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Food, Medicine, or Heat? How Firewood Banks Leverage Local Natural Resources to Support Fuel-Poor Households

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Abstract

Households in natural resource-dependent areas of the United States are particularly vulnerable to fuel poverty. Wood banks provide no-cost, local firewood to fuel-poor households. Little is known about key details such as where they are operating, who is accessing them, and why. To assess the mechanisms by which wood banks may help alleviate fuel poverty, we located 82 wood banks and identified that 20.7% of them operated in counties with high rates of poverty and firewood heating use, despite only 11.6% of counties satisfying those criteria, nationwide. Qualitative analysis of interviews with representatives from 21 wood banks identified four explanations for household fuel poverty preceding accessing a wood bank: economic poverty, health-related challenges, old age, and emergency need. In many cases, at least two of four vulnerabilities overlapped, indicating that a convergence of factors explains the establishment and use of a wood bank.

Keywords: community wood banks, energy insecurity, fuel poverty, firewood assistance program, wood banks

Nourriture, médicaments ou chaleur? Comment les banques de bois de chauffage tirent parti des ressources naturelles locales pour soutenir les ménages pauvres en combustible

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Résumé

Les ménages des régions des États-Unis qui dépendent des ressources naturelles sont particulièrement vulnérables à la précarité énergétique. Les banques de bois fournissent gratuitement du bois de chauffage local aux ménages pauvres en combustible. On sait peu de choses sur les détails clés tels que l'endroit où ils opèrent, qui y accède et pourquoi. Pour évaluer les mécanismes par lesquels les banques de bois peuvent aider à réduire la précarité énergétique, nous avons localisé 82 banques de bois et identifié que 20,7 % d'entre elles fonctionnaient dans des comtés où les taux de pauvreté et d'utilisation du bois de chauffage étaient élevés, bien que seulement 11,6 % des comtés satisfassent à ces critères, à l'échelle nationale. L'analyse qualitative d'entretiens avec des représentants de 21 banques de bois a identifié quatre explications à la précarité énergétique des ménages précédant l'accès à une banque de bois : la pauvreté économique, les problèmes de santé, la vieillesse et les besoins d'urgence. Dans de nombreux cas, au moins deux des quatre vulnérabilités se chevauchaient, indiquant qu'une convergence de facteurs explique la création et l'utilisation d'une banque de bois.

Mots clés : banques de bois communautaires, précarité énergétique, pauvreté énergétique, programme d'aide au bois de chauffage, banques de bois

1.0 Introduction

Households in natural resource-dependent areas (NRDAs) tend to use firewood for home heating at rates higher than in urban settings (Song et al., 2012a), suggesting a possible increased relevance of community wood banks in these areas. NRDAs in the United States (US) often feature elevated rates of unemployment and poverty in association with factors such as sector-specific job loss, slower economic recovery, illicit drug addiction, out-migration of workforce-aged individuals, and in-migration of retirees (Cromartie, 2018; Johnson & Lichter, 2019). NRDAs are defined here as rural locales where primary economic activity is based on a natural resources sector like agriculture, forestry, or fisheries. The Northeastern US typifies these trends, with 20% of households using wood as a primary energy source and rural households being approximately four times more likely to rely on firewood than urban households (US Energy Information Administration, 2013). Nationally in 2015, 3.0% (3.5 million) of US households were identified as relying on firewood as primary space heating—a 59% increase since 2001 (US Energy Information Administration, 2015). This same study concluded that an additional 7.8% (9.2 million) of households also rely on firewood as a secondary space heating fuel (US Energy Information Administration, 2015).

Fuel poverty is a particular concern for communities in NRDAs. Mohr (2018) estimates that as of 2009 56% of US households with incomes below 150% of the poverty line were considered fuel poor. (Note that Mohr, 2018, also discusses cooling homes, but this paper will focus on heating in relation to firewood.) Fuel poverty is defined as spending at least 10% of household income on fuel expenditures for energy services, as described by Boardman (1991). See Moore (2012) for a comprehensive discussion. Much of the past research on fuel poverty in the US, United Kingdom (UK), and other European countries has focused on household heating, although the definition of the term does include additional energy-related considerations (Liddell & Morris, 2010; Bouzarovski, 2014; Simcock et al., 2016; Meyer et al., 2018).

Some non-firewood related solutions for supplying heat to lower-income households include upgrading household infrastructure or conversion to district heating (Hawkey et al., 2013; Liu et al., 2018; Zach et al., 2019). However, similar to the circumstances in Scotland described by Illsley et al. (2007), NRDAs in the US are less likely to adopt these broader-scale non-firewood solutions. Factors that may inhibit broader-scale adoption in US NRDAs include the availability of firewood, competitive prices of wood relative to other heating fuels (Reeb, 2013), high upfront costs for household energy upgrades (MacDonald et al., 2020), existing wood burning capabilities (van der Kroon et al., 2013), and firewood entrepreneurial opportunities (Huttunen, 2012). Additionally, in many NRDAs, the use of firewood is strongly tied to cultural identity and desired way of life (Song et al., 2012b; Morse et al., 2014; Peters et al., 2015; U.S. Energy Information Administration, 2014; Schmidt et al., 2021). In short, it is unclear if NRDA communities have the capacity to support development aid projects promoting new or innovative energy technologies, suggesting that firewood will likely remain an integral heat source in these locales (see González-Eguino, 2015, for a review of similar projects in other countries).

Assuming a continued demand for household firewood use in NRDAs, and continued availability of firewood, it follows that a key strategy for ameliorating fuel

poverty is to supply raw fuels to vulnerable households. One part of the solution to help address this gap is the community wood bank.

Wood banks are described as a local community-based initiative where firewood is collected, processed, and distributed to fuel-poor households. Wood is amassed from various sources, including commercial arboriculture, municipal wood waste, and forest operations. If the wood is obtained in an unprocessed state, it is bucked (i.e., sliced), split, seasoned, and then distributed to households in need (Vivian & Leahy, 2015b).

Wood banks first emerged in the 1970s ("Student fills wood bank", 1979), and with the exception of landmark region-specific work conducted by Vivian and Leahy (2015b), they have not been formally studied in the conterminous US. Specifically, we were unable to locate any peer-reviewed academic articles addressing wood banks. More broadly, the gray literature (i.e., newspaper articles) provides only cursory information about local wood banks with little attention to broader trends in the US.[1] Given that community wood banks offer a potentially sustainable counterbalance to energy poverty, there is value in studying them further. For its part, the US government has made an initial acknowledgement regarding the potential utility of wood banks by including $8 million for wood bank investment in the Infrastructure Investment and Jobs Act, which became law on November 15, 2021.

We propose that the exploratory social science research on wood banks is important and relevant because they may be an understudied avenue that could alleviate a form of poverty using existing natural resources. The work presented here seeks to broaden the academic understanding of wood banks by examining where existing wood banks function and identifying some of the conditions experienced by the fuel-poor households accessing them. This paper also lays the groundwork for future social science research aimed at better understanding the value/effectiveness of wood banks as a community-centered model for distributing firewood to those who struggle to heat their homes.

Wood banks necessarily operate within an access theory framework since they supply heating fuel to community members who lack the *ability* to derive the *benefit* of their local resources (Hansen, 1959; Ribot & Peluso, 2003). While the research on fuel poverty considers population-level explanations in relation to why a particular local group might be fuel poor, it does not adequately contextualize the breadth of reasons as to why specific individuals within that group cannot heat their homes. A deeper investigation of wood banks will serve to elucidate the specific circumstances that prevent households from accessing heating resources. In terms of access theory, this translates to an examination of how some households have insufficient bundles of power—which Ribot and Peluso (2003, p. 154) explain are "embodied in and exercised through various mechanisms, processes, and social relations"—to stave off fuel poverty despite generally living near potential firewood sources.

Thus with the goal of elucidating the role of wood banks in rural US communities, we propose two exploratory research questions: (1) Are known wood banks serving areas characterized by high dependency on firewood for heating and high rates of poverty?, and (2) What circumstances precipitate households accessing wood banks?

[1] In a notable exception, The New York Times did publish a more comprehensive article about wood banks after speaking with this research team (Holloway, 2021).

2.0 Measures and Methods

2.1 Are Known Wood Banks Serving Areas Characterized by High Dependency on Firewood for Heating and High Rates of Poverty?

Since no national wood bank registry nor consensus terminology exists, we created a catalog of active wood banks in the conterminous US by employing targeted Internet searches using keywords like "wood bank," "firewood assistance program," "firewood ministry," "wood pantry," "firewood program," and related terminology. Searches continued for each term until no new organizations were identified. This Internet search approach is similar to qualitative social science research methods used in other studies (Belt et al., 2014; Noll et al., 2014).

We then mapped counties with households that possess high firewood dependency rates and high household poverty rates. In accordance with the criteria employed by Rogalsky et al. (2014), we defined high firewood-dependent counties as 10% or more of households using firewood as their primary heat source. We defined high household poverty using the 2017 average federal poverty rate of 12.3% or greater (U.S. Census Bureau, 2018). In 2018 the poverty threshold for a one-person household was $12,140, and for a household of four was $25,100 (U.S. Department of Health & Human Services, 2019). This mapping method modifies and builds upon the exploratory mapping work by Vivian and Leahy (2015a; 2015c), which identified communities of higher potential demand for a wood bank in two Maine counties. Using the ESRI Business Analyst Online Smart Map Search (ESRI, 2020), we mapped the following thresholds at the county level: (1) 2018 Households by Heating Fuel: Wood (American Community Survey [ACS] 5-Yr) data to 10% or greater, and (2) 2018 Households Below the Poverty Level (ACS 5-Yr) data to 12.3% or greater. The specific question asked in the American Community Survey and used as a variable here is, "Which FUEL is used MOST for heating this house, apartment or mobile home?" (U.S. Census Bureau, n.d.).

2.2 What Circumstances Precipitate Households Accessing Wood Banks?

We employed a community resilience and response theoretical framework (Norris et al., 2008), utilizing an inductive qualitative data collection and analysis approach, to investigate the second research question. Data were generated by interviewing wood bank managers and volunteers from multiple US states. Since there is a dearth of published research regarding wood banks, qualitative interviews were conducted to gather credible, in-depth data to describe the novel topic of investigation (Harper et al., 2020).

Twenty-one participants in 13 US states were interviewed primarily via phone during the spring of 2016. We contacted all wood banks from the catalog generated for research question 1. A representative from all wood banks that replied was interviewed; when arranging the interviews, we prioritized individuals who are highly knowledgeable in the establishment and operation of wood banks, are deeply involved and invested in the wood banks, and have an in-depth understanding of firewood recipients. Specific selection criteria for participants included:

- A founding member of a wood bank,
- a current manager or overseer of a wood bank, and
- an active volunteer at a local wood bank.

Wood bank attributes were collected, including the year of the wood bank establishment, US state, and organizational structure (i.e., a description of who runs the wood bank and what resources they employ in this process). Prior to conducting the interviews, an eight-question outline was developed to collect baseline organizational information and explore the factors underlying recipient requests for firewood. Substantive question themes were modified from the key wood bank principles outlined by Vivan and Leahy (2015b). Themes included:

A. origins and history of the wood bank,
B. individual's personal history as a leader or volunteer of the wood bank,
C. geographic area served,
D. sources and supply of wood,
E. wood processing,
F. equipment utilized,
G. general description of the volunteers, and
H. why recipients needed firewood.

The interviews followed a semi-structured protocol allowing for flexibility in question ordering and follow-ups, while also ensuring that all themes could be addressed. Interviews typically lasted 20-30 minutes and were transcribed. Sampling continued until data saturation was achieved after interviewing, coding, and analyzing the responses of the 20th participant[2] (Ritchie et al., 2020).

This study focuses specifically on the portions of the interviews describing why recipients needed firewood and accessed a wood bank (Theme H). Since household members from fuel-poor households were not interviewed directly, insights were indirectly obtained from those managing or working at a wood bank.

Interview transcriptions were imported into NVivo 11—a qualitative data analysis software (QSR International, 2015). A preliminary coding structure was established based on the predetermined themes of interest captured by the interview questions (Gillies et al., 2014; Saldana, 2015). Transcripts were randomized and reviewed by authors JD and CH to help ensure sufficient coding coverage. In addition to predetermined themes, emergent themes were also identified. Emerging themes were considered potentially valid if they appeared in at least three interviews (Berg & Lune, 2011) and were verified as valid and replicable by other members of the research team. Following this, author EG used thematic analysis to review the codes related to fuel access and synthesized four themes that best described the relevant codes. Authors JD and RH reviewed and confirmed the thematic synthesis.

3.0 Results

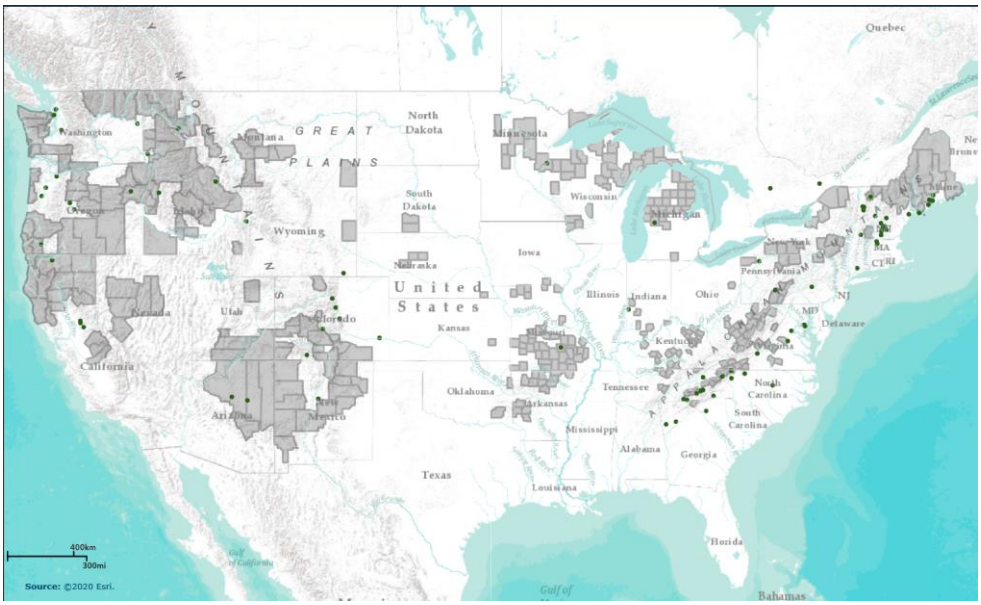
3.1 Research Question One

The Internet search identified 82 wood banks from 22 US states (plus two wood banks in Canada). Three hundred and fifty-nine counties met or exceeded firewood dependency and poverty thresholds. Collectively, those counties account for 2.7%

[2] An additional interview was scheduled before this determination was made so we still completed the interview to bring the total sample size to 21.

of the total US population, or 8.6 million individuals, and represent 11.6% of US counties and 33 of 48 conterminous US states. Of the 82 wood banks identified through Internet searches, 20.7% (17 of 82) operated in counties that met the criteria for high levels of poverty and firewood as the primary heating fuel. Nearly 44% (36 of 82) of the wood banks we identified operated in counties that met one of the criteria, and 35.4% (29 of 82) operated in counties that met neither of the criteria. In short, 20.7% of mapped wood banks operate in counties that meet the proposed criteria for higher demand despite that subset of counties only representing 11.6% of all counties in the US. A substantial proportion (35.4% mentioned above), however, operate in counties that are not high in firewood use, nor in poverty. Six of the 21 (38.1%) wood banks represented through interviews met or exceeded the county firewood dependency and poverty mapping thresholds.

Figure 1. US counties from conterminous states with firewood burning rate at or above 10% and household poverty rates at or above 12.3%.



Note: Shaded areas indicate US counties that are at or above the 10% threshold for households that heat with wood and are at or above the 12.3% threshold for households below the poverty level. Dark green dots indicate the location of a wood bank. (Map created using ArcGIS Business Analyst, Version 8.2, 2020 and is the intellectual property of Esri and is used herein under license. Copyright © Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com. 2018 American Community Survey [ACS] - Census Bureau, Five-year average).

3.2 Research Question Two

The 21 interview participants represented wood banks located in Connecticut, Maine, Maryland, Massachusetts, Missouri, Montana, New Hampshire, North Carolina, Oregon, Tennessee, Virginia, Washington, and Wisconsin. Some key details include:

A. One wood bank commenced in 1977. No participants represented wood banks founded in the 1980s. One participant represented a wood bank founded in the 1990s, 14 in the 2000s, and five after 2010.

B. Twelve wood banks existed as an extension of another organization (e.g., a ministry within a church), six as independent non-profits, and three operated as a unit of local government.

C. Nine participants represented wood banks that served an entire county, eight participants represented wood banks that served a multi-town area, three served a single town, and one served a multi-county area.

D. Twelve organizations delivered the wood to community members, three facilitated pick-up, and five both delivered and allowed for pick-up.

E. Amount of wood distributed ranged from about 6.5 cord to over 250 cord.

F. Many participants mentioned word-of-mouth or disseminating of information at community centers (e.g., local churches) as primary advertising strategies to raise.

We coded interview responses addressing why recipients needed firewood and accessed a wood bank (Theme H). Four pertinent themes of community need emerged: (1) poverty, (2) medical issues, (3) emergency need, (4) elderly.

3.3 Intersections of Vulnerability

The interviewees report that many fuel-poor households accessing wood banks have multiple compounding vulnerabilities. Fifteen of 21 interviewees indicated that households access their wood bank for multiple reasons; in four of the 21 interviews, all four primary themes were identified as reasons associated with the need for assistance (see Figure 2 for visualization). In this example, the interviewee describes how poverty was exacerbated by personal injury and forced one man to burn his kitchen cabinets for heat:

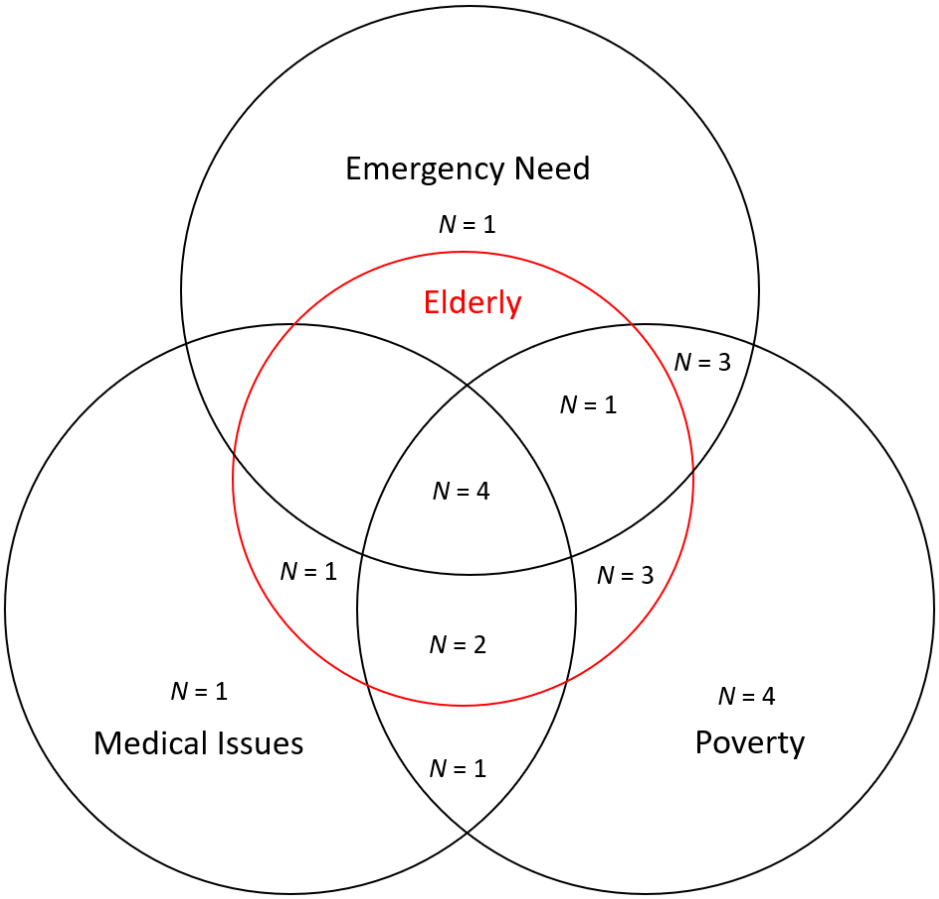
> Our part of the country is a poor, depressed area. We had a gentleman a couple of years ago call and ask for firewood. He had fallen on his chainsaw and gotten 500 stitches on his leg. So I said sure, I can bring you some firewood. When we got there, he was carrying a cabinet outside. *That's my kitchen cabinet*, he said. *I've got two left.* He had burned his others to keep his family warm.

The following example describes aging community members subsisting on a fixed income and beset by medical issues. The description is punctuated by a specific example of the intersection of poverty, the elderly, and medical issues:

> Most of the recipients are people who really need the wood. Helping them heat their house over the course of a makes a difference in whether they can go to the grocery store. It's very fundamental, very basic for most of these people. Most of the recipients are probably in their 60s or 70s; a number of them are living on social security. A lot of them have health problems to say the least.

The repeated overlap of the themes of vulnerability highlights that no one socioeconomic factor entirely explains reliance on wood banks in the rural US. Rather, several different vulnerabilities often interact to create heating fuel poverty. Specific examples for each type of vulnerability follow.

Figure 2. Venn diagram illustrating the intersections of the four primary themes of community need.



Note: Fifteen of the 21 interviews described overlapping categories of need for wood bank recipients. The trend was highlighted by concerns for the elderly (represented by the red circle), which was the second most common theme reported but also never mentioned without a second intersecting vulnerability.

3.4 Poverty

Poverty included stories about individuals being unable to afford firewood and other necessities. Poverty was the most common explanation for why community members sought wood bank assistance, mentioned in 18 of 21 interviews. Wood bank recipients often live in desperation. Many subsist on a fixed income, struggling to meet basic needs and sometimes necessitating trade-offs between food, heat, or medicine. One interviewee describes the impossible choice: “They have to decide, gee, do I put food on the table, do I buy medicine, or do I heat [my home]?” Other families used wood heating as a means of stretching financial resources to cover other utilities, using “the wood to offset the cost of electric or gas.” Several wood bank leaders recognized the pattern of economic trade-offs and responded by

collaborating with other community assistance programs, such as food banks, to identify households in need:

> We have a form that has to be filled out. And that has their income eligibility information on it—we usually set it by the poverty standards. And we get a lot of referrals from our community partners—so we get a lot of referrals from, like, Meals on Wheels or Home Health that let us know of the elderly that are in need of services.

Examples of poverty were directly observed by interviewees, underscoring the extreme desperation that some wood bank recipients experience. Stories included people disassembling and burning household items to stay warm; items including their kitchen cupboards, an old chair or scrap pallet, or even part of their shelter:

> All of our deliverers have at one time or another delivered to somebody who had, like, just busted up an old chair or a scrap pallet because they didn't have anything else to burn. Or they had all the burners on their stove turned on and the oven open.

In at least one case, a wood bank was established explicitly to address concerns related to poverty in the community:

> We're the only town in the county. We have one newspaper, which is a weekly. Last winter, they ran an article about the homeless issue in our county—squatting in shacks on the land. One of the guys was tearing apart part of his shelter to stay warm. A person in our church said, that's ridiculous—let's get a wood bank going.

3.5 Medical Issues

Gathering, processing, and storing firewood is laborious. Nine of 21 interviewees listed recipients living with physical limitations, often associated with a medical issue, as a reason for needing help accessing firewood. While some of the medical issues leading to wood bank dependence were temporary, such as running out of money after a long hospital stay, many were chronic physical limitations that permanently prevented households from obtaining firewood independently. Medical issues included individuals contending with serious health problems, such as cancer, and the recent death(s) of a family member. In one case, a person's spouse suffered brain damage in a car accident, making it impossible for the household to acquire and process its own firewood:

> I got a wonderful thank-you note the other day from a recipient that was really pretty touching. And it's a woman whose husband was in a car accident and experienced some pretty significant brain damage apparently. And, I mean, she's just so appreciative. It's just one thing off her to-do list.

> She's got her hands full, to say the least – just being able to make her life a little bit easier by getting the wood there is pretty significant.

In another example, two spouses were both physically disabled and relied on the wood bank for their firewood: "I have one where the husband's legally blind and the wife has lost two legs to diabetes. And they're scraping by on Social Security. So the need is deep and legitimate."

3.6 Emergency Need

Emergency need was defined as a household unexpectedly requiring firewood. Nine of 21 interviewees described an emergency need for wood. Interview participants provided several examples of wood bank recipients who were "caught short" unexpectedly but normally able to handle their own heating needs. The conditions leading to emergency reliance on a wood bank were generally temporary and caused by temporal circumstances, such as an unusually long winter or an unexpected rise in fossil fuel prices that necessitate supplementation of a household's usual firewood supply. The following is an example illustrating how high oil prices push community members towards wood bank assistance:

> We've found that wood—a lot of people have wood and wood stoves or something as a back-up. When oil was so expensive, they would burn the wood—just a little bit of oil, a little bit of wood – milk it back and forth to make it go.

Another interviewee was able to quantify the effect of a hard winter on recipients, describing how one truckload of wood might bridge a gap before receiving money:

> We distributed 26 cords this past winter, and 30 cords the winter before, when it was a colder winter. We probably hit about 20 families per year, with a very broad range of—there are some households to whom we might bring one truckload—you get about a third of a cord in a pick-up truck—so there might be some recipients where we give them one truckload, and that's all they need, because that's getting them over a hump until they get their tax refund check or whatever.

Accordingly, some wood banks are set up to operate only as emergency stopgaps and not as full-time suppliers:

> What I tell people is, this is a short-term solution. We're not set up to heat your house for the winter. This is a get-you-over-the-hump, couple of week supply so that you can go find a long-term solution. Occasionally I might help someone more than once in a season. But generally speaking, I try to let people know that this is not a long-term solution.

Wood banks also provided temporary assistance for households who do not have

access to social services for heating. In this example, health problems have created a temporary heating shortfall for a household, but they did not qualify for assistance from a local NGO:

> There was an elderly man who lives pretty near us, whose wife was ill…And he had to spend a lot of time taking care of her, and visiting her in the hospital and transporting her...And even though they didn't really qualify under the [NGO] guidelines, we helped them out with firewood– because it was that kind of a situation, where it was kind of a temporary emergency for them, and they were running out of firewood, and the guy didn't have any money or any way to get any more immediately available.

3.7 Elderly

The elderly code captured examples of members of the community who were senior citizens no longer able to perform the physical labor required to heat a household using firewood, but nonetheless a strong desire to age in place. The elderly were highlighted as wood bank recipients in 11 of 21 interviews. In all cases, respondents explained the needs of the elderly in relation to financial restrictions or health problems associated with aging. Interview participants relayed that many seniors in their communities were incapable of carrying out the manual labor related to firewood production, or living on fixed incomes and unable to afford firewood. According to one wood bank leader,

> A lot of the people are older people, so there's no way they can come pick it up and take care of it themselves…A lot of them are lower income with fixed income. That's what they've got. So we have to provide for them.

Another volunteer described a similar situation:

> Most of the households that we serve are seniors who are living on a limited income and use this exclusively to heat their home, or are using the wood to offset the cost of electric or gas. The referrals either come through a case manager—or, some are just word of mouth.

A more poignant example included a description of two widows hauling firewood in a 45-year-old car to heat their kitchen:

> And apparently they had like this old 1972 Bonneville, you know, with a trunk that you could live in… and they were 2 sisters…They'd both lost their husbands, so one sister moved in with the other sister. And she had an old wood stove in the kitchen, and they came to get wood to keep warm.

The interviewees were often explicitly aware of the increased vulnerability of senior citizens, to the point that some wood banks focused specifically on aiding their older neighbors:

> We try to concentrate on seniors. Seniors nowadays can buy food, medication, or utilities—on a fixed income, they can't do all three. So we try to help with food and firewood. The goal is to help these folks stay in their homes where they can be happy. Every once in a while, you get a younger couple.

Old age, alone, was never an explanation for needing wood bank assistance. Interviewees always related physical limitations or financial problems as the root cause for the elderly accessing a wood bank.

4.0 Discussion

4.1 Are Known Wood Banks Serving Areas Characterized by High Dependency on Firewood for Heating and High Rates of Poverty?

Although exploratory findings derived from Internet searches and mapping initiatives partially support the hypothesis that wood banks operate in counties most likely to include people who struggle to heat their homes, it is also important to acknowledge that many multi-county areas (e.g., northern Michigan, see Figure 1.) characterized by high wood burning and poverty rates do not support an identifiable wood bank. Access theory provides a possible framework to explain the lack of wood banks in these areas; communities that can be characterized as high-poverty may lack the ability to derive benefits from their local resources despite being literally surrounded by forests that could power woodstoves. This is an absurd paradox that can best be explained by considering the *inability*, or lack of exercisable power, to derive the full benefits of the forests surrounding many of these households. As such, a more in-depth analysis of the sociodemographic circumstances that predict wood bank success will provide additional nuance to the understanding of how people are interacting with their local forests in light of sociopolitical power structures, moving a step closer to a general theory of access *vis a vis* forestry in the United States (Levinson & Wu, 2020). In turn, those findings could provide insight into what type of support local communities need to operate their own wood bank. For example, more dispersed communities may have the equipment to fell and process firewood but lack the outreach resources to communicate availability and distribute the firewood to particularly remote community members.

Conversely, more than one-third of identified wood banks operate in counties with lower firewood heating rates and lower rates of poverty. The existence of wood banks in these areas may be attributed to both greater resource availability and greater community capacity necessary to develop and maintain a wood bank, even if the firewood demand is not as profound as it is in other counties with higher firewood burning and poverty rates.

Limitations of the mapping household criteria may also partially explain why wood banks were not always established in counties with high firewood use and high poverty. For example, if elderly people with health problems make up a high proportion of a community's population, but that community does not otherwise feature a high rate of poverty, a wood bank may offer some utility to the residents, but its success would not be self-evident. It is possible that existing wood banks are

operating in these areas but were missed due to the informal nature of their operations (e.g., no Internet-presence or a website not properly indexed by search engines). Finally, an important limitation to note is that the geographic data used in this analysis is only available at the county level; in contrast, wood banks may serve part of a county, an entire county, or parts of multiple counties.

4.2 What Circumstances Precipitate Households Accessing Wood Banks?

The multifaceted nature of fuel poverty paints the picture of households living on a proverbial razor's edge, in which one unexpected setback can force them to choose between food, medicine, or heat. In these scenarios, the elderly, who are typically reliant on social security or other fixed income, are often especially vulnerable. These findings align with several branches of existing research which have discussed the deleterious impact of fuel poverty on lived experiences in the rural US (Harrison & Popke, 2011), the impact of energy costs on the elderly living on fixed incomes (Tonn & Eisenberg, 2007), and the relationship between poor health and low household temperatures, especially among the elderly (for a review see Thomson et al., 2017).

In the context of access theory, these vulnerabilities explain why some households in natural resource-rich areas are unable to sufficiently heat their homes; they elucidate an underlying constellation of the dynamic processes inhibiting access, in line with Ribot and Peluso's (2003) operationalization of access theory. An element of daily life strips away the power to access firewood, despite living in areas with a sufficient supply, which is then embodied in the form of fuel poverty. In many cases, the vulnerabilities interact such that households lose the ability to heat their homes because they no longer have the social or financial capital to acquire/process firewood independently and also do not have the capacity to switch to other types of heating. Further, these findings provide a deeper understanding of the factors in play regarding how individuals access local natural resources, which helps move closer to the generalized theory of access posited by Levinson and Wu (2019). Specifically, wood banks are community-based operations that encourage more equitable distribution of natural resources—often redirecting resources that would otherwise go unused entirely. Wood bank participants are thus interacting with the local forest to build community resilience and also mitigate socioeconomic inequality by promoting access to firewood. The explanations given in this paper for why people access wood banks intersect with many of the broader social themes of concern in the US (e.g., an aging population, lack of access to medical care), further illuminating how wood banks are an example as to how forest management can intersect with social inequality.

Overlapping household vulnerabilities highlight that no single socioeconomic factor fully explains use of wood banks, but that several different vulnerabilities often interact to create conditions leading to fuel poverty. Interviewees' characterization of households prioritizing trade-offs of limited resources such as food, heat, or medicine corroborates findings from studies conducted in the UK (Roberts et al., 2015; Mould & Baker, 2017) and is aligned with research showing that financial constraints sometimes force households to maintain low inside temperatures in order to minimize heating fuel consumption (Anderson, 2012).

As a community-based initiative, wood banks are likely to be well adapted to supplement existing aid programs, offering a valuable service to mitigate the effects of fuel poverty on household space heating. Interestingly, our findings reveal an

occasional tension between wood bank function and community need. Some wood banks are only able to provide wood on an emergency basis, but the interview data show that many wood bank recipients face chronic problems. This tension suggests that it may be advantageous to not only promote the founding of new wood banks but also look for ways to bolster existing organizations. Previous research has also posited that community-based initiatives can be more adaptive in the use of ecological resources during extreme events (Tompkins & Adger, 2004). Wood banks demonstrate the broader viability of this concept as they have responded to emergency need of community members, and they have also helped to ensure that firewood proximate to the community is used locally, possibly reducing the carbon footprint of wood heating.

Further, by broadening the ability to access local heating resources through the direct action of community members, wood banks may be catalyzing efficient use of natural resources, thereby improving local resilience to climate change (Tompkins & Adger, 2004; Cinner et al., 2018). Underutilized wood waste from arboricultural and municipal operations (Marsinko, 1984; Nowak et al., 2019) may be salvageable for firewood (McKeever, 2004; McKay, 2006; Lyon & Bond, 2014), emphasizing that fuel poverty likely exists as a distributive injustice rather than a supply shortage as a consequence of procedures that fail to recognize the needs of vulnerable and marginalized social groups (Walker & Day, 2012). The underutilization of waste wood raises questions about whether firewood can be a carbon neutral energy source (e.g., is burning firewood obtained locally closer to carbon neutrality than transporting other fuel options?). Though questions of this nature may persist (see Pierobon et al., 2015 and Musule et al., 2021), it does seem likely that the salvaging of local wood waste by wood banks for use in cases where other heating options are not yet viable is a "least bad" solution.

4.3 Future Research Opportunities

Future research should focus more closely on both the demographics of counties with wood banks, as well as on thoroughly describing the diversity of wood bank operational structures with the intention to provide decision support tools to rural communities evaluating adoption. Additionally, now that baseline data on the nature of wood bank recipients exist, targeted surveys or in-depth interviews with community members from representative demographic groups who seek wood bank support would provide more insight into the nuances of their experiences. These data could be collected at the household level and examine factors such as occupation, gender, income, and other variables related to poverty in the US. Additional research opportunities may exist beyond the US. Our study identified two wood banks operating in Canada. It is likely, however, that wood banks are also operating in other circumboreal regions like Scandinavia or northern Russia. Within the US, Native American reservations may also have wood banks or similar programs. Future work should include an in-depth multi-case case study in these regions, where trust between researchers and wood bank recipients can be forged, acknowledging that household members may wish to keep their needs undisclosed due to concerns associated with stigma (Sherman, 2006).

Further, Cinner et al. (2018) propose a model for adaptive capacity described in terms of: (1) access to assets, (2) flexibility to change strategies, (3) ability to collectively organize, (4) recognizing and responding to changes, and (5) the autonomy to identify which changes should/should not be implemented. On the

surface, wood banks seem to satisfy these features of adaptive capacity, which may partially explain how they are able to service community members experiencing differing vulnerabilities. A more careful examination of organizational structure could further explicate the adaptability of these types of community-run mutual aid initiatives. This would be especially interesting if community wood banks do reduce the carbon footprint of wood heating.

Finally, these adaptive characteristics align with recent priorities of the USDA Forest Service, suggesting possible policy applications for community wood banks. Specifically, the Forest Service's Renewable Wood Energy plan considers the uses of wood waste or residues and the Community Wood Grant Program funds community wood energy systems. Wood banks operate at the intersection of both goals by creating utility for wood waste via *ad hoc* community efforts. Policy decisions driven by possible contamination and disease may also be relevant to community wood bank organizations. Several states across the country restrict the transportation of wood to protect forest health; since wood banks, for the most part, source their supply locally, they may help adhere to those requirements by reducing overall wood transport.

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