frontiers | Frontiers in Forests and Global Change

TYPE Policy Brief
PUBLISHED 09 May 2024
DOI 10.3389/ffgc.2024.1334857

OPEN ACCESS

EDITED BY
Milica Zlatkovic,
University of Novi Sad, Serbia

REVIEWED BY
Therese Marie Poland,
Forest Service (USDA), United States
Frank H. Koch,
Forest Service (USDA), United States

*CORRESPONDENCE
Emily S. Huff
✉ ehuff@msu.edu

RECEIVED 07 November 2023
ACCEPTED 26 April 2024
PUBLISHED 09 May 2024

CITATION
Budzyn E, Huff ES and Frei H (2024) Firewood transport and invasive insect spread in Michigan.
Front. For. Glob. Change 7:1334857.
doi: 10.3389/ffgc.2024.1334857

Firewood transport and invasive insect spread in Michigan

Erin Budzyn[1], Emily S. Huff[2]* and Heidi Frei[3]

[1]Department of Community Sustainability, Michigan State University, East Lansing, MI, United States, [2]Department of Forestry, Michigan State University, East Lansing, MI, United States, [3]Michigan Department of Natural Resources, Lansing, MI, United States

Transportation of firewood can be a vector for invasive insect spread resulting in damage to surrounding areas. In 2016 and 2021, surveys were conducted at campgrounds around Michigan to understand where campers were sourcing their firewood, awareness of the 'Do not move firewood' campaign, knowledge of invasive insects and pests, reactions to a potential ban on bringing firewood to campgrounds, and perspective on kiln-dried firewood – all potential policy levers to reduce the spread of invasive insects. Results indicated that campaign awareness slightly decreased between the survey years, personal firewood transport has decreased, and knowledge of invasives remains low. There is an opportunity for intensifying invasive species and firewood outreach efforts, however, regulation (and enforcement) may be more effective among those who would not comply or support a ban.

KEYWORDS

invasive (exotic non-native) species, recreation, behavior, outreach, campground

1 Introduction

Firewood has been documented as a vector for invasive insect spread in the United States (Solano et al., 2021), and camping has been identified as the main recreational driver for firewood transport (Solano et al., 2021). Although most campers visit federal campgrounds within 100 km miles of their home, at least 10% travel over 500 km to camp (Koch et al., 2012). Invasive pests often originate in metropolitan or suburban areas from infested nursery stock, pallets, or other shipping materials (Lovett et al., 2016); residents in these more densely populated areas may bring infested materials into more rural and forested areas, thereby spreading pests to vulnerable tree species. Emerald ash borer, for example, originated in lower Michigan, but was found in the Upper Peninsula of Michigan in 2005. Haack and Petrice (2021) reported that 581 vehicles were stopped from 2005 to 2011 on their way from the Lower Peninsula of Michigan to the Upper Peninsula, yielding 479 interviews (11 commercial drivers and 468 private vehicles) pertaining to transportation of firewood. Over 80% of interviewees reported that they were transporting firewood for camping and cottages and of the 59 vehicles transporting ash firewood, 15 had signs of emerald ash borer.

When invasive insects are introduced into forests it can lead to many different complications. Direct changes to tree species composition can be seen, with the most extreme cases resulting in whole tree mortality that removes entire species from forest stands. These changes to forest structure have cascading effects on the wildlife that rely on the forests for food and habitat, as well as the economic loss from the inability to harvest certain tree species for timber (Lovett et al., 2016). There is also a perceived decrease in aesthetic quality in forests that have been infested by these invasive species due to tree mortality, which reduces property values and reported enjoyment of public lands (Lovett et al., 2016). These aesthetic concerns

are often also tree hazard concerns, when mortality occurs in areas used for recreation. Standing dead trees are much more susceptible to falling during wind, snow, or ice events and are fuel for wildfires.

Recreational users, in addition to being affected by tree mortality, may contribute to the spread of invasive insects if they bring woody material with them for camping and vacationing instead of purchasing at or near the campground. Campground users typically have three choices for sourcing firewood. They can bring it from home, purchase it at the campground, or purchase it locally outside the campground area (Borchert et al., 2010). In 2018, a camper survey was completed in three northeastern U.S. states found that 25% of campers brought their own wood (Daigle et al., 2019). The risk of personal wood transport can be mitigated by only transporting heat-treated or kiln-dried firewood.

2 Policy options and implications

Heat-treated firewood is firewood that has been sterilized by being heated for various amounts of time to at least 133°F (Wang et al., 2009). Kiln-dried firewood is heat-treated firewood that has been treated in a United States Department of Agriculture (USDA) certified kiln, with the wood reaching an internal temperature of 160°F for 75 min, to properly ensure that the produced wood is USDA Animal and Plant Health Inspection Service (APHIS) approved and pest free (Wang et al., 2009, 2014). While heat-treated and kiln-dried firewood use the same basic thermal treatment strategies, only APHIS approved kiln-dried firewood is approved for transport across state lines. However, since emerald ash borer (the target threat in Michigan) is no longer federally-regulated, this may limit the implementation of federal regulation unless a state decides to implement their own regulation. There are also several cost concerns with both treatment strategies for consumers and producers alike. Both strategies come with high time, energy, and equipment cost that leads to more expensive products for the consumers (Wang et al., 2009). Mandating heat-treatment and kiln-drying, or subsidizing the cost of heat-treated and kiln-dried firewood may be the only way to overcome the cost barrier that producers and consumers perceive.

Additional policy levers to address the issues caused by spreading invasive insects include outreach campaigns, incentives (e.g., free firewood at destinations), and regulations (e.g., firewood quarantines and park gate bans). While some studies have documented use and preferences for transporting firewood in recreational settings, little research has documented the habits of campground users in states severely impacted by invasive species or sought to understand if the "Do not Move Firewood" campaign, led by The Nature Conservancy and other partners, has led to an increased knowledge of the risks of moving firewood long distances, and what the effect of additional regulation might be on behavior. Solano et al. (2020, 2022) are two exceptions. Solano et al. (2020) analyzed 4,840 survey responses to firewood awareness campaigns over 15 years (2005–2016). As awareness increases they found a greater willingness to take action. Moreover, small increases in education resulted in greater public concern about firewood movement and invasive species. Solano et al. (2022) also reported that participants would be most likely to pay attention to an on-site flyer in a campground, that state forestry agencies were the most believable sources of information, and that older and more educated people were more aware of campaigns.

This Policy Brief reports data from multiple campground surveys in Michigan, U.S.A, to understand firewood/invasive insect knowledge, firewood purchase and transport behavior, and perception of firewood/invasive insect risk 5 years after the Solano dataset. Given the increased number of state, regional, and national awareness campaigns like "Do not Move Firewood," it is important to continue measuring camper awareness and behavior to determine if more outreach is needed, or if different policy approaches are warranted to change behavior.

3 Methods

We used data from a 2005 to 2010 inspection report, a 2016 survey and a 2021 survey. The inspection report includes data from 11 to 67 campgrounds (varied by year) in Michigan in emerald ash borer quarantine areas. DNR park staff checked all incoming campers for firewood from 2005 to 2010, tallying whether the visitor had (1) brought firewood, (2) where the camper originated, and (3) where the firewood originated. Those that arrived from EAB-infested areas were given information about the pest and were not allowed to bring their firewood into the park. In 2016, DNR interns were dedicated to surveying park users at campsites for three state parks: Sleepy Hollow, P. J. Hoffmaster, and Holland. At the gate when checking in visitors during the summer months, people were surveyed if there was firewood visible at check-in. They were informed it was voluntary, but that ash firewood was not allowed in the park. The questions asked about the origin of the firewood they had with them, knowledge of invasive species, knowledge of the do not move firewood campaign, and perceptions of a firewood ban. Most park users for all three sites came from the metro Detroit area [Department of Natural Resources (DNR), 2023]. Sleepy Hollow is a park most often used by in-state residents and offers roadside stands for firewood purchase. Holland is a more urban park with no rustic camping, often used as a stopping point on the way to Sleeping Bear National Dunes. While there is an RV park, there is not much access to roadside firewood. P. J. Hoffmaster has more out-of-state clientele, but also some local interest some rustic tent camping, along with roadside stands for firewood purchase (Department of Natural Resources (DNR), 2023).

In the summer of 2021, we randomly sampled 4 campgrounds in lower Michigan, and 1 in the Upper Peninsula. Campgrounds were located in Luzerne (private), Porcupine Mountains (state), Algonac (state), Metamora-Hadley (state), and Muskegon (state). At each site, surveys were administered at entrances (stationary), by walking through the campground (roving) and at other points of interest (e.g., hiking trails, common spaces). Refusals were noted, in addition to responses. At least 3 h were spent administering surveys at each location over a 2–3 day period, during varying times of day and early evening. Each of these sites offer firewood for purchase either at the campground store or from roadside stands. Surveys could be completed verbally or on paper. All survey questions asked in 2016 were repeated in 2021, but a few additional detailed questions were asked in 2021, such as intended source of firewood, nuanced level of concern/knowledge of invasive species, perspectives on cost for heat-treated or kiln-dried wood, and specific responses to a hypothetical firewood ban. Across both surveys, questions covered knowledge of invasive species, firewood consumption behaviors, and distance traveled to campground. After survey

10.3389/ffgc.2024.1334857

completion, participants were offered handouts and stickers (Do not Move Firewood campaign) on invasive insects. Data was double entered and R software (CRAN, R Core Team, 2022) was used for data analysis. For open-response questions (e.g., "what would you do if outside firewood was banned") two researchers categorized responses into thematic groups and compared coding. Adjustments were made until at least 90% agreement was reached with different data subsets. Human Subjects approval was granted by the Michigan State University Institutional Review Board.

4 Results

Data from the 2005–2010 inspection report revealed that 20,988 out of 84,753 campers inspected (25%) brought firewood with them, of which 17,979 (21%) came from EAB quarantine areas.

In 2016, there were 116 surveys collected at P. J. Hoffmaster, 86 at Holland and 31 at Sleepy Hollow for a total of 233 responses. In 2021, 44 responses were collected across all state parks (Table 1), out of 115 people asked (38% response rate).

Awareness of the Do not Move Firewood (DMF) Campaign was slightly higher in 2016, but the percentage of individuals bringing their own firewood was about half as much in 2021 (Figure 1).

When asked about their perceptions of a potential firewood ban (meaning campers could not bring outside firewood into the park), survey respondents in 2021 were generally more supportive (Table 2), despite less awareness of the DMF campaign.

To better understand how campers would respond behaviorally to a ban, the 2016 survey asked respondents to explain what they would do if a ban was to be put in place; responses were thematically grouped into 6 themes (Figure 2). Most responded they would buy locally for their firewood needs, while others would either not return to the park or find other items to burn.

The 2016 survey found that for those who brought their own firewood, the wood traveled an average of 98.5 km. In 2021, average travel distance was 142 km, but sample size was smaller, so a statistical comparison would not be meaningful. This firewood was brought instead of purchased because it was free and readily available. When asked if they were concerned about invasive insects, 76% of those surveyed in 2016 stated they were concerned, compared with 58% in

TABLE 1 Sample size from two surveys done in 2016 and 2021 at 8 campgrounds across Michigan.

Campground	2016	2021
P.J. Hoffmaster	116	–
Holland	86	–
Sleepy Hollow	31	–
Luzerne	–	12
Metamora	–	4
Muskegon	–	11
Porcupine Mountains	–	11
Algonac	–	6
Total	233	44

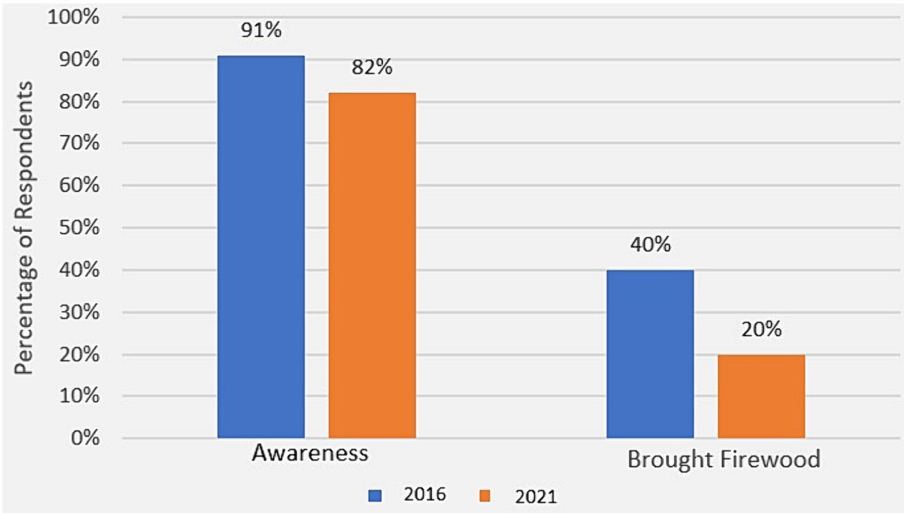

FIGURE 1
Awareness of do not move firewood campaign and percentage of campers bringing their own firewood compared across two surveys (2016 and 2021).

10.3389/ffgc.2024.1334857

TABLE 2 Campers' perceptions of a firewood ban across two surveys (2016 and 2021).

Year	Do not support (%)	Neutral (%)	Support (%)
2016	30	30	40
2021	25	13.6	59.1

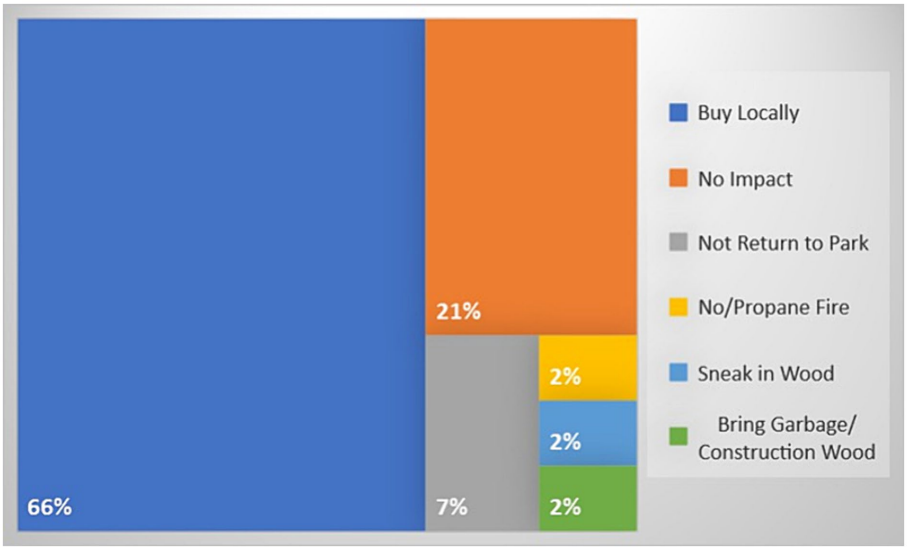

FIGURE 2
Campers' behavioral response to a ban on bringing firewood into parks.

2021. In 2021, 41% of campers purchased their firewood from the camp store, 2.3% from local vendors, and 20% from other sources (comparable data not collected in 2016). Most campers, 68%, felt they knew a little about the threat of invasive insects, 7% felt they knew nothing, 9% a moderate amount, 12% a lot, and 2% said they knew everything (comparable data not collected in 2016).

In 2021, campers were asked if they knew of kiln-dried firewood and if they would be willing to spend more for this certified pest free firewood that is permitted to travel across state lines and has no risk of spreading invasive insects. Just over half, 57%, of respondents have heard of kiln-dried firewood, but 75% of respondents are unwilling to pay extra for this pest free wood.

5 Actionable recommendations

There are two major policy instruments that would address firewood movement as a vector for invasive insect spread: outreach/education and regulation/enforcement. Outreach could include both the general awareness of the problem and suggest that campers buy locally or bring/use kiln-dried or heat-treated firewood. We found that interest in using kiln-dried firewood as an alternative to reduce the risk of spreading insects and pests when moving firewood is low, likely due to cost, and consistent with Daigle et al., 2019. The overwhelming majority of respondents are not willing to pay a higher price for this product, as Wang et al. (2009) identified as a possible limitation. If outreach campaigns do not clearly articulate the avoided cost of invasive insect damage for a consumer to compare with the increased price of kiln-dried firewood, there may be limited support. If kiln-dried/heat-treatment is a preferred option, subsidies or mandates may be the only viable way to change consumer behavior. If firewood prices were reduced (through subsidies to producers for technology), outreach campaigns have been shown to be effective (Solano et al., 2020, 2022).

There may also be an opportunity to scale up outreach efforts about both the threat of invasive insects and pests and how the use of kiln-dried firewood could reduce these threats, building on the success of the Do not Move Firewood Campaign (Solano et al., 2020). However, we found that a segment of those surveyed in 2021 (25–50%) are still opposed to these restrictions and some are willing to violate them; thus a regulatory approach paired with real enforcement may be the only option to influence visitor behavior. Conversely, nearly half of respondents supported a firewood ban measure. Although regulatory approaches can be costly, it is likely that the cost of doing nothing will be higher, due to expensive hazard tree removal (following insect-caused mortality) and decreased visitor satisfaction if widespread tree mortality changes the aesthetics, shade, and other tree-derived benefits from parks and campgrounds.

6 Conclusion and limitations

Awareness of the 'Do not Move Firewood' campaign from 2016 to 2021 decreased. We also found that fewer people are bringing their own firewood from home in 2021 when going camping. Campers are opting instead to either buy firewood from the camp store located within the campground or from local vendors in the surrounding areas. Similarly, most respondents stated they have concerns with invasive insects and pests in general, yet few feel they have any actual

knowledge about them, in keeping with other findings (Solano et al., 2022). While fewer people are bringing their own firewood from home while camping, this may be due to convenience or coincidence, rather than any actual worry about the damage that could be done by pests and insects in firewood. The 2016 surveys were conducted at parks closer to the quarantine area, where visitors may have had higher awareness than those from the 2021 surveys. Between 2016 and 2021, the emerald ash borer invasion shifted from intense outbreaks to post-invasion urban and suburban forest (Ward et al., 2021), thus outreach efforts likely decreased during this time as well. These could be potentially confounding factors that limit the comparability of survey results, thus the focus should be on general perspectives and concern for invasive insects and support for policy mechanisms overall.

While support for firewood-restricted behaviors may be increasing as outreach campaigns percolate to the public, at least 25–50% of respondents are still opposed to these restrictions and some are willing to violate them, in keeping with other findings (Robertson and Andow, 2010). Our results include data from two surveys conducted at different campsites across Michigan. They may not be directly comparable in terms of camper demographics, thus impacting generalizability of the results. To move beyond descriptive statistics and enable statistically comparable trends over time, future research could investigate experimental work that compares a site with regulation and enforcement vs. outreach and voluntary compliance to determine which is most effective in reducing firewood transport. Future research should also provide a full economic cost–benefit analysis to compare the cost of a regulatory approach versus the cost of 'doing nothing' and instead experiencing insect-induced tree mortality for critical and high-value parks and campgrounds.

Author contributions

EB: Data curation, Formal analysis, Writing – original draft, Writing – review & editing. EH: Conceptualization, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. HF: Conceptualization, Data curation, Methodology, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. Funding was provided by the Michigan Department of Natural Resources Invasive Species Grant Program Award IS17-4001.

Acknowledgments

We would like to acknowledge the campers who gave up their time to respond to this survey. We would also like to acknowledge the peer reviewers for their helpful comments.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Borchert, D., Newton, L., Culliney, T., Hartzog, H., Ahern, R., and Garrett, L. (2010). *Risk assessment of the movement of firewood within the United States*. Raleigh, North Carolina: USDA Animal and Plant Health Inspection Service.

CRAN, R Core Team (2022). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.

Daigle, J. J., Straub, C. L., Leahy, J. E., Urioste-Stone, S. M. D., Ranco, D. J., and Siegert, N. W. (2019). How campers' beliefs about Forest pests affect firewood transport behavior: an application of involvement theory. *For. Sci.* 65, 363–372. doi: 10.1093/forsci/fxy056

Department of Natural Resources (DNR). (2023). *Personal communication with park staff about visitor usage statistics*.

Haack, R. A., and Petrice, T. R. (2021). Public transport of firewood across the Mackinac bridge in Michigan, United States of America: origin, destination, woody taxa, and reasons for transporting firewood. *Can. Entomol.* 153, 586–597. doi: 10.4039/tce.2021.27

Koch, F. H., Yemshanov, D., Magarey, R. D., and Smith, W. D. (2012). Dispersal of invasive forest insects via recreational firewood: a quantitative analysis. *J. Econ. Entomol.* 105, 438–450. doi: 10.1603/EC11270

Lovett, G., Weiss, M., Leibhold, A., Holmes, T., Leung, B., Lambert, K., et al. (2016). Nonnative Forest insects and pathogens in the United States impacts and policy options. *Ecol. Soc. Am.* 26, 1437–1455. doi: 10.1890/15-1176

Robertson, D. R., and Andow, D. A.. (2009). Human-mediated dispersal of emerald ash borer: significance of the firewood pathway. Working paper, University of Minnesota, Department of Entomology. Available at: https://www.researchgate.net/profile/Desiree-Robertson/publication/303472591_Working_paper_Human-mediated_dispersal_of_emerald_ash_borer_Significance_of_the_firewood_pathway/links/5744752c08ae298602f65379/Working-paper-Human-mediated-dispersal-of-emerald-ash-borer-Significance-of-the-firewood-pathway.pdf (Accessed March 31, 2024).

Solano, A., Rodriguez, S. L., Greenwood, L., Dodds, K., and Coyle, D. (2021). Firewood transport as a vector of Forest Pest dispersal in North America: a scoping review. *J. Econ. Entomol.* 114, 14–23. doi: 10.1093/jee/toaa278

Solano, A., Rodriguez, S. L., Greenwood, L., Patrick, R., and Coyle, D. (2022). Achieving effective outreach for invasive species: firewood case studies from 2005 to 2016. *Biol. Invasions* 24, 3321–3339. doi: 10.1007/s10530-022-02848-w

Solano, A., Rodriquez, S. L., and Coyle, D. (2020). The nature conservancy's don't move firewood campaign: an analysis of the 2005–2016 survey data. Report submitted to the nature conservancy. Available at: https://www.dontmovefirewood.org/wp-content/uploads/2020/07/Solano-Rodriguez-and-Coyle-DMF-Report-for-2005-2016-Survey-Data_2.pdf (accessed March 31, 2024)

Wang, X., Bergman, R., Bradshaw, B., and Myers, S. (2014). Heat treatment of firewood for emerald ash borer (*Agrilus Planipennis* Fairmaire): case studies. *J. For.* 112, 361–370. doi: 10.5849/jof.14-033

Wang, X., Bergman, R., Simpson, W. T., Verrill, S., and Mace, T. (2009). *Heat-treatment options and heating times for ash firewood. General technical report FPL-GTR-187*. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, 29.

Ward, S. F., Liebhold, A. M., Morin, R. S., and Fei, S. (2021). Population dynamics of ash across the eastern USA following invasion by emerald ash borer. *For. Ecol. Manag.* 479:118574. doi: 10.1016/j.foreco.2020.118574