Continental Dialogue on Non-Native Forest Insects and Diseases, Nov 3-4, 2014, Charlotte, NC

NETWORK MODELING TO ASSESS RISK OF FOREST PEST SPREAD VIA CAMPER TRAVEL (AND FIREWOOD TRANSPORT)

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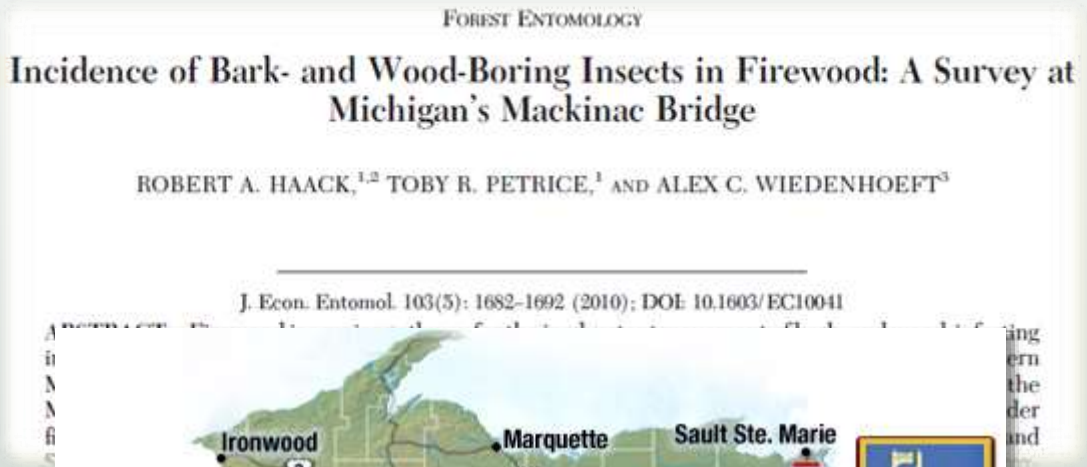
Firewood and Forest Pests

- Widespread concern in forest health community regarding accidental transport of forest pests in firewood
- Most states now have some restrictions on firewood movement, in some cases with penalties for violations

Images: Florida Dept of Ag and Consumer Services; New York Dept of Environmental Conservation; Iowa Dept of Natural Resources; USDA-FS, R9, Allegheny NF

Firewood and Forest Pests: Real Issue?

- Haack et al. (2010) looked at firewood surrendered at Michigan's Mackinac Bridge (due to EAB quarantine)
  - 16% of firewood was from out of state
  - 23% infested with live borers
  - Another 41% had evidence of previous borer infestation



FOREST ENTOMOLOGY

Incidence of Bark- and Wood-Boring Insects in Firewood: A Survey at Michigan's Mackinac Bridge

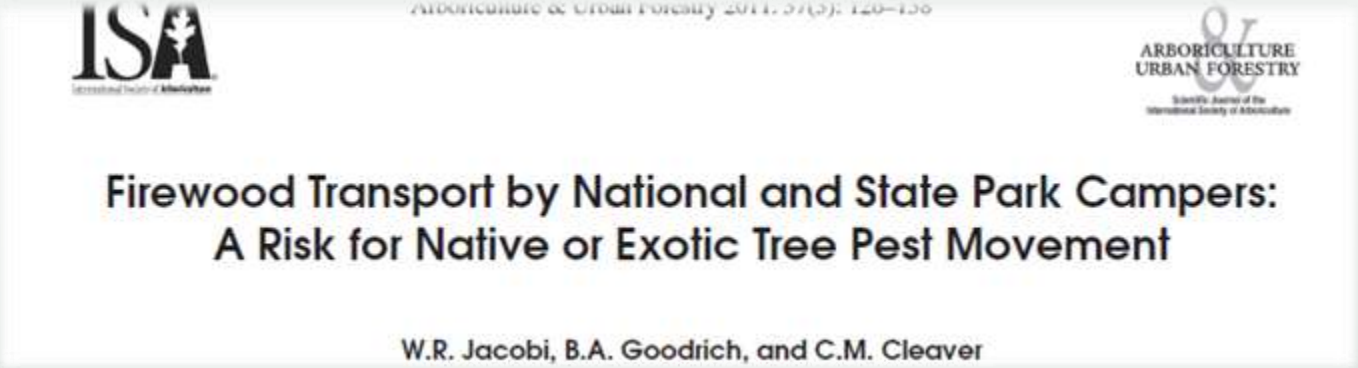
ROBERT A. HAACK,[1,2] TOBY R. PETRICE,[1] AND ALEX C. WIEDENHOEFT[3]

J. Econ. Entomol. 103(5): 1682–1692 (2010); DOI: 10.1603/EC10041

CITY	MILEAGE TO BRIDGE
Detroit	295
Flint	230
Grand Rapids	238
Grayling	90
Ironwood	306
Lansing	236
Marquette	161
Menominee	195
Sault Ste. Marie	51.5

Map: www.mackinacbridge.org

Firewood and Forest Pests: Real Issue?



- Jacobi et al. (2011) reported results of camper surveys in 7 Colorado state parks, 13 National Parks in AZ, CO, NV, UT, WY
  - 66% of CO state park campers brought firewood, only 4% from out-of-state
  - 60% of Nat'l Park campers brought firewood, 39% from out-of-state
  - 41% out-of-state firewood from non-adjacent states
  - 53% of surveyed firewood had evidence of previous insect presence, 39% fungal infestation
- An assortment of camper surveys from other states (e.g., WI, MN, VT) tell similar stories

Genuine Risk, But How to Assess?

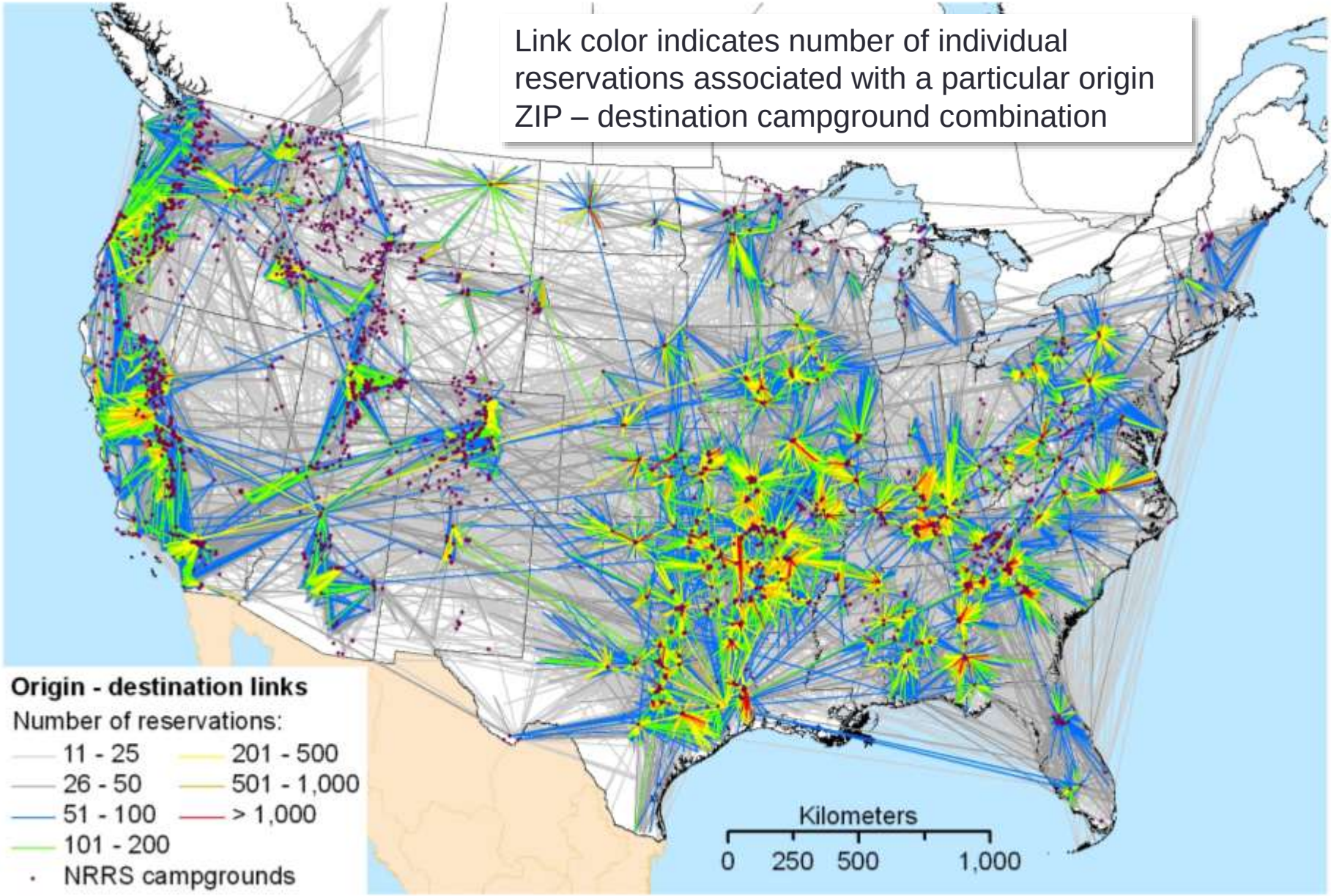
- Appears to be some risk of forest pest spread via camper travel and firewood transport
  - …although actual cases of pest spread in firewood only documented anecdotally
- Detailed (and broad-scaled) data on firewood transport and usage by campers are lacking
- Possible solution: Explore the travel behavior of campers in general, rather than their use of firewood
  - Can use camper reservation records to do this

One Data Source…

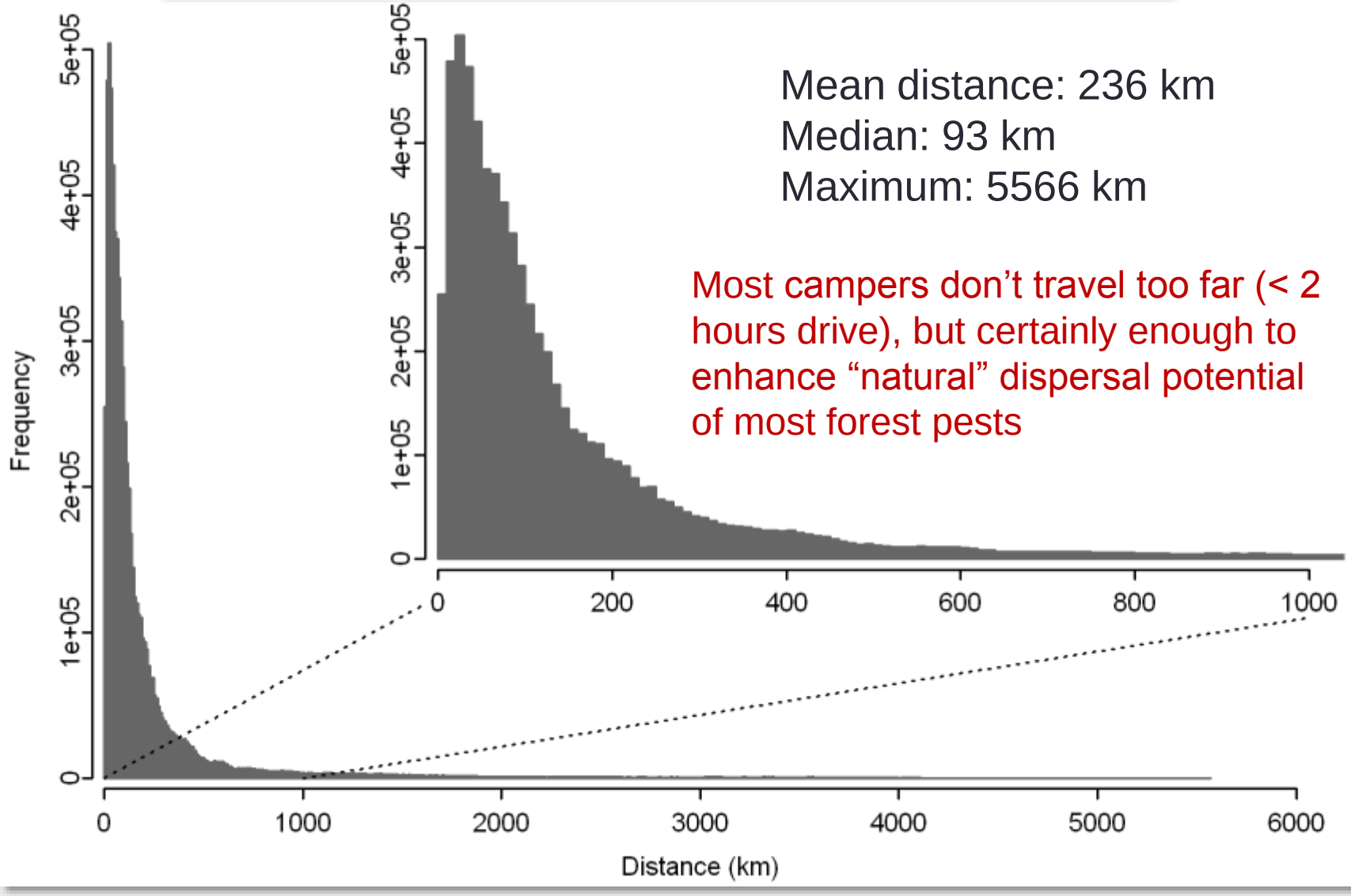
- National Recreation Reservation Service (NRRS)
  - Online reservations system for US federal camping facilities (Forest Service, National Park Service, BLM, others)
- NRRS data for 1/2004 - 9/2009
  - Approx. 7.2 million individual camper reservations
    - Including visitors from Canada
  - More than 2500 campground locations throughout U.S.
  - Each reservation record represents a “link” between a camper’s origin ZIP code and a destination campground

Images: NRRS; USDA-FS Cleveland NF; US Army Corps of Engineers

Map of links from visitor origin ZIP codes to destination campgrounds



Histogram of visitor travel distances, NRRS data set



Mean distance: 236 km
Median: 93 km
Maximum: 5566 km

Most campers don't travel too far (< 2 hours drive), but certainly enough to enhance "natural" dispersal potential of most forest pests

Koch et al. (2012): Preliminary Analysis of NRRS Data

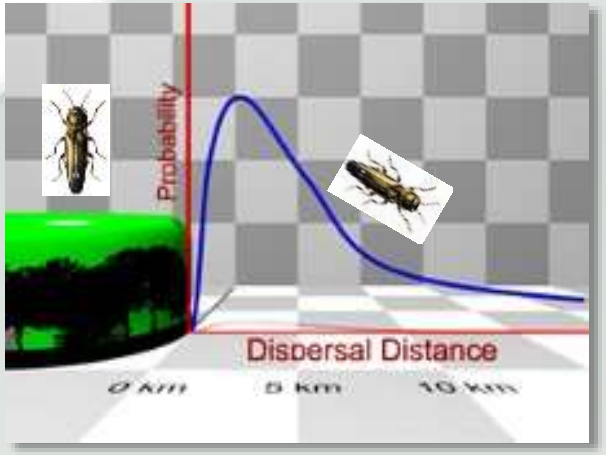
Dispersal of Invasive Forest Insects via Recreational Firewood: A Quantitative Analysis

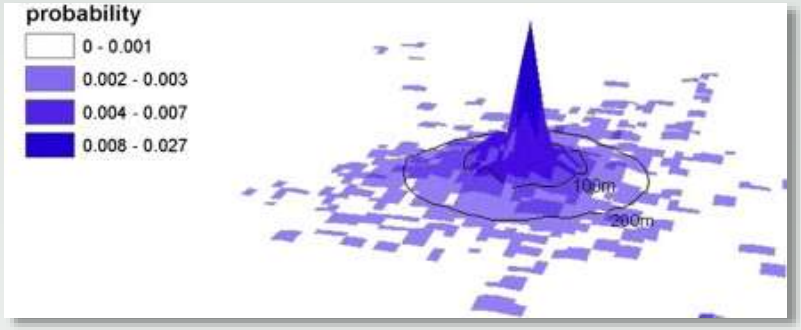
FRANK H. KOCH,[1,2] DENYS YEMSHANOV,[3] ROGER D. MAGAREY,[4] AND WILLIAM D. SMITH[1]

J. Econ. Entomol. 105(2): 438–450 (2012); DOI: http://dx.doi.org/10.1603/EC11270

ABSTRACT Recreational travel is a recognized vector for the spread of invasive species in N

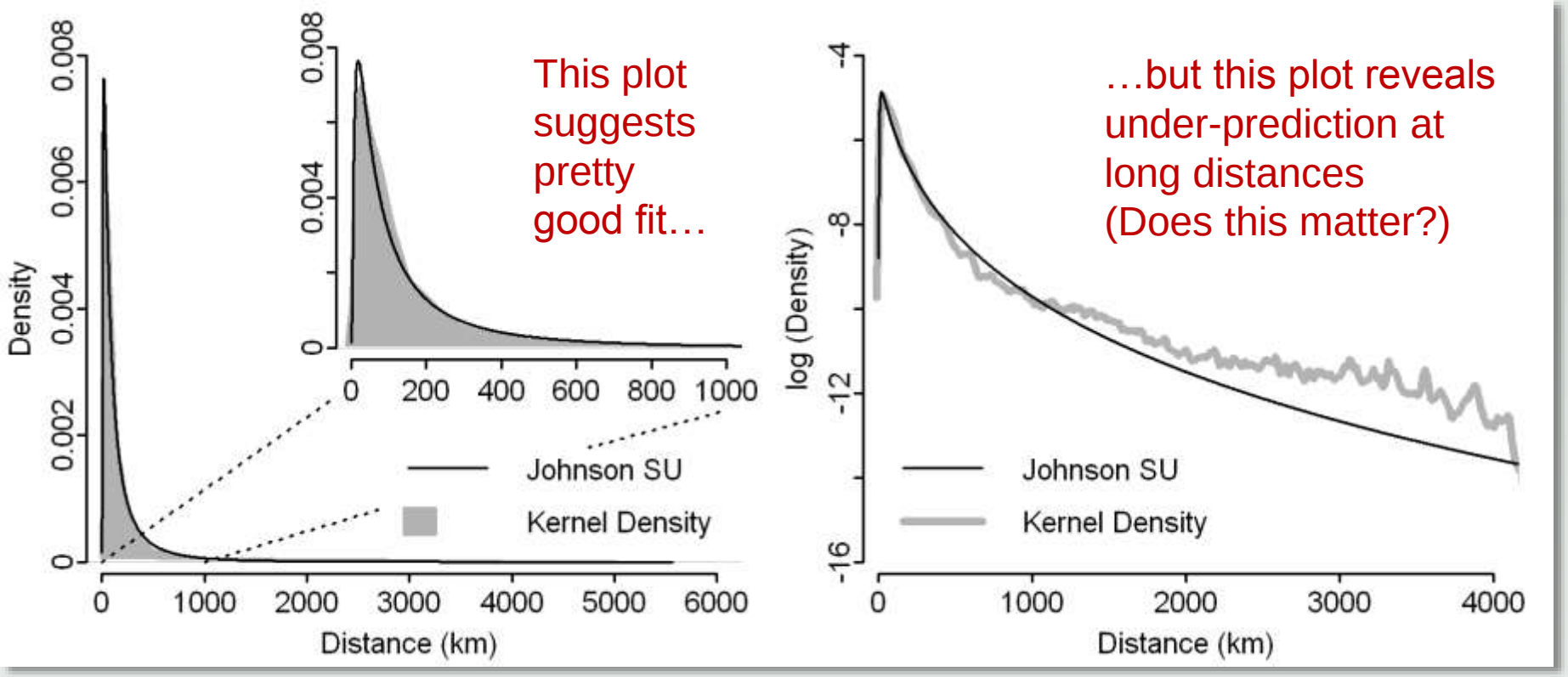
- In this paper, attempted to fit the NRRS distance data with theoretical distributions in order to develop dispersal kernels we could use in modeling human-mediated spread of forest insects





Distribution Fitting

- Best-fitting distribution: unbounded Johnson (SU); lognormal very similar



Plot of density vs. travel distance

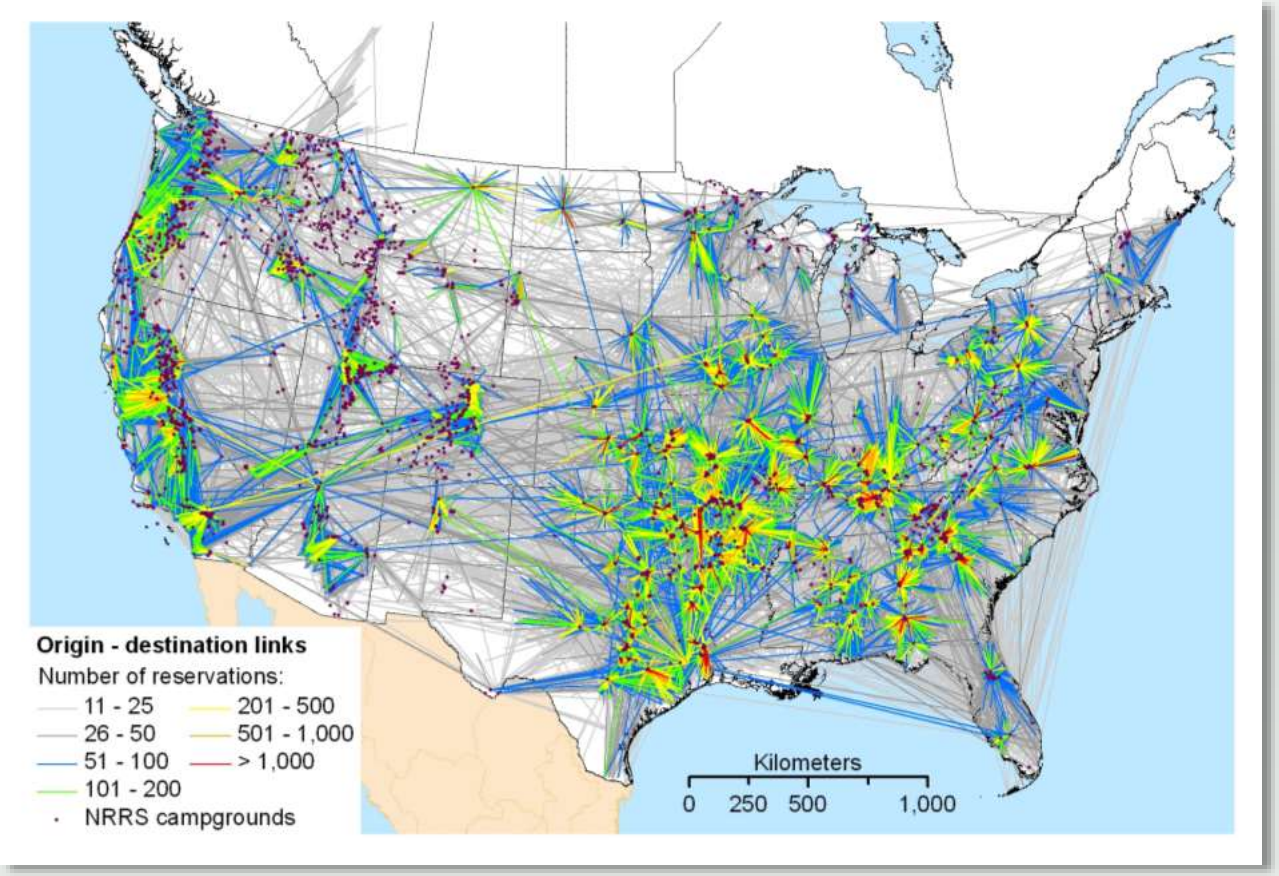
Plot of the logarithm of density vs. travel distance

Koch et al. (2012): Key Points

- Can derive a reasonable distribution (kernel) to simulate long-distance “recreational” dispersal for use in pest spread models
- Relating the NRRS data to firewood…based on the small number of firewood inspections and usage surveys from across U.S. …
  - 30-40% of campers bring firewood from home (or other distant locations)
  - If assume ~20% of firewood is infested with live borers, then 6-10% of campground visits involve movement of infested firewood
  - Accounting for factors such as burning of firewood before pests can escape, seems reasonable that 3-5% of campground visits pose a potential risk of firewood-facilitated dispersal of forest pests
- Even if a much lower percentage, millions of campground visits every year
  - 1.2 million per year in the NRRS data alone
- Current concerns about risk of pest spread due to firewood appear to be justified

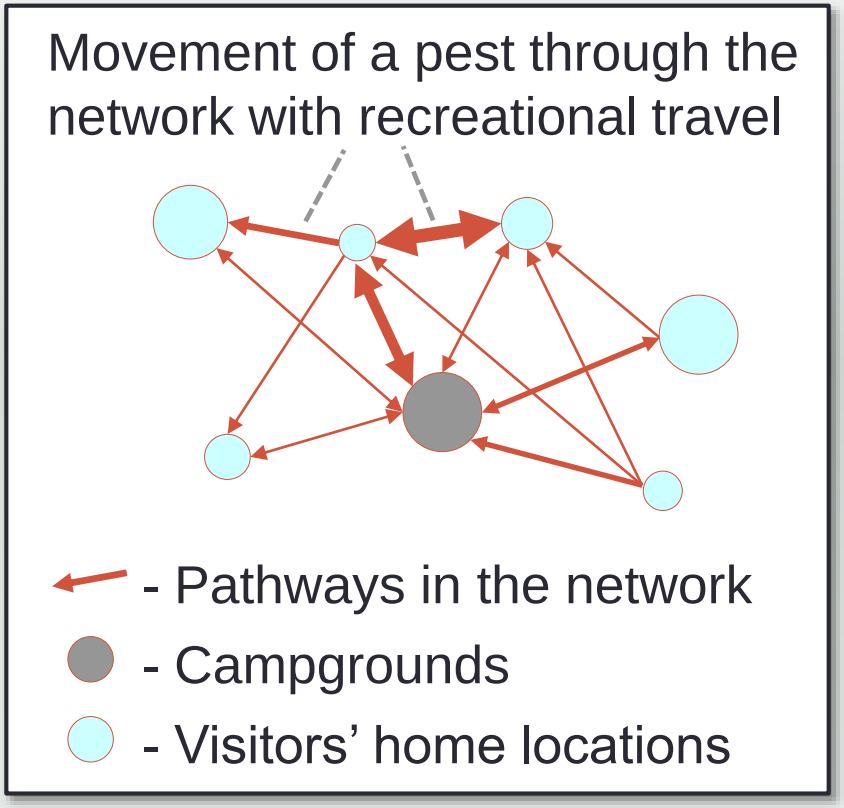
Limitation of “Kernel Approach”

- Recall map from earlier…
- Human-mediated dispersal follows specific routes and has a certain set of specific destinations
- In short, it’s a network

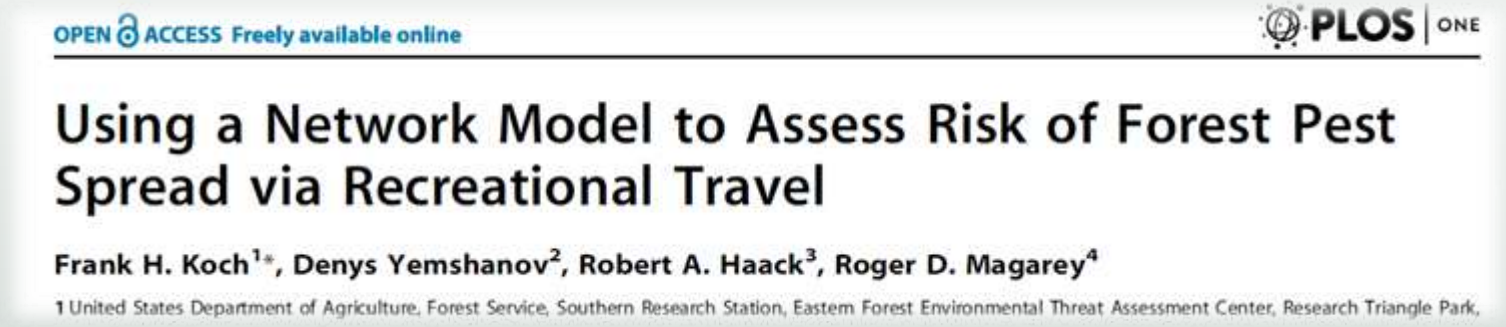


Network-Based Approach As Alternative

- What if we applied the NRRS data in a network setting?
  - Visitors' home and campgrounds = two sets of networked nodes
  - Strength of pathways defined by number of campers traveling along them
- Can use this "pathway model" to identify probable origins and destinations



Koch et al. (2014): Network Modeling with NRRS Data



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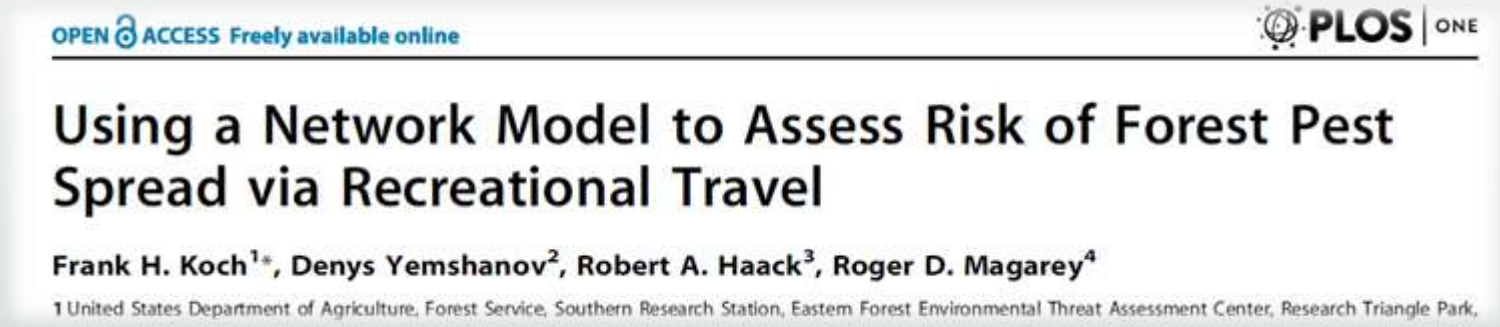
Using a Network Model to Assess Risk of Forest Pest Spread via Recreational Travel

Frank H. Koch[1]*, Denys Yemshanov[2], Robert A. Haack[3], Roger D. Magarey[4]

1 United States Department of Agriculture, Forest Service, Southern Research Station, Eastern Forest Environmental Threat Assessment Center, Research Triangle Park,

- As with Koch et al. (2012), focused on bark- and wood-boring insects that might use firewood as a host
- Key analytical steps:
  - Aggregating NRRS data to set of unique locations (i.e., map cells)
  - Developing pathway transmission matrix with approx. 15000 x 15000 elements
    - i.e., pairs of 15-km map cells representing origin and destination locations
    - Transmission matrix served as the foundation of a bi-directional model
  - Undertaking pathway simulations from each location in this network

Koch et al. (2014): Network Modeling with NRRS Data



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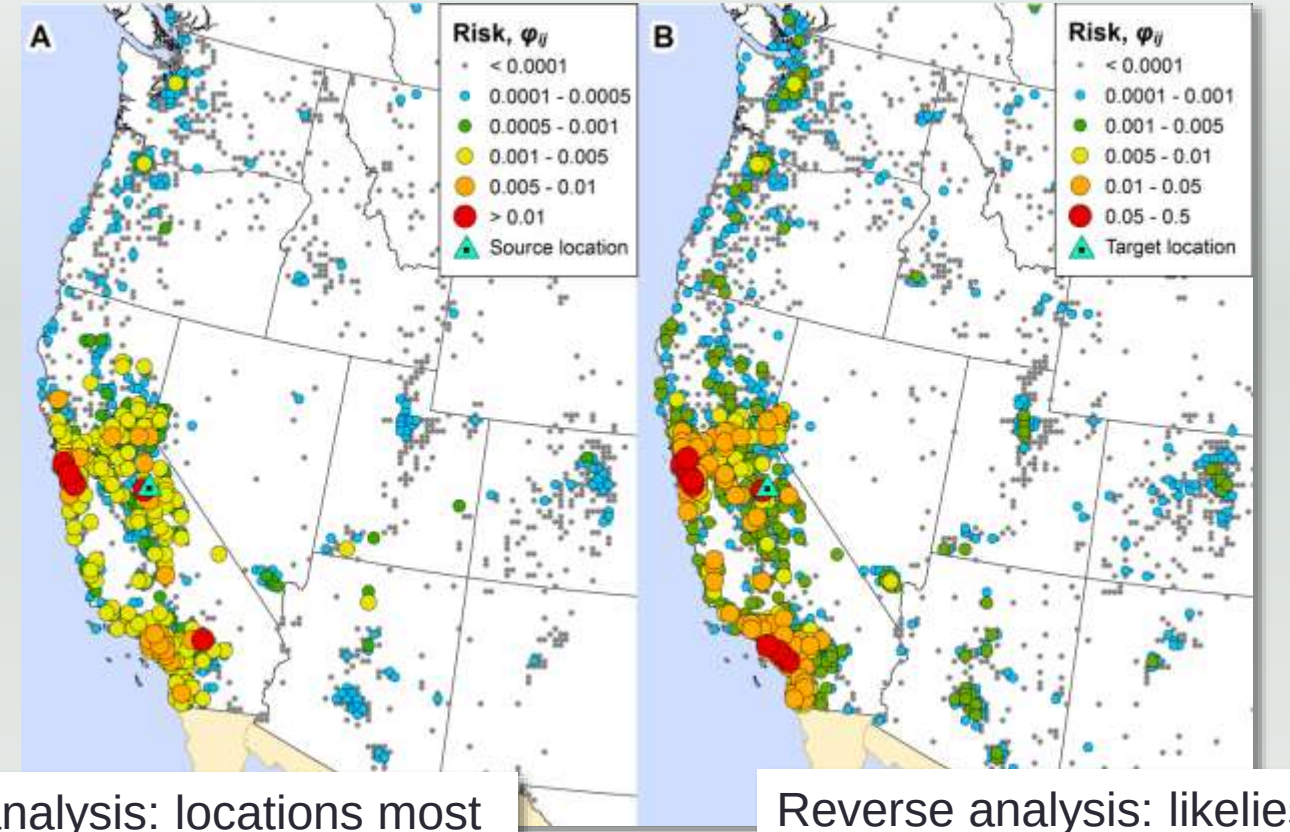
- Couple of key assumptions:
  - Only included reservations where both the visitor's origin location and the destination campground were in the late spring-early summer period when the visit occurred
    - Presumes that risk of successful borer invasion is greatest during time when adult insects emerge from host
  - Assumed that 15% of firewood-carrying campers brought unused firewood home with them (based on WI survey)

Network Model Application

- Forward and reverse pathway analysis
  - Yosemite Valley Area (in Yosemite NP) as hypothetical example



Forward analysis: locations most at risk of receiving forest pest from Yosemite Valley

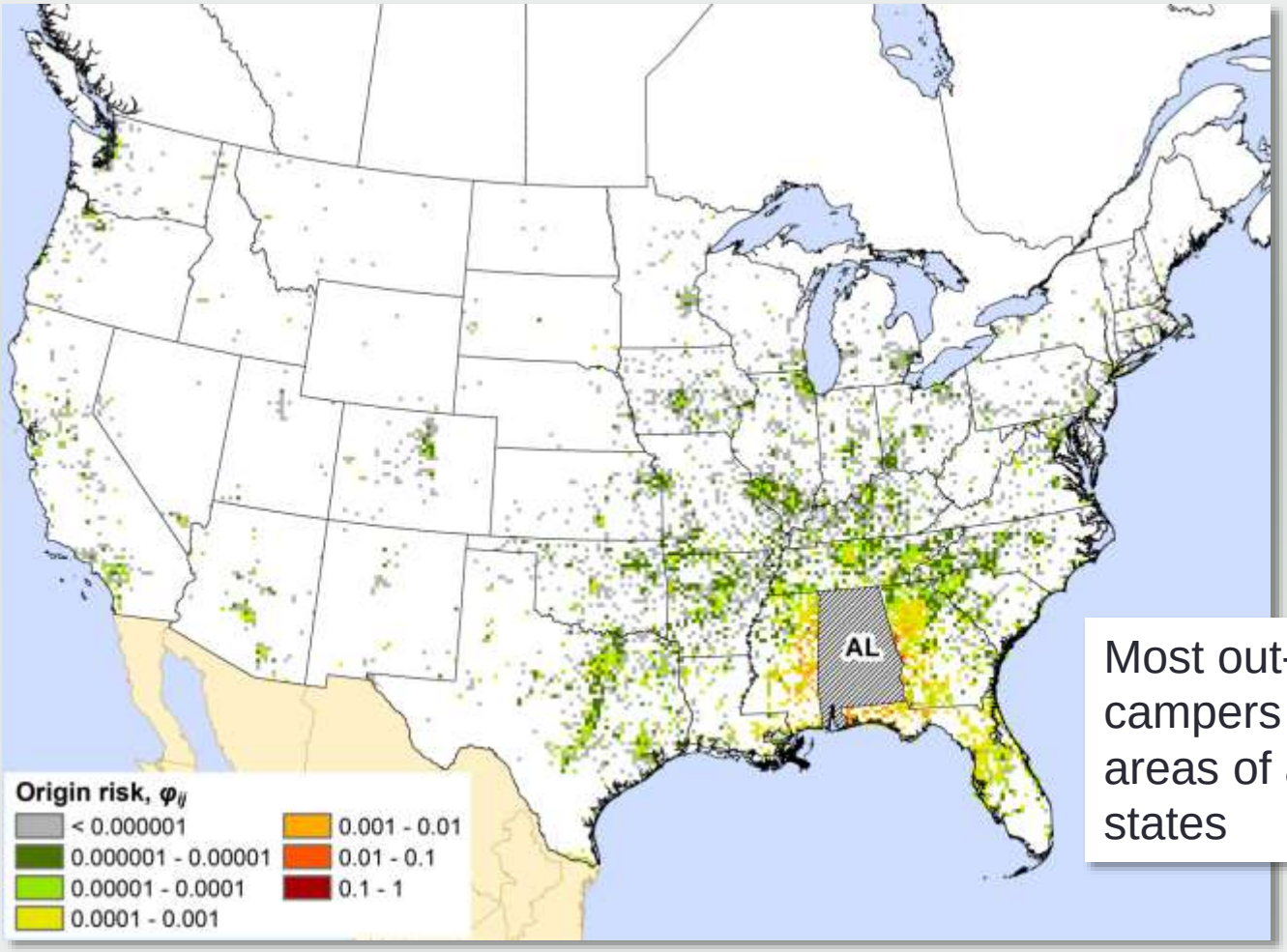
Reverse analysis: likeliest source locations if Yosemite Valley found to be infested

But How Best to Summarize to Model Results?

- Much regulatory decision making takes place at state or provincial level
  - For example, implementation of firewood movement restrictions
- So, for each US state (and Canadian province), we generated a map that sums – for each 15-km map cell outside the state of interest – the probabilities for all pathways between that cell and any destination cell within the target state
  - Maps depict most likely out-of-state origin (or source) locations for the target state

Two Main Patterns of Origin Risk…

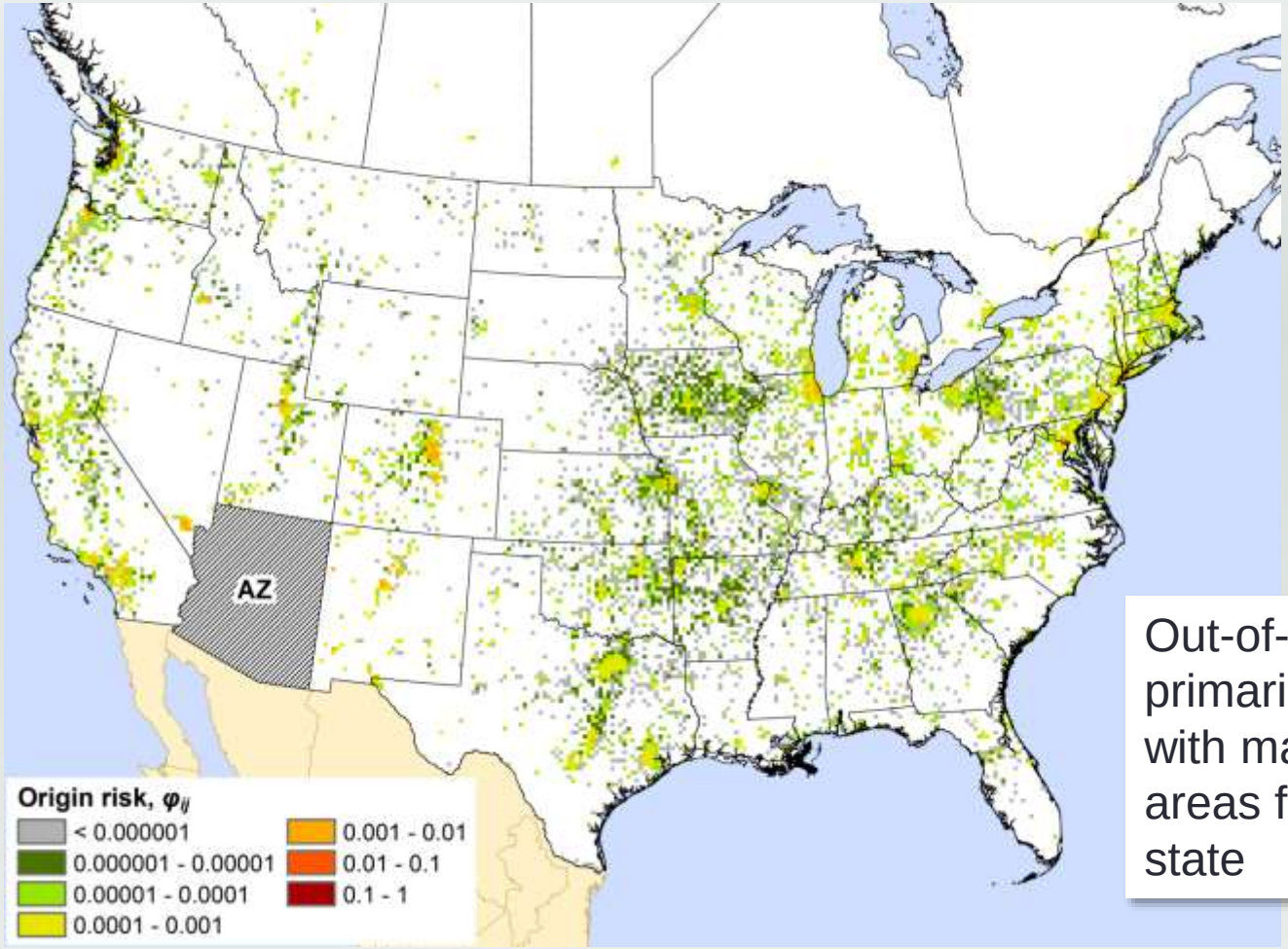
- First example: Alabama



Most out-of-state campers from nearby areas of adjacent states

Two Main Patterns of Origin Risk…

- Second example: Arizona



Out-of-state campers primarily associated with major urban areas far from the state

Koch et al. (2014): Key Points

- A few states and the Canadian provinces show aspects of both patterns
- Regardless, output maps can guide deployment of resources for surveillance, firewood inspections, or other activities
- No single response strategy is appropriate for all states (or provinces)
  - If most out-of-state campers are traveling from distant areas, could deploy resources at key points along major roads, i.e., “bottlenecks” of camper movement
  - If most out-of-state campers are from nearby areas, they may have many feasible travel routes, so more widely distributed deployment may be necessary

Koch et al. (2014): Key Points

- Some caveats:
  - We only analyzed federal campgrounds, and patterns almost certainly differ for state or private facilities
    - We're currently working on this using reservations data from states/provinces in the Great Lakes region
  - More important caveat is that relationship between campground travel and firewood transport has only been defined tentatively
    - Our data only covered camper travel, NOT firewood
    - We haven't truly quantified risk, merely represented it in relative terms
  - Some unanswered questions:
    - Does proportion of campers carrying firewood change with distance? (Jacobi et al. 2011 study suggests this is true)
    - Even if 3-5% of all camping trips involve infested firewood, how much of this represents a **meaningful** spread risk?
      - Chance carrying an invasive, non-native pest?
      - Populations sufficient for establishment?

So, What Next?

- We aren't quite "there" in terms of quantifying firewood risk
- However, research can still guide how or where to prioritize public awareness / outreach activities

Images: californiaagriculture.ucanr.org; catscorner.mlbblogs.com

Some Recommendations

- Engage others with a clear, simple message
  - Don’t move firewood more than 50 miles
  - Buy and burn your firewood locally
    - Positive message – DO, not DON’T – might be easier to promote
- Encourage and aid development of clear firewood policies for parks, campgrounds
- Promote “wood swap” programs and the like
- Communicate with the public, and each other, regarding emerging forest pest problems!

Acknowledgements

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- Kirsty Wilson & Marty Siltanen – Canadian Forest Service
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