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Optimizing service center siting for disaster response

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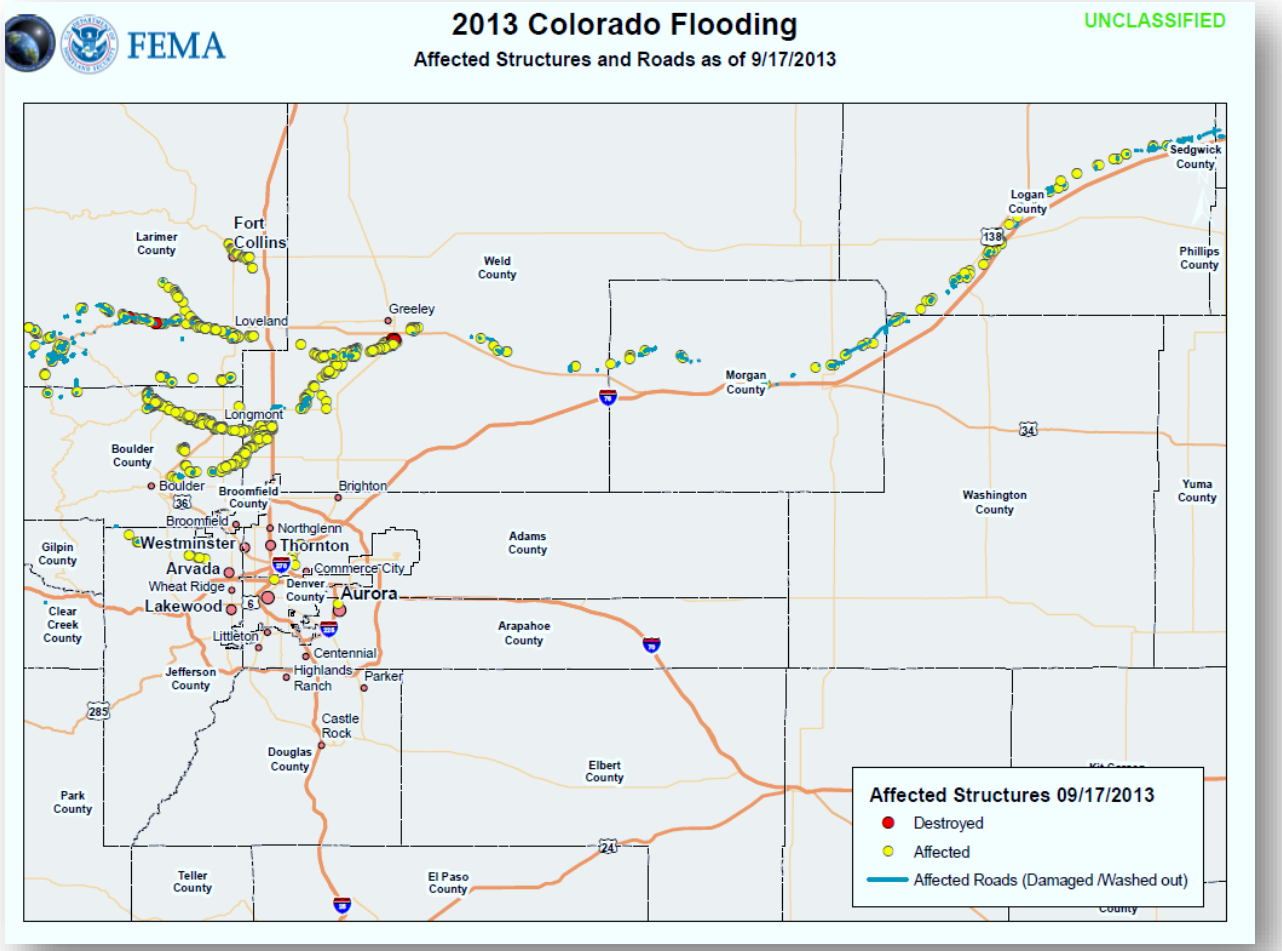
Introduction

- **Where to site *distribution points* or *service centers* after a disaster?**
- Multiple goals
  - Enable easy access for affected population
  - Use resources efficiently (cost, staff)
- This presentation describes work with the US Federal Emergency Management Agency (FEMA)
  - Model and lessons are transferable to international context, siting distribution points or service locations



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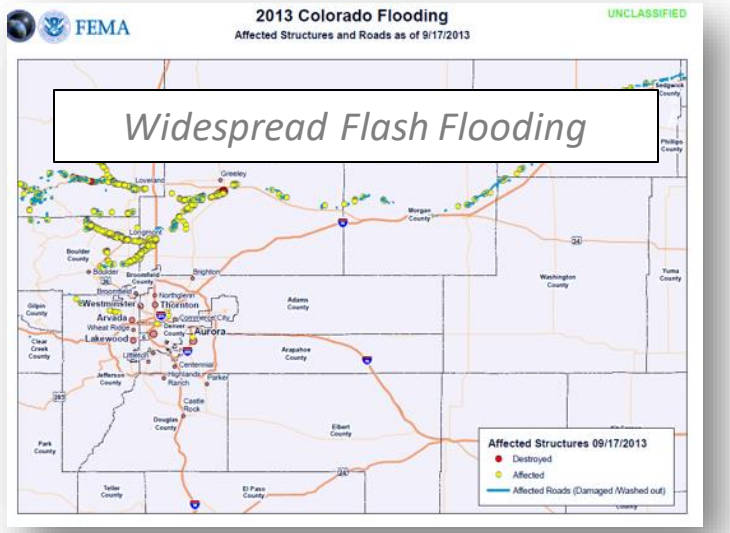
FEMA Disaster Recovery Centers (DRCs)

- Set up by FEMA near disaster-impacted areas
- Opened quickly after disaster for limited time
- Population can access assistance on disaster relief resources available from multiple government and non-government sources

Source: https://www.fema.gov/media-library-data/1565187021337-6c65cb031104bf24f64a58e68dbb927a/FACTSHEET_DisasterRecoveryCenters_FINAL2019Compliant.pdf

Colorado floods (2013)

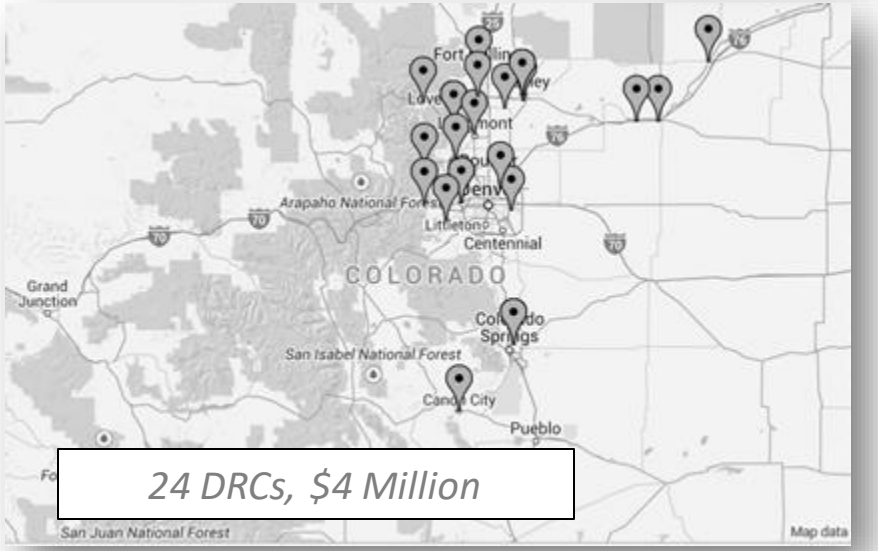


Widespread Flash Flooding

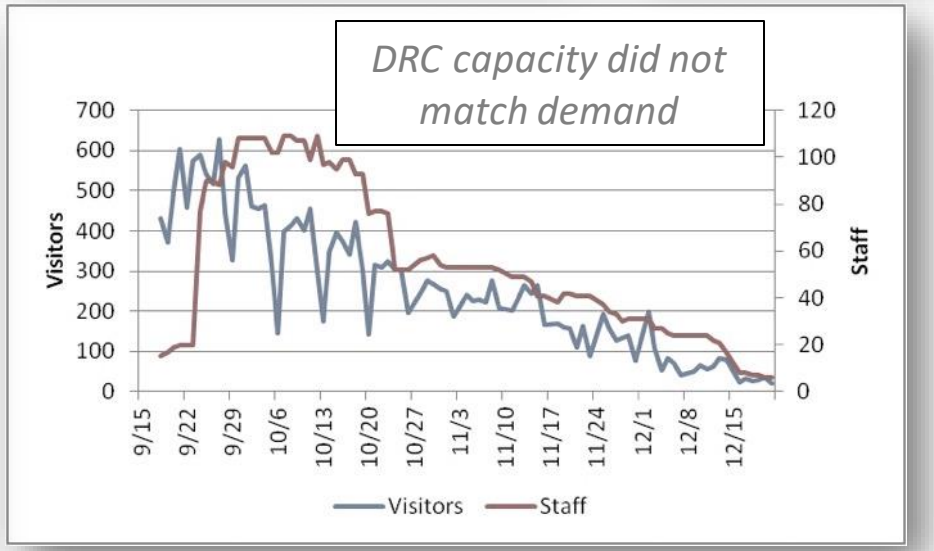
Major damage to homes and infrastructure

Disaster Recovery Centers provide services to "survivors"

Source: fema.gov



24 DRCs, $4 Million

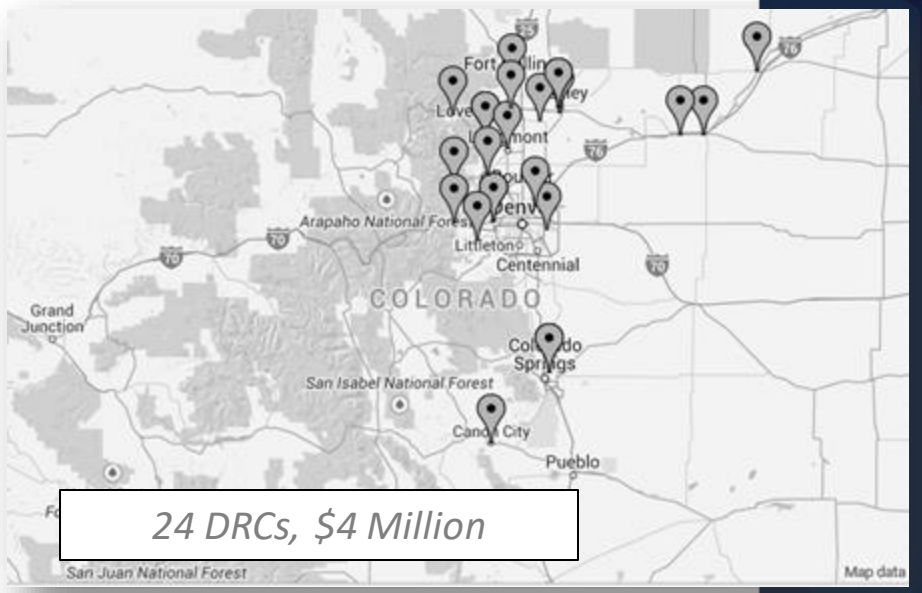


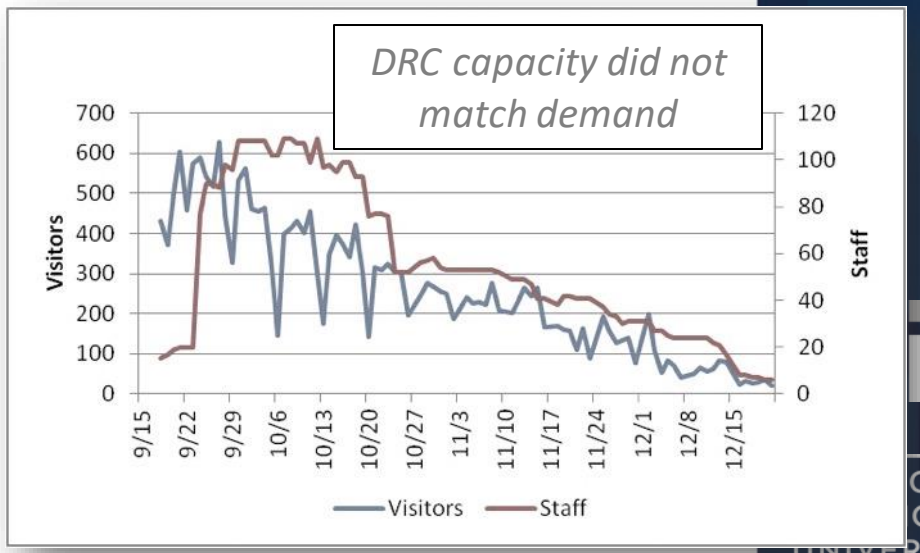
DRC capacity did not match demand

How to locate and staff DRCs initially, and how to adjust and close them over time?

Research goals

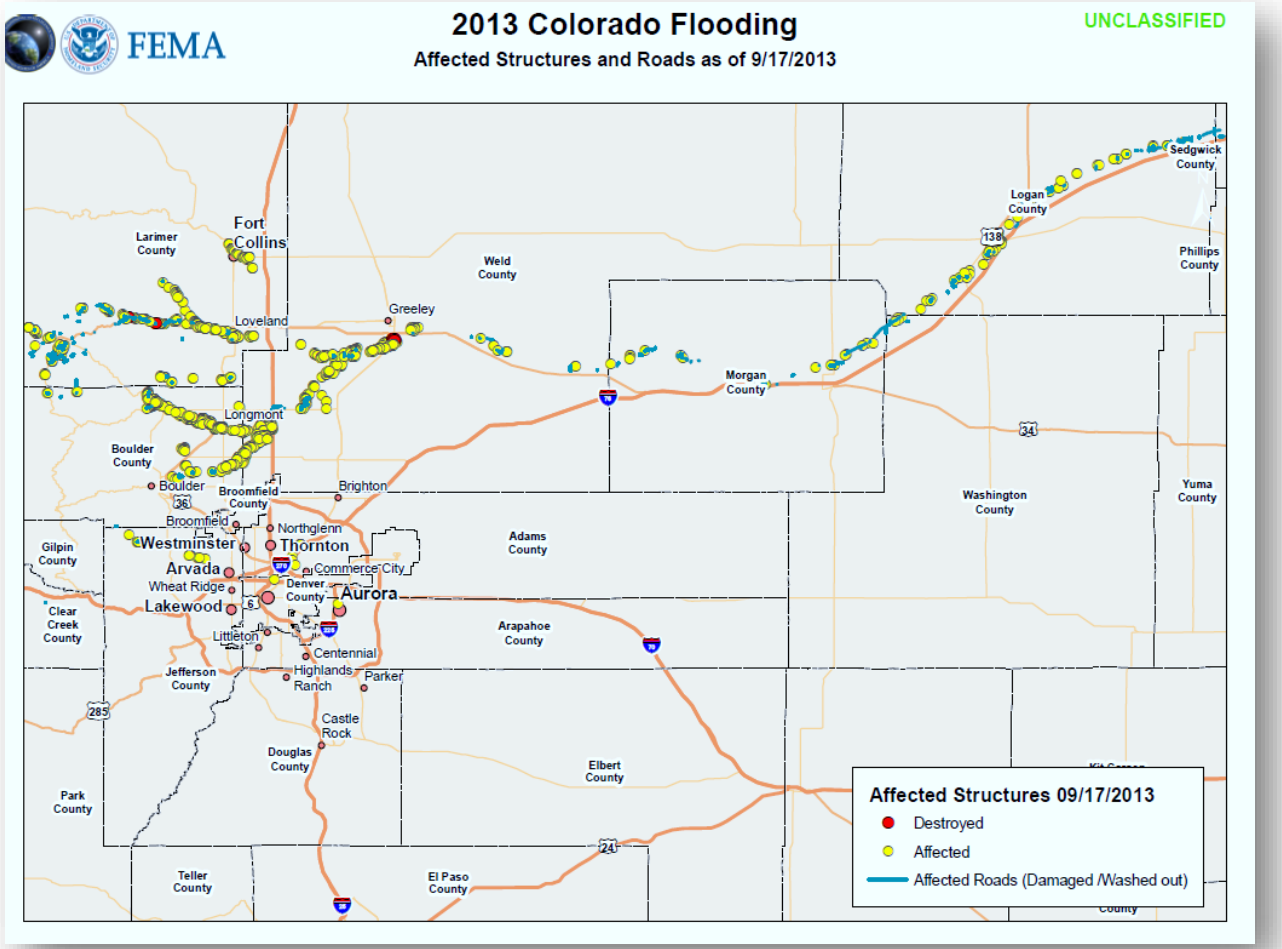
- Help FEMA **effectively utilize resources** and **improve service** through decision support for locating and staffing DRCs
- Explore implementation challenges for data-driven decision support in disaster response practice
  - Lack of trust for 'inflexible' models
  - Urgency trumps efficiency
  - Policy and regulations





Service center siting decisions

- A disaster has occurred
- You know:
  - What kind of damage and where
  - Approximate population of these areas
  - (maybe) some relevant data on who needed assistance in similar disasters
- You decide:
  - Where to site service centers and how many staff to allocate to each center



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Need for decision support

- Complex coordination is required
  - Federal/state/local stakeholders have varying incentives and objectives (social, economic, political, etc.)
  - No formal decision process for opening/closing and staffing DRCs

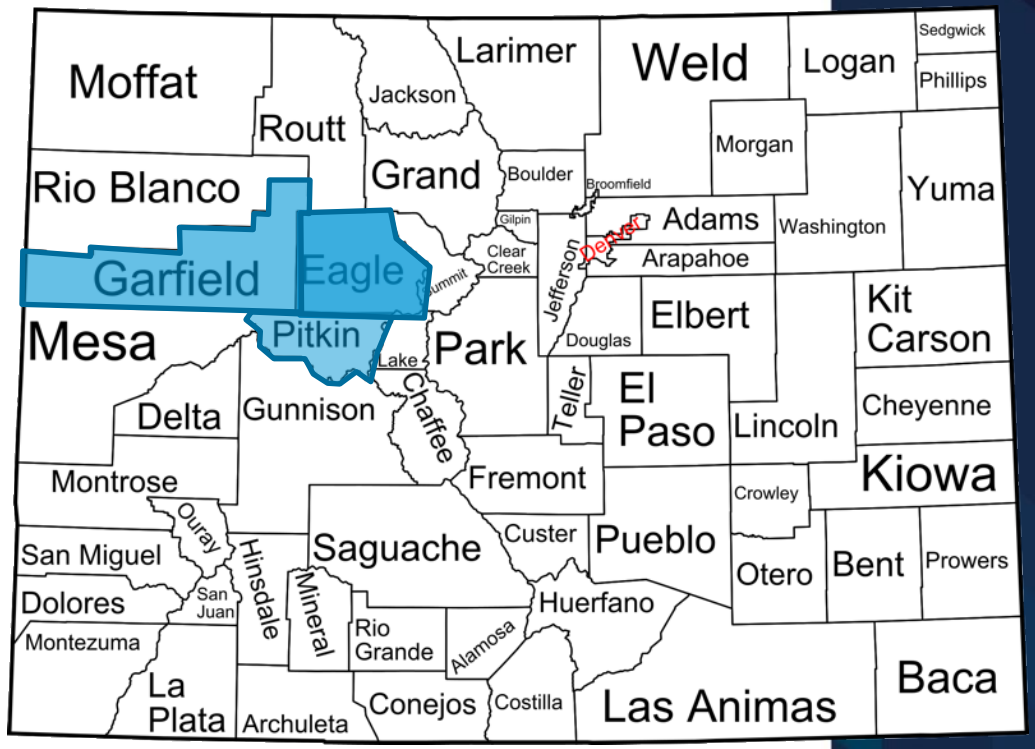
- Multiple competing goals
  - Reasonable travel time for affected population
  - Sufficient staff to provide services
  - Highly visible help to population
  - Minimize costs
- Our aim: develop systematic decision support tool
  - Mitigate complex incentives
  - Align stakeholders

Two models for decision support

- Jurisdiction model
  - Simple, easy to understand
  - Formalizes what decision-makers are already doing
  - Uses data and models to make current process more efficient
- Travel time model
  - Sophisticated optimization is powerful but harder to understand
  - Challenges current assumptions to improve service and save costs

Jurisdiction model

- Decisions are made on a county-by-county basis.
- Approach: DRCs are opened if the expected demand (visitors) exceeds a minimum threshold.
  1. Set a minimum threshold for opening a DRC
  2. Estimate expected demand (relationship from historical data)
  3. Open min. DRCs with required staff



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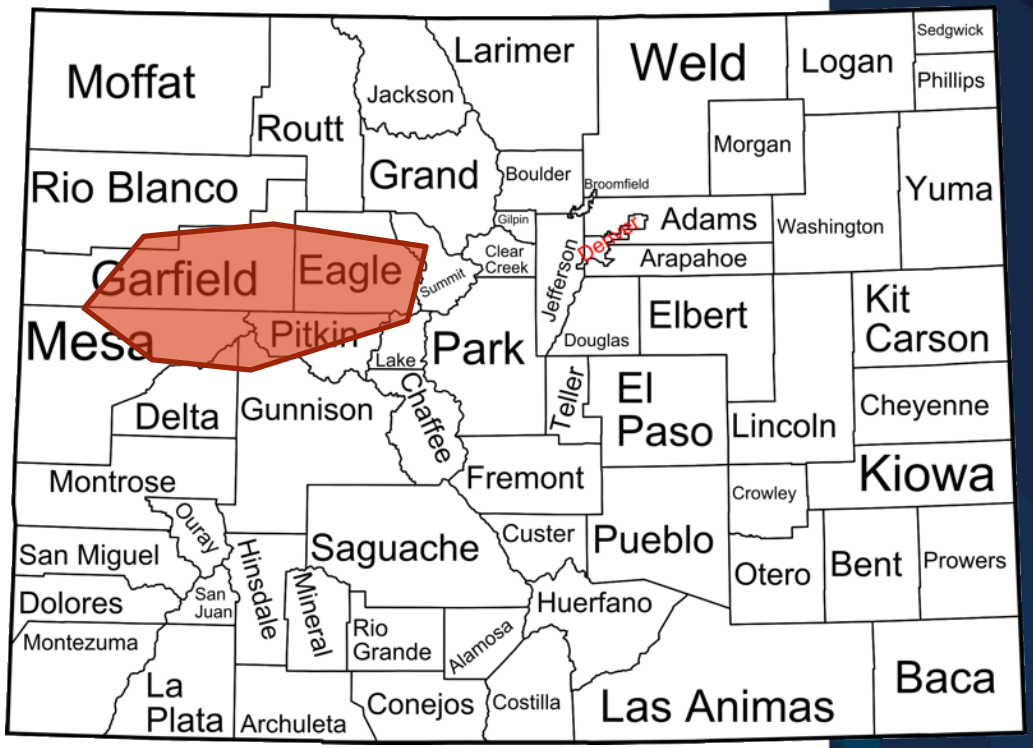
Travel time model

- Decisions are made on the whole disaster level (i.e. county lines do not matter).
- Approach: Optimization model (MILP) ensures every visitor can reach a DRC within one hour while minimizing cost
  - Fixed and variable DRC costs
  - Travel time costs



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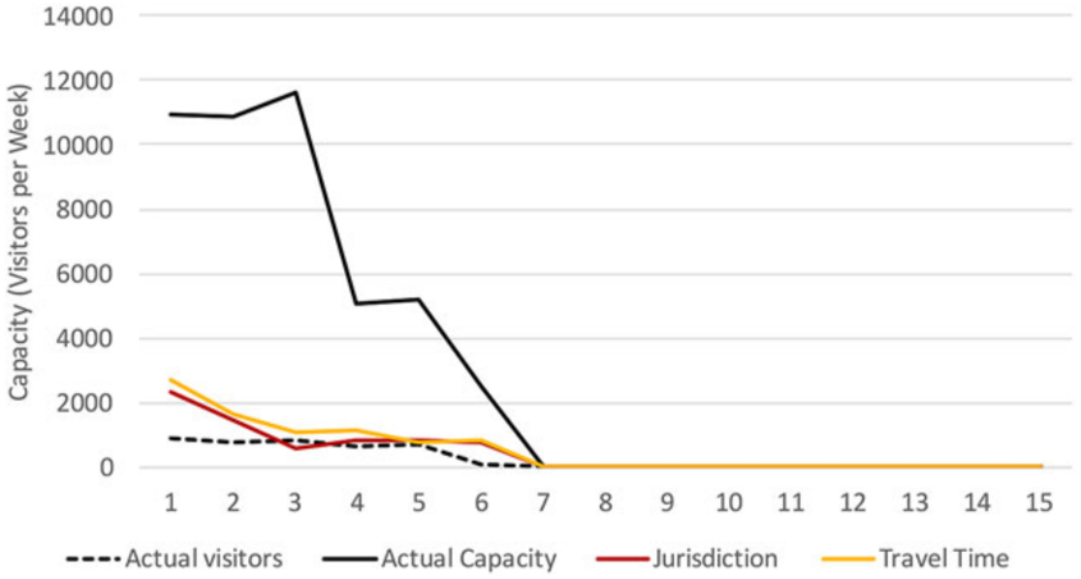
Ongoing operations

- Approach
  - Project next week's expected demand
    - Based on data from four past disasters
  - Reduce staff-hours and/or close DRCs as warranted by lower demand
    - Using thresholds used in the Jurisdiction Model
- Jurisdiction model applies this approach for each county
- Travel time model applies this approach system-wide, closing the lowest-trafficked DRCs first

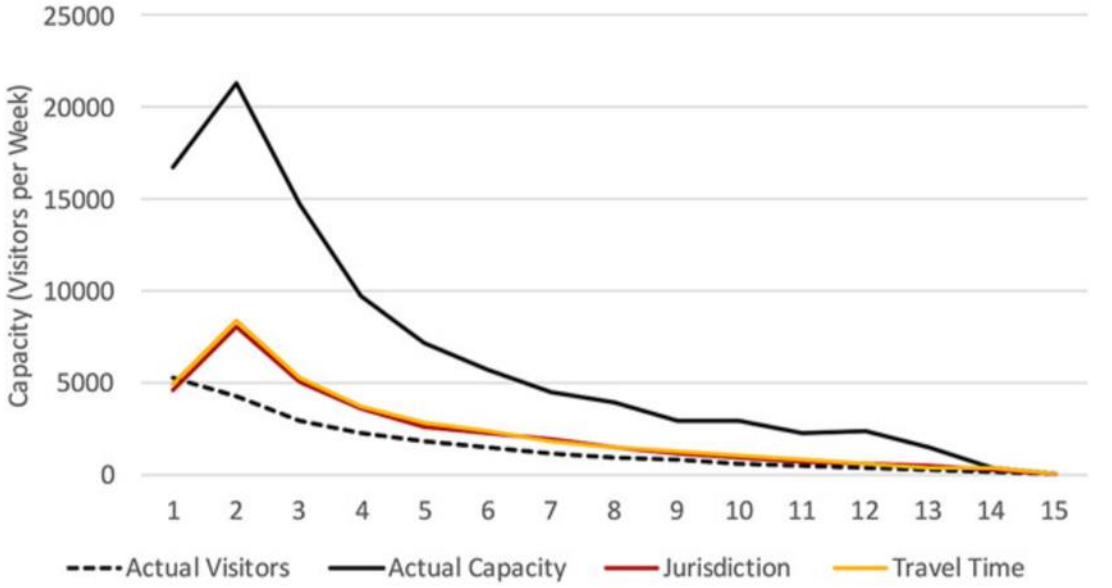
Evaluating the models

- Compare models to actual results in three past disasters in 2013
  - Flash floods in Colorado (FEMA Disaster Number 4145)
  - Flash floods in Illinois (4116)
  - Tornadoes in Illinois (4157)
- Disasters were chosen to explore different disaster types and rural/urban settings and where sufficient data were available to make comprehensive comparisons

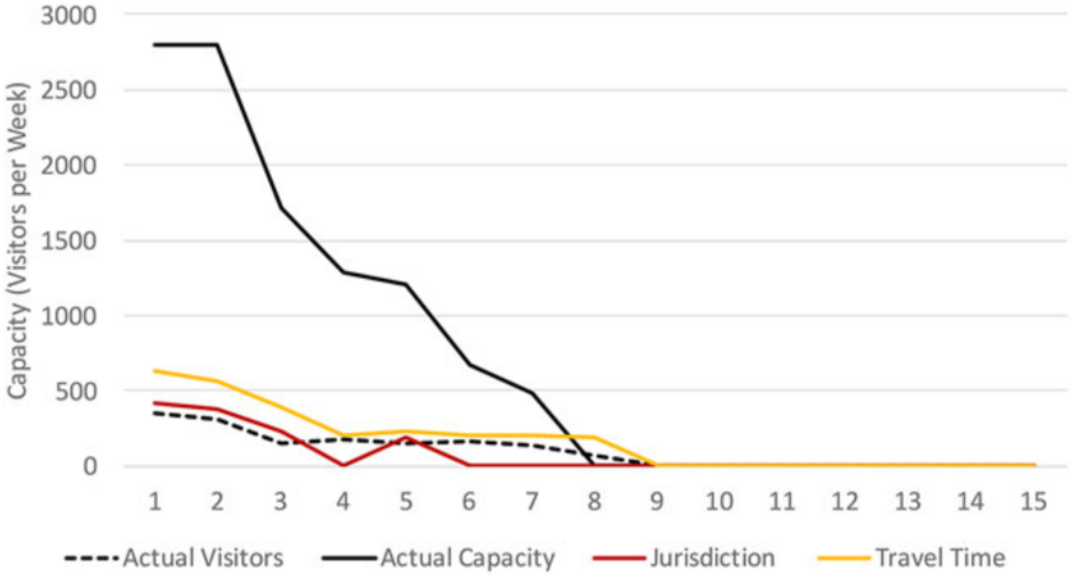
Results: capacity



Chicago-area floods



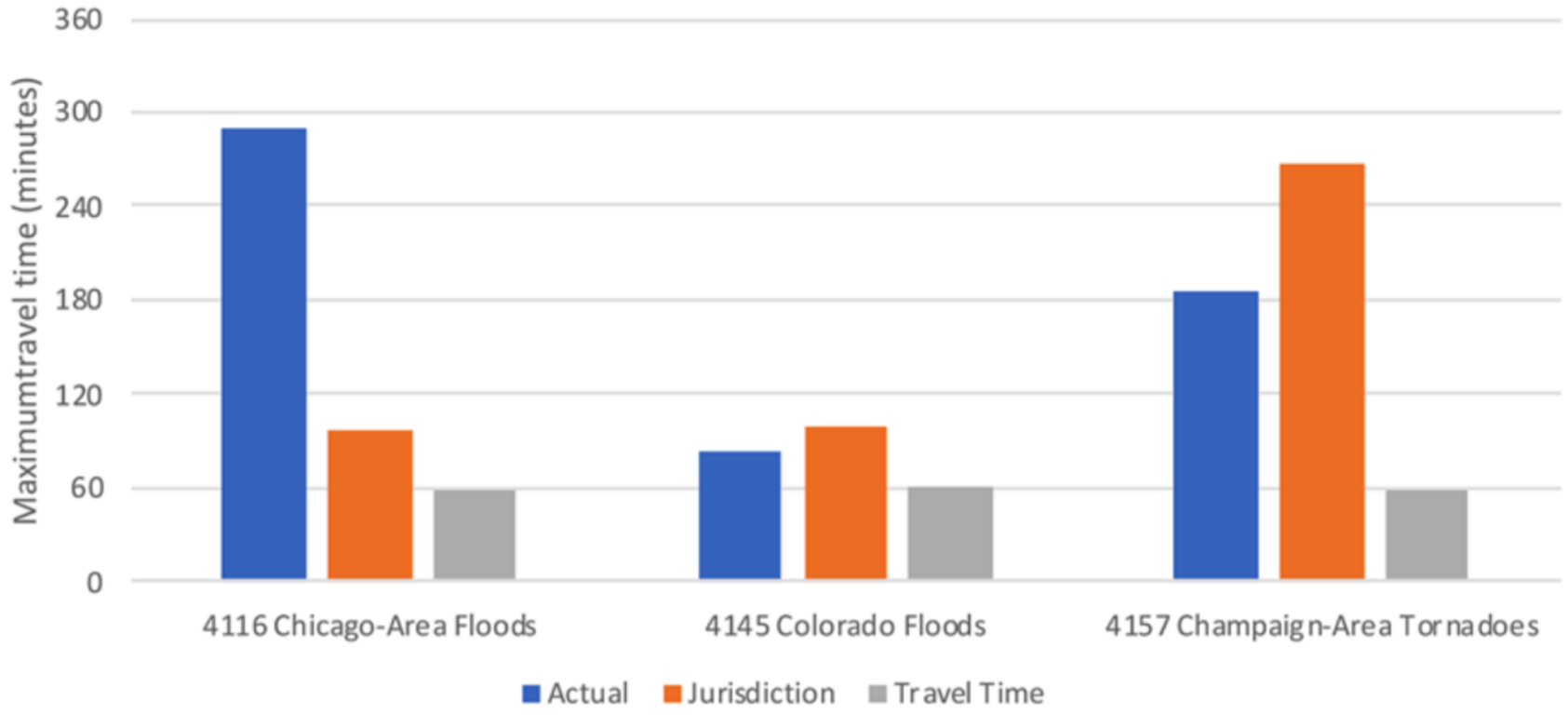
Colorado floods



Champaign tornadoes

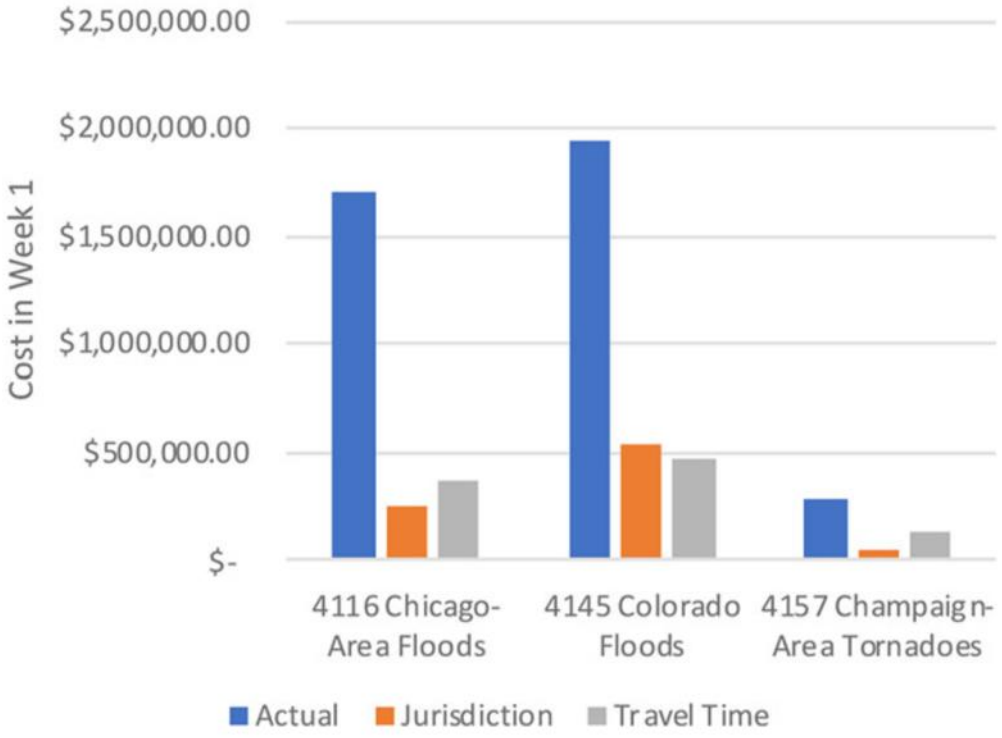
Actual capacity was far greater than demand. Both models provide a much better match.

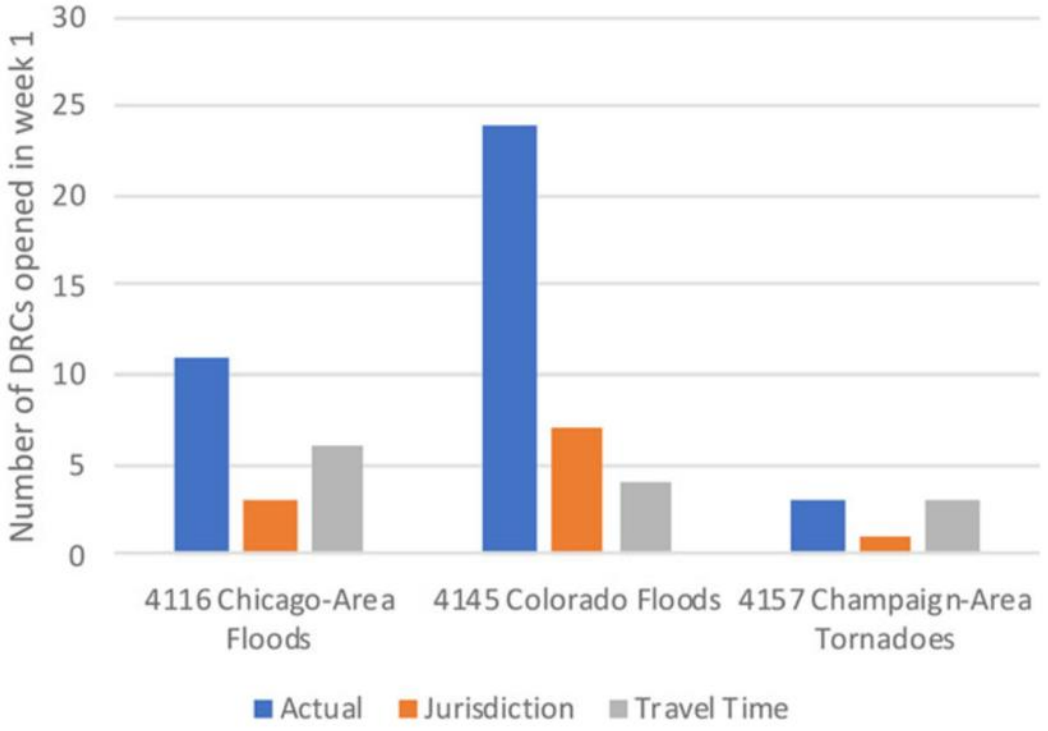
Results: travel time



Some visitors had to travel quite far.
The travel time model guarantees improvement.

Cost and number of DRCs





Costs in week 1 were far greater than necessary.
Both models significantly reduce costs, largely through reductions in number of DRCs.

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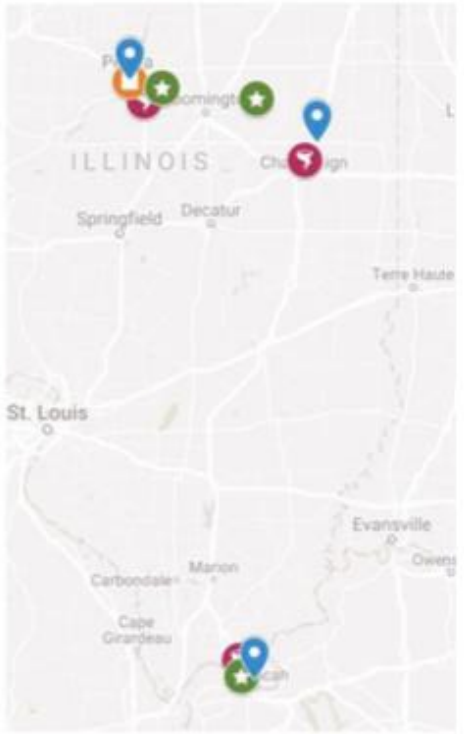
Results: Maps

Travel time model (green stars) places centers more equitably than jurisdiction (orange squares); both are more efficient than actual response (blue pins).

Chicago-area flooding

Colorado flooding



Champaign-area tornadoes

Summary of results

- Major improvements over current method of DRC allocation
  - Cost savings of **55-85%**, or $158k-$1.5m just in the first week
  - Sufficient service to meet nearly all demand
  - Travel time model guarantees improved service and equitable access

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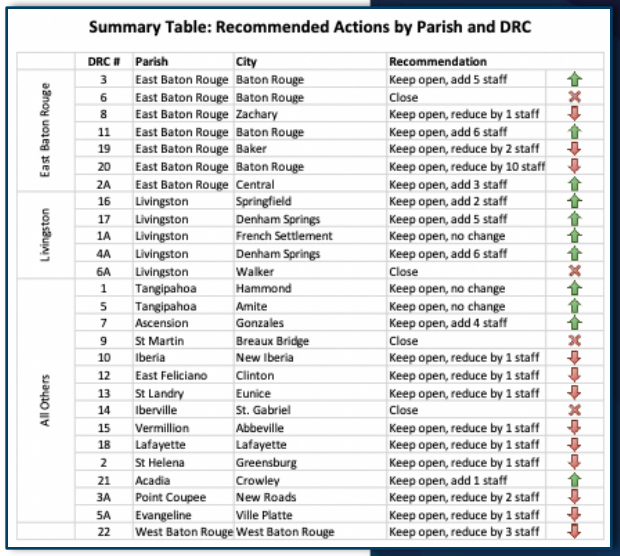
Discussion

- Both models save significant costs and better meet capacity
- Jurisdiction model is easy to use, fits current processes, uses data to support collaborative decision-making, and highlights the key decision points (e.g., threshold)
  - But it may leave a small number of people without access to a DRC in their counties
- Travel time model ensures reasonable and equitable DRC access, and gains efficiencies by ignoring county lines
  - But it is harder to use and to understand

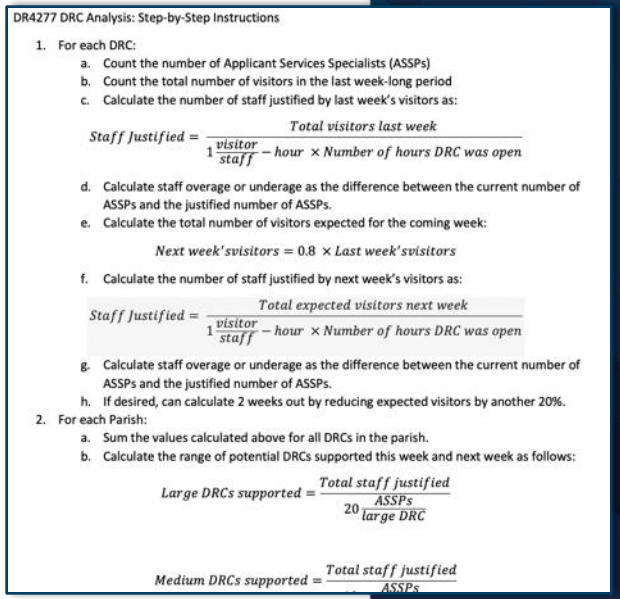
Implementation at FEMA

- Jurisdiction model has been partially implemented at FEMA
  - 2014 Michigan floods
  - 2016 severe storms and flooding in Louisiana
  - 2016 Hurricane Matthew
  - 2017 hurricanes in Texas, Florida, and Puerto Rico
  - …
- Barriers to full implementation
  - FEMA works with stakeholders, who vary from response to response, and have different goals, approaches, considerations
- Record of success in past disasters helps to build trust for future use
  - More easily implementable model paves the way for further sophisticated approaches



Summary Table: Recommended Actions by Parish and DRC

	DRC #	Parish	City	Recommendation
East Baton Rouge	3	East Baton Rouge	Baton Rouge	Keep open, add 5 staff
	6	East Baton Rouge	Baton Rouge	Close
	8	East Baton Rouge	Zachary	Keep open, reduce by 1 staff
	11	East Baton Rouge	Baton Rouge	Keep open, add 6 staff
	19	East Baton Rouge	Baker	Keep open, reduce by 2 staff
	20	East Baton Rouge	Baton Rouge	Keep open, reduce by 10 staff
	2A	East Baton Rouge	Central	Keep open, add 3 staff
Livingston	16	Livingston	Springfield	Keep open, add 2 staff
	17	Livingston	Denham Springs	Keep open, add 5 staff
	1A	Livingston	French Settlement	Keep open, no change
	4A	Livingston	Denham Springs	Keep open, add 6 staff
	6A	Livingston	Walker	Close
All Others	1	Tangipahoa	Hammond	Keep open, no change
	5	Tangipahoa	Amite	Keep open, no change
	7	Ascension	Gonzales	Keep open, add 4 staff
	9	St Martin	Breaux Bridge	Close
	10	Iberia	New Iberia	Keep open, reduce by 1 staff
	12	East Feliciana	Clinton	Keep open, reduce by 1 staff
	13	St Landry	Eunice	Keep open, reduce by 1 staff
	14	Iberville	St. Gabriel	Close
	15	Vermillion	Abbeville	Keep open, reduce by 1 staff
	18	Lafayette	Lafayette	Keep open, reduce by 1 staff
	2	St Helena	Greensburg	Keep open, reduce by 1 staff
	21	Acadia	Crowley	Keep open, add 1 staff
	3A	Point Coupee	New Roads	Keep open, reduce by 2 staff
	5A	Evangeline	Ville Platte	Keep open, reduce by 1 staff
	22	West Baton Rouge	West Baton Rouge	Keep open, reduce by 3 staff



DR4277 DRC Analysis: Step-by-Step Instructions

1. For each DRC:
   a. Count the number of Applicant Services Specialists (ASSPs)
   b. Count the total number of visitors in the last week-long period
   c. Calculate the number of staff justified by last week's visitors as:

$$Staff\ Justified = \frac{Total\ visitors\ last\ week}{1\frac{visitor}{staff} - hour \times Number\ of\ hours\ DRC\ was\ open}$$

   d. Calculate staff overage or underage as the difference between the current number of ASSPs and the justified number of ASSPs.
   e. Calculate the total number of visitors expected for the coming week:

$$Next\ week's visitors = 0.8 \times Last\ week's visitors$$

   f. Calculate the number of staff justified by next week's visitors as:

$$Staff\ Justified = \frac{Total\ expected\ visitors\ next\ week}{1\frac{visitor}{staff} - hour \times Number\ of\ hours\ DRC\ was\ open}$$

   g. Calculate staff overage or underage as the difference between the current number of ASSPs and the justified number of ASSPs.
   h. If desired, can calculate 2 weeks out by reducing expected visitors by another 20%.
2. For each Parish:
   a. Sum the values calculated above for all DRCs in the parish.
   b. Calculate the range of potential DRCs supported this week and next week as follows:

$$Large\ DRCs\ supported = \frac{Total\ staff\ justified}{20\frac{ASSPs}{large\ DRC}}$$

$$Medium\ DRCs\ supported = \frac{Total\ staff\ justified}{ASSPs}$$

Conclusions

- There are significant cost savings opportunities
- Data- and model-driven decision support tools (even simple ones) can lead to major benefits in practice
- Building easy-to-implement models can build support for decision support tools

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Thank you

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