Firewood Movement – A Threat to California's Forests?

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Introduction

The movement of firewood has been implicated as a source of introduction and dissemination of invasive forest insects and diseases (United States Department of Agriculture Animal and Plant Health Inspection Service, 2010). The rapid interstate spread of the highly destructive forest pest emerald ash borer (*Agrilus plannipennis*) is a prime example of where new infestations have been linked, in part, to the movement of firewood. However, minimal factual data and quantitative information is available about the interstate movement of firewood and potential forest pests. The inherent risks associated with firewood movement within California and at bordering states need to be fully understood to effectively develop appropriate policies, guidelines, and public messages. The goal of this project was to assess the risk of pest introductions or spread related to firewood movement into the state.

The California Department of Food and Agriculture (CDFA) maintains sixteen agricultural border protection stations. Since 2008, these stations have inspected and recorded details on firewood entering the state. Additionally, pests intercepted on firewood since 1990 have been recorded in Pest Detection Reports (PDRs) which are stored digitally in a central CDFA database. These two datasets provide a unique opportunity to quantify interstate movement of firewood and associated forest pests.

An analysis of the CDFA datasets was conducted to: a) determine how much firewood is entering the state of California; b) determine where firewood is coming from and where it is going; c) identify the forest pests that have been intercepted on firewood entering the state, their origins and destinations; and d) investigate the potential threat to California forests, parks, and urban plantings from pests transported on or in firewood.

Methods

CDFA border station staff ask motorists if they are transporting firewood and inspect it when present. Any potential pests found on or in firewood are captured and sent to the CDFA labs for identification to at least the family taxonomic level. A PDR is filed on every intercepted pest and includes details on its taxonomy, origin, and destination. Since 2008, border station staff have also been recording the following details about any firewood they inspect: quantity, species, origin (to at least state), destination (to at least state but usually city), vehicle type (private versus commercial), handling (allowed entry; denied entry; confiscated); and the PDR identification number(s) for any intercepted potential pests that are present on or in the wood. All firewood data collected between 2008 and 2010 were compiled into a single firewood database.

The CDFA PDR database was queried for all records where the *Host* field included the word "firewood". PDR identification numbers that had been recorded on firewood datasheets were also extracted. The resulting dataset included records dating from 1990 to present. Data was summarized by taxonomic family, since this was the minimum level to which identifications always occurred, and focused on the following insect taxa:

Beetles (Coleoptera): wood borers (Buprestidae), longhorn beetles (Cerambycidae), bark beetles (Scolytinae);
True bugs (Hemiptera): scale bugs (Margardodidae);
Termites (Isoptera): (all families);

Butterflies and moths (Lepidoptera): tent caterpillars (Lasiocampidae), gypsy/tussock moths (Lymantriidae), leafrollers/budworms (Tortricidae)

For the purposes of this study, these taxonomic groups represent the most destructive “potential forest pests.”

Domestic firewood and pest origins were summarized by state and origins in Canada or Mexico were summarized at the national level. Firewood and pest destination information was summarized by city or other specific location (e.g., National or State park), though some records only recorded destination to the county or state level. Additionally firewood data was summarized by vehicle type, e.g., commercial or private.

Geographic information systems (GIS) point layers were developed from coordinates of the sixteen CDFA border stations as well as for all locations mentioned as a firewood and/or pest destination. Straight-line distances from the border stations to destinations were calculated to estimate distances that firewood and/or potential pests were expected to travel after entering California. These distances were summarized for the firewood data into “expected distance” categories in increments of 50 miles.

Various Animal and Plant Health Inspection Service (APHIS) and state-level quarantines and firewood regulations have established 50 miles as the maximum distance which firewood can be moved. Following this standard, all the destinations to which firewood bearing a potential forest pest was being moved were buffered by 50 miles to determine how much of the state was potentially at risk for an infestation of a forest pest. To further assess the potential threat to California’s natural areas, all State and National Parks and Forests were buffered by 50 miles to determine how much of the state’s land area fell within this buffer.

Firewood Survey Results

The sixteen CDFA border stations recorded approximately 24,062,000 pounds of firewood in over 10,600 individual loads entering the state between 2008 and 2010. Firewood transported to California came from 45 states, Canada, and Mexico. However, by mass, almost 96% of the wood originated from California, its three adjacent states, and Canada.

Almost 600 unique destinations were listed for firewood entering California. The top destinations by mass were Alturas and Crescent City in northern California, and Reno, Nevada. Nearly 84% of all wood by mass was headed to a destination within California, and almost all of the remainder was headed to a destination in Nevada. Over half of the wood being transported across California to Nevada was in commercial loads bound for Reno. Firewood was headed (in many cases returning) to every major urban area in California and at least five National Parks within the state.

The expected distance that firewood was transported to destinations within California was extremely different between private and commercial vehicles. The average expected transported distance of loads in private vehicles (n=8,843) was 70 miles compared to 226 miles in commercial loads (n=571). Almost 80% of the wood in private vehicles was being moved less than 50 miles from the border station, and an additional 15% of it was moved less than 200 miles. In contrast, only 24% of the wood in commercial vehicles was being transported less than 50 miles, over a third of it was transported between 200 and 400 miles, and over a quarter of it between 500 and 700 miles.

Firewood in private vehicles was almost 10 times more likely to be denied entry into the state and/or confiscated than commercial loads of firewood (11.7% and 1.5% of loads, respectively). PDRs were generated on 396 loads of firewood in private vehicles and only once in a commercial vehicle. An out-of-state load of firewood was 8.4 times more likely to generate a

PDR and 4.5 times more likely to be carrying a potential forest pest. Compared to adjacent states, firewood arriving from non-adjacent states was 13.4 times more likely to generate a PDR and 8.5 times more likely to be carrying a potential forest pest. Firewood bearing a potential forest pest was on average also expected to move further within the state – 165.1 miles versus 78.4 miles.

Pest Detection Report Results

Potential forest pests accounted for 497 (24.7%) of the PDRs filed on firewood between 2008 and 2010 (Table 1). The majority (445, or 89.5%) of intercepted forest pests were beetles and almost half of them (247, or 49.7%) were longhorn beetles. Some of the notable species that were intercepted on firewood include: emerald ash borer (*Agrilus plannipennis*), gypsy moth (*Lymantria dispar*), spotted pine sawyer (*Monochamus clamator*), flatheaded appletree borer (*Chrysobothris femorata*), and Eastern tent caterpillar (*Malacosma americanum*). The first two of these species were transported to California illegally in violation of nationwide APHIS quarantines.

Potential forest pests arriving in California on firewood came from 42 other states, Canada, and Mexico (Fig. 1). Oregon and Texas were the most frequent source of potential forest pests with 51 each, followed by Arizona (46), and Missouri (28). Twenty of the pests were on firewood that had originated from, and was returning to, California. The Needles border station intercepted almost half (49.2%) of the pests.

Potential forest pests were intercepted on firewood being transported to over 150 named destinations, the majority of them in California (Fig. 2). Nearly every major urban area in California was represented, as well as at least five National Parks and five National Forests within the state. Top destinations to which firewood bearing potential pests was being transported were the greater Los Angeles urban area (75 forest pests); the Sacramento urban area (36); the San Diego urban area (32); Crescent City and Fresno (24 each); and the San Francisco-Oakland urban area (23).

Nearly all (95.8%) of the land area of California is within 50 miles of a destination for a potential forest pest that was prevented from entering the state on firewood. An even larger proportion – 99.8% – of the state's land area is within 50 miles of a State or National Park or Forest.

Discussion

This analysis demonstrates that: a) firewood is an important interstate vector of potential forest pests, in terms of both quantity and distribution; b) pests were much more likely to be in firewood transported by private vehicles; c) pests were much more likely to be transported in firewood from other states and especially non-adjacent ones; and, d) any pest that manages to enter the state on firewood poses a potential threat to California's natural resources.

Some caution is required in interpreting these results due to the dynamic conditions at the border stations. Not all stations are open 24 hours/day. Border station staff are instructed to stop all out-of-state and large vehicles for inspection, but are not likely to stop private vehicles bearing California license plates if there is no external evidence that the vehicle might be carrying agricultural products, especially during very busy times. It's much easier to find pests in a small load of firewood in a private vehicle – where potentially every piece of wood can be inspected – than it is to find pests within a tightly-packed enormous load in a large commercial truck. However, while all of these errors might overestimate the relative risks posed by private and/or out-of-state vehicles, this is countered by the fact that every number reported is almost certainly an underestimate, since only a small proportion of all vehicles are stopped for inspection.

Regardless of the "true" values that they represent, these results illustrate the large threat that firewood movement poses to natural resources nationwide. As a single dramatic example, firewood from Michigan bearing emerald ash borer adults and larvae had to traverse at least seven other states before it was stopped from entering California in July 2010. However, even insects native to the United States can become devastating pests if moved to an adjacent state. Less than half (46.6%) of the wood borers native to Arizona also occur in California (C. Bellamy, CDFA, pers. comm.) The gold-spotted oak borer (*Agrilus aurogutattus*) is a wood borer native to southeastern Arizona that was introduced into San Diego County, California in the early-2000s, most likely from firewood (Coleman & Seybold 2008). In its new environment this beetle infests at least four new host species of oak that have no co-evolved defense mechanisms. The result has been tens of thousands of trees killed with no mechanism for containing the insect's spread currently known. Any one of the hundreds of firewood-borne pests intercepted at CDFA border stations every year could be the next gold-spotted oak borer or emerald ash borer in its effects if successfully introduced into a new area. This is particularly true in California, where non-native pests could have infested over 95% of the state had they reached their destinations, which were almost always within 50 miles of Federal or State natural resource management lands.

References

Coleman, T.W. & Seybold, S.J. 2008. Previously unrecorded damage to oak, *Quercus* spp., in southern California by the goldspotted oak borer, *Agrilus coxalis* Waterhouse (Coleoptera: Buprestidae). *Pan-Pacific Entomologist* 84:288-300.

United States Department of Agriculture Animal and Plant Health Inspection Service. 2010. *Risk assessment of the movement of firewood within the United States.*

Forest Pest Taxa	Total
Beetles (Coleoptera)	
Wood Borers (Buprestidae)	**105**
Long-Horned Borers (Cerambycidae)	**247**
Bark Beetles (Scolytinae)	**93**
True Bugs (Hemiptera)	
Scale Bugs (Margarodidae)	**2**
Termites (Isoptera)	**29**
Butterflies and Moths (Lepidoptera)	
Tent Caterpillars (Lasiocampidae)	**7**
Gypsy/Tussock Moths (Lymantriidae)	**12**
Leafrollers/Budworms (Tortricidae)	**2**
Total	**497**

Table 1. Number of potential forest pests transported to California in firewood by taxon, 1990-2010.

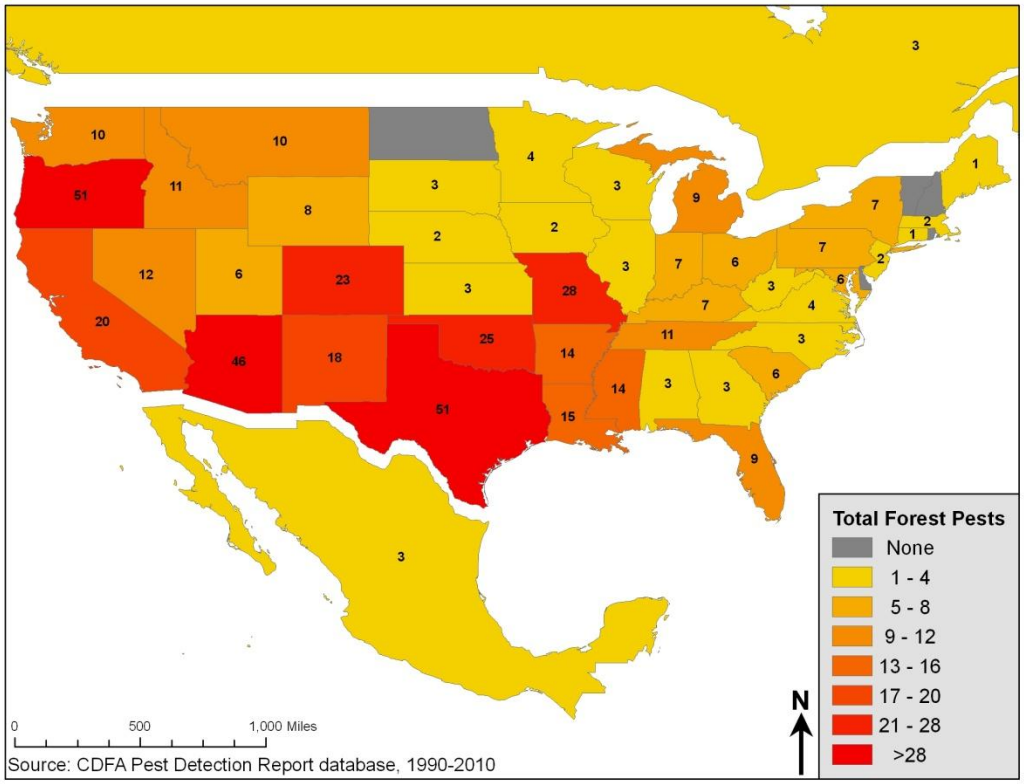

Figure 1. Number of potential forest pests transported to California in firewood, by state or country of origin, 1990-2010.

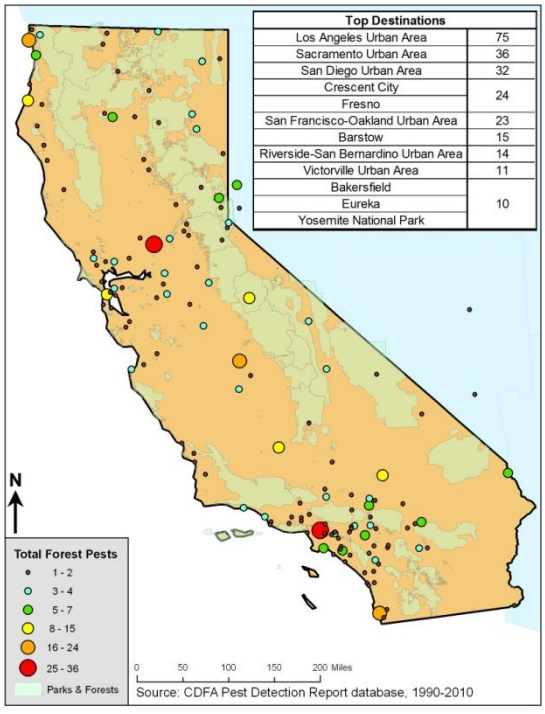

Figure 2. Number of forest pests being transported to California in firewood, by stated destination, 1990-2010.