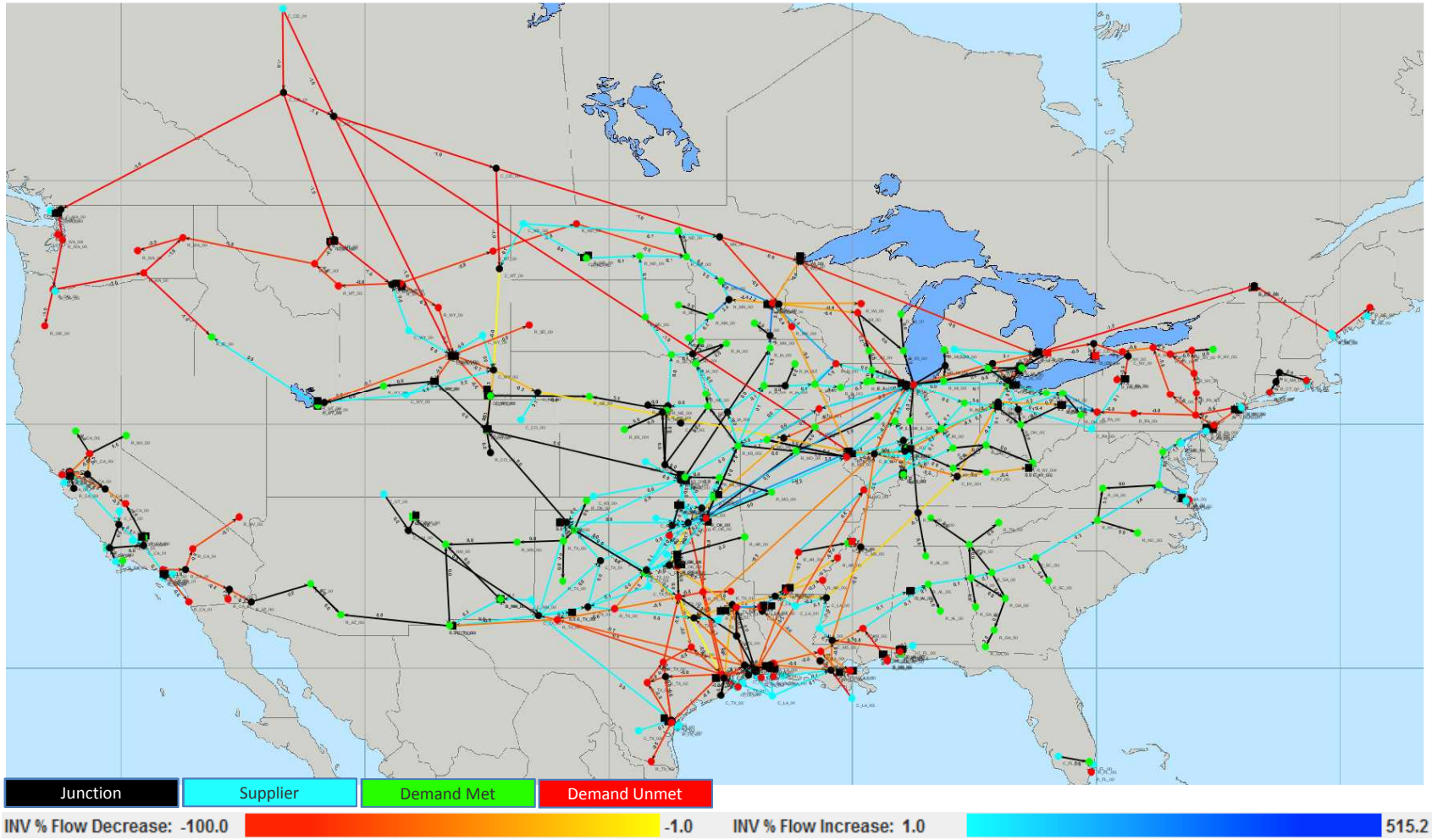
Simulation: Disruption Day 60



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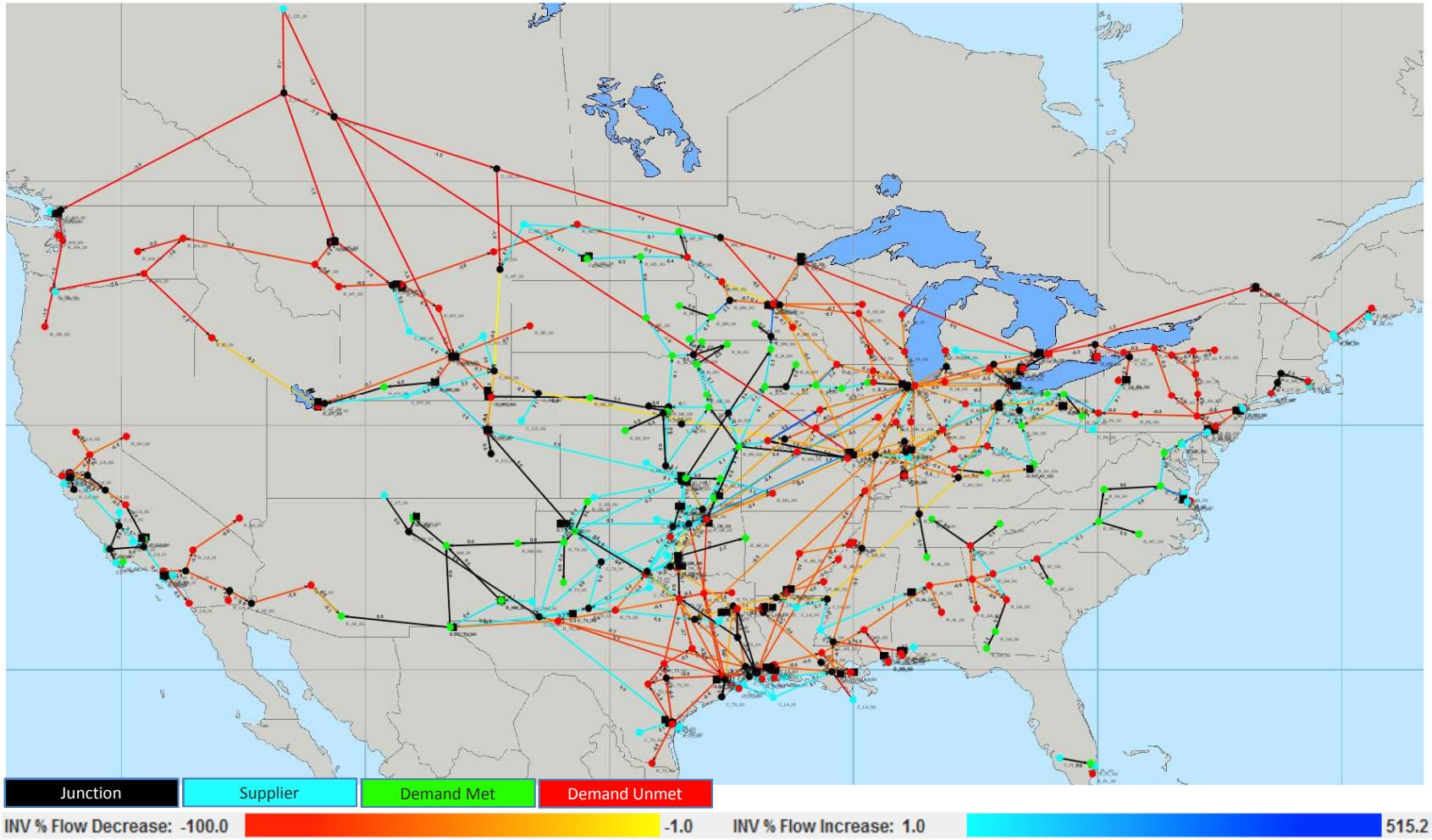
Simulation: Disruption Day 90



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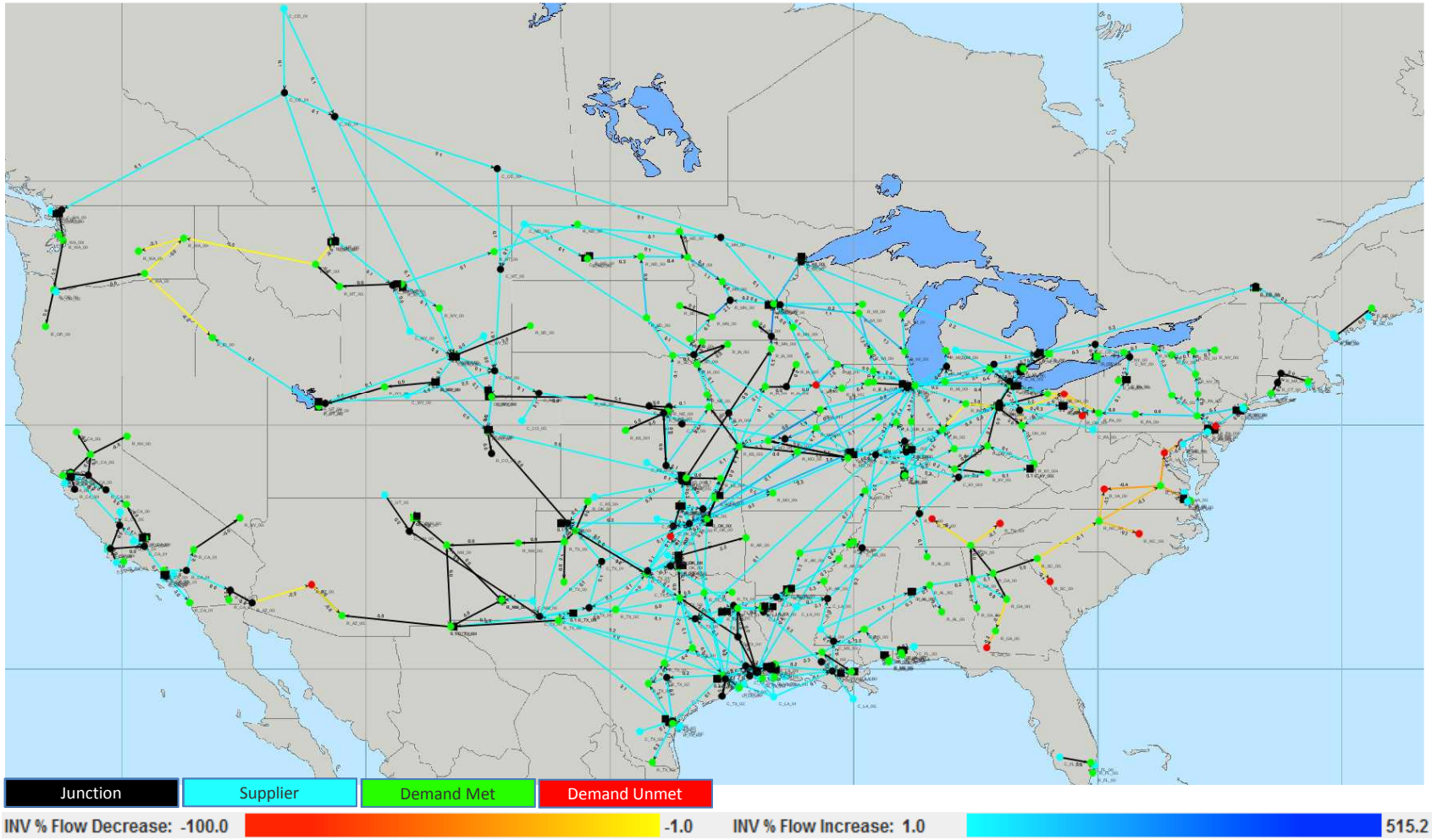
Simulation: 20 Days After Disruption Ends



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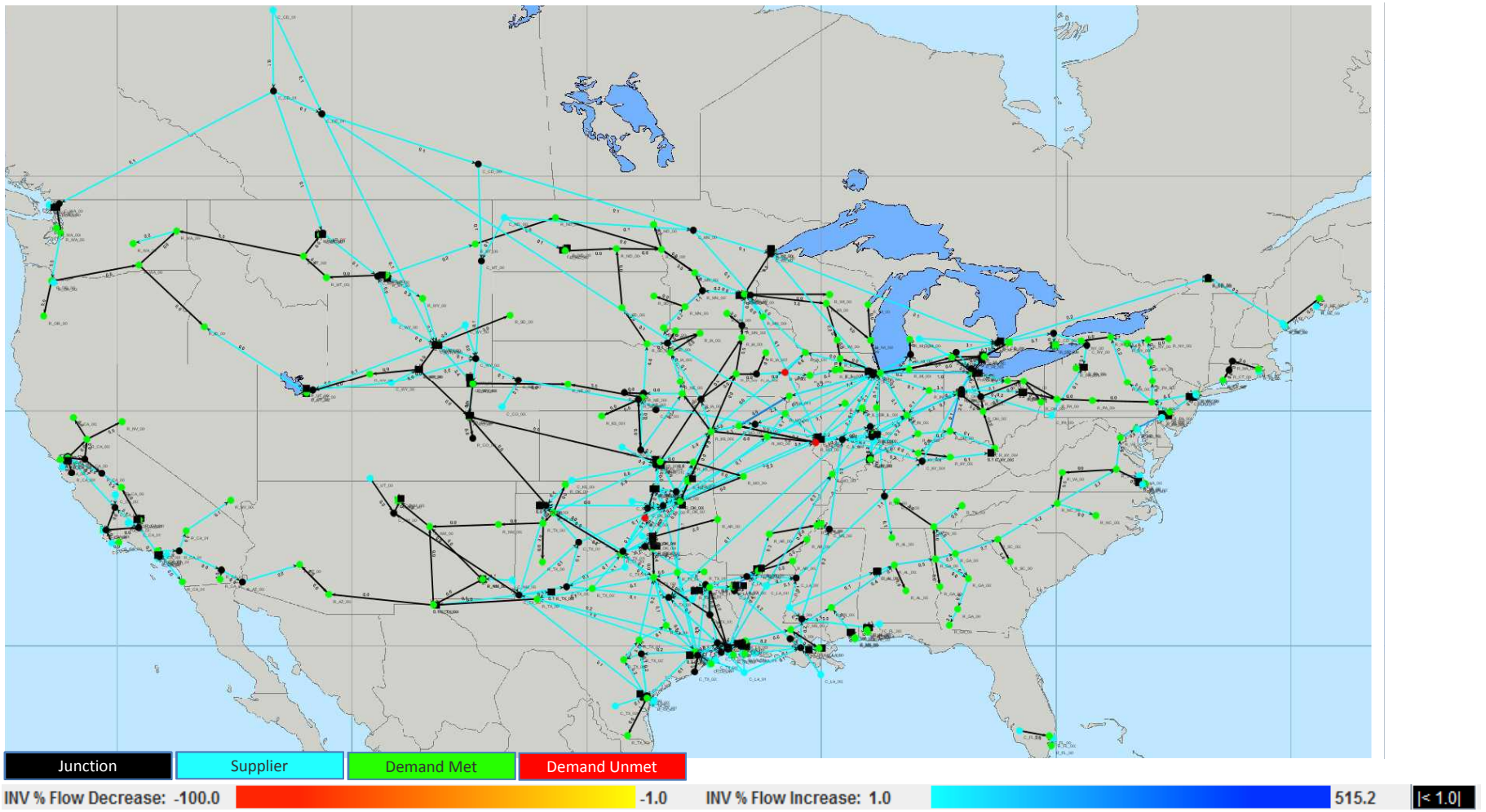
Simulation: 50 Days After Disruption Ends



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Petroleum: Conclusions

- Refining Capacity is not a limiting factor in the U.S.
- Petroleum production capacity is insufficient to withstand a disruption of this magnitude
- The SPR helps, however it is not sufficient to replace imports or even non-North American imports
- Transportation fuels are the largest user of petroleum products, and therefore will likely suffer the greatest
- A shortage in crude will lead to nationwide shortages according to NISAC models, however, some areas near (relatively isolated) oil production may be able to meet consumption

Petroleum: Unanswered Questions

- How would the U.S. seek to ration the supply of oil during disruption?
- The SPR exists for military purposes, how might the U.S. government try to preserve these important reserves for those uses under such a scenario?
- What would the economic impact of lacking availability of petroleum products?
- Is there any easy petroleum consumption measures that could be taken to increase short term availability? (e.g. higher subway/bus ridership, telecommuting, etc.)
- What are the impacts to secondary products stemming from petroleum (chemicals)?

Supply Chain Analysis: Antibiotics & Medical Isotopes

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Antibiotics: U.S. has Sufficient Domestic Production Capacity for Human Doses of Antibiotics, However Supply Chain Needs to be Further Characterized

- Antibiotics Consumption:
  - "Only 20% of the antibiotics sold in the U.S. are given to people …. Most of the penicillin, tetracycline and other antibiotic drugs used in this country are given to livestock that are perfectly healthy." (LA Times, Confirmed by Congress & FDA)
  - Animal Consumption: 28.7 M lbs
  - Human Consumption: 7.1 M lbs (6.4 B - 500 mg doses)
- Antibiotics Production:
  - Production Within U.S.: 6.9 B human doses (Commerce, approved for human consumption within U.S. - Assumes adequate supplies of inputs)
  - Phosgene production (key for synthetic antibiotic production)in the U.S. is sufficient to continue production of human consumption use
- Observations:
  - U.S. can likely produce antibiotics for human need
  - Companies report that they can increase antibiotic production in short-order
  - Data on the production side of agricultural antibiotics was not found, therefore impacts on agriculture cannot be fully captured

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Medical Isotopes: The U.S. May Lose a Significant Portion of Medical Diagnostic Imaging

- In 2010 NISAC completed an analysis on specific medical isotopes
- Medical isotopes looked at in the 2010 NISAC study are mainly used for diagnostic imaging, including:
  - Bone scans,
  - Organ function scans, and
  - Vital organ perfusions
- Certain isotopes are not produced in the U.S.
- Medical isotopes have a very short half-life if not used within several days, some are no longer usable (cannot be stockpiled)
- Globally there exist very few facilities that produce isotopes for medical use, and even fewer that are able to export these isotopes to the U.S.
- While the 2010 NISAC analysis reviewed a handful of isotopes, it is clear that the U.S. might lose a significant portion of medical diagnostic imaging during a trade disruption

Antibiotics and Medical Isotopes: Conclusions & Gaps

- The U.S. might be able to meet demand for human consumption of antibiotics, however the total supply chain needs to be further characterized
  - Better data is needed to locate where antibiotic fermentation is processed
  - Antibiotic production for animal use needs to be better understood as well as the likely impacts of reduced antibiotics use in animals
- The medical isotopes supply chain is made up of a few firms globally, only a handful in the U.S., making this supply chain susceptible to disruption
  - We need a broader understanding of all isotopes, greater collaboration with professionals in the area would allow us to account for adaptation
- Medical supplies in general need further analysis
  - We need to analyze more domestic supply / demand levels to understand if medical supplies in general could pose a problem under trade disruptions
  - Understanding how medical professionals can adapt to shortages is important

Questions?

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For more information visit:
www.dhs/gov/criticalinfrastructure

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