Indigenous Biomass Use for Forest and Community Well-Being: A Case Study of Wood for Life

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A Professional Paper Submitted in Partial Fulfillment

of the Requirements for the Degree of Master of Forestry

Northern Arizona University, School of Forestry

March 20th, 2024

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Acknowledgements

I would like to thank my advisor, Dr. Andrew Sánchez Meador for his support, encouragement, and confidence in me throughout this project, and for taking me on as his first M.F. student. Thank you to the team at the Ecological Restoration Institute, Dr. Melanie Colavito, Dr. Niki vonHedemann, Jon Martin, and Tayloe Dubay. It has been a joy to work with you all. I have learned so much from this experience, discovered new opportunities and skills, and received wonderful mentorship. I would like to thank the many Wood For Life partners that I have had the privilege to work with. In particular, thank you to Jake Dahlin, Sasha Stortz, Erik Stanfield, Maddie Smith, and the many chapters, villages, and nonprofits of the Navajo Nation and Hopi Tribe who work so hard on this collaboration. I would also like to thank my family, friends, and partner for their continued support and encouragement throughout this experience. I could not have done it without all your love and care.

Land Acknowledgement:

Northern Arizona University sits at the base of the San Francisco Peaks, on homelands sacred to Native Americans throughout the region. We honor their past, present, and future generations, who have lived here for millennia and will forever call this place home. This paper also acknowledges the Indigenous peoples of all North America, who have been stewards of the land and its forests since time immemorial.

Box 1. Glossary of Terms

Indigenous Nation: Used for Indigenous Nations in the United States (US) and Canada together
Tribal Nation: Used for Indigenous Nations in the US alone
First Nation: Used for Indigenous Nations in Canada alone
Biomass: Organic matter often used as a fuel
Forest biomass: Woody organic matter
Feedstock: The raw material (source of forest biomass)
Bioenergy: Renewable energy produced by living organisms (forest biomass)
Restoration: The process of assisting the recovery of an ecosystem that has been degraded to create and maintain healthy and resilient forests
Firewood bank: provides emergency or seasonal wood for heating homes and/or cooking to those in need, they often operate on models similar to those of food banks

Executive Summary

Indigenous Nations in Canada and the United States have deeply-rooted knowledge and long-standing relationships with the forests of their traditional lands. These communities have used forest biomass for millennia to help maintain the health of the forests and provide wood for heating, cooking, building, and cultural uses. Forest biomass is becoming increasingly important worldwide to decrease fossil fuel reliance, expand forest health treatment options, and increase energy sovereignty. Indigenous nations have a significant role in forest biomass use; however, gaps in our knowledge of Indigenous forest biomass use remain, including an understanding of the role of partnerships, barriers to long-term sustainability, and organizational structures that contribute to success. The goals of this paper are to: 1) better understand trends in Indigenous forest biomass use in the US and Canada through a systematic review of published literature, 2) examine the Wood for Life (WFL) partnership as a local case study of Indigenous forest biomass use in the US Southwest, and 3) capitalize on our improved understandings to provide recommendations for further development of Indigenous forest biomass partnerships.

The systematic review synthesized results from 16 peer-reviewed publications on Indigenous nations in the US and Canada. Findings showed common patterns among the drivers and barriers to communities' biomass use. Solutions to these barriers, however, were mentioned infrequently in the literature. These results highlight policy and organizational structure gaps, including challenges with forest use guidelines, land ownership, energy subsidies, funding, and everyday operations. Trends also showed opportunities for Indigenous-led co-learning, shared stewardship of lands, and development of multiple objective projects that meet diverse economic, environmental, and social needs.

Next, this paper explores the WFL collaborative partnership as an example of Indigenous forest biomass use. The WFL partnership was developed in 2020 to provide firewood to the Hopi Tribe and Navajo Nation in northern Arizona, northern New Mexico, and southern Utah from forest restoration treatments aimed at decreasing the risk of wildfire and improving forest health on US Department of Agriculture (USDA) Forest Service lands. This partnership came to fruition in response to the closure of the Navajo Generating Station and the Black Mesa coal mine on the Navajo Nation and Hopi Tribe land, combined with the lack of markets for the small-diameter ponderosa pine coming out of forest restoration and fuel reduction projects on federal land.

The rapid growth of the WFL partnership and interest in developing a similar framework in other regions highlights the need for targeted recommendations concerning: 1) policy, 2) Indigenous community engagement, and 3) organizational structure of Indigenous biomass partnerships. Simplified policy and targeted funding must be created with tribal leaders and funneled directly to tribal communities for capacity enhancement. There is a significant need for partnership learning and training opportunities associated and to tailoring them to the needs of different partners. Dedicated needs assessments show potential for facilitating greater understanding of tribal needs and capacity and creating strong working relationships. Organization and funding of biomass transportation is a key element to the success of these partnerships and must be prioritized. Clarity must be established around roles, responsibilities, and communication to build strong and clear organizational structures in partnerships. The lessons learned in this paper can facilitate the effective and collaborative enhancement of the WFL framework and aid in the continued development of policies that impact this work.

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Introduction

The Indigenous Nations of North America have deeply rooted knowledge and long-standing relationships with the forests of their traditional lands. These communities have used forest biomass for millennia to help maintain forest health and provide wood for heating, cooking, building, and cultural uses. Increased use of fossil fuels for energy, implementation of fire suppression policies, and dispossession of Indigenous lands caused Indigenous use of forest biomass to decrease (Martin 2021). Many fire-adapted forests simultaneously became overstocked and at risk for wildfire (Bowman 2011, Iglesias 2022). Recent increases in support for forest restoration projects and Indigenous energy sovereignty have led to new partnerships between Indigenous nations and federal land management agencies. These partnerships can act as guides to creatively support healthy forests and tribal communities.

New policies and funding allocation in the last decade have put US tribes in a new position to engage directly with land management agencies to benefit both tribal communities and forests (Martin 2021). These changes in legislation also promote cross-boundary shared stewardship that can facilitate partnerships around forest biomass use. Combining a systematic review of literature on Indigenous biomass use with a local case study, this paper aims to answer three primary questions: 1) How are Indigenous nations engaged in large-scale forest biomass use in the US and Canada, and how can they be supported in their biomass use? 2) How does the WFL partnership function as a local case study of Indigenous forest biomass use? And 3) How can improved understandings be capitalized upon to provide recommendations for further development of Indigenous forest biomass partnerships?

Background

Before the rise in fossil fuel use across North America, forest biomass was the primary household energy source for heating and cooking (Sikka 2013). The shift to fossil fuel use in the 20th century was inequitable, creating expensive dependencies for many rural communities, especially the Indigenous Nations of North America (Sikka 2013). Indigenous peoples were shaping the landscapes of this continent long before European colonization began in the 15th century (Christianson 2022). Indigenous peoples used fire to fulfill multiple objectives, including plant production, hunting, and fuel reduction (Christianson 2022). However, fire was not the only mechanism influencing forests: tree thinning and forest biomass collection also occurred. This accumulated biomass was used for food, shelter, basketry, firewood, and canoe building (Markwith 2021). Indigenous peoples applied a holistic and interconnected view of forests and whole landscapes.

The onset of European colonization changed the lives of Indigenous peoples forever, greatly impacting modes of land stewardship. The brutal history of North America includes the physical and cultural colonization of Indigenous peoples over several hundred years (Fryberg 2018; Benvenuto 2014; Ramirez 2014). The genocide, mandated assimilation, and erasure of Indigenous people caused immense disruptions to families, cultures, and languages (Fryberg 2018). Despite the violent history and land seizure, tribal resiliency secured the continuation of their cultures. This history of colonization, however, often led to a separation of Indigenous peoples from their lands and traditional management practices. This is now starting to be remediated through increasing acknowledgement of Indigenous sovereignty by settler culture, incorporating traditional ecological knowledge (TEK) into land management, and referencing

examples of Indigenous management that persisted. This TEK includes traditional forest biomass collection and uses.

As climate change becomes an increasingly serious threat, reliance on fossil fuels is being reconsidered by policymakers world-wide (Krupa 2012). Forest biomass is no small player in this energy transition; it has the potential to satisfy approximately 18% of the worlds' energy needs by 2050 (Menghwani 2022). Traditional use of biomass for heating and cooking still contributes to about 10% of the global energy supply. The rising costs of diesel and oil have enormous implications for rural Indigenous families, where up to 80% of a home's utility bills in Alaska and Canada are often from diesel and oil costs (Sikka 2013). Indigenous Nations are important players in transitioning from fossil fuels to renewable energy due to their long-term use of forest biomass, the cultural importance of wood burning, the lower costs of firewood compared to other energy sources, and large populations of people who live off-grid.

There is a clear need for alternative energy and heating sources to increase energy resilience, and forests have enormous potential to facilitate this transition. In the US, the Forest Service manages over 193 million acres of land once stewarded by hundreds of individual Indigenous Nations (Vinyeta 2021). Across these and other lands in North America, anthropogenic influences, including climate change and fire suppression policy, have altered the historical fire regimes to which ecosystems were adapted (Bowman 2011; Iglesias 2022). Now fires are larger, more widespread, more frequent, and more likely to co-occur with other fires than in recent decades (Iglesias 2022, Dennison 2014). Public acceptance of the need to restore forests to their historical fire regimes is growing through thinning, prescribed burning, and managing lightning-ignited fires (Franz 2023). However, removing forest biomass to decrease fire risk is a challenge in many locations in terms of finding a market for the low-quality, small-

diameter wood and getting funding for projects focused on forest restoration rather than timber production. Here, Indigenous biomass use and resource availability align.

Methods

To better understand trends in Indigenous forest biomass use in the US and Canada, we used systematic review and method guidelines developed by the Collaboration for Environmental Evidence (CEE) and Reporting Standards for Systematic Evidence Syntheses (ROSES) (CEE 2022, Haddaway 2017). The search process yielded 16 papers matching all necessary inclusion criteria and of sufficient quality for review (See Appendix 1 for more information on methods). Relevant information was extracted and recorded for further comparison and analysis. The results of this synthesis were analyzed according to two research questions: 1) How are tribal nations and First Nations engaged in large-scale forest biomass use in the US and Canada? and 2) How can agencies and collaborative groups creatively use forest biomass in the US and Canada improve partnerships with tribal nations and First Nations?

The Indigenous Nations in the papers used in this review included the Gwich'in, the Yakama Nation, the Nuxálk First Nation, the Cold Lake First Nation, the White Mountain Apache, the Colville, the Spokane, the Kalispel, the Pic River First Nation Ojibways, the Tlingit, the Haida, and others referenced generally in the individual papers as Indigenous Nations, tribal Nations, or First Nations (Brewer 2018; Richardson 2011; Menghwani 2022; Bull 2014; Buss 2021; Mansuy 2020; Neary and Zieroth 2007; Bullock 2020; Buss 2022; Corrao 2022; Gray, R.W. 2013; Kooistra 2021; Krupa 2012; Menghwani 2023; Sikka 2013; Stephen 2015).

Based on the research questions, the following list of search terms was created: "*biomass, biofuel, bioenergy, wood, woody, firewood, Indigenous community, Indigenous communities,*

Indigenous people, Indigenous peoples, tribe, tribal, First Nation(s), Native American, Native Americans, American Indian, and American Indians." The combination and phrasing of terms were varied to produce all relevant results. The search queries were then entered into the chosen databases: CAB Abstracts, GreenFILE, Academic Search Complete, Business Source Premier, SocINDEX, BIOSIS Citation Index, Web of Science, Google Scholar, and the Agricultural and Environmental Science Collection. Searches were recorded, identifying 269 initial papers. Papers were screened according to the inclusion criteria, set before the search:

- Relevant subjects: tribal Nations/First Nations
- Relevant intervention: Forest biomass use
- Relevant setting: United States and tribal Nations; Canada and First Nations
- Timeframe: 2000-2023 (chosen to keep the information current)

Papers were narrowed to the final review group according to exclusion criteria:

- Duplicates
- Not on topic
- Theses/Dissertations/Non-published works (Gray Literature)
- No relevant subjects (Indigenous Nations)
- Conflict of interest
- Supporting literature

Information on the WFL collaborative partnership case study, based in the Southwest US, was obtained using participant-observation methodology (Kearns 2005). After the establishment of WFL in 2020, the Forest Service asked the Ecological Restoration Institute (ERI) at Northern Arizona University to complete a needs assessment for WFL to better understand the scale and distribution of firewood need and local capacities for firewood distribution among tribal partners.

Throughout 2023, the ERI worked to complete a firewood needs assessment with the Navajo Nation and Hopi Tribe. This needs assessment aimed to gather information on the scope of need for firewood and the local capacity for processing and distribution of wood and looked to strengthen relationships with tribal partners (Stortz and Colavito 2021). To collect this information, meetings were conducted with Navajo Chapter officials, managers, and administrators, and Hopi Community Service Administrators (CSAs), and tribe-based nonprofits working with firewood distribution. Observations were developed from these meetings, the WFL monthly meetings, and other meetings relevant to the partnership, informing the following sections of this paper. The author worked for the ERI throughout 2023 and participated in the WFL partnership.

Systematic Literature Review: Indigenous Forest Biomass Use Landscape

Drivers

The Indigenous systems of biomass use covered in this systematic literature review are large-scale, community-wide, and often collaborative. While use of firewood by individuals through permits is an important piece of the biomass use landscape, the focus in this review was on biomass use by Indigenous communities and tribes at larger scales. These types of systems include, but are not limited to, community-wide firewood distribution, district energy systems (DES), wood-pellet boilers, and combined heat and power (CHP) systems. Community-wide firewood distribution and wood-pellet boilers are both mobilizations of biomass (firewood or pellets) to individual homes where people burn in their own stove or boiler. DES and CHP are

types of bioenergy where the biomass is all burned in one place, and then that heat is distributed to public buildings or households through piping distribution networks. These are

Figure 1. Map of North America, displaying the locations of all Indigenous biomass use study sites described in this paper.

intended to provide energy for heating and cooking to many buildings or households in each community. The biomass use systems differ in terms of land ownership, feedstock sources, and

levels of collaborative engagement with partners. The systems are designed to meet the unique circumstances and needs of each Indigenous community.

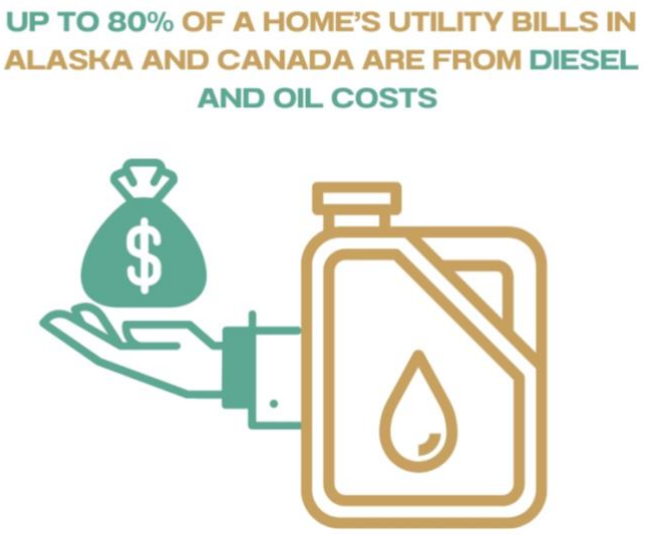
The drivers for forest biomass use within Indigenous Nations are varied, and communities are looking to develop projects that simultaneously meet economic, environmental, and social/cultural needs. The objectives described in the literature include developing energy sovereignty, decreasing wildland fire risk, using wood for cultural and ceremonial purposes, and acquiring affordable heat sources for community members. For example, the *Tlingit* and *Haida* tribes in Alaska emphasized that their biomass use projects could turn forest residues into energy, help prevent forest fires, introduce an alternative, renewable energy source, and be a cost-effective form of energy sovereignty for their communities (Sikka 2013). In one study, the Alaskan Natives who own the Native corporation *Gana-A'Yoo*, Ltd., stressed that community leadership and institutional support must come together to achieve stable and prosperous Indigenous-led bioenergy options that meet the varied objectives of communities (Menghwani 2022). Another study, with the Cold Lake First Nations in Canada, emphasized the desire to build opportunities for co-learning between partners and local workforce knowledge building in project development (Buss 2021). The systematic literature review findings indicate that meeting these multiple objectives would help support the long-term sustainability of Indigenous biomass use projects.

Barriers

While Indigenous forest biomass use projects have great potential to meet varied needs, challenges can slow or halt their successful implementation. The policy landscape influencing Indigenous biomass use is one challenge. The US has many loosely related forest management

and tribal engagement policies. These policies generally lack specific language around biomass use by Indigenous Nations, fail to include funding, and were largely written without collaboration with Indigenous representatives (Box 2). This has created a complex policy landscape that can exclude those outside of government and other cultural groups. The complexity has often been navigated creatively by managers and tribes, out of necessity, to develop Indigenous forest biomass use partnerships.

Lack of funding for partnerships working on Indigenous biomass use was mentioned consistently throughout the reviewed literature as a major barrier. Current high prices of energy (usually diesel and oil) often drive forest biomass use. For the *Gwich'in* tribe in Fort Yukon, Alaska, community members pay twice as much on average for diesel than those in the lower 48 states (Brewer 2018). However, high initial costs for biomass energy development keep Indigenous Nations from exploring this form of renewable energy. A 2020 analysis of the Collaborative Forest Landscape Restoration Program (CFLRP) proposals demonstrated the desire for funding to support these projects. Findings indicated that nearly half of all proposals would use funds to increase investments in federal forest thinning projects, biomass processing



facilities, market demand, and transportation costs for Indigenous and non-Indigenous community use (Kooistra 2021). While these CFLRP projects occur on federal land, stewardship contracting could be used to employ Indigenous crews, and the resulting biomass could be provided to nearby Indigenous communities for use as energy or for traditional purposes.

Other common barriers to Indigenous biomass use projects come from organizational and logistical challenges. These challenges often center around transportation, long-term sustainability, and the lack of readily available feedstock (the source forest biomass is harvested from). Transportation is often a main challenge to biomass use due to the high costs and rural

Box 2. Systematic Review: Relevant Policies

Policy Name	Description
Alaskan Native Claims Settlement Act ANCSA (1971)	Directed the Bureau of Land Management (BLM) to give 45.5 million acres of public land to Native corporations in Alaska.
Alaska National Interests Lands Conservation Act ANILCA (1980)	Set aside 104 million acres as national parks, wildlife refuges, and conservation areas, and 56 million acres as wilderness in Alaska.
Indian Self-Determination and Education Assistance Act (1975)	Authorized tribes and tribal organizations to contract with the federal government for the administration and operation of federal programs that provide services to tribes. Also known as the 638 authority.
Omnibus Appropriations Act (2003)	Authorized the Forest Service and the BLM to undertake stewardship contracting.
Healthy Forest Restoration Act (2003)	Directed the BLM to plan and conduct hazardous fuel reduction projects on federal lands through collaboration among state and local governments and with tribes. Title 2: Biomass authorizes the Forest Service in collaboration with other institutions, to accelerate adoption of biomass technologies, create community-based enterprises, and establish small-scale businesses to make use of biomass.
Stewardship Contracting (2003)	Allowed the Forest Service and BLM to apply the value of timber or other forest products removed as an offset against the cost of services received through contracts and agreements awarded up to ten years, hopefully stimulating long-term investment in the local community. These are agreements between the Forest Service or BLM and another entity such as a nonprofit. They allow the other entity to complete forest restoration treatments on federal lands and utilize the resulting biomass as they wish. The focus is on restoration and shared stewardship rather than timber revenue.
Tribal Forest Protection Act (2004)	Directed the Forest Service and BLM to consider stewardship contracting or other projects proposed by a tribal entity on federal land adjacent to Indian Trust land to protect that Indian Trust land from threats originating on federal land.
Omnibus Public Lands Act (2009)	Established the Collaborative Forest Landscape Restoration Program (CFLRP), which provides funding to competitively selected Forest Service units and their collaborators for cross-boundary forest restoration. Many CFLRP proposals relate to Indigenous use of forest biomass.
Good Neighbor Authority (2014)	Allowed the Forest Service to enter into agreements with state forestry agencies, to perform planning and management activities on federal land.
Farm Bill (2018)	Reauthorized CFLRP.

locations of many Indigenous communities. The logistics of moving biomass from the forest to community hub locations or individual households also pose a challenge to communities where financial and staff capacity are ongoing barriers. A *Gwich'in* community in Fort Yukon, Canada described their struggles with transportation as they worked to develop an 85-kilowatt wood pellet boiler and CHP wood-based bioenergy system. Their region's lack of road infrastructure and long transport distances from sawmill locations were logistically challenging and prohibitively expensive (Buss 2022). The long-term sustainability of biomass use systems is an often-cited challenge due to the ever-changing political will toward funding and ongoing relationships with partners who provide the biomass, transportation, technology, or other key inputs for a biomass use system to function (Menghwani 2022). The ongoing availability of feedstock sources is another potential barrier to successful Indigenous biomass use projects. Some communities, like the *Koyukon Athabascan* in Galena, Alaska rely on residues from forest industries for their biomass. If these forest industries were to shut down or move the community would lose a major energy source and must look elsewhere for usable feedstock (Menghwani 2022). This issue is exacerbated by the seizure of Indigenous lands, which took place across North America and separated many Indigenous peoples from the forests they historically relied upon.

Solutions

Creative solutions are needed to tackle the existing challenges and encourage the drivers of Indigenous forest biomass use. The systematic review demonstrated that creative navigation of the current policy landscapes in the US and Canada (Box 2) has allowed for varying degrees of biomass use and collaborative forest stewardship between Indigenous Nations and federal and

local governments. In the US, the Indian Self-Determination and Education Assistance Act, the Tribal Forest Protection Act, stewardship contracting, 638 agreements, and the Good Neighbor Authority all provide the ability for tribes to collaborate with the federal government on forest management and access forest biomass resources on federal lands (Box 2) (Martin 2021). An example of this collaboration is the Anchor Forest concept. In development in Washington state, the partnership proposes shared stewardship in areas where tribal lands, federal and state lands, and private lands all share boundaries. This partnership will be founded on the premise of long-term stewardship and cross-boundary collaborative management, using the Good Neighbor Authority and stewardship contracting policies to improve forest health and provide firewood to the local Yakima, Colville, Spokane, and Kalispel tribes (Corrao 2022).

A partnership formed between the White Mountain Apache and the Forest Service in Arizona after the Rodeo-Chediski Fire in 2002, demonstrates another creative navigation of the challenging policy landscape. This partnership worked to remove excess biomass from forests after harvesting and to prevent fires (Neary 2007). Stewardship contracting, the Healthy Forest Restoration Act, and the Omnibus Appropriations Act of 2003 were used to reduce small-diameter fuels and send them to a small biomass power plant that benefits the White Mountain Apache and surrounding communities (Box 2).

Strong organizational structures can also greatly contribute to the success of Indigenous biomass use partnerships. The five studies in this systematic review with strong and replicable structures fell into two categories. Three studies represented those where the Indigenous Nations used forest biomass through the development of a native-owned corporation that harvests biomass from their own privately held lands or contracts through timber sale agreements with the Forest Service (Sikka 2013; Menghwani 2022; Brewer 2018). Unique to Alaska, these native-

owned corporations were created through the Alaskan Native-lands Settlement Act (ANSCA) to act as for-profit organizations provided with private land ownership by the federal government and the ability to develop bioenergy from the forests of those lands. Two other studies represented organizational structures where a co-stewardship model, based on the use of stewardship contracting, the Good Neighbor Authority, and the Healthy Forests Restoration Act of 2003, was used to treat federal forests and make wood available for use by the tribes (Corrao 2022; Neary 2007). The remainder of the studies in this review had organizational structures focused on very small, remote communities in Alaska and were, therefore, more self-sufficient than collaborative. These communities generally had access to their own forested land and were therefore able to collect and use biomass without as much collaboration with outside entities. These, therefore, had less broad relevance for other partnerships to adopt.

These two categories of organizational structures for Indigenous biomass use differed in terms of their land ownership, feedstock sources, and levels of collaborative engagement with partners. Both models demonstrated creative use of existing policy, long-term access to forest resources, ongoing funding for project use, and consistent systems of using biomass for energy (systems include small bioenergy power plants, wood chip manufacturing and distribution, community boilers, etc.). (Sikka 2013; Menghwani 2022; Brewer 2018; Corrao 2022; Neary 2007).

When compared, there is still substantial room for development between these offered solutions and the barriers identified by Indigenous Nations. The offered solutions address navigation of the policy landscape and provide reference organizational structures. However, challenges with funding, transportation, feedstock sources, logistical barriers, and opportunities for improved community engagement still must be tackled. Part of the difficulty can be the

exclusion of communities where cultural differences make systems of bureaucratic governance less approachable. Addressing these gaps is discussed in detail in the "Lessons Learned and Recommendations" section of this paper.

Management and Policy Implications

Opportunities exist for innovative policy development, targeted funding, and new organizational systems of collaborative forest biomass use. Collaborators engaged in Indigenous biomass use need clear policies and guidelines when developing projects, which could increase both the quantity and quality of new and existing partnerships. Policy changes at federal, state, and agency scales, as well as policy adaptations by tribal governments, could give Indigenous Nations clear, long-term access to forest resources for forest biomass use through land ownership or co-stewardship agreements. The necessary funding for these types of biomass use projects must be included in federal policy language. New policies could address the issue of competition with conventional fossil-fuel-based energy sources. The current federal subsidies to fossil fuels could be cut back, or new subsidies could be put in place specifically for Indigenous use of forest biomass resources as a form of renewable energy. To complete the enhancement of this policy landscape, there must be inclusion of how climate change is and will continue to reshape the use of forest biomass as a renewable energy. Fire policy across North America will need to include the potential role of Indigenous Nations in the use of small-diameter biomass that may otherwise be left in forests and pose a fire risk.

The previously described need for improved supporting policy was a primary area of misalignment, which will require substantial political will but could make a significant impact toward supporting Indigenous-led development of forest biomass use. The current favorable political climate toward improving tribal relations could create momentum for these changes

(Martin 2021). Additionally, targeted funding opportunities for Indigenous Nations to draw upon can increase capacity on the tribal side for implementing biomass use projects. Though not all biomass-related CFLRP proposals were directed at working with tribes, those that were tribal partnerships could use CFLRP funding to address costs associated with Indigenous biomass use. Relationship building and collaboration are further clear needs for these partnerships expressed in the literature. The stronger the relationships and more open the communications, the more likely projects are to succeed in meeting objectives for all involved. Strong relationships, co-stewardship agreements, clear division of roles, and Indigenous leadership helped to increase the projects viability in these cases. However, even the strong examples of organizational structure discussed struggling with issues of transportation and scale. Most studies mentioned the challenges associated with transporting wood to those in need. This could include the associated costs, difficulty hiring drivers, and geographic remoteness of communities. Scale was frequently mentioned as an issue where project timeframes fail to match funding timelines. Projects are often planned for up to a decade, whereas funding is provided on 1–2-year timescales. These common issues will require local managers' creative and often site-specific solutions.

Case Study: Wood For Life

Across the US, the use of biomass for energy and support for "firewood banks" has grown significantly in the last few years. In particular, a partnership founded in northern Arizona and expanding across the West has recently been pushing the envelope on what these projects and partnerships can accomplish within the landscape of Indigenous forest biomass use. The WFL partnership was initiated in 2020 between (in no particular order) the Forest Service, numerous Navajo Nation chapters and Hopi Tribe

Figure 2. Timeline of policies relevant to the Wood for Life partnership and Indigenous biomass use in the United States.

villages, the National Forest Foundation (NFF), and several other organizations in northern Arizona (Ancestral Lands Conservation Corps, *Koho for Hopi, Chizh for Cheii, Pikyanivi Wood Haulers*, Red Feather Development Corporation, United Natives, ERI, The Nature Conservancy). This partnership came to fruition in response to the closure of the Navajo Generating Station (NGS) and the Black Mesa coal mine in the Navajo Nation combined with the lack of markets for the small-diameter ponderosa pine coming out of forest restoration and fuel reduction projects on federal land. This 2020 formation of the WFL partnership came after several years of conversations between the Hopi Tribe and Navajo Nation and the Coconino and Kaibab national

forests. After the closure of the NGS and Black Mesa coal mine, the Hopi Cultural Preservation Office emphasized the use of and need for firewood. The development of this partnership was influenced by the current environmental, political, and social climate, and stands on the foundation of many thousands of years of Indigenous forest biomass use. Though the Navajo Nation and Hopi Tribe have used coal, propane, pellets, and other energy sources, firewood has remained central to home heating, cooking, and traditional uses. Anecdotal evidence from conversations with leaders of the Navajo Nation and Hopi Tribe suggests that currently an estimated 90% of households rely on firewood for heating. The western edges of the Navajo and Hopi nations are also near the Coconino and Kaibab national forests, once stewarded by these and other tribes and currently managed by the Forest Service (Martin 2021). This proximity and the motivation and funding for the Forest Service to remove wood from the forests play an important role in the continuation of this partnership. Given this context, the WFL partnership presents the opportunity to learn and create recommendations for current and future partnerships within the sphere of Indigenous biomass use.

Box 3. Wood for Life: Vision and Mission

Vision: Tribal communities are supported through the provision of firewood from timber, restoration of forests, and improvement of sustainable partner relationships for the needs of present and future generations.

Mission: Relationship building, coordination, and information exchange across a network of partners in northern Arizona facilitates the supply, transportation, and processing and distribution of firewood to tribal communities in need and promotes the sustainability of healthy forests (*WFL Partnership Statement).*

Wood For Life Drivers

The Black Mesa coal mine operated on Navajo Nation and Hopi Tribe land in northern Arizona for decades. In conjunction with the NGS, the mine provided jobs and an energy source to the people of the Navajo Nation and Hopi Tribe and energy to other areas of Arizona, Nevada,

and California (Bureau of Reclamation 2018). In 2019, the coal mine was permanently closed and NGS was demolished. Many households within the Navajo Nation and Hopi Tribe are not connected to the electrical or natural gas grids and/or rely on burning firewood and coal in their homes as an economical heating source due to the expense of other sources such as pellets or propane. As expressed throughout the WFL needs assessment meetings, some residents use firewood for cooking or other traditional uses, such as kiva ceremonies or sweat lodges. The closure of the mine and a movement away from coal use by households due to health concerns increased the already existing need for firewood. Lack of access to forested areas, a large elderly population, limited transportation, and rising costs of purchased wood helped to spur the WFL partnership's development (Stortz and Colavito 2021).

Simultaneously, managers on the Coconino and Kaibab national forests in northern Arizona were seeking an outlet for the forest biomass from their forest restoration projects focused on reducing fuel loads in ponderosa pine forests throughout the region to decrease the risk of catastrophic wildfires like the impactful Schultz (2010), Museum (2019), Pipeline (2022), and Tunnel (2022) fires (Stortz and Colavito 2021). However, due to the small-diameter and poor quality of the wood removed, there are very limited markets for the forest biomass from these projects. Additionally, the costs of moving biomass are very high, so it is often left piled in the forest to be burned when conditions allow. In 2020, the WFL partnership was formed as a creative way to address the firewood needs of local tribal communities and better facilitate the removal of forest biomass from restoration project sites.

The Collaborative Partnership Model

The current WFL partnership describes itself as an "inclusive, open group [of organizations with a common goal]" (WFL Partnership Statement). Their partnership statement emphasizes that WFL is not a formal entity, a decision-making body, or a funding organization (WFL Partnership Statement). The members of this collaborative partnership include the Forest Service, NFF, representatives from the Hopi and Navajo tribes, the ERI, and several other organizations, including those representing each of the tribes.

To provide free wood to tribal partners, the WFL collaborative currently uses three methods of supply associated with different Forest Service policies (personal communication, Jake Dahlin). The first method is the free tag program. The Forest Service can provide free firewood tags to tribes through the 36 CFR 223.2 code that allows for the Disposal of Timber for Administrative Use. This means that trees, portions of trees, or other forest products may be cut and distributed by sale or free of charge, in this case because removal is desirable to protect and enhance multiple-use values of the forest. Administrators within the Navajo Nation and Hopi Tribe receive the firewood tags and distribute them to individuals to collect the firewood

themselves for personal use. National forests also have policies allowing free permits to be granted to tribal members to collect their own wood for traditional and ceremonial use (personal communication, Jake Dahlin). WFL aims to support the supply of this traditional and ceremonial wood to tribes, which includes firewood for heating and cooking.

The second method for providing wood is free use, where the Forest Service can designate timber for free firewood use to aid in the protection and improvement of forests. Free use granted to individuals is authorized under the 36 CFR 223.5 policy and free use to federally recognized tribes is authorized under the Forest Service Handbook 2462.2 policy (Stortz and Colavito 2021). This wood is made available for tribal individuals, tribal nonprofits, or village and chapter leaders to pick up from the location where it was harvested in the forest either as logs or stove-ready firewood. Each permit holder can collect up to five cords (1 cord measuring 4 feet by 8 feet by 4 feet) of wood each season, approximately May through December (USDA Forest Service 2023).

The final method used by WFL to supply wood is through stewardship agreements. The Forest Service uses these agreement mechanisms to give partner organizations the authority to perform services on National Forest Service (NFS) land and then distribute that wood to tribes for free (Stortz and Colavito 2021). In this partnership, the NFF and Ancestral Lands Conservation Crews (ALCC) are the main organizations using this method. The NFF has entered into a Master Stewardship Agreement with the Forest Service and uses contractors to complete projects on NFS land. NFF then relies on donations to support it as a nonprofit to transport wood to the Navajo Nation and Hopi Tribe as logs, or more often, as stove-ready wood. ALCC is a corps organization which partners with tribal communities and land managers to accomplish conservation projects rooted in the culture and heritage of local tribal communities. ALCC has

also entered a stewardship contract with the Forest Service in which their crews complete projects on NFS lands. ALCC then makes the wood available for tribal members to pick up. This stewardship contracting method allows the Forest Service to sell the timber to the partner organization for a low cost, thereby meeting sale target regulations for the forest (personal communication, Jake Dahlin).

While not currently used as a method for supplying wood through the WFL partnership, the passage of the 2018 Farm Bill also authorized the use of 638 agreements between tribes and the Forest Service. These 638 agreements allow "recognized tribal entities" to propose co-management of federal Forest Service projects and to contract with the Forest Service using existing resources such as program funding (Martin 2021). Recognized tribal entities may submit contract proposals to the Forest Service. These proposals are then assessed and accepted or returned to the tribal entity with feedback for changes. After this step, the partners may then enter an agreement for up to 10 years (personal communication, Jon Martin). These agreements could allow tribal entities to carry out long-term projects on federal land, receive funds for wood

Box 4. Wood for Life: Relevant Policies

Policy	Description
Stewardship Agreements/Contracting	Allowed the Forest Service and BLM to apply the value of timber or other forest products removed as an offset against the cost of services received through contracts and agreements awarded up to ten years, hopefully stimulating long term investment in the local community.
Master Stewardship Agreements	Aims to exchange goods for services, exchange funds for services, or a combination, to complete restoration activities on National Forest System lands.
36 CFR 223.S(a) (Forest Service Handbook)	223.2: Disposal of timber for administrative use 223.5: Scope of free use granted to individuals 223.6: Cutting and removal of timber in free-use areas 223.15: Provision of trees, portions of trees, or forest products to Indian tribes for traditional and cultural purposes
36 CFR 223.S(b) (Forest Service Handbook)	Timber sale contracts authorized and regulated.
2018 Farm Bill	Authorized tribal Forest Management Demonstration Project "638" agreements with the Forest Service. This amended the tribal Forest Protection Act.
Forest Service Target Regulations	All forests have fiscal year timber sale targets that must be met.
Coconino and Kaibab Forest Service Policies on Forest Products for Traditional Use	Allowed for free permits to tribal members for wood for traditional use, including ceremonial fuelwood.
2021 Bipartisan Infrastructure Law	Allocated billions to the Forest Service for fuels management programs and projects.

processing equipment, hire personnel to assist with wood processing and distribution, and

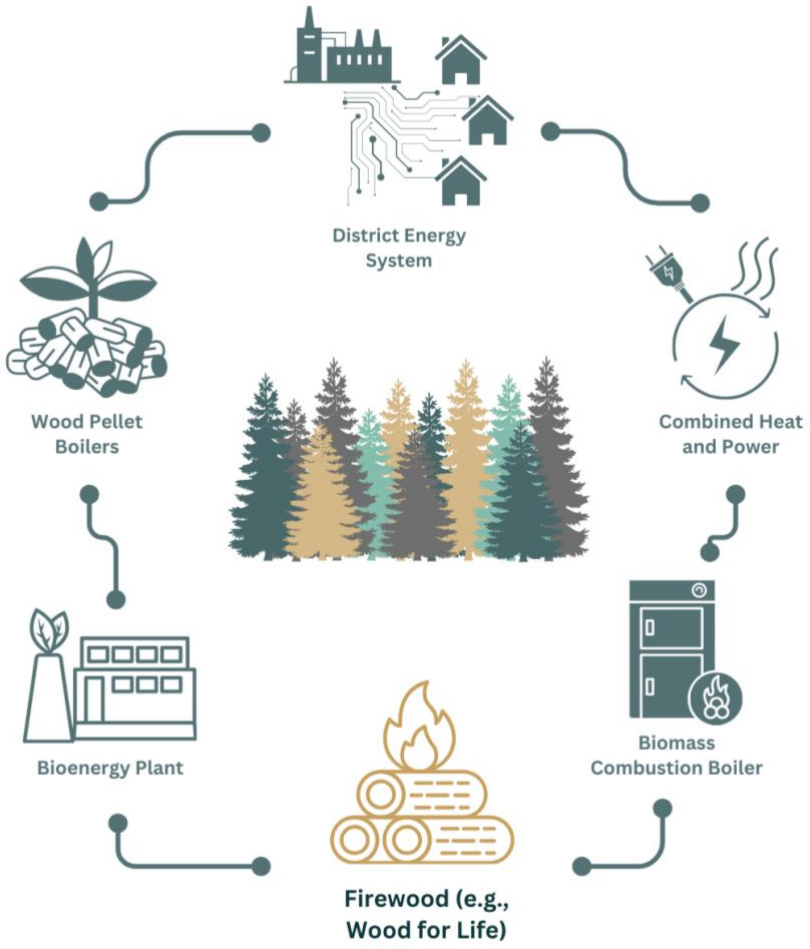


Figure 3. The biomass use ecosystem. Each icon represents a different method of biomass use employed by Indigenous communities mentioned in the literature. The WFL case study has been highlighted as this system stands apart from the others.

manage various other firewood-related projects. These agreements can potentially place more autonomy in the hands of tribal partners and create increased long-term security and sustainability for access to firewood by tribes. 638 agreements have been in use between the BIA and tribes since 1975. However, the first 638 contract between a tribal entity and the Forest Service was only signed in 2020 (USDA Forest Service 2020). The relative newness of 638 agreements as a tool for tribes to pursue with the Forest Service helps to explain why they are not yet widely used. Other types of agreements, such as interagency agreements and stewardship contracts are currently in use.

Before the development of the WFL partnership, the use of Forest Service policy in these ways had not been attempted. One of the keys to the successful development of this collaboration was a national forest, and particular leaders within it, who were willing to innovate around challenging policies and organizational logistics. While the WFL partnership is still learning and growing in northern Arizona, the framework has begun to spread throughout the western United States. Today the beginnings of WFL frameworks are being used in Colorado, California, Idaho, Utah, New Mexico, and Nevada (personal communication, Sasha Stortz). In 2021, the Wood for Life partnership won the Volunteer and Service Citizen Stewardship and Partnerships Award and, in 2022, won the Forest Service Chiefs Award. This increased federal recognition of the importance of firewood projects and Indigenous forest biomass use, more generally, could help spur the uptake of similar models throughout the country and help meet both ecological and socio-economic goals.

Wood For Life Barriers

While the WFL partnership has successfully and creatively been working to bring firewood to the Navajo Nation and Hopi Tribe from NFS lands, challenges and barriers to further development of the partnership still exist. The largest barrier, consistently mentioned by all partners in WFL, is transportation. Many of the people most in need of firewood do not have the ability to go pick it up themselves. Often, this is due to a lack of a household vehicle or because much of the neediest population is elderly or disabled and, therefore, do not have the physical capacity to transport wood. For this population, wood that is made available for tribal members to pick up from the forest themselves is not a viable option due to the transportation barrier, and even picking up wood from their local chapter is sometimes not possible. On the other side of the

partnership, there are also transportation challenges related to the costs of transporting wood and paying drivers, the large size of the Navajo Nation, and logistics around what hub locations to dump large wood hauls. The WFL partners would like to increase transportation capacity to deliver wood to chapter houses, villages, or nonprofits. These locations would then distribute the wood to individual households, often by arranging for residents to pick up firewood, but occasionally delivering it to households without transportation. There has also been some suggestion of delivering wood to several selected hub locations, such as centrally located chapters or villages, for further distribution from there. This simulates the national wood bank concept, and managers hope that it will create buy-in from local communities to volunteer at their local wood bank hubs (personal communication, Jake Dahlin). However, while hubs can promote transportation efficiencies, chapters and villages may not have the capacity (in terms of personnel, vehicles, and storage space) or partnerships in place to facilitate this model of distribution.

Once the wood is delivered to chapters, villages, and nonprofits, the barrier becomes that entity's capacity to store, process, and distribute the wood, as well as all administrative coordination. Through the WFL needs assessment, it has become clear that the tribal entities tasked with distributing wood to individual households often do not have the capacity and support that they would like to fill this intermediary role. Many tribal leaders have emphasized the need for increased funding opportunities for tribal entities and nonprofits to pay workers to process and deliver wood and buy the equipment necessary for processing and delivery, such as log splitters, chainsaws, protective equipment, trucks, and trailers. Once wood is delivered, it must be circulated through distribution events (which require advertising, deciding who to prioritize, and staffing to load trucks) or deliveries to homes. Many chapters and villages opt to

store wood for emergency winter supplies, which requires fencing and security. Without proper equipment and staff, Navajo chapters and Hopi villages are limited in their capacity to process, store, and distribute the wood they receive from partners. ALCC is looking to address this need by working at the chapter and village level to train locals in running a successful wood bank and splitting and stacking firewood, to build local capacity (personal communication, Jake Dahlin).

Recent policies, such as the 2021 Investment in Infrastructure and Jobs Act (Bipartisan Infrastructure Law), allocated billions of dollars of funding to the Forest Service to engage in fuels management projects, such as those that provide the WFL partnership with firewood. More than $10 million has been allocated from the Forest Service to the Coconino and San Juan forests over the next five years, with $2 million allocated to the NFF specifically for WFL (USDA Forest Service 2022). With 638 agreements, the Forest Service can funnel some of this funding to the tribal entities working to make the WFL partnership possible. These agreements have not been pursued, and the funds have largely not reached the tribal partners. Two exceptions are, the Alliance for Green Heat grants, funded by the 2021 Bipartisan Infrastructure Law, and the Forest Service's Wood Innovations grant, both of which tribal entities have applied for and received. Wood Innovations grants, however, cannot be used to purchase moveable equipment such as chainsaws and log splitters, commonly needed for processing wood (personal communication, Jake Dahlin).

Lessons Learned and Recommendations

The systematic literature review and case study described here elucidated key lessons learned and recommendations for ongoing and future projects of Indigenous biomass use. These sets of lessons and recommendations have been broken apart according to the main themes

previously identified through the systematic literature review and case study: policy, Indigenous community engagement, and organizational structure of Indigenous biomass partnerships.

Policy

Lesson Learned:

- The policy landscape affecting Indigenous biomass use is complex, challenging to navigate, and was written without the input of tribes and Indigenous peoples.

Recommendation:

- Co-write policies and guidelines with Indigenous representatives in a manner which goes beyond consultation and includes tribes and Indigenous peoples as equals in policymaking. Policies should be assessed and updated regularly with meaningful input from tribes and Indigenous peoples.

Lesson Learned:

- Though more funding recently has been appropriated at a federal level for forest restoration and related projects, very little of this funding has made its way to Indigenous forest biomass projects. This can be due to contractual and organizational challenges both within the Forest Service and within tribal structures of governance. The funding which does make it, however, may not be available for the same amount of time that a project is planned to exist (where 638 agreements can last for up to 10 years, funding is often available for 5 years).

Recommendation:

- Make funding sources directly accessible to tribal entities. Increase understanding by the Forest Service and tribes on how to use 638 agreements to facilitate Indigenous biomass use through workshops and distribution of resources such as those linked below. Tribes have experience using 638 agreements with the Bureau of Indian Affairs (BIA) and can provide examples for future implementation by the Forest Service (Martin 2021). Expanding knowledge and use of other agreements and contracts such as co-stewardship agreements can facilitate participation by smaller entities like chapters and villages. The Forest Service and partners must also plan for the 5-year changes in funding and apply for new funding sources ahead of time. (Martin 2021, DOI 2023).

Indigenous Community Engagement

Lesson Learned:

- It is critical to build relationships through which the culture, needs, and capacity of individual Indigenous communities, as voiced by their leaders and members, can be identified and understood (Browning 2023).

Recommendation:

- Visit in-person and talk directly with Indigenous communities to better understand capacities, needs, and potential communication or accessibility gaps that exist. If possible, use bridging organizations like research institutes, universities, or nonprofits to act as a liaison and form strong working relationships with communities. Consider the roles which Indigenous sovereignty and data sovereignty play. Mindfully integrate

traditional ecological knowledge (TEK) according to the wishes of the individual Indigenous community.

Lesson Learned:

- Communities involved in Indigenous forest biomass use projects have frequently advocated for increased training opportunities for both community members and partners. Previous work on the WFL partnership has also identified trainings and co-learning as essential for growth (Browning 2023).

Recommendation:

- Integrate ongoing trainings into Indigenous forest biomass use projects. Opportunities should be inclusive of all involved partners and community members and should address the needed workforce skills of the specific biomass use project, Indigenous energy and data sovereignty, and facilitated dialogues around topics such as collaborative agreements, administration challenges, and wood stove improvements.

Organizational Structure of Indigenous Biomass Partnerships

Lesson Learned:

- The WFL project has a unique operational structure. While this format has initially provided a lot of flexibility, WFL has largely prioritized formal agreements with chapters and villages with the most capacity and has not been able to move wood to other chapters and villages in need.

Recommendation:

- Look to increase equity in the provision of agreements with tribal entities. Cooperatively establish guidelines and build intentional operational structures that reach chapters and villages with less capacity (Browning 2023). Tangible steps could include developing a communication plan to reach more chapters and villages and increasing outreach to foster agreements such as stewardship contracts and Memorandums of Understanding (MOUs). An MOU is a semi-formal written agreement between two or more parties (such as the Forest Service and a tribal entity) that expresses a convergence of will and indicates an

Box 5. Practical Examples of Relationship Building and Agreements

Example 1: Relationship Building

In 2023, the ERI completed a needs assessment to support the WFL partnership. The aim of the needs assessment was to estimate of the amount of firewood needed for underserved households as well as the capacity of chapters and villages to receive, process, and deliver wood to households. Through this process, 15 of 18 chapters in the Western Agency of the Navajo Nation and 11 of the 13 Hopi villages were visited, largely in person. At each chapter and village, the ERI staff met with leaders and officials. The conversations during these meetings included an overview of the WFL partnership, discussion of informal and formal agreement options, and the answering of a predetermined list of questions about needs and capacities. These visits also included tours of the current or potential wood bank site at each location. These in-person visits with chapter and village leaders allowed for in-depth conversations and the building of trusting personal relationships. Connections between these leaders and other WFL partners were also facilitated during this process.

Example 2: Hypothetical 638 Agreement

At this point in time, no 638 agreements have been used in coordination with the WFL partnership. A hypothetical 638 agreement used in this context might function as follows: A recognized tribal entity, such as a local governance certified chapter of the Navajo Nation, decides to pursue a 638 agreement with the Forest Service. This chapter then creates a proposal. This proposal can be created using the Tribal Forest Protection Act Proposal Template. (Information on the proposal development and implementation processes can be found here: Intertribal Timber Council 2024).

In this context, the tribal entity may propose putting together a crew to complete a fuels reduction project on a certain area of National Forest land. The proposal may also include taking biomass off the forest for use as firewood by the households of the community. This proposal may be approved by the National Forest or returned with requests for specific adjustments. After final approval, the National Forest works to designate funding for the project. Within the terms of the agreement this funding may go toward paying crews, purchasing equipment, transportation, paying staff to process the logs into firewood, and other necessities to increase capacity for the chapter.

intended common line of action to be taken as well as planned outcomes. Clear agreements within partnerships can increase inter-partnership trust, foster long-term sustainability, and create more efficiency.

Lesson Learned:

- Transportation is one of the biggest and most complex challenges facing the successful implementation of Indigenous forest biomass use projects. Transportation is limited by costs, long distances, lack of vehicles, lack of staff or ability to pay staff adequately, and the remote location of many tribal elders living without access to transportation.

Recommendation:

- Provide funding from federal, state, and other grant sources to support transportation infrastructure necessary for moving wood to those living in remote rural areas. Funds should be directed for vehicles, loading and processing equipment, and to pay staff to load and transport the wood. Funds should be allocated for transportation both on the forest restoration side of projects and directly to tribes to increase their capacity to move wood from hub locations to individual homes. Fund allocation must be updated to allow purchase of large and moveable equipment such as trucks, trailers, chainsaws, and log splitters. Fund allocation can be supported by agreements and contracts.

The Future of Indigenous Forest Biomass Utilization

Forest biomass is becoming increasingly important worldwide to decrease fossil fuel reliance, expand forest health treatment options, and increase energy sovereignty. The role of

Indigenous Nations in this forest biomass use is significant. Passage of legislation and allocation of funding in the last decade has put US tribes in a new position to engage directly with land management agencies to benefit both tribal communities and forests (Martin 2021). These changes in legislation promote cross-boundary shared stewardship that can facilitate partnerships around forest biomass use. The WFL partnership is clearly demonstrating its role here and rapidly expanding throughout the western US. In the face of climate change, increased wildfire, and growing socio-economic need, this project and others like it stand to support both forest and community well-being. The systematic literature review and WFL case study presented here illustrate how innovators at the front of the large-scale Indigenous biomass movement can help future partnerships learn and improve their models to best serve all involved.

Professional Ethics

Ethics Overview

In any work pertaining to human subjects and environmental management, the associated ethical considerations must be carefully reflected upon. The Indigenous biomass use topics and partnerships evaluated in this paper, however, are particularly important to assess with an ethical lens due to the colonial history in North America, attempted erasure of Indigenous peoples, and disenfranchisement of TEK in forest management. This section aims to reflect upon the many ethical considerations of Indigenous biomass use partnerships respectfully and with consideration that the author is not Indigenous and, therefore, cannot speak from those perspectives.

The study of ethics is a philosophical pursuit of morality and assessment of personal values concerning ideas of “right” and “wrong.” Ethics are values that exemplify justice,

integrity, competence, and utility (Raiborn and Payne 1990). Moral absolutism, the unconditional, overriding, and limiting belief that certain actions are always right or wrong will not be included in this discussion for full consideration of diverse viewpoints.

Box 6. Land Ethics Categories Based on Western Values

Land Ethic Category	Definition
Egalitarian	Based on the idea that all humans are of equal value. In land ethics this means all humans deserve equal access to the resources on the land and the land itself.
Utilitarian	The goals of natural resource management should be to provide the greatest good to the greatest number of people.
Ecological	Based on environmental stewardship and the intrinsic values of nature.
Libertarian	Private property owners feel they have a natural right to do what they want with their forests and natural resources as long as their actions do not interfere with the freedoms and rights of their neighbors.
Economic	Monetary self-interest, value on species that provide financial return.

There are five main categories of land ethics stemming from Western values: economic, utilitarian, libertarian, egalitarian, and ecological. The United States (US) federal land management agencies were founded on the utilitarian ethic, the doctrine that actions are "right" if they are useful (Batavia and Nelson 2018). Gifford Pinchot, one of the founders of forestry in the US, once stated that the goals of land management "shall always be answered from the standpoint of the greatest good of the greatest number in the long run" (Pinchot 1947). This land ethic led to decades of indiscriminate logging, fire suppression practices, and the myth of the omnipotent forester, where the forester alone determines the best interest of the land and the public (Behan 1966). Historically, this discussion has only been applied to the ethics of the land itself. More recently, the federal land management agencies have moved to a multiple-use ethic and begun to focus on the humans who use the land and are impacted by decisions about it. Most recently, the goal has become to encompass all these land ethics into management practices. While this idea is appealing in theory, in practice agencies have been given minimal direction on

how to balance the widely divergent set of values they now must encompass. The main questions now are: who should be represented and at what level of priority should their interests fall?

In the hope of addressing the values behind multiple-use ethics, forestry organizations have developed statements of professional ethics. The Forest Service Employees for Environmental Ethics (FSEEE) have stated that lands held in public trust should be valued for the benefits they may provide to future generations (FSEEE 2023). The Society of American Foresters (SAF) has a range of pledges and principles aiming to foster stewardship for the well-being of society and the environment (Society of American Foresters 2000). Beyond these are the ethical values of many partners and shareholders and the personal ethics held by the land managers themselves, creating a complex web of morality to navigate in decision-making.

In the next paragraphs, I discuss Indigenous ethics and the role of Indigenous communities in wildfire management and biomass use. That being said, there have been decades of exploitative research on Indigenous peoples. As a Euro-American, it is not my place, nor possible, to speak for Indigenous communities. This work is intended to approach the topics ethically and reciprocally alongside Indigenous peoples, recognizing the inherent inequities within historical, political, and societal contexts (Dickson-Hoyle 2023). My findings in this paper and my description of ethical behavior in this context were formed within the lens of my perspective and understandings, not intending to speak for others whose experiences and perspectives I do not possess. My hope is that this paper engages in an ongoing dialogue about Indigenous forest biomass use and provides useful recommendations to facilitate the enhancement of the WFL framework and aid in the continued development of policies that impact this work.

Indigenous Land Ethics

In the literature, authors discuss how Indigenous land ethics may differ from those rooted in Western values (Groenfeldt 2003; Tuhiwai Smith 2021; Harmsworth 2002). They may reflect cultural values of whole ecosystems, Indigenous knowledge (IK), the spiritual value of forests, environmental justice, holistic ecosystem management, and relationality among species (Dockery et al. 2022). They may also include pieces of all five land ethics described previously: economic, utilitarian, libertarian, egalitarian, and ecological. In land management, the literature emphasizes the critical importance of considering the role of ancestral Indigenous lands. These lands were taken by Euro-American settlers and have promoted "Western-style economic development initiatives that seldom acknowledge the legitimacy of values outside the materialist rational paradigm" (Groenfeldt 2003; Dockery et al. 2022). In the face of this injustice, Indigenous communities have developed their own sets of ethical guidelines due to the insensitive research historically "conducted 'on' Indigenous people" (Christianson 2015). Many of these ethical guidelines call for collaboration through community-based or participatory research and the formation of trusting relationships. One proposed action-oriented framework is "walking on two legs," similar to two-eyed seeing and both-ways management models. This framework has been proposed as a decolonizing forest restoration approach. It "seeks to bring Indigenous knowledges into balance with Western scientific knowledge in service of upholding an Indigenous stewardship ethic" (Dickson-Hoyle 2022).

The role of data sovereignty has also grown in importance in discussions of ethical land management (Dockery et al. 2022). Existing scientific research and statistical frameworks have raised concerns for Indigenous peoples about the representation of their world views and their participation in data collection and control over its use. However, many Indigenous communities

today “are asserting their own statistical identity and ownership of information” (Kukutai and Taylor 2016). Understanding and respecting these Indigenous ethics, as well as Indigenous research and data, as voiced and created by the partners themselves, is critical to strong and trusting relationships with better outcomes for communities and ecosystems alike (Goldstein and Kennedy 2022).

Indigenous Biomass Use Ethics

The use of biomass (especially small diameter, low-quality biomass) has become an important consideration in fuel reduction projects and community wildfire risk reduction. Ethical considerations are critical to successful partnerships and management outcomes in the interactional area between Indigenous communities, fuel reduction, and wildfire management. A review of the ethics literature identified key areas where ethics must be examined:

- Use of local knowledge during hazard events
- Power dynamics
- Distribution of political and financial capital
- Simplification of risk
- Historical relationships
- Collaborative action

In highly contested areas, such as hazard management, the question of what knowledge and whose perspectives count is crucial (Goldstein and Kennedy 2022). Current social science research has shown that considering local knowledge and unique contextual experiences in hazard management and risk mitigation reduces conflict between locals and agencies (Paveglio et al. 2018; Paveglio et al. 2017; Vedwan and Rhoades 2001; Thomas et al. 2007; Adger et al. 2009; Brenkert-Smith et al. 2017). Integration of local IK into community wildfire management

through willing and equal participation of Indigenous communities not only serves this conflict-reducing role but embodies the “walking on two legs” framework for decolonizing forest restoration.

In land management, structural inequities in power dynamics serve to reinforce existing arrangements (Cheng and Dale 2020). The power dynamics stem from a long history of Indigenous oppression, removal from homelands, forced assimilation policies, and ingrained systems for seizing sovereignty and decision-making power. This history has led to inequities in political power and a need for more respect for Indigenous knowledge and practices. Recognition of how these power dynamics manifest and the restructuring of management systems with active Indigenous participation is critical for enhanced equity.

The long history of structural power inequities has created a disparity in the distribution of political and financial capital. For Indigenous communities working in fire management and fuel reduction, landscape-level fire adaptation requires capital that is unevenly distributed across communities and their leadership (Brenkert-Smith 2017). Even within communities, as was highlighted in the Wood For Life (WFL) needs assessment, there are differences in the capacity that different chapters and villages can leverage. This is showcased in grant applications to improve participation in programs like WFL. The literature shows the “capacity of successful applicants begets more capacity through large funding awards, thereby creating a positive cycle for enhancing the capacity of these already-high-capacity-organizations” (Cheng and Dale 2020). For partner agencies and organizations, a willingness to work with small communities, despite challenges in capital, is the ethical thing to do, and it pays off in long-term outcomes (Paveglio and Edgeley 2023).

There has been a historical simplification of risks in the management of hazards like wildland fire. Failure to account for the social and ecological diversity of fire-prone areas has disenfranchised Indigenous peoples. Questions of who defines and addresses fire risk have been approached from a Western, utilitarian point of view (Essen et al. 2023). Addressing the complexity of risk-inclusivity instead calls for knowledge pluralism, multidirectional social learning, and collective action.

Historical relationships with Indigenous peoples in land management have largely been founded on lack of: respect for the land, commitment to long-term management, mutual confidence, and honest and open communication. These relationships have greatly influenced the levels of trust from Indigenous communities. Careful efforts by managers, researchers, and policymakers to understand communities' values and perspectives are needed to build new relationships and trust moving forward (Paveglio and Edgeley 2023).

Collective action is an aligning principle between Indigenous ethical guidelines and the commitments of SAF and the Forest Service. Collective action is often referred to as shared stewardship by the Forest Service. Collective action includes working toward shared understandings, fostering open communication and coordination, capacity building, and creating trust and reciprocity in relationships (Charnley 2020). It has been demonstrated that spending time and resources up front can prevent conflict and litigation (Steelman and Burke). Collective action creates inclusivity and improved outcomes.

Ethical Consideration of Recommendations

In the context of this paper's recommendations regarding WFL and Indigenous biomass use, there are six main ways in which these ethical considerations have been and must continue to be integrated:

Relationships

- Face-to-face communication builds trust and creates an understanding of the unique needs and values of an Indigenous community. The WFL needs assessment conducted by the Ecological Restoration Institute (ERI) exemplifies this practice. By meeting with individual chapter and village leaders of the Navajo Nation and Hopi Tribe, strong relationships were fostered, and co-learning occurred. This, in turn, has added and strengthened the WFL partnership relationships and provided detailed information to improve wood delivery that meets Indigenous needs. These relationships additionally require consistency and continuity over time.

Redistribution of Capital

- Funds and grants to support biomass use must be made accessible to small Indigenous communities with lower capacity. The use of 638 agreements between tribal entities and the Forest Service has the potential to redistribute capital and expand communities' capacity. Boundary organizations such as the ERI can be

useful in this work by conducting needs assessments, acting as liaisons between partners, and connecting people to available resources.

Policy

- There must be greater attention paid to the equitable implementation of existing policy by land management agencies. Co-writing of policy with Indigenous leaders should integrate IK as well as community-based and participatory research.

Consideration of the Politically Possible

- Leadership culture and incentives can help managers embrace creative alternatives to the status quo, as has been demonstrated by Region Three of the Forest Service in the support and funding of WFL.

Power Dynamics

- Agencies must address power differentials through co-creation of policy, relationship building, integration of workforce and capacity training into projects, and improving accessibility of funding. Easy-to-navigate grant applications with accessible support (such as the Alliance for Green Heat grants) have been a

starting point for national and regional-level opening of funds. Forests and districts could work to create similar solutions locally.

Research

- The WFL needs assessment was conducted with Jon Martin of the ERI, and a member of the Navajo Nation, as a lead partner. Ongoing work should continue to involve Indigenous peoples in knowledge production and support Indigenous goals. Access to the findings will be open and distributed to tribal partners and all tribal members impacted.

The study of ethics is often seen as purely philosophical and strongly tied to personal morality. The consideration of ethical ideas in land management, however, offers great benefits to the ongoing improvement of equity within the field. Within this discourse I welcome the discussion of these thoughts and ideas and remain excited to continue my learning process in this area.

Conclusion:

Many factors play a role in Indigenous biomass use, not least of which are climate change, energy costs, wildfire risk reduction, and shared stewardship. This paper aims to untangle these many factors and provide recommendations for the development of successful biomass use partnerships. Specifically, the goals were to: 1) assess the trends in Indigenous forest biomass use in the US and Canada through a systematic review of published literature, 2)

examine the Wood For Life (WFL) partnership as a local case study of Indigenous forest biomass use in the US Southwest, and 3) capitalize on our improved understandings to provide recommendations for further development of Indigenous forest biomass partnerships. Information gathered from a systematic literature review and local case study demonstrate the need for targeted recommendations with respect to: 1) policy, 2) Indigenous community engagement, and 3) organizational structure of Indigenous biomass partnerships. The lessons learned in this paper can facilitate the effective and collaborative enhancement of the WFL framework and aid in the continued development of policies that impact this work. The ethical dimensions of the work discussed here can help provide partners with deeper understandings and aid in the development of trusting collaborations.

References:

Advanced Solutions International, Inc. 2000. SAF Code of Ethics. *Code Of Ethics*, Society of American Foresters, www.eforester.org/Main/About/Code_of_Ethics/CodeofEthics.aspx?hkey=7ab0631-be80-43ff-8089-8cc2f6e2c50d

Batavia, C., and Nelson, M. P., 2018. Translating Climate Change Policy into Forest Management Practice in a Multiple-Use Context: The Role of Ethics. *Climatic Change* 148, no. 1–2: 81–94, https://doi.org/10.1007/s10584-018-2186-2

Benvenuto, J., A. Hinton, and A. Woolford, Eds. 2014. Colonial Genocide in Indigenous North America. *Duke University Press*. https://books.google.com/books?hl=en&lr=&id=xBPqBQAAQBAJ&oi=fnd&pg=PT6&dq=indigenous+colonization+north+america&ots=TrSeVw7vpG&sig=4uTxbMkXlO3JUDLpPVWGnnIx4Ig#v=onepage&q&f=false.

Brenkert-Smith, H., et al., 2017. Where You Stand Depends on Where You Sit: Qualitative Inquiry into Notions of Fire Adaptation. *Ecology and Society* 22, no. 3: art7, https://doi.org/10.5751/ES-09471-220307

Brewer, II, J.P., S. Vandever, and J.T. Johnson. 2018. Towards Energy Sovereignty: Biomass as Sustainability in Interior Alaska. *Sustainability Science,* 13(2): 417–29, https://doi.org/10.1007/s11625-017-0441-5

Browning, Z. 2023. “The Emergence of Adaptive Governance and the Role of Informality: A Case Study of Restoration Thinning and tribal Home Heating in Northern Arizona.” *Thesis: Northern Arizona University*, May 2023.

Bowman, D.M.J.S., et al. 2011. The Human Dimension of Fire Regimes on Earth,” *Journal of Biogeography,* 38(12): 2223–36, https://doi.org/10.1111/j.1365-2699.2011.02595.x

Buss, J., et al. 2022. Greenhouse Gas Mitigation Potential of Replacing Diesel Fuel with Wood-Based Bioenergy in an Artic Indigenous Community: A Pilot Study in Fort McPherson, Canada. *Biomass and Bioenergy,* 159: 106367.

Bull, G., et al. 2014. Culturally driven forest management, use and values: A Nuxalk First Nations case study. *Forestry Chronicle, Ottawa, Canada: Canadian Institute of Forestry*, vol. 90, 620–27, https://doi.org/10.5558/tfc2014-126

Bullock, R.C.L., et al. 2020. Open for Bioenergy Business? Perspectives from Indigenous Business Leaders on Biomass Development Potential in Canada. *Energy Research & Social Science,* 64: 101446.

Bureau of Reclamation. 2018. Navajo Generating Station web page. US Department of Interior, Bureau of Reclamation, www.usbr.gov/ngs/

Buss, J., et al. 2021. De-Risking Wood-Based Bioenergy Development in Remote and Indigenous Communities in Canada. *Energies,* 14(9): 2603.

Carroll, M. S., et al., 2005. Fire as a Galvanizing and Fragmenting Influence on Communities: The Case of the Rodeo–Chediski Fire. *Society & Natural Resources* 18, no. 4: 301–20, https://doi.org/10.1080/08941920590915224

Charnley, S., Kelly, E. C., and Fischer, A. P., 2020. Fostering Collective Action to Reduce Wildfire Risk across Property Boundaries in the American West. *Environmental Research Letters* 15, no. 2: 025007, https://doi.org/10.1088/1748-9326/ab639a

Cheng, A. S., and Dale, L., 2020. Achieving Adaptive Governance of Forest Wildfire Risk Using Competitive Grants: Insights From the Colorado Wildfire Risk Reduction Grant Program. *Review of Policy Research* 37, no. 5: 657–86, https://doi.org/10.1111/ropr.12379

Christianson, A., 2015. Social Science Research on Indigenous Wildfire Management in the 21st Century and Future Research Needs. *International Journal of Wildland Fire* 24, no. 2: 190, https://doi.org/10.1071/WF13048

Christianson, A.C., et al. 2022. Centering Indigenous Voices: The Role of Fire in the Boreal Forest of North America. *Current Forestry Reports,* 8(3): 257–76, https://doi.org/10.1007/s40725-022-00168-9

Corrao et al. 2022. Carbon Monitoring and above Ground Biomass Trends: Anchor Forest Opportunities for tribal, Private and Federal Relationships. *Trees, Forests and People,* 9: 100302

Dahlin, J. 2023. (District Timber Staff, Flagstaff Ranger District, Coconino National Forest) in discussion with the author, (May 2023)

Dennison et al. 2014. Large Wildfire Trends in the Western United States, 1984–2011. *Geophysical Research Letters,* 41(8): 2928–33, https://doi.org/10.1002/2014GL059576

Dickson-Hoyle, S., et al., 2022. Walking on Two Legs: A Pathway of Indigenous Restoration and Reconciliation in Fire-adapted Landscapes. *Restoration Ecology* 30, no.: e13566, https://doi.org/10.1111/rec.13566

Dockry, M. J., et al., 2023. An Assessment of American Indian Forestry Research, Information Needs, and Priorities. *Journal of Forestry* 121, no. 1: 49–63, https://doi.org/10.1093/jofore/fvac030

Essen, M., et al., 2023. Improving Wildfire Management Outcomes: Shifting the Paradigm of Wildfire from Simple to Complex Risk. *Journal of Environmental Planning and Management* 66, no. 5: 909–27, https://doi.org/10.1080/09640568.2021.2007861

Forest Service Employees for Environmental Ethics. 2023. Our Mission & Programs. *Forest Service Employees for Environmental Ethics*. www.nationalforestadvocates.org/about-us/

Fowler, C. T., 2018. Emerging Environmental Ethics for Living with Novel Fire Regimes in the Blue Ridge Mountains. *Ethnobiology Letters* 9, no. 1: 90–100, https://doi.org/10.14237/ebl.9.1.2018.1049

Franz, S.T., M.M. Colavito, and C.M. Edgeley. 2023. The Evolution of Wildfire Policy Governing Management of Natural Ignitions. ERI White Paper—Issues in Forest Restoration. Ecological Restoration Institute, Northern Arizona University. 31 p.

Fryberg, S., R. Covarrubias, J. Burack. 2018. "The Ongoing Psychological Colonization of North American Indigenous People: Using Social Psychological Theories to Promote Social Justice." *In* The Oxford Handbook of Social Psychology and Social Justice. Oxford University Press.

Gray, R.W. 2013. Bioenergy Is a Viable Solution to BC's Wildland-Urban Interface Fuels Problem; However, a Number of Policy Changes Are Needed First. *Journal of Ecosystems and Management,* 14(3).

Goldstein, D., and Kennedy, E. B., 2022. Mapping the Ethical Landscape of Wildland Fire Management: Setting an Agendum for Research and Deliberation on the Applied Ethics of Wildland Fire. *International Journal of Wildland Fire* 31, no. 10: 911–17, https://doi.org/10.1071/WF22020

Groenfeldt, D., 2003. The Future of Indigenous Values: Cultural Relativism in the Face of Economic Development. *Futures* 35, no. 9: 917–29, https://doi.org/10.1016/S0016-3287(03)00049-1

Iglesias, V., J.K. Balch, and W.R. Travis. 2022. US Fires Became Larger, More Frequent, and More Widespread in the 2000s. *Science Advances*, 8(11), https://www.science.org/doi/10.1126/sciadv.abc0020

Intertribal Timber Council. 2024. "Tribal Forest Protection Act: All Reports, Videos, Materials, and Resources web page." https://www.itcnet.org/resources/publications.html

Kearns, R.A. 2005. "Knowing Seeing? Understanding Observational Research." *Qualitative Research Methods in Human Geography*, Iain Hay, ed., 2nd ed., Oxford University Press Canada, Don Mills, 2005, pp. 192–206.

Kooistra, C., E. Sinkular, and C. Schultz. 2022. Characterizing the Context and Demand for the US Forest Service's Collaborative Forest Landscape Restoration Program in 2020. *Journal of Forestry,* 120(1): 64–85, https://doi.org/10.1093/jofore/fvab044

Krupa, J. 2012. Blazing a New Path Forward: A Case Study on the Renewable Energy Initiatives of the Pic River First Nation. *Environmental Development,* 3: 109–22.

Kukutai, T., and Taylor, J., 2016. Data Sovereignty for Indigenous Peoples: Current Practice and Future Needs. in *Indigenous Data Sovereignty*, ed. Tahu Kukutai and John Taylor, 1st ed. (ANU Press), https://doi.org/10.22459/CAEPR38.11.2016.01

Kukutai, T., and Taylor, J., 2016. *Indigenous Data Sovereignty: Toward an Agenda.*, vol. 38 (ANU Press), https://www.jstor.org/stable/j.ctt1q1crgf

Long, J.W., F.K. Lake, and R.W. Goode. 2021. The Importance of Indigenous Cultural Burning in Forested Regions of the Pacific West, USA," *Forest Ecology and Management,* 500: 119597, https://doi.org/10.1016/j.foreco.2021.119597

Martin, J. 2021. Implications for Tribal Forest Management Under New Federal Legislative Directions. ERI White Paper—Issues in Forest Restoration. Ecological Restoration Institute, Northern Arizona University. 15 p.

Mansuy, N., D. Staley, and L. Taheriazad. 2020. Woody Biomass Mobilization for Bioenergy in a Constrained Landscape: A Case Study from Cold Lake First Nations in Alberta, Canada. *Energies,* 13(23), https://doi.org/10.3390/en13236289

Markwith, S.H., and A. Paudel. 2022. Beyond Pre-Columbian Burning: The Impact of Firewood Collection on Forest Fuel Loads. *Canadian Journal of Forest Research,* 52(3): 365–71, https://doi.org/10.1139/cjfr-2021-0207

Menghwani, V., et al. 2022. Harvesting Local Energy: A Case Study of Community-Led Bioenergy Development in Galena, Alaska. *Energies,* 15(13): 4655.

Menghwani, V., et al. 2023. Bioenergy for Community Energy Security in Canada: Challenges in the Business Ecosystem. *Energies,* 16(4): 1560.

Neary, D.G., and E.J. Zieroth. 2007. Forest Bioenergy System to Reduce the Hazard of Wildfires: White Mountains, Arizona. *Biomass and Bioenergy,* 31(9): 638–45, https://doi.org/10.1016/j.biombioe.2007.06.028

O'Flaherty, R.M., I.J. Davidson-Hunt, and M. Manseau. 2008. Indigenous Knowledge and Values in Planning for Sustainable Forestry: Pikangikum First Nation and the Whitefeather Forest Initiative. *Ecology and Society,* 13(1): 6, https://doi.org/10.5751/ES-02284-130106

Paveglio, T. B., et al., 2018. Incorporating Social Diversity into Wildfire Management: Proposing 'Pathways' for Fire Adaptation. *Forest Science* 64, no. 5: 515–32, https://doi.org/10.1093/forsci/fxy005

Paveglio, T. B., and Edgeley, C. M., 2023. Variable Support and Opposition to Fuels Treatments for Wildfire Risk Reduction: Melding Frameworks for Local Context and Collaborative Potential. *Journal of Forestry* 121, no. 4: 354–73, https://doi.org/10.1093/jofore/fvad021

Paveglio, T. B., Boyd, A. D., and Carroll, M. S., 2017. Re-Conceptualizing Community in Risk Research. *Journal of Risk Research* 20, no. 7: 931–51, https://doi.org/10.1080/13669877.2015.1121908

Raiborn, C. A., and Payne, D., 1990. Corporate Codes of Conduct: A Collective Conscience and Continuum. *Journal of Business Ethics* 9, no. 11: 879–89, https://doi.org/10.1007/BF00382911

Ramirez, L.C., and P.L. Hammack. 2014. Surviving Colonization and the Quest for Healing: Narrative and Resilience Among California Indian Tribal Leaders. *Transcultural Psychiatry,* 51(1): 112–33, https://doi.org/10.1177/1363461513520096

Rasch, R., and McCaffrey, S., 2019. Exploring Wildfire-Prone Community Trust in Wildfire Management Agencies. *Forest Science* 65, no. 5: 652–63, https://doi.org/10.1093/forsci/fxz027

Richardson, J.J., et al. 2011. Uncertainty in Biomass Supply Estimates: Lessons from a Yakama Nation Case Study. *Biomass and Bioenergy,* 35(8): 3698–3707, https://doi.org/10.1016/j.biombioe.2011.05.030

Setten, G., and Lein, H., 2019. 'We Draw on What We Know Anyway': The Meaning and Role of Local Knowledge in Natural Hazard Management. *International Journal of Disaster Risk Reduction* 38: 101184, https://doi.org/10.1016/j.ijdrr.2019.101184

Sikka, M., T.F. Thornton, and R. Wori. 2013. Sustainable Biomass Energy and Indigenous Cultural Models of Wellbeing in an Alaska Forest Ecosystem. *Ecology and Society,* 18(3), https://doi.org/10.5751/ES-05763-180338.

Steelman, T. A., and Burke, C., 2007. Is Wildfire Policy in the United States Sustainable? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1931057

Stephen, J.D., et al. 2016. Biomass for Residential and Commercial Heating in a Remote Canadian Aboriginal Community. *Renewable Energy,* 86: 563–75.

Stortz, S., and Colavito, M.M. 2022. "Wood for Life: Partnership Statement." Ecological Restoration Institute at Northern Arizona University and National Forest Foundation. 5 p.

Stortz, S., and Colavito, M.M. 2021. "Wood for Life: A Tribal Firewood Partnership in Northern Arizona." Project Highlights. Ecological Restoration Institute at Northern Arizona University and National Forest Foundation. 7 p.

Stortz, S. 2023. (Southwest Program Senior Manager, National Forest Foundation) in discussion with the author, (June 2023).

Toman, E., et al., 2014. Public Acceptance of Wildland Fire and Fuel Management: Panel Responses in Seven Locations. *Environmental Management* 54, no. 3: 557–70, https://doi.org/10.1007/s00267-014-0327-6

Tuhiwai Smith, L., 2021. *Decolonizing Methodologies: Research and Indigenous Peoples*, 3rd ed. (Zed Books)

USDA Forest Service. 2020. "Recorded Webinar - Signing of the First USDA 638 Agreement with the Tulalip Tribes." US Department of Agriculture Forest Service. Sept. 9, 2020. https://www.fs.usda.gov/restoration/tribal-forest-protection-act/tulalipagreement/signing/signing.html

USDA Forest Service. 2022. "National Forest Foundation Receives $2 Million for Firewood Banks." US Department of Agriculture Forest Service, Press Release. Nov. 15, 2022. www.fs.usda.gov/news/releases/national-forest-foundation-receives-2-million-firewood-banks

USDA Forest Service. 2023. Firewood Permits and Cutting Season web page. US Department of Agriculture Forest Service. https://www.fs.usda.gov/detail/coconino/passes-permits/forestproducts/?cid=fseprd497256

Vinyeta, K. 2022. Under the Guise of Science: How the US Forest Service Deployed Settler Colonial and Racist Logics to Advance an Unsubstantiated Fire Suppression Agenda. *Environmental Sociology,* 8(2): 134–48, https://doi.org/10.1080/23251042.2021.1987608

Wilson, P., Paveglio, T., and Becker, D., 2018. The Politically Possible and Wildland Fire Research. *Fire* 1, no. 1: 12, https://doi.org/10.3390/fire1010012.

Zurba, M., and R. Bullock. 2020. Bioenergy Development and the Implications for the Social Wellbeing of Indigenous Peoples in Canada. *Ambio,* 49(1): 299–309.

List of Acronyms:

WFL: Wood For Life
TEK: Traditional Ecological Knowledge
ERI: Ecological Restoration Institute
NFS: National Forest Service
NFF: National Forest Foundation
NGS: Navajo Generating Station
CSA: Community Service Administrator
MOU: Memorandum of Understanding
ALCC: Ancestral Lands Conservation Corps
BIA: Bureau of Indian Affairs

Appendix:

Supplemental Figures and Tables

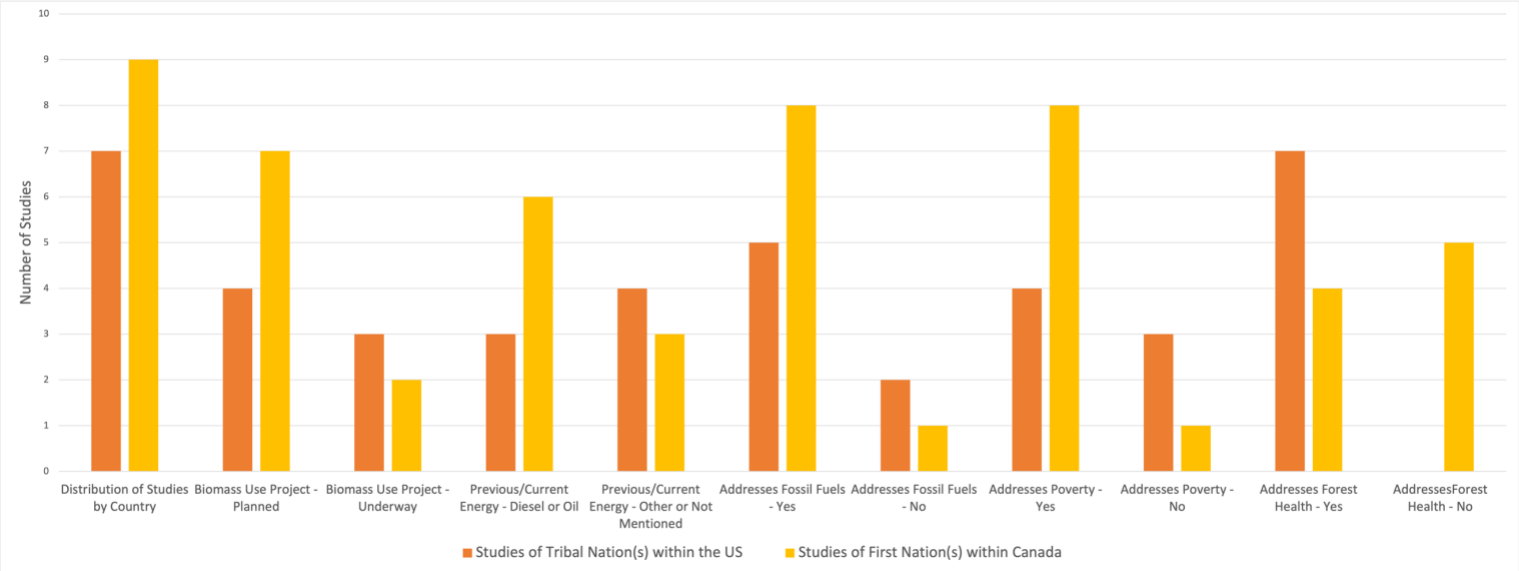


Figure. Quantitative comparison of frequently mentioned topics in papers on Indigenous forest biomass utilization in the U.S. versus Canada.

Table. Drivers of forest biomass utilization.

Category	Drivers
Economic	•Desire to reduce heating/diesel costs •Abundance of the resource •Economic security/diversification for the community
Environmental	•Reduce GHG •Support forest health and fuels reductions projects
Social/Cultural	•Energy Sovereignty •Community autonomy •Community well-being •Cultural reconnection to land

Table. Systems/types of forest biomass utilization.

US	Combined Heating System
US	Biomass Combustion Boiler
US	Boiler System
	Small biomass power plants, wood

Table. Barriers to forest biomass utilization.

Category	Barriers
Political	•Land tenure status •Need for better policy •Navigation of regulatory, legal, banking, etc. systems
Economic	•Need for funding
Logistical/Operational	•Feedstock not readily available •Transportation •Supply chain •Issues of scale •Sustainability
Environmental	•Concern over forest harm •Concern over greenwashing

Table. Solutions to barriers of forest biomass utilization.

Category	Solutions
Political	•Multi-year predictable policy •Long term funding
Community	•Community involvement and ownership (if possible) from beginning •Community on board- aligned vision •Positive externalities like job creation, training , etc. •Education •Use of TEK

Database/Website	Date	Search Terms	Hits	Saved To
Google Scholar	2/20/23	“biomass utilization” AND “indigenous nations” OR “tribal nations”	17	Review Search 1
Google Scholar	2/20/23	"woody biomass" AND "indigenous nations" OR "tribal nations" AND "united states"	44	Review Search 2
Google Scholar	2/20/23	“woody biomass” AND “first nations” AND “Canada”	163	Review Search 3
CAB Abstracts, GreenFILE, Academic Search Complete, Business Source Premier, SocINDEX	2/20/23	“firewood” OR “biomass” AND “indigenous people” AND “united states”	1	Review Search 4
CAB Abstracts, GreenFILE, Academic Search Complete, Business Source Premier, SocINDEX	2/20/23	“firewood” OR “biomass” AND “tribal” AND “united states”	2	Review Search 5
CAB Abstracts, GreenFILE, Academic Search Complete, Business Source Premier, SocINDEX	2/20/23	“firewood” OR “woody biomass” AND “first nations” AND “Canada”	2	Review Search 6
Web of Science	2/25/23	“biomass” OR “biofuel” OR “bioenergy” AND “wood” OR “woody” OR “firewood” AND “ "indigenous community" OR "indigenous communities" OR "indigenous people" OR "indigenous peoples" OR tribe OR tribal OR "first nations" OR "native american" OR "native americans" OR "american indian" OR "american indians" AND “Canada”	9	Review Search 7
Web of Science	2/25/23	“biomass” OR “biofuel” OR “bioenergy” AND “ wood” OR “woody” OR “firewood” AND “ "indigenous community" OR "indigenous communities" OR "indigenous people" OR "indigenous peoples" OR tribe OR tribal OR "first nations" OR "native american" OR "native americans" OR "american indian" OR "american indians" AND “United States”	11	Search Results 8
BIOSIS Citation Index	2/25/23	“biomass” OR “biofuel” OR “bioenergy” AND “wood” OR “woody” OR “firewood” AND "indigenous community" OR "indigenous communities" OR "indigenous people" OR "indigenous peoples" OR tribe OR tribal OR "first nations" OR "native american" OR "native americans" OR "american indian" OR "american indians"	0	N/A
Agricultural & Environmental Science Collection		“biomass” OR “biofuel” OR “bioenergy” AND “wood” OR “woody” OR “firewood” AND "indigenous community" OR "indigenous communities" OR "indigenous people" OR "indigenous peoples" OR tribe OR tribal OR "first nations" OR "native american" OR "native americans" OR "american indian" OR "american indians"	20	Search Results 9

Exclusion #	Date	Reason	# of articles	Saved to
1	2/25/23	Duplicates	25	Exclusion 1
2	2/25/23	Not on topic	183	Exclusion 2
3	2/22/23	Theses/Dissertations /Not published	16	Exclusion 3
4	2/22/23	No relevant population	12	Exclusion 4
5	2/22/23	Conflict of interest/industry	7	Exclusion 5
6	3/5/23	Moved to supporting literature	9	Supporting Lit

Author/Date	Country	Indigenous Nations	Biomass Use (Undergoing/Plan)	Feedstock Source(s)	Bioenergy Type	Current/Previous Energy Type	Addresses Fossil Fuel Use?	Addresses Poverty?	Drivers for Utilization	Land Ownership	Relevant Policies	Barriers to Biomass Use	Solutions to Barriers	Mention of Forest Health?
Brewer et al. (2018)	US	Gwich'in	Underway.	Nearby cottonwoods from wildfire risk reduction projects.	High-efficiency wood-chip fed combined heating system.	Diesel	Yes	Yes	High diesel fuel costs, economic opportunity, sovereignty, cultural significance, environmental.	Gwichyaa Zhee Corporation, a local Alaska Native owned company is the forest landholder.	Alaskan Native Claims Settlement Act (1971) ANCSA. Alaska National Interests Lands Conservation Act (ANILCA) 1980.	Land tenure status.	None mentioned.	Yes, wildfires.
Richardson et al. (2011)	US	Yakama Nation	Planned.	Urban residues, agricultural residues, thinning and slash from logging.	Biomass combustion boiler.	None mentioned.	No	No	Economic/resource availability	Yakama Nation has large forested landholdings. But other fragmented land ownership.	None mentioned.	Varied land ownerships, spatial variability in feedstock prices, types, and densities. Cost of fuels reductions thinnings.	None mentioned.	Briefly, fuels reductio
Menghwani et al. (2022)	US	Tribal association not stated. Native corporation Gana-A'Yoo Ltd.	Underway	Local paper birch. Residue from forest industries.	Boiler system.	Diesel	Yes	Yes	Energy self-sufficiency and sovereignty, renewability, proximity, abundance of resource.	Access to forest resources through timber sale agreement (TSA).	Alaskan Native Claims Settlement Act (1971) ANCSA.	Complex supply chains, issues of scale, feedstock availability and sustainability, regulatory frameworks, integration into infrastructure, public perception.	None mentioned.	Yes, harvest amounts and seasonality.
Bull et al. (2014)	Canada	Nuxalk First Nations	Planned/explored. (8 project options)	Sawmill and forest harvest residues.	District Energy System, decentralized wood pellet boiler system.	Diesel and some hydropower.	Yes	Yes	Ecosystem and economic drivers.	Timber tenures from province (BC). Community forestry agreements.	None mentioned.	Residues not readily available due to topography and lack of transportation infrastructure.	None mentioned.	None mentioned.
Buss et al. (2021)	Canada	Gwich'in, Cold Lake First Nations (5 communities)	Planned/scenarios explored.	FP: pellets shipped or harvested local willow, fuels reduction, residues from sawmill. CL: biomass delivered and willow plantation. N, B, T: fire residues, forestry mgmt harvesting.	CHP wood-based bioenergy system.	Diesel	Yes	Yes	Price of energy, GHG emissions reduction, promote community development, energy independence and security.	Depended on the community. Tribal ownership, external companies.	None mentioned.	Environmental, policy & economic, social & cultural, logistic & operational. (More in depth in article).	Include positive externalities (job creation), procure long term external funding, develop community-based entrepreneurship, utilize local sources of biomass, co-learning, restore community-based management, train local workforce, implement asset-based community development, integrate climate change impacts, utilize local TEK	Yes, fire relationship. Harvesting pressure on environment.
Mansuy et al. (2020)	Canada	Cold Lake First Nations	Planned/explored.	Harvest and fire residues.	Pellet based bioenergy.	Diesel	Yes	Yes	Energy prices, need to diversify economy, community well-being, GHG emissions reduction.	Limited access to their land. Some reliance on others for feedstock.	None mentioned.	Spatial constraints, lack of ownership of traditional lands, impacts on landscape, pricing makes it hard for biomass to compete, not always local job creation.	None mentioned.	Yes, fire relationship.
Neary and Zieroth (2007)	US	White Mountain Apache	Underway	Small diamter tree thinning/fuels reduction.	Small biomass power plants and wood-heating pellet manufacturing. (Stone Forest and Snowflake white Mountain.)	None mentioned.	Yes	No	Fuels reductions, support local economies, reduce cost of treatments, encourage new industries.	USFS Land, bordering Tribal lands, WUI in particular.	Omnibus Appropriations Act for Fiscal Year 2003, stewardship contracts, Healthy Forest Restoration Act.	None mentioned.	None mentioned.	Yes, wildfires.
Bullock et al. (2020)	Canada	First Nations leaders and buisiness people broadly.	Various, underway and scenarios.	Variable	Variable	Often Diesel	Yes	Yes	Fuels reductions, untapped residue resource, cleaner energy, employment, energy independence, autonomy, collaboration.	Variable	UN Declaration on the Rights of Indigenous Peoples	Benfit to risk ratio, negative envrionmental impacts, greenwashing, lack of capacity, start-up costs, need for government support, competition with large energy providers, banking system, land tenure.	None mentioned.	Yes, fires, harvesting impacts.
Buss et al. (2022)	Canada	Gwich'in	Planned/scenarios explored. Underway, 85 KW boiler, want to expand and implement CHP wood-based bioenergy system.	Wood chips from local willow or imported pellets from sawmill residue.	85 KW boiler, want to expand and implement CHP wood-based bioenergy system.	Diesel, some homes use wood pellet stoves.	Yes	Yes	GHG emissions reductions, price of diesel. Other environmental, health, and economic issues associated with diesel.	Some forest tenures, some forests just managed by natives.	None mentioned.	Lack of road infrastructure, long transport distances,	None mentioned.	None mentioned.
Corrao et al. (2022)	US	Yakima, Colville, Spokane, and Kalispel.	Planned/options explored. Anchor Forest concept.	Residues from forest health management.	General.	None mentioned.	Yes	No	Cross-boundary forest management.	Tribal lands. NFS Land, bordering Tribal lands.	Stewardship Contracting, Shared Stewardship, and the Good Neighbor Authority	None mentioned.	None mentioned.	Yes fire risk reduction, and forest health improvement generally.
Gray, R.W. (2013)	Canada	First Nations generally.	Planned.	Residues from fuels reductions in WUI.	General.	None mentioned.	No	No	Market for biomass from fuels reductions.	WUI land in BC. Shared ownerships.	BC Strategic Wildfire Prevention Program Initiative and Provincial Strategic Threat Assessment.	Economic.	None mentioned.	Yes, wildfire.
Kooistra et al. (2021)	US	Indigenous Nations generally.	Proposed. For CLFRP funding.	Forest health management residues, and fuels reduction residues.	General. Rio Charma: biochar, pellets, firewood, bioenergy. Western Klamath: Tribal Biomass Demonstration Project. NC Wash: Yakima Forest Products Tribal Mill.	None mentioned.	No	Yes	Forest health	USFS Land, bordering Tribal lands.	Omnibus Public Lands Act 2009, 2018 Farm Bill, Indian Self-Determination and Education Assistance Act, Tribal Forest Protection Act, Good Neighbor Authority.	Funding.	None mentioned.	Yes fire risk reduction, and forest health improvement generally.
Krupa (2012)	Canada	Pic River First Nation-Ojibways	Underway.	Not clear. Possilbe dedicated forestry company owned by the nation.	Partnership in a $650 million biofuels facility.	Already engaged in other renewable energy projects, especially hydro.	Yes	Yes	Sustainable Renewable Energy Development. Indigenous Development Perspective. Energy security. Climate change.	None mentioned. Brief mention of issues with land rights.	Crown Forest Sustainability Act.	Lack of financial resources, insufficient human capacity, difficulty navigating regulatory and legal frameworks, issues with grid connection, permitting, and project sites. Issues with societal and cultural barriers, percieved lack of sophistication,uncertainty around technical options, land rights.	Reasons for success: lack of substance abuse in community, focus on education, minimal politicking, timely policy developments and governmental support, clarity in vision, liasion with outside experts.	None mentioned.
Menghwani et al. (2023)	Canada	First Nations generally.	Planned/explored.	Variable	Variable	Variable	Yes	Yes	Energy security, GHG reductions, social benefits. Cost reductions and improved environmental outcomes.	Variable	None mentioned.	Lack of cross-jurisdictional consistency in legislation and policies, structural issues like subsidized energy and utility ownership, misdirected support for local capacity building, existing support systems are prone to misuse.	Community involvement and ownership form the beginning. Multi-year, predictable policy	None mentioned.
Sikka et al. (2013)	US	Alaska Natives (mainly Tlingit and Haida)	Planned/explored.	The Tongass. Sealaska-Native Corporation. Residues from forestry and agriculture.	Wood-pellet heating.	Oil/diesel.	Yes	Yes	Renewable energy, carbon sequestration, rural development, oil costs, economic/energy security. Triple bottom line approach.	NFS. Timber development allowed on parts. Natives retained 3% of Tongass from US.	Alaskan Native Claims Settlement Act (1971) ANCSA.	Practical, environmental, local culutral values and well-being. Possible degradation of forests, transportation, supply decrease, uptake of tech, high production costs, need for policy support measures.	Triple bottom line, TBL approach.	Yes, residues from forestry. Concern over harvesting sustainability and forest degradation.
Stephen et al. (2015)	Canada	Nuxalk First Nation	Planned/scenarios explored.	Local forest resources, generally. Purchase from pellet plant.	DES vs. Decentrailized heating system (wood pellet boilers).	Combination, oil, propane, electricity, and cord wood.	Yes	Yes	Reduce heating costs, reduce GHG emissions, increase independence of community.	None mentioned.	None mentioned.	Displacement of cord wood use. Costs.	None mentioned.	None mentioned.