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ACCEPTING CHANGE: FACETS OF ACCEPTANCE & SUSTAINABLE REDEVELOPMENT

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Author Contribution Statement

I conducted the research in this thesis under the supervision of Dr. Chelsea Schelly, Dr. Roman Sidortsov, and Dr. Mark Rouleau at Michigan Technological University, Department of Social Sciences, Environmental and Energy Policy program between August 2021 and May 2023.

Chapter 2: Genetically Improved Forests
The USDA National Institute of Food and Agriculture, Agricultural and Food Research Initiative Competitive Program, Agriculture Economics and Rural Communities, grant # 2020-67023-31638 supported research for this manuscript. This project is entitled "Social Implications of Genetically Improved Trees: Assessing Public & Forest Owner Attitudes and Risk Perceptions." This project was conducted by myself, Dr. Chelsea Schelly, and Dr. Mark Rouleau at Michigan Technological University, Department of Social Sciences in collaboration with Dr. Carsten Kulheim (PI) and Swapan Chakrabarty at Michigan Technological University, College of Forest Resources and Environmental Science, Forest Molecular Genetics and Biotechnology.

As lead author of this manuscript, I was responsible for all project research related to social acceptance, including survey design and distribution, data analysis, and literature review. I was responsible for survey design and analysis with oversight from Dr. Mark Rouleau. The manuscript was prepared with oversight from my co-authors, though I was primarily responsible for its preparation. My co-authors were involved in idea sharing and manuscript editing before the final submission.

I have presented preliminary findings from this study at the International Association for Society and Natural Resources (IASNR) 2022 conference in Costa Rica. I will deliver further results at the 2023 IASNR conference in Portland, Maine. A version of this manuscript has been submitted to *Society & Natural Resources* for publication consideration as of 9 March 2023.

Chapter 3: Renewable Energy on Brownfields
I collected research for this manuscript from the state of Michigan and federal brownfield redevelopment statutory laws to conduct a legal framework analysis. This analysis examined how brownfield redevelopment law enables or hinders renewable energy development and community priorities. This research was not funded by any institution and was conducted by myself with input from Dr. Roman Sidortsov at Michigan Technological University.

As lead author, I conducted data collection and analysis under the direction of my co-author. I was responsible for preparing and editing the manuscript with oversight and guidance from my co-author. My co-author was involved in manuscript editing in advance of the papers intended submission to *Energy Policy.*

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Definitions

Level 1 genetic modification - traditional breeding techniques. Trees from the same or different species are crossed to produce more robust plants. Compared to its parent trees, the cross-bred tree might have disease or pest resistance, modified stress tolerance, or improved product yield (e.g., timber, maple syrup). *Example: The apple variety 'Gala' was bred from apple varieties 'Golden Delicious' and 'Kidd's Orange Red' in the 1930s* (Brown, 2018).

Level 2 genetic modification involves traditional breeding as in the Level 1 description, but tree DNA is used to predict the traits of the bred offspring. This prediction allows scientists to avoid waiting for the trees to mature, saving time and money. *Example: Cacao production is threatened by black pod disease. Cacao breeding uses molecular markers to select plants resistant to this disease. Resistant trees are identified at the seedling stage and do not need exposure to the disease* (Meuwissen et al., 2001; Gill, 2018).

Level 3 genetic modification involves the introduction of foreign genes (genes from different plants) to local tree species, making them genetically modified organisms. Foreign genes are selected in response to a single trait, such as to create resistance in one tree species to an existing disease or improve a forest product (e.g., fiber quality in timber, maple syrup yield). *Example: A gene from wheat is introduced into American chestnut trees that allows them to survive chestnut blight* (Pinchot, 2018).

Environmental Justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (US EPA, 2022).

Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

Sustainable Redevelopment is the sustainment of existing economies while restoring damaged ecologies (Unruh, 2008).

A community is a specified body of individuals who share specific characteristics. (Oxford Learner's Dictionaries, n.d.) This might include a group of people who share common interests or who live in a shared, identifiable, bounded geographical area.

Social Acceptance is when an individual or group provides admittance or approval to a particular occurrence or an event (Merrimack-Webster, n.d.; Wüstenhagen et al., 2007).

Social License to Operate is the acceptance a community grants a company to engage in its operations (Moore, 1996).

List of Abbreviations

BRA - Brownfield Redevelopment Authority

EGLE - Michigan Department of

Environment, Great Lakes, and Energy

EPA - Environmental Protection Agency

FAO - Food and Agriculture Organization

FDA - Food and Drug Administration

FFO - Family Forest Owner

GIT - Genetically Improved Tree

GM - Genetically Modified

GMO - Genetically Modified Organism

IPR - Intellectual Property Rights

LFA - Legal Framework Analysis

NIPF - Nonindustrial Private Forest Landowner

RE - Renewable Energy

SLO - Social License to Operate

SDG - Sustainable Development Goals

UN - United Nations

Abstract

As the effects of climate change worsen, it becomes increasingly apparent that just development efforts must be rooted in principles of sustainability and community engagement. This research addresses the role that acceptance plays within two different examples of sustainable redevelopment. The first empirical case examines acceptance of genetically improved trees among family forest owners. The second case explores policy acceptance of community-centric redevelopment of brownfield sites for renewable energy generation. This work uses a combination of survey data and document analysis to shed light on two specific forms of sustainable redevelopment and the consideration given to community priorities and acceptance before making informed policy recommendations. The findings presented in this thesis aim to contextualize what community acceptance can mean for supporting effective redevelopment in an era where sustainability is paramount. This research explores what successful policy implementation that is considerate of community engagement and acceptance can mean for sustainable redevelopment across its diverse domains. While not every instance of redevelopment can be expected to be acceptable for every person, every instance of redevelopment must make space for the disadvantaged and disenfranchised populations that may be impacted by it. Engaging communities in justice centered development can be prioritized through environmental and energy policies that recognize the differences in what different community groups may accept, adopt, impede, or be impacted by during redevelopment efforts.

Chapter 1: Introductions

This introduction presents key topics and themes of this thesis. It briefly reviews sustainable redevelopment, community acceptance, and social license to operate as these ideas relate to policy formulation and implementation before introducing two specific forms of sustainable redevelopment. Prefatory literature on genetically improved forests and renewable energy (RE) brownfield redevelopment is explored in relation to concepts of justice and power, setting the stage for this work to scrutinize the policy formulation-implementation gap that occurs when formulation fails to consider the true policy adopters. This section later defines the structure of this thesis and its goals.

1.1 Key Themes & Topics

Sustainability and its concepts are often treated like a buzzword with numerous definitions that fail to align or make progress against the world's unsustainable norms (Apetrei et al., 2021; Curran et al., 2012). Still, corporations and consumers use sustainable development as a path forward (Castellino & Bradshaw, 2015; Ditlev-Simonsen, 2021; Pintér et al., 2005). The United Nations (UN) defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p. 41). The sustainability of sustainable development is sometimes questioned (Blowers et al., 2012); however, the idea is often treated as non-negotiable. Sustainable development is built around technological innovation (Anadon et al., 2016; Nidumolu et al., 2009) and social inclusion (Dugarova, 2015). The UN calls out three core elements of sustainable development necessary for success: economic growth, social inclusion, and environmental protection (United Nations, n.d.). Sustainable development is primarily discussed in low- and middle-income nations (Meyer & Helfman, 1993). Its definitions are often ambiguous and fail to consider existing environmental conditions, geographic domains, or human activities (Grosskurth & Rotmans, 2005). While sustainable development is critical, the term lacks a common meaning inclusive of social values and community-based work, and the concept fails to consider development in previously colonized nations (Leal Filho et al., 2022). An alternative concept, sustainable redevelopment, becomes more valuable in nations where heavy, unsustainable industrialization has already occurred (Meyer & Helfman, 1993).

Sustainable redevelopment focuses on sustaining existing economics while restoring damaged ecologies by making explicit considerations for existing damage and the impact this damage has on meeting future needs (Unruh, 2008). This concept also focuses on growth for low and middle-income nations without transferring the environmental damage that higher-income nations have already caused and which unchecked globalization may enable (Unruh, 2008). This thesis will use sustainable redevelopment throughout, given its ability to provide a more realistic understanding of the challenges and opportunities for sustainability worldwide.

Sustainable redevelopment is about more than its definitions. Beyond its bid to support economies and repair ecologies, sustainable redevelopment has the potential to be as much about community as it is environment. The UN's 11th Sustainable Development

Goal (SDG) focuses on making sustainable cities and communities that are inclusive, safe, and resilient (*Goal 11,* n.d.). Sustainable redevelopment can contribute to this SDG by helping to reduce the adverse environmental impacts of sites (target 11.6) through the redevelopment of existing hazardous sites, by providing universal access to green and public spaces (target 11.7), and by supporting positive links between urban, peri-urban, and rural areas (target 11.a) as harmful spaces are redeveloped. Sustainable redevelopment can provide a unique opportunity for communities to engage with the UN's SDG 11, and other goals, by allowing individuals to participate in redevelopment conversations and ensure that the project can support their community. In doing so, sustainable redevelopment can contribute to improving environmental justice of sites throughout the world by giving community members a voice in spaces where they historically have had none.

The chapters of this thesis will focus on two specific instances of sustainable redevelopment that require consideration of adopter acceptance – genetically improved trees (GIT) and redeveloping brownfield sites for renewable energy (RE). These instances of redevelopment both rely on some technological innovation, which is often at the core of sustainability efforts (Moffat et al., 2016). These redevelopment examples additionally highlight that any redevelopment will require some degree of social license to operate (SLO) or more general acceptance from impacted communities to achieve success (Moffat et al., 2016).

Acceptance takes many forms. In its simplest terms, acceptance is when an individual or group provides admittance or approval to a particular occurrence or an event (Merriam-Webster, n.d.). Regarding sustainable redevelopment, community and social acceptance become forefront considerations to ensure successful site or policy implementation. Social acceptance deals with socio-political, market, and community acceptance (Wüstenhagen et al., 2007). Community acceptance often involves the "element of social acceptance dealing with local opposition to specific projects, particularly by residents and local government" (Velasco-Herrejon & Bauwens, 2020, p. 3). Community acceptance is often considered synonymous with the concept of social license to operate, or SLO, though SLO is most commonly referenced in literature regarding extractive industries (Boutilier & Thomson, 2011; Syn, 2014). SLO can be considered an aspect of social acceptance in sustainable redevelopment, given its relation to previous extractive activities.

The concept of SLO was introduced in 1996 and has since been used to describe the acceptance a community grants a company to engage in its operations and the subsequent relationships between the two (Moffat et al., 2016; Moore, 1996). Gaining and maintaining SLO can prove particularly important in communities with post-industrial sites left over from previous extractive industry activity or other environmental concerns (Ketola et al., 2022). This importance highlights sense of place, another important consideration of acceptance. Sense of place is the meaning and attachments that residents hold towards their community (Stedman, 1999). Sense of place can encourage the engagement of collaboration of actors during sustainability transitions (Grenni et al., 2019). Place attachments contribute to understanding social acceptance (Devine-Wright & Patel, 2017; Hou et al., 2019). The type of attachment (local, national, global) can help explain what types of technology or behavior modification individuals may be willing to accept (Devine-Wright & Patel, 2017; Hou et al., 2019). This understanding can contribute to narrowing the policy formulation-implementation gap and ensuring successful policy implementation.

A well-identified gap exists between policy formulation and implementation (Engert & Baumgartner, 2016; James et al., 1999). This gap contributes to policy failures, or a mismatch between policy goals and outcomes, but more so, it contributes to the public's loss of confidence in their government (McConnell, 2015; Volcker, 2014). Much like sustainable redevelopment, the idea of what constitutes a policy failure is widely contested, especially when there is a mismatch in intentions between groups (Howlett, 2012; Ferman, 1989; McConnell, 2015). A lack of acceptance from a policy's target group can lead to one of these mismatches. Policy failure enables the community or other actors to reimagine key policy concepts and make their own goals and strategies for the policy such that they stray from the intended initial objectives, interfering with the policy's implementation (Ferman, 1989; Milhorance et al., 2022). Ensuring community acceptance within sustainable redevelopment spaces can help minimize the risk of policy failures and lessen the formulation-implementation gap.

Conversely, engaged individuals that have the potential to impact decision-making through their acceptance of policies can lead to improved coherence between policy formulation and implementation (Hecker et al., 2018). In both examples of sustainable redevelopment discussed in this thesis, the underrepresentation of adopting populations can potentially interfere with successful policy implementation. This underrepresentation can lead to concerns about the justice of redevelopment efforts, which in certain instances have been found to contribute to environmental injustice (Bryson et al., 2012).

GITs and brownfield redevelopment each fill a particular niche within sustainable redevelopment. While each relies on technological innovation, successful implementation ultimately relies on non-technical considerations, including acceptance and SLO provided by their adopters. The ability of acceptance to shape project success and successful policy formulation and implementation is undeniable. The marked inclusion of acceptance in redevelopment efforts is critical to long-term community building and project success in a landscape continuously altered by human activity.

1.2 From Tree to Shining Tree

Sustainable redevelopment is a conglomerate of activities, approaches, ideas, and theories that work together to support a greater idea of what redevelopment can be. Referring back to the core definition provided by Unruh (2008), sustainable redevelopment has the potential to be any activity that supports economies and protects ecologies. Types of sustainable redevelopment may vary widely, ranging from forests to brownfield sites to other post-industrial landscapes.

GITs can contribute to sustainable redevelopment to support forest-dependent economies as the climate changes and for species protection and restoration. For instance, GITs are being used to restore American chestnut trees to their native range in the U.S. (Pinchot, 2014). GITs can additionally serve as a means to support forest resources that are significant to communities, so long as these communities are supportive of their development and deployment.

Literature on the acceptance of GITs and their applications is limited. What information does exist primarily focuses on specific instances of acceptance among specific populations, such as acceptance of GITs by the general public in Petit et al. (2021a, 2021b, 2021c). The findings from these existing studies indicate mixed levels of acceptability for GITs (Petit et al., 2021a, 2021b, 2021c, Hajjar & Kozak, 2015; Hajjar et al., 2014; Porth & El-Kassaby, 2014). This limited understanding of acceptance may contribute to underwhelming SLO in forest-adjacent communities, whose acceptance is critical for the successful deployment of GITs. Additionally, it highlights how acceptance can contribute to policy formulation and implementation. If there is little to no data on how acceptance manifests among adopting populations, and existing research focuses instead on populations that may not directly impact GIT implementation, it seems unlikely that GITs will be able to avoid the policy formulation-implementation gap.

Furthermore, a lack of understanding of what adopting populations deem acceptable may lead to years of research on a particular GIT that adopters deem entirely unacceptable due to a specific change in its characteristics independent of its modification reason. For instance, maple syrup is an important non-timber forest product in the U.S. Lake States (Snyder et al., 2019). If a maple tree is modified to withstand rising temperatures but this modification leads to declined sap quality and, by extension, lower quality maple syrup, potential adopters that grow maple trees to make syrup will be unlikely to plant these modified maples.

While GIT acceptance research is limited, there is a substantial body of literature on genetically modified organisms (GMOs) in the food and agricultural industry. While notable differences exist between GITs and GMOs, primarily related to consumption, similar scientific approaches, risks, and potential distribution indicate that GIT acceptance may be similar to GMO acceptance. Risks related to the environmental impacts of GMOs, such as effects on biodiversity and species-specific concerns (Habibi, 2018; Rihn et al., 2021), may also exist with GITs should they be planted in native forests. Additional concerns from the GMO movement, such as demands for labeling GMOs versus non-GMOs, may also arise with GITs. Some evidence indicates that labeling holds sway over consumer purchasing decisions regarding other agricultural products (Dagan et al., 2018), such as turfgrass (Campbell et al., 2021), increasing the likelihood of labeling issues arising with GITs. Another potential source of conflict for GITs is intellectual property rights (IPR). The handling and success of GMO IPR have varied between nations, with instances handled mainly on a case-by-case basis (Aghamodhammadi & Azizi, 2022; Smith & Kong, 2022). Given the scientific development required for each GIT, there is certainly potential that scientists or industries will attempt to control the IPR of their developments. While other aspects of GMO acceptance are less likely to be relevant to GIT, such as issues related to direct consumption of a GMO product or human health impacts, they may require consideration if certain species of trees that produce human consumables are genetically improved, such as fruit or syrup species. Further research is required to understand the potential relationship between GMO and GIT acceptance and how it may be able to inform more successful implementation of GITs.

GMOs and their policy acceptance vary. In the U.S., GMOs are perceived as relatively safe and are widely accepted among agricultural producers (Hamilton, 2001). Regulation in the U.S. is contentious (Hamilton, 2001), and GMOs were only required to be labeled as “bioengineered” starting in 2022 (FDA, 2022). In addition, U.S. public policy allows ownership over GMOs through IPR (Hamilton, 2001). U.S. residents have been found to be more willing to consume GMOs than those in other nations, including Japan, Norway, and Taiwan (Chern & Rickersten, 2001). In the European Union (EU), very few nations allow the cultivation of GMO crops, and the EU is known for its strict regulation of GMOs (Ichim, 2021). In a collection of EU nations, researchers found that all residents were willing to pay to avoid rice labeled as genetically modified (GM) (Delwaide et al., 2015). However, some residents were willing to buy GM rice if it had environmental benefits, indicating that not all GMOs are considered equally (Delwaide et al., 2015). This finding tracks with additional data that indicates concern about GMO usage in the EU has declined significantly in recent years (Ichim, 2021). EU regulation still leaves the region at odds with U.S. GMO usage. Further specifics regarding GIT and GMO acceptance are detailed in Chapter 2.

1.3 Brownfields with Bright Futures

Brownfields are properties that are or may be contaminated with hazardous substances. Their existence contributes to health and aesthetic concerns and, in some cases, is linked to population loss (Leonard, 2014). Brownfield regeneration is not a new concept and is often a key component of sustainable redevelopment (Franz et al., 2006), but acceptance of these sites can be complex. It requires acceptance of repurposing specific sites that may be significant to communities or individuals as well as of the proposed redevelopment activities and technologies. While this can lead to more complex cases of redevelopment, the inclusion of acceptance criteria remains paramount to support community priorities and maintain justice within these spaces.

RE development on brownfield land serves as a way to practice sustainable land practices, a consideration of sustainable redevelopment (Waite, 2017). Revitalizing brownfields for RE contributes to sustainable redevelopment by using technology to restore contaminated landscapes into spaces that support local communities, economies, and the environment. Coupling brownfield redevelopment with RE allows a net negative, the contaminated site, to turn into a net positive, a remediated site that provides clean energy to the grid. In addition, this type of redevelopment can give communities a voice in remediating significant local spaces that may have caused them historical harm.

The acceptance and feasibility of RE projects on brownfield sites has been studied in several locations (Adelaja et al., 2010; Hartmann et al., 2014; Roddis et al., 2020). Existing data regarding these types of projects indicates generally positive public perception and indicates that the inclusion of community perspectives in reclamation efforts and decision-making can foster feelings of belonging and collectivity (Loures & Crawford, 2008; Loures et al., 2015) while also reducing conflict (Schelly et al., 2020). In brownfield redevelopment, communities brought into redevelopment processes to participate in decision-making made few attempts to interfere with redevelopment (Flynn, 2001). Further, mixed-use renewable developments, such as on landfill sites, are strongly supported in certain communities (Schelly et al., 2019). Understanding community acceptance of these projects can support successful policymaking. On Long Island in New York, ratepayers supported brownfield solar developments and were most interested in financial models that could be supported by prioritizing permits and incentives in a policy environment (Schelly et al., 2019).

Developing renewables on brownfield sites certainly comes with some benefits, such as potentially lower development constraints and fewer other uses for the land (Adelaja et al., 2010). However, it also poses unique and site-specific challenges compared to greenfield development (Glumac & Decoville, 2020). It often requires increased stakeholder and community engagement than greenfield sites due to the complicated histories of many brownfield sites, which may include conflicting visions for what the site should become (Bartsch, 2003). Brownfield site redevelopment is not an inherently sustainable option and still requires sustainability assessments of each site (Franz et al., 2006).

Certain aspects of brownfield redevelopment have been questioned, including what constitutes sustainable brownfield redevelopment has often been unclear (Pahlen & Glöckner, 2004) as if acceptance indeed varies that much from greenfield site development (Spiess & De Sousa, 2015). Other research has identified so-called “green on green” tension, related to using green spaces for green developments over using brownfields or existing spaces (Roddis et al., 2020; Zhao & Du, 2021), while brownfield redevelopment has been linked to urban gentrification and other justice concerns (Bryson, 2012; Meenar et al., 2019). These factors may contribute to increased policy implementation challenges and indicate underdeveloped acceptance criteria or SLO in the communities where development occurs.

Brownfield redevelopment relies on the policy and regulatory acceptance of municipal, state, and federal governments in addition to community acceptance. Some states, such as Michigan, have significant brownfield redevelopment resources (Thomas, 2002), though how easy these resources are to access is a different matter. While brownfields present a significant land resource, there is limited policy acceptance data surrounding their redevelopment. Acceptance data that does exist is often concerned with only the community approval of individual sites, which contributes to a gap in our understanding of successful redevelopment.

Renewables are also subject to formulation-implementation challenges that can be exacerbated when policymakers assume inherent support for renewable projects (Wolsink, 2007) or assume that renewable installation is always due to environmental motivators (Bamberg, 2003; Owens & Driffill, 2008) instead of other factors. Energy sites often operate on relatively small scales, relying heavily on outside investment and support from small groups of stakeholders (Wüstenhagen et al., 2007). These smaller scales can raise questions about appropriate engagement with the entire affected community instead of only engaging with supportive stakeholders. Renewable projects on brownfield sites typically require high degrees of SLO, given the potentially complicated history of the site and the expected long-term operation of the new technology. However, brownfield investment can positively influence renewable energy consumption (Yahya & Rafiq, 2019).

Community involvement in these redevelopment efforts often comes with negative associations - of protests, blocked projects, and more (Bartsch, 2003). Additionally, local community acceptance is not always a project consideration. Existing programs, such as

Michigan's brownfield redevelopment efforts and the EPA's RE-Powering America's Land Initiative, touch on the importance of engagement or community vision in site development (EGLE, 2022; US EPA, 2022). However, the programs do not share how they consider or pursue community inclusion in the development process nor how influential it is to development efforts. In Escanaba, MI, solar developers intended to convert forest land into a large utility solar array but made little consideration for the community's desires and concerns, leading to the project's ultimate failure (TV6, 2019).

The value of SLO concepts has been found for supply and demand side energy resources (Adams et al., 2021). SLO and community acceptance were paramount to the timely implementation of new technology in the mining industry (Gunningham et al., 2002). Both factors may have similar effects in the energy sector, which experiences similar technological opportunities and localized site development challenges. Energy projects that fail may have failed to consider stakeholder concerns and perspectives regarding the site specifics or relevant technology, possessing inadequate SLO and harming project outcomes (Azubuike et al., 2022; Hall, 2014). Further specifics regarding the acceptance of RE and brownfield development will be discussed in Chapter 3.

Beyond general concerns about obtaining SLO, developers must obtain the *appropriate* SLO from specific stakeholder groups relevant to each site and community. Community acceptance should align with groups impacted by the project and able to influence its implementation. Understanding the relevant stakeholder groups also contributes to understanding the place attachments between the site and the community, which may contribute to broader community sustainability (Stedman, 1999). This understanding can aid in furthering acceptance levels and ensuring justice regarding site development while supporting successful policy implementation (Hammami et al., 2016).

While at first glance, brownfield redevelopment and GIT usage in forests may seem vastly different, both approaches to sustainable redevelopment indicate a need for acceptance-informed policy formulation and implementation. Each approach may be construed as antithetical – GITS may alter historical forest landscapes, while brownfield redevelopment may alter landscapes that are significant to local communities, for better or worse. However, they each provide an opportunity to support present and future economies while protecting and restoring unique environments. In doing so, both approaches to redevelopment provide an opportunity to support communities and decision-makers by giving them a voice in how their local landscapes are altered.

1.4 Justice and Decision-Making

Revisiting Unruh's (2008) definition of sustainable redevelopment and coupling it with the UN's SDGs show that sustainable redevelopment is built around several ideas. That being said, almost every SDG and redevelopment effort can be linked to the idea of justice and a just society. Justice has taken on many forms as societies pursue the most equitable version of themselves, making it challenging to equivocate a single definition (Sovacool & Dworkin, 2014). However, it can still be helpful to ground this work around a central theory or idea. John Rawls's theory of justice as fairness is perhaps one of the most quintessential. Rawls considers justice the most basic structure of society, defining and distributing rights and duties among the population (Rawls, 1999). Under these assumptions, justice should act as a core tenet of all redevelopment efforts and form the base of the UN's SDGs. An additional consideration is that of human dignity. Sovacool et al. (2014) present that a core conception of justice is to respect the dignity of every human being per the Universal Declaration of Human Rights. Any conceptualization of justice, whether distributive, procedural, or otherwise, must protect this dignity lest it becomes unjust itself.

Distributive justice focuses on the allocation of resources (Cook & Hegtvedt, 1983). It additionally examines where and how injustices result from these allocations. For instance, consider a public GIT seed distribution program that distributes the same number of seeds, of the same type of tree, to landowners with similar or the same characteristics (land type, common tree species, etc.). Issues of distributive justice may arise when permitting brownfield sites if financial or other resources are misallocated between sites.

Procedural justice focuses on the fairness of the processes themselves (Cook & Hegtvedt, 1983). Procedural justice relies on how individuals perceive the fairness of a procedure and is influenced by their perceptions of decision-making and the sources of justice (Blader & Tyler, 2003). An issue of procedural justice might include how GIT seeds are distributed to landowners or how brownfield sites for redevelopment are selected. If participants view processes like these as legitimate, they are more likely to accept them (Tyler, 2003).

It is worth noting that there are other commonly recognized dimensions of justice. For instance, recognition justice deals with fair representation and involvement. Fraser posits that justice requires both recognition and redistribution (Fraser, 1997), making the consideration of recognition or other dimensions of justice important in future research. However, examining these other types of justice is beyond the scope of this thesis.

Justice is as much about its applications as it is about its theories. Environmental justice applies the core theories of justice to the allocation of environmental benefits and burdens in society. Initially, it dealt with the unequal distribution of environmental risks in poor communities of color (Schlosberg, 2013), to whom many environmental justice accomplishments can be credited (Agyeman et al., 2016). Environmental justice has been popular since the early 1980s and has become a core tenet of some governmental agencies, such as the U.S. Environmental Protection Agency (EPA) (Agyeman et al., 2016; Phillips & Sexton, 1999). While understandings of environmental justice continue to expand (Walker, 2009), the U.S. EPA defines it on their website as:

> *"The fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies"* (US EPA, 2014).

Sustainable redevelopment requires engagement with ideas of environmental justice, given its propensity to interact with vulnerable communities. This angle presents inevitable struggles. Environmental justice is, at its core, rooted in science. Its practitioners must have a certain degree of faith in science and its champions as being unbiased and trustworthy. This belief can be challenging to maintain in capitalist societies where science has been used, by both private industry and government, against the interests and safety of the people (Akaba, 2004) that sustainable redevelopment aims to help.

Power is an essential aspect of redevelopment and can be considered a key element in issues of justice. What power exists within redevelopment efforts, and with whom, can dictate how projects proceed. Power can change what a project looks like, whom the project aims to benefit, and what considerations are made regarding community inclusion or justice impacts.

Following John Locke, Stephen Lukes defines power as "the ability to make or receive any change, or to resist it" (Locke, 1946; Lukes, 2005, p. 478). This definition introduces that power defines a capacity and is a potentiality while working to avoid the two common fallacies of power. The exercise fallacy tricks us into thinking that power is only the ability to exercise it (Lukes, 2007). It implies that to have power is only to win or to prevail (Lukes, 2005). The vehicle fallacy leads us to believe that power is simply its means or resources (Lukes, 2007). It implies that power is just whatever the resources used in operationalization were (Lukes, 2005).

Lukes' conceptualization of power comes from a line of earlier definitions and identified faces of power. One of the earliest comes from Dahl, who identifies it as a relationship between people, a relativity of the power they hold over each other (Dahl, 1957). Bachrach and Baratz's definition followed, highlighting Dahl's failure to include "unmeasurable elements" of power (1962, p. 952). They call for a need to study power based on their two proposed faces, decision, and non-decision-making power, as opposed to Dahl's (Bachrach & Baratz, 1962). Later, Lukes presents a third dimension of power, in addition to the two proposed by Bachrach and Baratz: decision-making, non-decision-making, and ideological power (Lukes, 1974). Decision-making power is the ability to make or not make intentional decisions and exercise control over the political agenda (Lukes, 1974). Non-decision-making power is the ability to silence demands for change before they can even be vocalized in decision-making. Ideological power is more abstract and pertains to the ability to shape norms and beliefs, potentially for the influencers benefit over the influenced (Lukes, 1974).

The three dimensions of power all hold a place within sustainable redevelopment. Decision-making and non-decision-making power may work in tandem, determining if a redevelopment project is allowed to happen or even be considered. Ideological power shapes the conversation around sustainable redevelopment. Even in this work, ideological power shapes the presentation and discussion of sustainable redevelopment efforts.

1.6 Policy context

In a representative democracy, the value of acceptance to policymakers is clear policymakers are elected officials who must maintain public support if they wish to maintain office. Campaigns often run on what their target voter population values and accepts, whether it be marriage rights, gender rights, or religious rights. These officials then go on to try and formulate policies that are in line with campaign rhetoric. Ideally, since their voters accepted these ideas, they will accept them now and support the implementation of related policies. Acceptance-informed policy like this has the potential to foster more successful policy implementation by creating a point of collectivity between communities and their elected officials, which in turn, benefits the community and the officials alike.

From a research perspective, the interest in social acceptance during policy-making is relatively recent (Dermont et al., 2017). It has been wrought with conceptual differences, brought on in part by differences in understandings of acceptance and how it can be obtained across disciplines and topics. This is further complicated by research perspectives on policy, formulation, instrumentation, and goals (Dermont et al., 2017). How necessary social acceptance is and whether it should be about a lack of opposition or a more encompassing understanding of attitudes and behaviors is another common point of contention (Aitken, 2010; Barry & Ellis, 2010; Batel & Devine-Wright, 2017). In some instances, opposition to projects is logical if the project or policy is inappropriate or underdeveloped (Aitken, 2010). In addition, multiple studies have found that project design and processes may limit acceptance and provoke resistance, while the technology used on a project is less likely to do so (Bidwell, 2016; Gross, 2007; van der Horst, 2007). These factors become important when considering the varied landscapes in which redevelopment occurs. There is no overarching approach for each redevelopment effort, making faulty project design or poorly planned processes a real risk and threat to acceptance.

The inclusion of acceptance criteria within policy formulation and implementation is further complicated because relatively few acceptance studies occur before projects are proposed (Devine-Wright & Wiersma, 2020). Policymakers may be less impacted by post hoc studies focusing on particular places, spaces, and times than by a priori works (Devine-Wright & Wiersma, 2020). This can make it challenging to implement acceptance strategies across policy-making. Some studies, like Leiren et al. (2020), study acceptance in regions with little experience in RE and indicate that any acceptance strategies for policy should include transparent, understandable, and unbiased information from people trusted by relevant communities. Works like this become necessary in guiding future development and policy making such that it includes acceptance themes (Bell et al., 2013; Devine-Wright & Wiersma, 2020) to help minimize gaps between policy and project formulation and their implementation.

Some forms of acceptance can be more important to than others in certain instances. Much of acceptance literature, regardless of topic, focuses on greater social acceptance or acceptance of an issue among the general public (Dermont et al., 2017; Devine-Wright & Batel, 2017; Petit et al., 2021a; Petit et al., 2021b; Petit et al., 2021c) or non-implementing populations (Devine-Wright & Wiersma, 2020; Hajjar et al., 2014). While these findings can be interesting and add value to discussions of acceptance, these populations often do not directly adopt or experience immediate effects from redevelopment. In these instances, it is more valuable to examine acceptance among those directly impacted by a technology or redevelopment, such as technology adopters or implementers (Schelly et al., 2020). These populations contribute an important perspective that is often missing from discussions of technology or redevelopment acceptance, and their acceptance may be more important to deploying technologies or successful redevelopment efforts.

1.7 The Structure and Aim of this Thesis

This thesis explores acceptance within two distinct examples of sustainable redevelopment to show how acceptance-informed redevelopment and policy matter. In doing so, the research performed here aims to articulate components of acceptance. It additionally works to relate forms of redevelopment while finding common ground between them that can be used to inform policy formulation and implementation.

The work performed here is based on a core belief that development for its own sake is unethical. Any pursuit of new development or redevelopment should be conducted explicitly for the betterment of society and aim to uphold principles of justice and human dignity throughout its tenure. The chapters presented here acknowledge that sustainable redevelopment is a vast topic, hence the diversity of topics and analysis methods used. However, despite their differences, both chapters highlight the need for the inclusion of accessible, acceptance-centric redevelopment and policy formulation to ensure justice and support successful policy implementation that serves communities who adopt or are directly impacted by a technology.

Chapter 2 presents findings regarding the opinions of family forest owners in Michigan, Minnesota, and Wisconsin on GITs. These findings were collected via an independent, mailed survey. This chapter aims to shed light on acceptance and SLO among the sample population, which has not yet been studied in this context. It reviews existing literature surrounding the social acceptance of GITs and GMOs before presenting findings from the survey. Survey data was analyzed using SPSS statistics.

The USDA National Institute of Food and Agriculture, Agricultural and Food Research Initiative Competitive Program, Agriculture Economics and Rural Communities, grant # 2020-67023-31638 supported research for Chapter 2. This project is entitled Social Implications of Genetically Improved Trees: Assessing Public & Forest Owner Attitudes and Risk Perceptions. This project was conducted by myself, Dr. Chelsea Schelly, and Dr. Mark Rouleau at Michigan Technological University, Department of Social Sciences, Environmental and Energy Policy program in collaboration with Dr. Carsten Külheim (PI) and Swapan Chakrabarty at Michigan Technological University, College of Forest Resources and Environmental Science, Forest Molecular Genetics and Biotechnology.

As the lead author of the chapter, I was responsible for all project research related to social acceptance, including survey design and distribution, data analysis, and literature review. Survey design and analysis were conducted with oversight from Dr. Mark Rouleau. The manuscript was prepared with oversight from my co-authors, and all co-authors were involved in idea sharing and manuscript editing before final submission.

Preliminary findings from this study have been presented at the International Association for Society and Natural Resources (IASNR) 2022 conference in Costa Rica. Additional findings will be presented at the IASNR 2023 conference in Portland, Maine. This manuscript has been submitted for publication consideration to Society & Natural Resources as of 9 March 2023.

Chapter 3 examines brownfield redevelopment law and its considerations for community-centric RE development within federal and state contexts. It seeks to understand how Michigan and U.S. federal law enables or restricts the redevelopment of brownfield sites for RE projects, and what considerations are made for community engagement and acceptance. The chapter identifies a legal framework that can encourage community-centric RE development on contaminated lands, making policy and documentation recommendations to do so.

Data for Chapter 3 was collected from the state of Michigan and the U.S. federal statutory brownfield laws. As lead author, I conducted data collection and analysis under the direction of my co-advisor, Dr. Roman Sidortsov. I was responsible for preparing and editing the manuscript with oversight and guidance regarding the structure and content from my co-advisor. This chapter is intended to be submitted for publication consideration.

Conclusions will be presented in Chapter 4. However, given the nature of each chapter, individual findings related to each topic can be found in their respective chapter conclusion. The final chapter will include recommendations for future work, limitations of this work, and policy recommendations for just, community-focused sustainable redevelopment.

Chapter 2: Understanding Perceptions of Genetic Improvement of Tree Species Among Family Forest Owners (FFO) in Three Midwestern States

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2.1 Abstract

Trees are faced with challenges to their survival, including pests, disease, and climate change, every day. Genetic engineering allows scientists to modify the genetic code of certain tree species to improve their chances of survival or reestablish species. While existing research indicates varying levels of acceptance of genetic improvement as a forest management intervention among the public or certain groups, little research exists regarding acceptance among family forest owners (FFO). This research intends to address this critical gap in acceptance research given the amount of U.S. forest land that is privately held. This paper provides an overview of existing acceptance research surrounding genetically improved trees (GIT) before presenting an analysis of survey data focused on acceptance among FFOs in the midwestern U.S. We problematize the idea of "social acceptance" when detached from the realities of adoption, implementation, and decision-making. While public concerns surrounding GITs may be valid and interesting, GITs can only succeed if specific actors in specific contexts show a willingness to adopt. This work contributes insights on perceptions of tree genetic improvement techniques as well as general insights on research design for similar studies.

2.2 Introduction

Genetic modification (GM), or genetic improvement (GI), is not a new concept. Genetically modified organisms (GMO) have been available for sale in the U.S. since the mid-1990s (Food and Drug Administration (FDA), 2022). According to the World Health Organization (WHO), a GMO is a plant, animal, or microorganisms that has had its genetic material altered in a way that is not naturally occurring, such as through mating or natural recombination (2014). Humans have been performing certain types of GM, including selective and cross breeding, for thousands of years (FDA, 2022). Genetically improved trees (GIT) are a type of GMO that could potentially provide support to forests worldwide as trees face new and continued threats to their survival. GIT efforts are well underway, including the State University of New York's (SUNY-ESF) College of Environmental Science and Forestry's American Chestnut Research and Restoration project, which aims to distribute blight-tolerant chestnut trees in the U.S. pending government approval (*2022 Progress Report,* 2022). GITs, like SUNY-ESF's chestnut trees, use genetic improvement techniques to create improved versions of certain trees to address challenges unique to that species, such as diseases, pests, or climate change. While geneticists have made great progress in terms of creating GITs, comparatively little is understood about how GITs are perceived and accepted by decision makers and potential adopters.

Acceptance of GITs will play a critical role in their success (Jacobs et al., 2013). Existing research has primarily examined acceptance among the general public and found varying levels of acceptance of GI for the purposes of forest management. For instance, the Canadian public showed low levels of acceptance of GITs (Hajjar and Kozak, 2015; Hajjar et al., 2014) while the American (Petit et al., 2021a) and the U.K. public found GITs (Jepson and Arakelyan, 2017) more acceptable. Existing research also indicates that forest management strategies that require increasing human intervention, such as GM, show lower levels of acceptance than methods that are perceived as more "natural," like traditional breeding (Hajjar and Kozak, 2015; Hajjar et al., 2014; Fuller et al., 2016; Petit et al., 2021a). Studies have additionally examined acceptance among American forest interest groups (Petit et al., 2021a), who found GITs more acceptable than the public, and Canadian forest community leaders (Hajjar et al., 2014), who showed low acceptance of GITs. Other studies have examined opinions on GITs among U.K. forest advisors and land managers (Marzano et al., 2019), who showed limited support for GITs, and U.S. land managers (Brennan et al., 2021), who overall accepted the use of GITs. While acceptance among these populations is valuable to understand, it provides little insight on acceptance among populations with the ability to directly adopt GITs, such as family forest owners (FFO) and other nonindustrial private forest (NIPF) owners, on their own property. FFOs are estimated to control 272 million acres of the US's 765 million acres of forest land (Butler, et al., 2021; Oswalt et al., 2019), making their acceptance and adoption necessary if scientists hope to plant GITs in all of the nation's forests.

This paper explores acceptance of GITs among FFOs in the lake states of Michigan, Minnesota, and Wisconsin. This region is home to nearly 55 million acres of diverse forest land area (United States Department of Agriculture (USDA), 2020), with over 17 million acres of family owned forestland (Butler et al., 2021). Lake state FFOs and how they manage their land have been studied extensively (e.g., Daniels et al., 2010;

Fischer, 2019; Helman et al., 2021; Kilgore et al., 2008; Miller et al., 2014). However, no research currently exists regarding their perception of GITs. This project examines the perceptions of FFOs regarding the risks and benefits of GITs in relation to themselves, their forest property, their regional forests, and society to understand how acceptance and distribution may later be supported. This includes questions focusing on 4 regionally relevant tree species (ash, jack pine, maple, oak) with potential for modification, questions related to reasons for modification, and questions regarding their reasons for ownership. A mail survey was sent to a random sample of FFOs in the study region and was chosen over other administration methods due to the project's geographic range and size of the sample population. Additionally, a mail survey was chosen as there were concerns about internet access as well as an expected older sample population. The survey questions were informed by previous studies on GIT acceptance, such as Petit et al. (2021a; 2021b; 2021c) and Hajjar et al. (2014). Respondents received three mailings, as follows: an initial introductory letter preceding the survey, the survey and a postage paid return envelope, and a reminder postcard.

Respondents show limited acceptance of GITs of species they are personally concerned about, such as ash, jack pine, or oak, which is supported by their willingness to plant. Survey results show mixed support for GI and GITs, with respondent concern being weakly positively correlated to a willingness to plant some species of trees. In addition, FFOs show greater acceptance of GI approaches that may be perceived as more "natural," like traditional breeding and marker assisted breeding, than of more involved techniques, like the introduction of foreign genes, which is consistent with findings by Hajjar and Kozak (2015), Hajjar et al. (2014), Fuller et al. (2016), and Petit et al. (2021a). While additional research is necessary, these findings can provide a preliminary view of FFO landowner risk and benefit perception regarding GITs while contributing to research design for similar projects, recognizing that perceptions of potential adopters can provide insights that can shape implementation more directly than public perceptions in cases where adoption will involve a niche social group.

GITs in existing literature may be referred to as GI at all levels, with little or no differentiation to the type of modification being used. This can create confusion given the varied acceptance of GMOs depending on how they are modified. The use of GIT in this paper refers to trees modified or improved at all levels. If a specific level of improvement is being referenced, it will be called out as such. Additionally, the authors of this paper have chosen to use "improved" over "modified" in both the survey described below and in this paper because using the term "modified" may instigate an inherently negative bias triggered by the existing dialogue around GMOs. While the inverse can be said about the use of the word "improved" triggering a positive bias, we believe that this is potentially less harmful to the data overall. Further, some of the purposes for which this study is suggesting trees be modified can be an inherently beneficial type of GI, protecting trees from extinction on a changing planet, which may differ from existing conversations around GMOs.

2.3 Literature review

While GMOs have existed in some capacity since 1994, their use is often still subject to skepticism, particularly in food products (Bredahl, 2001; FDA, 2022). GMOs have been met with varying degrees of acceptance and support depending on the type of product, its labeling, individual knowledge, and trust in GMO institutions (Baker & Burnham, 2001; Bernauer, 2003; Lucht, 2015; Lusk & Sullivan, 2002). Information on the acceptance of GMO foods is plentiful and has a number of potential similarities to GIT acceptance given similar scientific approaches, possible risks, and potential distribution of products. For instance, concerns regarding widespread environmental impacts or acceptance by different populations have arisen with GMOs (Habibi, 2018; Lucht, 2015; Rihn et al., 2021) and may become relevant for GITs should they be planted throughout forests or regions. GITs may also be subject to similar social movements to GMOs regarding their labeling such that people are aware they are GI (Bain & Dandachi, 2014; Velardi & Selfa, 2020), or they may become implicated in cases of intellectual property rights as GMOs have been throughout the world (Aghamohammadi & Azizi, 2022; Smith & Kong, 2022). Other aspects of GMO acceptance, such as those related to consumption, are less relevant to GITs given that many will not produce products directly for consumption or human use (notable exceptions to this exist, such as for fruit, nut, or syrup bearing species). This is supported by findings that people are more supportive of non-food GMOs than of food GMOs (Kikuchi et al., 2008; Kubisz et al., 2021; Lusk & Sullivan, 2002; Yu et al., 2019). This information is useful to consider alongside recent findings regarding the acceptance of GITs to form a more complete image of what, and who, acceptance may include.

Existing GIT acceptance studies have examined a number of populations among whom acceptance has varied. These studies include the general public (Hajjar et al., 2014; Hajjar and Kozak, 2015; Petit et al., 2021a; Jepson and Arakelyan, 2017), forest interest groups (Petit et al., 2021a), forest community leaders (Hajjar et al., 2014; Hajjar and Kozak, 2015), land managers (Marzano et al., 2019), and forest advisors (Brennan et al., 2021; Marzano et al., 2019). GIT acceptance between study populations has varied. The Canadian public showed low levels of acceptance of GITs (Hajjar and Kozak, 2015; Hajjar et al., 2014) while the U.S. (Petit et al., 2021a) and U.K. (Jepson and Arakelyan, 2017) public were more accepting of GITs. These variations may be explained by GMO acceptance within various countries (Areal et al., 2011; Chern et al., 2002; Diamond et al., 2020; Haniotis, 2001). Studies have additionally examined acceptance among U.S. forest interest groups (Petit et al., 2021a), who found GITs more acceptable than the U.S. public, and Canadian forest community leaders (Hajjar et al., 2014), who showed low acceptance of GITs. Other studies have examined opinions on GITs among UK forest advisors and land managers (Marzano et al., 2019), who showed limited support for GITs, and American land managers (Brennan et al., 2021), who overall accepted the use of GITs. Level of acceptance may be related to knowledge levels, as some research has found that opposition to a technology may be related to holding less knowledge on the topic (Fernbach et al., 2019). Acceptance can also be impacted by message framing, as found by both Hajjar et al. (2014) and Petit et al. (2021b). Lastly, existing research indicates that forest management strategies that require increasing human intervention, such as the introduction of foreign genes, show lower levels of acceptance than methods that are perceived as more “natural,” like traditional breeding (Hajjar and Kozak, 2015; Hajjar et al., 2014; Fuller et al., 2016; Petit et al., 2021a).

While public or stakeholder acceptance is valuable to understand, it provides little insight on acceptance among populations with the ability to directly adopt GITs, such as FFOs on their own property. Brennan et al. (2021) and Marzano et al. (2019) provide the greatest insight in regard to populations with the ability to directly adopt GITs, finding support among U.S. land managers (Brennan et al., 2021) and limited support from U.K. forest managers and advisors (Marzano et al., 2019). Through an online survey, Brennan et al. (2021) found that land managers primarily agreed with using hybrid trees and GITs for a variety of uses. The surveyed land managers were the most concerned with ecological issues as opposed to economic concerns, and were most agreeable about using hybrid and GITs for conservation and species restoration (Brennan et al., 2021). However, surveyed land managers still clearly had strong concerns regarding the impact of GITs on native species and local ecologies (Brennan et al., 2021). Another study by Marzano et al. (2019) interviewed forest managers and advisors in the U.K. regarding GITs and the introduction of non-native ash trees as a means to resist ash dieback, a disease that impacts the highly valued European ash. Marzano et al.'s respondents showed interest in dieback resistant trees, but showed limited support for the introduction of non-native ash species or the use of GI to create resistant trees (2019). Instead, they were more likely to be in favor of traditional breeding approaches within the species. Respondents shared concerns about the time to produce dieback resistant trees, if resistant trees would be truly resistant following experiences with supposedly resistant elm, and greater environmental impacts (Marzano et al., 2019). Both Brennan et al. (2021) and Marzano et al. (2019) contribute to the gap in acceptance studies among populations with the ability to influence GIT distribution, but still do not address the role of FFO landowners planting GITs on their own property that this study aims to address. Further, this study considers levels of GI and reasons for GI as explanatory factors that may shape FFOs acceptance of GITs as a viable land management strategy.

FFOs are defined by Butler et al. as "a family, individual, trust estate, or family partnerships that owns at least 1 acre of land with tree cover of at least 10 percent, and the land is not used for other purposes, such as lawn, that would impede natural processes" (p. 3, 2021). Given the breadth of this definition, it is understandable that FFOs hold diverse values and beliefs with contribute to their management (Erickson et al., 2002; Kluender & Walkingstick, 2000; Potter-Witter, K., 2005) of over 253 million acres, or 39%, of US forest land in 2018 (Butler et al., 2021). While their land is privately held, it often contributes significant public benefits to the economy and environment (Butler et al., 2014; Schaaf & Broussard, 2006; Stein et al., 2009). These factors make FFOs an important stakeholder in forest management decisions, such as the introduction of GITs..

The study target population consisted of FFOs that owned forest land in Michigan, Minnesota, or Wisconsin This region was selected due to its diverse forest land area (USDA, 2020) and its 17 million acres of family owned forest land (Butler et al., 2021). This population was selected as lake state FFOs control over 30% of forest land in the region, making them a key stakeholder in forest management decisions in their local area and the region. FFOs own their land for a variety of reasons (Erickson et al., 2002; Kluender & Walkingstick, 2000; Potter-Witter, K., 2005), which may lead to different acceptances of GITs when compared to the general public.

Michigan, Minnesota, and Wisconsin have FFOs that are largely older and male, and who state their number one reason for ownership as "beauty or scenery" in Michigan and

Minnesota and as “wildlife habitat” in Wisconsin (USDA Forest Service, 2021a; 2021b; 2021c). These ownership reasons are consistent with findings that aesthetic appreciation and protecting the environment are strong motivators to retain woodlots among FFO owners (Erickson et al., 2002). Existing research has found that factors such as social influence, values and beliefs, and overall ownership reason also contribute to land management decisions among FFO owners (Kuipers, 2012; Lind-Riehl et al., 2015; Makinen, 2010).

The authors are not aware of any literature regarding specifically the acceptance of GITs among FFOs and other NIPF landowners. However, other aspects of FFO ownership have been studied that relate to GIT implementation. Fischer (2019) found that FFOs in the U.S.’s upper lake states execute planned and autonomous responses aimed at making their land resilient in the face of climate change, a pursuit to which GITs may contribute. Daniels et al. (2010) found that landowners from Minnesota, among other states, considered forest continuity, benefit/profit, and doing the “right” thing to be key in their land purchase and management decisions, all aspects that may also be a factor in planting GITs. Additional studies have found evidence that financial incentives are a factor in forest owners' decision to participate in forest management programs such as carbon offsets (Miller et al., 2017) or specific types of land use and management (Kilgore et al., 2008), indicating that GITs may seen greater success if accompanied by a financial incentive. While these management approaches differ from GITs, they indicate that a financial incentive for planting GITs may prove useful in adoption.

2.4 Methods

Survey participants were selected from the region using an external survey firm, Dynata, and a sample size of n = 1500 was obtained. The sample consists of randomly drawn property addresses and acreages in the three state region. Dynata was responsible for drawing the sample from their proprietary sampling frame, however, owners with less than 5 acres of land were excluded from the sample. 3 mailings took place. The initial mailing included a letter of intent for the survey (n = 1500). The secondary mailing followed 2 weeks later and included the survey. The survey was mailed to n = 1499 respondents (following one respondent’s declining to participate), along with a postage paid return envelope. A final reminder mailing was sent to n = 1499 respondents two weeks following the survey mailing. No financial incentive was offered for this survey. 156 total surveys were returned, with 149 valid survey responses producing a response rate of ~10%. The remaining 7 surveys were omitted from the data set to being completely blank or including a refusal to participate. Valid survey responses were input into IBM SPSS Statistics (SPSS) Version 28.0.0.0. All missing responses from the surveys were coded as -111 and omitted from analysis. Additionally, any responses of “not ecologically relevant” were coded as -99 and also omitted from analysis.

The survey returned demographics consistent with what is expected of the study population based on findings from the 2018 National Woodland Owner Survey (NWOS), shown in Table 1. Survey respondents were, on average, in their sixties (mean respondent age = 60.91 years) and predominantly male (65.97% of respondents), which is supported by the NWOS, as FFOs who responded in 2018 had a median age in their sixties (MI = 64, MN = 66, WI = 63) and were mostly male (MI = 83%, MN = 84, WI = 89%) (USDA, 2021a; 2021b; 2021c). Survey respondents held some degree of higher education beyond highschool (77.46% of respondents), which is a greater proportion than NWOS respondents (MI = 50%, MN = 49%, WI = 39%)(USDA, 2021a; 2021b; 2021c).

Table 1. FFO Statistics, NWOS (10+ acres owned), Survey

Demographic Category	***Michigan***	***Minnesota***	***Wisconsin***	***Survey***
Average Age	64	66	63	60.91
% College Degree	50	49	39	77.46
% Male	83	84	89	65.97
% Privately Owned, Family	43	33	57	-
Total Acres Owned	8, 124, 000	537, 700	9, 000, 000	-
Number One Ownership Reason	Beauty or Scenery	Beauty or Scenery	Wildlife Habitat	Natural Beauty

A majority of survey respondents made at least $50,000 USD annually (70.22% of respondents). Survey respondent political ideologies were varied, and the largest group considered themselves politically neutral (28.37% of respondents). Forest land specific survey demographic questions indicate that 51.3% of respondents own 0-20 acres of land, and it is most often a single parcel (66.89% of respondents). A large majority of respondents (89.12% of respondents) reside in a house on their forestland for at least 6 months of the year. Additionally, many respondents have land that has been in their family for 11-50 years (59.18% of respondents). While the demographic findings cannot be used to draw inferences about the general FFO population, they are of interest given the limited literature studying GIT acceptance among similar populations. These summary statistics can be found in Table 2.

Table 2. Respondent Sample Summary Statistics

Demographic	**Survey respondents (n = 149)**
Income: 0-$50,000 (%)	15.6
Income: $50 - 100, 000 (%)	40.43
Income: $100, 000+ (%)	29.79
Income: Decline (%)	14.18
Ideology: Very Liberal (%)	1.42
Ideology: Liberal (%)	15.6
Ideology: Neutral (%)	28.37
Ideology: Conservative (%)	26.95
Ideology: Very Conservative (%)	7.8
Ideology: Decline (%)	19.86
Acreage Owned: 0-20 acres (%)	51.35
Acreage Owned: 20-40 acres (%)	24.32
Acreage Owned: 40-60 acres (%)	7.43
Acreage Owned: 60-80 acres (%)	6.78

Acreage Owned: 80-100 acres (%)	4.05
Acreage Owned: 100+ acres (%)	6.08
Parcels Owned: 1 (%)	66.89
Parcels Owned: 2-5 (%)	31.08
Parcels Owned: 6+ (%)	2.03
Reside on forest land (%)	89.12
Do not reside on forest land (%)	10.88
Land in Family: 0-10 years (%)	25.85
Land in Family: 11-50 years (%)	59.18
Land in Family: 50-100 years (%)	13.61
Land in Family: 100+ years (%)	1.36

Respondent Ownership Reasons

Respondents were asked to rank their reasons for owning forest land to shed light on how reasons for ownership may influence GIT perception. Respondents were given the following 5 reasons to choose from: economic, conservation, natural beauty, personal enjoyment, and family legacy. They were then asked to rank each reason “least important” (-2) to “most important” (2). Natural beauty was ranked as a “most important” (2) ownership reason by 73.29% of respondents, with responses overall leaning towards “most important” (2) (response mean = 1.62). This is consistent with FFO responses on ownership from NWOS, 2018, where the number one reason for ownership in MI and MN was beauty or scenery (USDA, 2021a; 2021b). 44.06% of respondents ranked “economic” as a “least important” (-2) ownership reason, and the response overall leaned towards “somewhat unimportant” (response mean = -0.81). These findings make this survey better able to discuss FFOs who value the natural beauty of their land, versus those who value it for economic reasons. Personal enjoyment saw similar results to natural beauty, with 69.18% of respondents ranking it as the “most important” (2) ownership reason and a response mean of 1.55. Conservation was considered important (1) by 45.5% of respondents, which is supported by a mean response value of 1.08. Family legacy as a reason for ownership experienced a greater spread of responses, though “neither unimportant or important” received the largest proportion of responses at 30.34% and a response mean of 0.51. Some responses from NWOS, 2018, do not fit into these categories; for example, the number one ownership reason in WI was listed as “wildlife habitat” (USDA, 2021c). The complete statistics regarding reason for ownership responses can be found in Table 3.

Table 3. Reason for Ownership Summary Statistics (%)

Importance	*Economic*	*Conservation*	*Natural Beauty*	*Family Legacy*	*Personal Enjoyment*
Least Important (-2)	44.06	3.50	1.37	4.83	1.37

Somewhat Unimportant (-1)	16.08	2.80	2.05	13.79	2.74
Neither (0)	18.88	11.89	2.74	30.34	4.79
Somewhat Important (1)	18.88	45.45	20.55	27.59	21.92
Most Important (2)	2.10	36.36	73.29	23.45	69.18
Mean	-0.81	1.08	1.62	0.51	1.55
Std. Deviation	1.244	0.953	0.762	1.137	0.823
N	143	143	146	145	146

Survey Design & Distribution

The survey consisted of 45 questions aimed at understanding perceived risks, benefits, and forest values of FFO landowners in the tri-state area. A mailed survey was designed to collect data from respondents over the age of 18 that privately owned forest land in the region. The questionnaire primarily consisted of 5-point Likert scale items. The survey also included standard and forest landowner specific demographic questions and a long-form response for additional comments. Tree species discussed in the survey were informed by regional relevance and scenarios were designed with forest geneticists to assign appropriate issues to each species.

The project was initially designed with the intention of survey design being informed by a preliminary focus group with forest landowners. However, COVID-19 negatively impacted the ability of the research team to gather in-person feedback using an in person focus group. Thus, the survey was also pretested using cognitive interviewing that took place in Michigan with members of the target population. The survey was revised following these interviews to improve clarity and remove repetition before mailing to the identified study population.

The first section of the survey consisted of 5 questions assessing forest landowner demographics, such as acreage owned and level of concern about ecological issues relevant to the region. This includes the presence and effects of emerald ash borer, the loss of hard maples, the threat of sudden oak death, and the loss of critical jack pine habitat. Respondents were given the opportunity to mark “not ecologically relevant” in regard to any species specific scenarios. These questions identified the details about the respondents' forest land such as size and residency as well as relevant ecologic concerns. In doing so, the questions aim to understand what forest property looks like among respondents and what concerns they hold in regard to their property.

The second section of the survey consisted of 3 genetic improvement scenarios. These scenarios each focus on a level of GI and associated risks and benefits. Respondents were asked to indicate to the extent that they agreed or disagreed with potential risks and benefits on a 5-point Likert scale ranging from “strongly disagree” (-2) to “strongly agree” (2). These questions identified respondent risk and benefit perceptions of different types of GI as identified in Table 4. In doing so, these questions assess how respondents feel about 3 levels of GM as explained in the survey.

Table 4. Levels of GI

Table 4. Levels of GI

Level of GI	Description	General Example	Survey Example Scenario
Level 1	Level 1 GI relies on what may be considered traditional tree breeding techniques, such as when trees from the same or different species are cross-bred to produce and select trees that have desirable traits (FDA, 2020), such as disease or pest resistance.	Gala apples are an example of a Level 1 GI. They are the result of cross-breeding Golden Delicious and Kidd’s Orange Red apples (Brown, 2018).	The emerald ash borer has devastated ash populations throughout regions of the United States. Genetic improvement could provide ash trees that are resistant to the emerald ash borer, allowing populations to recover. If scientists provided a genetically improved ash that was resistant to emerald ash borer through local nurseries, what do you think about the relative risks versus benefits of doing so?
Level 2	Level 2 GI involves traditional breeding like Level 1, but marker assisted breeding or genomic selection are used to predict the traits of the offspring in advance to save time and money (Meuwissen et al., 2001)	Cacao breeding is an example of Level 2 and uses molecular markers to select plants resistant to black pod disease, which threatens the plant’s production (Gill, 2018). Resistant trees are identified as seedlings and do not to be exposed to the disease to test their resistance.	The northern red oak holds significant economic value in local and regional timber markets. Genetically improved northern red oaks would see improved growth, increasing the value of your harvested trees in these markets. If scientists selected northern red oaks for improved growth and provided them through local nurseries, what do you think about the relative risks versus benefits of doing so?

Level 3	Level 3 GI involves the introduction of foreign genes from different plants (Pinchot, 2014). Foreign genes are selected in response to a single trait, e.g., to create resistance to an existing disease or improve a forest product, such as enhanced timber quality or increased maple syrup yield.	American chestnut trees, for instance, were once a dominant species in eastern U.S. forests. However, at the start of the 20th century, chestnut blight began to decimate American chestnuts throughout their native range. GI chestnut trees from the SUNY project are able to withstand the blight, potentially allowing the tree to return to its native range throughout the U.S. (Pinchot, 2014).	The jack pine is vital to the survival of the Kirtland's Warbler, a bird that will only build its nests under the tree. Loss of jack pines would also mean the loss of the Kirtland's Warbler. Researchers have shown that it is possible to make genetic improvements to improve a tree's heat tolerance, one critical factor endangering jack pine. If scientists provided a genetically improved jack pine through local nurseries, what do you think about the relative risks versus benefits of doing so?

The third section included 12 questions and presented 4 scenarios focused on individual tree species (ash, jack pine, maple, oak) that have the potential to be improved. Each scenario asked the respondents to indicate the extent to which they agreed or disagreed with potential risks and benefits on a 5-point Likert scale ranging from "strongly disagree" (-2) to "strongly agree" (2). Respondents were also asked to share their likelihood to consider planting a GIT, with the option to select "not ecologically relevant." These questions identified respondent risk and benefit perceptions related to specific species of trees modified in a particular way, as well as assessing their acceptance of these trees through asking about their willingness to plant. These species are each regionally relevant to portions of the lake states and provide unique environmental and economic contributions to the region. These questions were used to assess how risk and benefit perception varied between species that provided different environmental and economic contributions.

The fourth section asked respondents questions about their environmental values and beliefs. It includes a modified NEP scale after Hajjar & Kozak (2015), as well as forest value questions designed by Petit et al. (2021a; 2021b; 2021c) and used in other studies assessing acceptance of GITs. These questions aimed to gauge how respondents' values and beliefs related to their perceptions of GITs and their land. In doing so, these questions assess if a relationship exists between environmental values and beliefs and GIT acceptance. The final section asked respondents to share their demographic information and rank the importance of their reasons for owning forest land. These questions were asked to provide a more complete image of the respondent pool as well as understanding what they most valued about their forest land and how it may impact their perceptions of GITs. The complete survey instrument is located in Appendix A, A.1.

2.5 Data Analysis

Descriptive statistics were conducted for questions that identify basic characteristics of the data set, including questions about general and forest specific demographics. These were followed by frequency analysis of questions relating to GI levels and GIT risk and benefit scenarios to assess possible data patterns among responses. Bivariate correlation analysis was then conducted to assess relationships between concern for specific tree species and a willingness to plant GITs of that species. Correlation analysis was used to assess relationships between concern for a specific tree species and reasons for land ownership, as well as assess the relationship between perceived risks and benefits and reason for land ownership. Independent sample t-tests were conducted to compare the means of independent groups to determine if there were significant differences between groups.

Reliability analyses were conducted for question sets as indicated in Appendix A, A.2 to assess if related items should be combined into a singular item for analysis. This included sets of questions related to levels of GI, GIT risks and benefits, value and beliefs, a modified New Ecologic Paradigm scale, and questions related to forest values. Question sets that returned a Cronbach's Alpha greater than 0.7 were combined into an item; these items and their included questions can be found in Appendix A, A.2. This was done as these sets consisted of related questions that addressed a similar topic, such as assessment of GIT risks, and respondents may answer questions from the same group similarly. Combining these questions into an item allows analysis of the greater concept, perception of GIT risks, instead of only the individual question. One exception was granted for an item consisting of all risk and benefit questions, which returned a Cronbach's Alpha of 0.695. This item was still created given the high Cronbach's alpha values that the benefit and risk items achieved independently as well as its proximity to the accepted value of 0.7. Certain items, including the modified NEP scale used following Hajjar et al. (2014), were tested with the intent to be used as an item but did not return adequate Cronbach's alpha values to do so.

2.6 Results

Respondent Risk & Benefit Perceptions

Respondents held differing levels of concern for the 4 species detailed in the survey. When asked to rank their level of concern from "very unconcerned" (-2) to "very concerned" (2) in regard to potential risks to the aforementioned species, respondents expressed the most concern for oak trees (response mean = 1.04). They expressed slightly less concern for maple (response mean = 0.99), and less again for ash (response mean = 0.9). Respondents showed the least concern for jack pine (response mean = 0.37). Specifics about concern based responses can be found in Table 5.

Table 5. Species Specific Concern Summary Statistics

Species Scenario	***The presence and effects of emerald ash borer***	***The loss of hard maples***	***The threat of sudden oak death***	***The loss of critical jack pine habitat***
Very Unconcerned (-2)	10.71	12.14	12.14	14.84

Somewhat Unconcerned (-1)	10	3.57	3.57	8.59
Neither (0)	6.43	6.43	6.43	24.22
Somewhat Concerned (1)	24.29	28.57	24.29	26.69
Very Concerned (2)	48.57	49.29	53.57	22.66
Mean	0.9	0.99	1.04	0.37
Std. Deviation	1.385	1.344	1.359	1.327
N	140	140	140	128

Respondents were asked to respond to 3 scenarios assessing the potential risks of varied levels of genetic improvement to assess their perceptions of the defined levels of GI. Respondents were asked to assess potential risks and benefits using a scale from "strongly disagree" (-2) to "strongly agree" (2), to themselves, their property, their regional forests, and society. Respondents felt that level 1 GI, traditional tree breeding techniques, had the most risk to their regional forests (response mean = -0.37). However, they also felt that level 1 GI posed potential benefits to their regional forests (response mean = 0.96) and to society (response mean = 0.96). For level 2 GI, marker assisted breeding, and level 3 GI, the introduction of foreign genes, respondents continued to believe that they posed the most risk to their regional forests (response mean = -0.5, -0.05). Respondents again believed that level 2 GI posed the most potential benefit to their regional forests (response mean = 0.99), but agreed level 2 GI also provided great potential benefit to their property (response mean = 0.96). For level 3 GI, respondents believed it posed the most benefit toward society (response mean = 0.68) and their property (response mean = 0.62), though to a lesser extent than they perceived the benefits of level 1 and 2 GI. GI risk and benefit summary statistics for all 3 levels can be found in Table 6.

Table 6. Levels of GI Risk and Benefit Summary Statistics

Level 1 Risk/Benefit Perception	*There is potential risk to myself*	*There is potential benefit to myself*	*There is potential risk to my forest property*	*There is potential benefit to my forest property*	*There is potential risk to trees and forests in*	*There is potential benefit to trees and forests in*	*There is potential risk to society as a whole*	*There is potential benefit to society as a whole*

					my region	my region		
Strongly Disagree (-2)	29.5	0.00	23.40	1.41	14.18	0	21.9	0
Disagree (-1)	38.13	7.91	42.55	3.52	39.55	5.11	40.15	4.29
Neutral (0)	22.3	24.46	19.86	19.72	22.39	18.25	22.63	22.14
Agree (1)	9.35	46.04	14.18	50	17.16	51.82	10.22	46.43
Strongly Agree (2)	0.72	21.58	0	25.35	6.72	24.92	5.11	27.14
Mean	-0.86	0.81	-0.75	0.94	-0.37	0.96	-0.64	0.96
Std. Deviation	0.972	0.865	0.972	0.849	1.128	0.799	1.091	0.817
N	139	139	141	142	134	137	137	140
Level 2 Risk/Benefit Perception	*There is potential risk to myself*	*There is potential benefit to myself*	*There is potential risk to my forest property*	*There is potential benefit to my forest property*	*There is potential risk to trees and forests in my region*	*There is potential benefit to trees and forests in my region*	*There is potential risk to society as a whole*	*There is potential benefit to society as a whole*
Strongly Disagree (-2)	28.26	0.72	19.12	0	14.29	0	20	0.73
Disagree (-1)	41.3	3.60	47.79	5.07	47.37	2.94	42.22	7.3
Neutral (0)	21.01	25.18	22.79	18.84	16.54	19.85	22.22	18.98
Agree (1)	9.42	51.8	9.56	51.45	18.05	52.94	12.59	51.09
Strongly Agree (2)	0.00	18.71	0.74	24.64	3.76	24.26	2.96	21.9
Mean	-0.88	0.84	-0.75	0.96	-0.5	0.99	-0.64	0.86
Std. Deviation	0.929	0.792	0.901	0.8	1.063	0.75	1.034	0.868
N	138	139	136	138	133	136	135	137
Level 3 Risk/Benefit Perception	*There is potential risk to myself*	*There is potential benefit to myself*	*There is potential risk to my forest property*	*There is potential benefit to my forest property*	*There is potential risk to trees and forests in my region*	*There is potential benefit to trees and forests in my region*	*There is potential risk to society as a whole*	*There is potential benefit to society as a whole*
Strongly Disagree (-2)	20.59	1.46	12.59	1.48	9.85	2.22	12.5	2.99
Disagree (-1)	32.35	13.87	34.81	11.85	29.55	13.33	28.13	8.96
Neutral (0)	24.26	26.28	21.48	22.96	22.73	23.7	22.66	23.88
Agree (1)	16.18	41.61	22.96	46.67	31.82	41.48	30.47	45.52
Strongly Agree (2)	6.62	16.79	8.15	17.04	6.06	19.26	6.25	18.66
Mean	-0.44	0.58	-0.21	0.66	-0.05	0.62	-0.1	0.68

Std. Deviation	1.179	0.975	1.172	0.948	1.121	1.014	1.156	0.978
N	136	137	135	135	132	135	128	134

Respondents were asked to assess the potential risks and benefits of using GI on 4 regional tree species to assess their perceptions as related to specific uses. Respondents were asked to assess potential risks and benefits of specific modification scenarios using a scale from "strongly disagree" (-2) to "strongly agree" (2), to themselves, their property, their regional forests, and society. Scenarios can be found in Table 4, or as part of the survey instrument in Appendix A, A.1. Respondents perceived the most risk from GITs to their regional forests and to society for each of the 4 species. They perceived the greatest risk to be related to modified jack pines and their impact on regional forests (response mean = -0.28). Respondents perceived overall high levels of potential benefit across species, but perceived the greatest benefits to be from modified ash trees to regional forests (response mean = 1.03) and to society (response mean = 0.97). Respondents were additionally asked to assess if the benefits of a GIT outweighed the risks, and indicated that they agreed this was the case for all 4 species. They indicated that they most believed benefits outweigh risks for modified ash trees (response mean = 0.89) and maple trees (response mean = 0.86). These statistics can be found in Table 7.

Table 7. Species Specific GIT Scenario Summary Statistics

GI Ash Risk/Benefit Perception	*There is potential risk to myself*	*There is potential benefit to myself*	*There is potential risk to my forest property*	*There is potential benefit to my forest property*	*There is potential risk to trees and forests in my region*	*There is potential benefit to trees and forests in my region*	*There is potential risk to society as a whole*	*There is potential benefit to society as a whole*	*The benefits of emerald ash borer resistance outweigh the risks associated with genetic improvement*
Strongly Disagree (-2)	24.09	0.72	24.26	0.72	16.42	0.73	19.12	0.74	4.51
Disagree (-1)	45.99	10.87	44.85	8.7	42.54	4.38	41.91	5.88	6.77
Neutral (0)	21.17	25.36	16.18	15.94	20.9	14.6	22.79	16.18	15.04
Agree (1)	7.3	41.3	13.24	47.83	17.16	51.82	14.71	50	42.86
Strongly Agree (2)	1.46	21.74	1.47	26.81	2.99	28.47	1.47	27.21	30.83
Mean	-0.84	0.72	-0.77	0.91	-0.52	1.03	-0.62	0.97	0.89
Std. Deviation	0.925	0.95	1.011	0.916	1.053	1.053	1.003	0.86	1.064
N	137	138	136	138	134	134	136	136	133

GI Jack Pine Risk/Benefit Perception	*There is potential risk to myself*	*There is potential benefit to myself*	*There is potential risk to my forest property*	*There is potential benefit to my forest property*	*There is potential risk to trees and forests in my region*	*There is potential benefit to trees and forests in my region*	*There is potential risk to society as a whole*	*There is potential benefit to society as a whole*	*The benefits of protecting the Kirtland's Warbler outweigh the risks associated with genetic improvement*
Strongly Disagree (-2)	20.86	4.35	16.79	2.92	12.78	2.99	14.93	2.21	5.3
Disagree (-1)	46.04	13.77	45.26	13.14	33.83	9.7	35.07	8.09	12.12
Neutral (0)	22.3	31.88	19.71	19.71	27.07	22.39	28.36	29.41	25.76
Agree (1)	10.07	34.78	16.06	47.45	21.05	43.28	17.91	45.59	34.09
Strongly Agree (2)	0.72	15.22	2.19	16.79	5.26	21.64	3.73	14.71	22.73
Mean	-0.76	0.43	-0.58	0.62	-0.28	0.71	-0.4	0.63	0.63
Std. Deviation	0.921	1.046	1.019	1.008	1.097	1.01	1.062	0.91	0.91
N	139	138	137	137	133	134	134	136	136

GI Maple Risk/Benefit Perception	*There is potential risk to myself*	*There is potential benefit to myself*	*There is potential risk to my forest property*	*There is potential benefit to my forest property*	*There is potential risk to trees and forests in my region*	*There is potential benefit to trees and forests in my region*	*There is potential risk to society as a whole*	*There is potential benefit to society as a whole*	*The benefits of protecting hard maples outweigh the risks associated with genetic improvement*
Strongly Disagree (-2)	22.46	1.45	21.01	2.17	15.27	1.46	18.8	0.74	5.47
Disagree (-1)	47.83	8.70	40.58	8.7	41.98	5.11	42.11	5.19	4.69
Neutral (0)	20.29	19.57	21.01	10.14	22.14	13.87	23.31	19.26	20.31
Agree (1)	7.97	47.1	15.94	52.9	18.32	56.93	13.3	51.85	37.5
Strongly Agree (2)	1.45	23.19	1.45	26.09	2.29	22.63	2.26	22.96	32
Mean	-0.82	0.89	-0.64	0.92	-0.5	0.94	-0.62	0.91	0.86
Std. Deviation	0.922	1.277	1.032	0.952	1.033	0.838	1.013	0.833	1.092
N	138	138	138	138	131	137	133	135	128

GI Oak Risk & Benefit Perception	There is potential risk to myself	There is potential benefit to myself	There is potential risk to my forest property	There is potential benefit to my forest property	There is potential risk to trees and forests in my region	There is potential benefit to trees and forests in my region	There is potential risk to society as a whole	There is potential benefit to society as a whole	The benefits of increased economic value outweigh the risks associated with genetic improvement
Strongly Disagree (-2)	18.52	2.24	15.15	2.24	11.45	1.52	15.91	0.77	5.43
Disagree (-1)	48.15	9.70	47.73	8.96	41.98	6.82	45.45	7.69	13.18
Neutral (0)	23.7	20.9	21.97	14.93	19.85	18.18	20.45	22.31	34.88
Agree (1)	8.89	50	13.64	55.97	22.9	51.52	15.91	49.23	31.78
Strongly Agree (2)	0.74	17.16	1.52	17.91	3.82	21.97	2.27	20	14.73
Mean	-0.75	0.7	-0.61	0.78	-0.34	-0.34	-0.57	0.8	0.37
Std. Deviation	0.887	0.942	0.954	0.921	1.073	1.073	1.013	0.875	1.061
N	135	134	132	134	131	131	132	130	129

In order to assess the relationship between FFO GIT risk and benefit perceptions, risk and benefit items were created following reliability analyses detailed in Table 1, Appendix B. These results indicated that FFOs risk and benefit perceptions were significantly and negatively correlated to one and other (Pearson = -0.613, S = <0.001). That is, as benefit perceptions increased, risk perceptions decreased, and vice versa. This correlation continued to exist between levels of GI risk and benefits (i.e. level 1 risks vs level 1 benefits, etc).

Respondent Reason for Ownership & Species Specific Concern
Respondents were asked to rate their level of concern regarding specific threats to 4 tree species from very unconcerned (-2) to very concerned (2). Correlation analysis was then conducted to assess relationships between stated level of concern regarding a specific threat to a species and a willingness to plant a modified GIT of that species. Greater concern regarding these specific threats was found to be positively correlated with a willingness to plant a GIT of that species for 3 of the 4 species present in the survey. This relationship was strongest for jack pine (Pearson = 0.313), indicating that respondents who expressed concern for threats to jack pines were more willing to plant a GI jack pine to resist those threats. Weaker positive correlations existed between concern for ash (Pearson = 0.251) and oak (Pearson = 0.201). Concern for maple trees was not correlated with a willingness to plant GI maples. Additionally, it was found that concern for one species was at least moderately correlated with concern for other species in all instances. Maple and jackpine exhibited the strongest example of this concern correlation (Pearson = 0.794). These results can be found in Table 8 & 9.

Table 8. Correlation of Species Concern and Willingness to Plant, Pearson

	Willingness to Plant	*Ash*	*Jack Pine*	*Maple*	*Oak*
Concern	*Ash*	0.251*			
	Jack Pine		0.313*		
	Maple			0.160	
	Oak				0.201*

*Significant

Table 9. Correlation of Species Concerns, Pearson

	Concern	*Ash*	*Jack Pine*	*Maple*	*Oak*
Concern	*Ash*	-	0.551*	0.674*	0.680*
	Jack Pine	0.551*	-	0.551*	0.577*
	Maple	0.674*	0.550*	-	0.794*
	Oak	0.680*	0.577*	0.794*	-

*Significant

Respondents were asked to rank their reasons for owning forest land. A correlation analysis was then performed to assess relationships between reasons for ownership and level of concern regarding species specific threats. Conservation as a reason for ownership was found to be positively correlated to concern for each of the 4 species, though most strongly for ash trees (Pearson = 0.333. Concern for ash was also weakly positively correlated with natural beauty as a reason for ownership. Concern regarding species specific threats was found to be weakly correlated to conservation as an ownership reason for the remaining 3 species, with maple trees exhibiting the weakest relationship (Pearson = 0.206). These results can be found in Table 10.

Table 10. Correlation of Ownership Reason and Species Concern, Pearson

	Ownership Reason	*Economic*	*Conservation*	*Family Legacy*	*Personal Enjoyment*	*Natural Beauty*
Concern	*Ash*	0.007	0.333*	0.021	0.101	0.238*
	Jack Pine	0.06	0.252*	0.047	0.078	0.098
	Maple	0.117	0.206*	0.017	0.12	0.159
	Oak	0.054	0.226*	-0.009	0.089	0.157

*Significant

Respondents & their Environment
Respondents were asked a number of questions related to forest and environmental values. These questions were based on a modified NEP scale defined in Hajjar & Kozak (2015) and value questions presented in Petit et al. (2021a, 2021b, 2021c). Most responses did not vary significantly with respect to demographic characteristics. However, female respondents tended to agree or disagree more strongly with certain value questions than male respondents did. This included questions about protecting forests and forest value. This trend did not repeat with other value and belief questions. These results may be a result of the survey's small sample size and predominance of male respondents.

2.7 Discussion

Lake state FFOs show mixed perceptions of risks and benefits of GI and GITs, though they indicate that they believe the benefits of GITs outweigh the risks for each of the 4 example species. Individually, modified jack pines were perceived to be the greatest risk to regional forests, while modified ash were perceived to have the greatest benefit to regional forests. When asked to consider if the benefits of a GIT outweighed their risk, they believed that this was most strongly the case for ash and maple trees. They perceived the most risk to be to their regional forests from all levels of GI, though they also felt that level 1, traditional breeding, and level 2, marker assisted breeding, provided potential benefit to these forests. This preference for level 1 GI, traditional breeding, is supported by Marzano et al.'s (2019) finding that U.K. forest managers and advisors prefer traditional breeding approaches to create dieback resistant trees. Survey respondents felt that level 3 GI, the introduction of foreign genes, was the greatest risk to their regional forests. Respondents show greater acceptance of GI approaches that may be perceived as more "natural," such as level 1 GI's traditional breeding approach. This preference for seemingly more natural processes is consistent with findings by Hajjar and Kozak (2015), Hajjar et al. (2014), Fuller et al. (2016), and Petit et al (2021a) and may indicate that regional approaches to GIT should focus on bolstering more natural approaches that support regional forests to encourage FFO acceptance.

FFO respondents indicated species specific concern for each of the 4 species listed in the survey, and their concern for a specific species shows some correlation to their willingness to plant a GIT of that species. Concern was greater for ash, maple, and oak than for jack pine. Respondents who expressed concern for one species were also likely to express concern for other species. This variation in concern could be the result of where these trees are native species and potential concern for local ecologies, as was found in Brennan et al.'s (2021) survey of U.S. land managers. However, it may also be a sampling error related to the survey's small sample size. Additional research is necessary to understand this relationship, though these survey findings may indicate that GIT messaging and distribution should focus on native species ranges and protection of local ecologies.

Respondents owned their land for a variety of reasons, but consistently ranked factors of natural beauty, followed by personal enjoyment, as a most important reason for ownership. Conversely, respondents consistently ranked economic reasons as a least important reason for ownership. This is consistent with other research that has found aesthetic appreciation to be a stronger motivator to retain woodlots than economic motivators (Erickson et al., 2002), however, requires greater study among FFOs to draw further inferences.

Female participants responded more strongly to certain questions related to forest values and protecting forests. This finding has not occurred in other studies of similar populations. This finding may be attributed to the survey's small sample size and predominance of male respondents. Further research studying the relationship between gender and forest values and beliefs is necessary to draw further conclusions on the topic.

2.8 Conclusion

GITs are likely to become more and more relevant to land and forest management decisions in years to come. This research aimed to examine risk and benefit perceptions of GITs among FFO landowners in the lake states and how these perceptions inform acceptance. U.S. FFO landowner acceptance will be critical to GIT planting and distribution throughout the U.S., making the consideration of their perceived risks and benefits a key component of future research efforts. Determining the type and degree of risks and benefits that FFO landowners associate with GITs can help to shed light on what steps forest geneticists can take to create GITs that are more likely to be accepted among this population. In addition, an understanding of perceived risks and benefits can help to inform GIT education and, potentially, distribution efforts in the future.

These findings indicate that GIT science and policy should consider a focus on methods that FFOs and like groups will perceive as "natural" enough to be acceptable in their regional forests. In addition, GIT policy should focus on protecting local ecologies and bolstering native species' genetics before introducing foreign genetic matter or introducing new species that are more tolerant of a disease, pest, or climatic change. Policy should include robust consideration for local landowner groups, such as FFOs, that focus on land management concerns by working to understand local land management practices and perceived risks to regional forests.

This study is limited by nonresponse error and its small sample size, as well as a lack of understanding of each respondents forest property beyond its size and tenure. The survey achieved an overall response rate of 10%, however, many survey questions had responses of "not ecologically relevant" or missing responses. The survey could potentially be improved for higher response rates by being tailored to each state or geographic region, thus omitting irrelevant questions and shortening overall length of the survey, which would potentially improve response rates. In addition, the survey did not ask respondents to specify what species of trees they had on their property, nor assess their knowledge level of GI and GITs. An improved survey may include more property specific questions related to present species of trees and related concerns, as well as asking respondents what they know and understand about GITs. In addition, this survey saw a significantly greater proportion of respondents who valued natural beauty and personal enjoyment as reasons for land ownership over economic reasons for ownership, indicating that the population who considers economic reasons most important for ownership may be missing from the survey population.

Future research should consider examining how a preference for more “natural” approaches to GI matters for GIT risk and benefit perception throughout their native ranges, and work to understand what FFOs deem as “natural” enough to be acceptable for distribution. There is additionally a need to examine how species specific concern influences acceptance of GITs when the species is located on the forest property, as well as how concern for regional forests influences acceptance of certain GITs. Additionally, future research should more closely examine the relationship that exists between reasons for land ownership and GIT risk and benefit perception to better understand what niche GITs can fulfill in FFO land management practices.

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Chapter 3: Brownfields for Green Futures: A Legal Framework Analysis of Brownfield Redevelopment for Renewable Energy

3.1 Abstract

The world's energy needs grow greater each day. This increasing need is accompanied by an exponential growth in renewable energy (RE) and the ever-present question of where projects will be sited. A potential solution includes redeveloping existing brownfield sites for RE projects, which capitalizes on reusing already developed spaces that may be unsightly and provides a new RE resource to the surrounding community. This study analyzes the extent to which federal and Michigan law pertaining to brownfield redevelopment enables or restricts community-centric RE development on brownfield sites. It utilizes Legal Framework Analysis to assess applicable laws at the federal and state levels to identify a legal framework to encourage this type of redevelopment before addressing the vertical and horizontal alignment of these laws. Findings indicate that while brownfield redevelopment law exhibits medium to high degrees of horizontal and vertical alignment, limited to no considerations are made for community priorities or RE. Future research and policy recommendations are then made based on these findings.

3.2 Introduction

As the world's human population grows, so do its energy needs. This growth is accompanied by exponential growth in RE (Jaeger, 2021) and the ever-present question of where projects will be sited (Fulton, 2022). A potential solution includes redeveloping existing brownfield sites for RE projects, capitalizing on already developed spaces that may be unsightly, and providing a new, renewable energy resource to the surrounding community. Site redevelopment can prove especially useful in states like Michigan, where a rich industrial past has left its mark and brownfields are scattered across its landscape (EGLE, 2023a). Brownfield sites often require remediation related to their previous use before being redeveloped, giving way to numerous pieces of legislation focused on site remediation. How well this legislation addresses the site's future use beyond making it safe for reuse is a different matter. Funding typically only covers actual remediation activities rather than site improvement or later stages of redevelopment (Meenar et al., 2019).

Limited access to site redevelopment funding following remediation activities, coupled with the complexities of brownfield sites, can lead to interference with their redevelopment (Rey et al., 2022). While some federal brownfield-related legislation, such as the Comprehensive Environmental Response, Compensation, and Reliability Act (CERCLA), has seen amendments to address some of these issues, problems still emerge. It is unclear if redevelopment laws align with each other to ensure consistency between legislative bodies and avoid conflict. Furthermore, it needs to be clarified if federal and Michigan brownfield redevelopment legislation make provisions for community engagement or RE.

This study analyzes the extent to which existing federal and Michigan law enable or restrict the redevelopment of brownfield sites for RE. It aims to identify a legal framework that encourages this type of redevelopment through state and federal findings. Legislative documents at the state and federal levels were used to assess how existing systems contribute to redeveloping brownfields for RE projects. These documents were reviewed to assess horizontal and vertical policy alignment and their provisions for community involvement in redevelopment efforts, specifically RE development. In doing so, potential barriers and improvement opportunities were identified so that policy can better support community-centric renewable redevelopment efforts on brownfield sites.

3.3 Background & Literature

Brownfields and their Communities

Brownfield remediation has been recognized as an essential aspect of sustainability for several years (Franz et al., 2006), and site redevelopment is a familiar idea (Wagner, 1998). CERCLA (42 USC 9601 *et seq.*) has addressed brownfield remediation since its inception, with amendments making its purpose more explicit throughout the years (Bearden, 2012). CERCLA is a hallmark of brownfield legislation, without which there would be little ground for remediation efforts to stand on. However, there is more to redevelopment than remediation. The U.S. Environmental Protection Agency (EPA) identifies three stages of brownfield redevelopment: pre-development, development, and management. Pre-development requires conducting due diligence and analyses, securing funding, and preparing redevelopment plans, including a community engagement plan (EPA, 2019). The development stage requires permitting, marketing, and remediation before opening the project (EPA, 2019). Remediation, or clean-up activities, occur during the development stage, potentially concurrently with new construction (EPA, 2019). The final stage, management, encompasses what happens to the project following its redevelopment and if the developer will hold or sell the property (EPA, 2019). Brownfield funding via grants and loans typically only cover remediation costs, including environmental assessments of the site (EGLE, 2023b; EPA, 2014; EPA, 2020). This limitation in funding use leaves the costs of new construction to be covered by private investors or other funding sources. Nothing explicitly prohibits using brownfield redevelopment funds alongside RE development funds. However, separating the two processes leads to a disconnect about what funds may be available for a project. This disconnect contributes to the well-identified gap between policy formulation and implementation (James et al., 1999; Engert & Baumgartner, 2016; Hudson et al., 2018; Mueller, 2020).

Data indicates that brownfield redevelopment generally has positive public perceptions (Loures & Crawford, 2008; Loures et al., 2015) and potentially comes with lower development constraints given limited uses for the site (Adelaja et al., 2010). However, brownfields often come with unique, site-specific challenges compared to greenfield development, including sociocultural barriers, regulatory constraints, and more (Dylewski, 2002; Glumac & Decoville, 2020; Rey et al., 2022). In addition, the limited legislative support for the later stages of brownfield redevelopment throughout the U.S. limits redevelopment to sites that private entities have a personal interest in developing. For RE, this means that sites that may benefit communities but not utilities might be passed up for redevelopment.

Existing research has examined the use of brownfields for RE developments worldwide, particularly regarding project feasibility (Adelaja et al., 2010; Hartmann et al., 2014; Roddis et al., 2020). In Michigan alone, it is estimated that brownfield sites have the potential to produce over 5,000 MW of electricity (Adelaja et al., 2010). Some work has examined the risks (Neuman & Hopkins, 2009) and liability (Nasca, 2012) associated with these developments or the legality of similar projects in other countries (Kanevce et al., 2020). Limited studies examine the legislation surrounding renewable energy development on brownfields in the U.S.

While the U.S. does not provide explicit statutory federal law encouraging the reuse of brownfields for renewable energy projects, the EPA does present ways that developers can pair brownfield remediation funding with RE funding and is home to the RE-powering America's Land initiative (EPA, 2015; EPA, 2021). RE-powering encourages energy development on brownfield sites that align with community priorities and provides resources for accessing funds for redevelopment, though the program does not provide any itself (EPA, 2015). Certain states, including Massachusetts (Mass.), have supported renewable energy brownfield redevelopment through state-level programs (EPA, 2022). Mass. boasts strong solar incentives alongside virtual net metering that benefits municipalities building solar projects on specific brownfield sites, such as landfills, via the Solar Massachusetts Renewable Target (SMART) program (EPA, 2022)(225 CMR 20.00). Landfill redevelopment like this allows underutilized spaces to be used for energy gains (Ferrey, 2007). SMART works alongside accelerated permitting procedures for some renewable projects (Massachusetts Department of Environmental Protection, 2023) to support renewable energy redevelopment of the state's brownfields, making it home to more RE projects and generation capacity than any other state that participates in EPA's RE-powering initiative (EPA, 2022). In addition, Mass. provides a guide for redeveloping landfills into solar projects that considers community involvement in projects (DOER, 2020). Given that brownfield development often requires increased stakeholder and community engagement compared to greenfield sites due to their potentially complicated histories (Bartsch, 2003), including community priorities is critical for redevelopment efforts to minimize policy gaps. However, there is little effort to make this inclusion a part of just redevelopment law.

Developers have historically often struggled to include justice considerations, disenfranchising the very populations they may intend to aid (Felten, 2006; Meenar et al., 2019). Further, some legislation, such as the 2002 Small Business Liability Relief and Brownfields Revitalization Act, has been criticized for failing to consider or require environmental justice considerations, making some question if communities can even be protected under these laws (Freeland, 2004). What constitutes environmental justice, however, can vary. Some communities have been found to perceive even being invited to participate in redevelopment as a form of justice (Flynn, 2000), indicating a need for social license to operate (SLO) on brownfield sites.

SLO is the license to operate that a community grants developers such that they are beholden to community desires and expectations about acceptable activities (Gunningham et al., 2002). The idea of SLO is most common in resource extraction industries, such as mining and forestry (Moffat et al., 2016), but has been found to have practical applications concerning RE projects (Hall, 2014; Azubuike et al., 2022). While SLO is not without critique about its possible ambiguity (Gehman et al., 2017) and abuses by industry (Lester, 2016), it has the potential to strengthen both community and industry when correctly applied (Ketola et al., 2021).

There are a small number of RE projects in Michigan that have successfully engaged their impacted community. The Michigan Department of Environment, Great Lakes, and Energy (EGLE) recognizes nearly 24,000 properties in the state as brownfield sites (EGLE, 2023a). In 2022, EGLE awarded over $5 million for brownfield redevelopment alone (EGLE, 2023d). Michigan's brownfield redevelopment program has worked to provide incentives to over 600 brownfield projects throughout the state since its inception, although a limited number of these have been RE projects (EGLE, 2023a). In 2019, a solar garden was developed on a former brownfield site in Cadillac, MI (Sertic, 2020). This solar garden was able to leverage state brownfield funds alongside utility funds for redevelopment and, as of the writing of this piece, was seemingly the only project in the state to do so successfully. The Mitchell Bentley Solar Garden in Cadillac, Michigan is a redevelopment project that turned a former Mitchell Bentley Plant into a ½ MW solar installation (Sertic, 2020). The project required collaboration between the city of Cadillac, EGLE, and the local utility. The city of Cadillac acquired $1,000,000 in state brownfield grants and loans for site redevelopment, while the utility financed RE installation (Schaap et al., 2019). The project's success can be attributed to the utility buy-in and the high community support it received (Schaap et al., 2019). Other similar, successful projects have not accessed state funds for remediation preceding a RE project as Cadillac did and instead relied on other funding sources for remediation (Schaap et al., 2019).

3.4 Data & Methods

This study utilized principles of legal framework analysis (LFA) to assess statutory law relevant to redeveloping brownfield sites for renewable energy within the U.S. and Michigan. Statutory law is recognized as a distinct tract of law with an unmistakable role in defining policy (Boughey & Burton Crawford, 2019). Legislation was evaluated at the state and federal level to recognize the legal issues that may exist for brownfield redevelopment within different jurisdictions of the law. While federal law takes precedence over state law, it often delegates responsibility of statute enforcement to state agencies (Lemos, 2011). This delegation allows states to dictate interpretation and enforcement of the law, encouraging state-centered policy (Lemos, 2011). Considering the power given to state enforcement and legislation within the federal context, it is necessary to consider both federal and state law in this analysis.

LFA has been used for a variety of applications, including to assess energy and agricultural law and policy (Carleyosen, 2006; Muller, 2015; Sunila et al., 2019; Pascaris, 2021; Ramos et al., 2021; Terjanika et al., 2022). The Food and Agriculture Organization (FAO) of the United Nations provides guidelines to perform LFA for rural and agricultural projects, which were used to inform this study (FAO, 2000), given their breadth and accessibility. FAO's guidelines focus on a close analysis of applicable legal frameworks for the viability of projects, making their guidelines applicable in both rural and urban settings with the added benefit of being accessible to non-legal scholars. FAO's process consists of identifying relevant components of the law, analyzing the law itself, and identifying outcomes of the law with potential solutions (FAO, 2000).

This process began with a review of existing brownfield legislation at the federal and state level. The Federal Register was used to search federal documents for the term “brownfield.” This search yielded 563 results, with the EPA identified as the principal overseeing agency. This search and a subsequent review of the EPA’s brownfields webpage (EPA, 2014) produced 4 main pieces of relevant legislation for this study, located in Table 3. CERCLA and its relevant amendments are treated as one piece of legislation for this study’s purposes. CERCLA’s amendments are listed separately in this table for clarity regarding which were included. Much of federal brownfield legislation falls under CERCLA and its subsequent amendments. However, more recent legislation including the 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act (IRA) have also contributed to federal brownfield law.

These pieces of legislation were then each reviewed to assess how they address aspects of brownfield redevelopment. These aspects include brownfield definitions, site eligibility, liability, funding opportunities, and site permitting. The documents were additionally reviewed for mention of RE and community engagement.

Table 1. Relevant Federal Legislation

Legislation	Description	Public Law Number

1980, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	CERCLA provides a federal superfund to address uncontrolled or abandoned hazardous-waste sites as well as releases of pollutants and contaminants into the environment.	PL 96-510 42 USC 9601 *et seq.*
1986 Superfund Amendments and Reauthorization Act (SARA)	SARA reauthorized CERCLA and provided site-specific amendments, definitions, clarifications, and technical requirements to the original legislation.	PL 99-499
1996 Asset Conservation, Lender Liability, and Deposit Insurance Protection Act	This act amended CERCLA to protect certain fiduciaries and financial lenders from site liability.	PL 104-208 Division A, Title II, Subtitle E
2002 Small Business Liability Relief and Brownfields Revitalization Act	This act amended CERCLA and provided relief from liability for certain groups, including protection for "innocent" owners of contaminated property.	PL 107-118
2017, Tax Cuts and Jobs Act	This act created qualified opportunity funds, which can invest in brownfield properties.	PL 115-97
2018, Brownfields Utilization, Investment, and Local Development (BUILD) Act	BUILD amended CERCLA to enhance liability protections, address funding, and more.	PL 115-141, Division G, Title II
2021, Infrastructure Investment and Jobs Act	This act improved funding opportunities for brownfields.	PL 117-58
2022, Inflation Reduction Act (IRA)	The IRA provides certain renewable energy tax incentives for brownfield sites.	PL 117-169

The Michigan Compiled Laws (MCL) Chapter Index was used to search Michigan legislation for the term “brownfield” to inform what state documents may be relevant. This search yielded 68 total results, which produced 2 pieces of relevant legislation for this study following review, found in Table 4. EGLE’s webpage on brownfield sites was also reviewed and found to support the same pieces of legislation for this research (EGLE, 2023c). Michigan brownfield legislation largely falls under the state’s 1994 Natural Resources and Environmental Protection Act (NREPA) or their 1996 Brownfield Redevelopment Financing Act (BRFA). NREPA provided the state with liability reform, risk-based cleanup strategies, and new financial incentives (Card & Kummler, 1999; MCL 324.101 *et seq.*) BRFA provided new financial options and strategies for brownfield redevelopment in the state (MCL 125.2651 *et seq.)*. These pieces of legislation were then each reviewed using the same process used to review the federal documents.

Table 2. Relevant Michigan State Legislation

Legislation	Description	Public Act Number
1994, Natural Resources and Environmental Protection Act (NREPA)	NREPA protects the state's natural and environmental resources.	1994 PA 451 MCL 324.101 *et seq.*

1996, Brownfield Redevelopment Financing Act	This act allows the create of brownfield redevelopment authorities (BRA), brownfield revolving funds, and facilitates brownfield revitalization planning	1996 PA 381 MCL 125.2651 *et seq.*

Following these searches, the identified pieces of legislation were compiled into 3 tables to analyze their substance, vertical alignment, and horizontal alignment. The horizontal and vertical alignment definitions used in this study can be found in Table 3 and Table 4, respectively. Alignment was assessed in several categories, including brownfield definition, eligibility, liability, financial, and permitting. This assessment included identifying clarity, contradiction, and identity allocation between authorities to find roadblocks or opportunities for redevelopment (FAO, 2000). After assessing the degree of alignment in each category, brownfield RE redevelopment inhibitors were identified, and recommendations were made to enable multi-level and sector brownfield RE redevelopment that supports community priorities.

3.5 The Problem with Policy: An Analytical Framework for Policy Alignment

Redeveloping brownfield sites explicitly for RE projects presents a complex, multi-level policy integration challenge that requires government and individual engagement at the federal, state, and local levels (Cairney, 2020). The inherent complexity of this system contributes to the policy formulation-implementation gap, leaving policy at risk of failure (McConnell, 2015; Hudson et al., 2018; Bernardo, 2020). Policy integration can help to alleviate some of these issues by helping to align goals and outcomes between dimensions of government and the law (Howlett & del Rio, 2015; Cejudo & Michel, 2017). This alignment takes on two primary dimensions of horizontal and vertical alignment.

Horizontal policy alignment addresses the relationships between tools, goals, and policies at a single level of government, such as the state level (Howlett & del Rio, 2015). Alignment depends on how well these instruments agree amongst themselves, such as how all state policies interact with each other without transcending levels of government. Horizontal alignment can support links between levels of government and policy actors to achieve particular policy goals (Hsu et al., 2017). This study segments horizontal alignment into three degrees of high, medium, and low, as shown in Table 3, taking inspiration from how alignment is defined by Howlett and del Rio (2015) and Hsu et al. (2017).

Table 3. Levels of Horizontal Policy Alignment.

Levels of Horizontal Alignment

HIGH	HIGH degrees of policy alignment are characterized by consistency between policy domains at one level of governance. This includes interactions between policy, instrumentation, and goals for a certain issue. Agencies intentionally avoid conflict or actively pursue closing policy gaps.
MEDIUM	MEDIUM degrees of policy alignment are characterized by limited similarities between policy domains at one level of governance. This includes interactions between policy, instrumentation, and goals for a certain issue. Agencies may avoid conflict or close policy gaps, but neither may be done with the intention of doing so.
LOW	LOW degrees of policy alignment are characterized by little or no similarities between policy domains at one level of governance. This includes interactions between policy, instrumentation, and goals for certain issues. Agencies do not avoid conflict between domains, and are unlikely to make progress towards addressing policy gaps.

Vertical alignment deals with multiple levels of government and policy sectors and each level's tools, goals, and policies (Howlett & del Rio, 2015). Alignment here is more about how instruments agree across levels of government, such as alignment between state and federal policies, rather than within a single level. Vertical alignment can support the coordination of policies and policy actors across levels of government (Hsu et al., 2017). This study segments vertical alignment into three degrees of high, medium, and low, as shown in Table 4, taking inspiration from how alignment is defined by Howlett and del Rio (2015) and Hsu et al. (2017).

Table 4. Levels of Vertical Policy Alignment.

Levels of Vertical Alignment	
HIGH	HIGH degrees of policy alignment are characterized by consistency between policy domains between levels of governance. This includes interactions between policy, instrumentation, and goals for a certain issue. Agencies intentionally avoid conflict or actively pursue closing policy gaps

MEDIUM	MEDIUM degrees of policy alignment are characterized by limited similarities between policy domains between levels of governance. This includes interactions between policy, instrumentation, and goals for a certain issue. Agencies may avoid conflict or close policy gaps, but neither may be done with the intention of doing so.
LOW	LOW degrees of policy alignment are characterized by little or no similarities between policy domains between levels of governance. This includes interactions between policy, instrumentation, and goals for certain issues. Agencies do not avoid conflict between domains, and are unlikely to make progress towards addressing policy gaps.

3.6 Results

U.S. federal law displays a high to medium degree of horizontal policy alignment for brownfield redevelopment. However, it gives minimal consideration to RE development or community priorities. Brownfield relevant legislation, such as CERCLA and its amendments, the 2017 Tax Cuts and Jobs Act, the 2021 Infrastructure Investment and Jobs Act, and the 2022 IRA, work together to comprehensively define a brownfield site, the eligibility of that site for brownfield initiatives, and liability considerations. In addition, federal law provides numerous financial incentives for redevelopment that can work together to make redevelopment possible. CERCLA allows brownfield response actions to be exempt from permits for on-site activities, further decreasing barriers to redevelopment. Federal legislation is highly internally consistent and supportive of each other between definitions, eligibility criteria, and liability considerations. Financial and permitting considerations are less consistent, though they do not conflict. While EPA mentions ways to redevelop brownfield sites for EPA, the law fails to support this type of brownfield redevelopment. Furthermore, while EPA discusses the importance of community-engaged projects, the law fails to protect community priorities or ensure their involvement in brownfield redevelopment efforts. The results of this analysis can be found in Table 5.

Table 5. U.S. Federal Horizontal Alignment.

Legislation	Agency	Definition	Eligibility	Liability	Financial	Permitting	Alignment
1980, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) *P.L. 96-510* Amended: 1986, Superfund Amendments and Reauthorization Act (SARA), *P.L. 99-499*; 1996, Asset Conservation, Lender Liability, and Deposit Insurance Protection Act, *P.L. 104-208*; 2002, Small Business Liability Relief and Brownfields Revitalization Act, *P.L. 107-118*; 2018, Brownfields Utilization, Investment and Local Development (BUILD) Act, *P.L. 116-342*	U.S. EPA, U.S. Coast Guard	A brownfield site is real property that expansion, redevelopment, or reuse of is complicated by the presence or possible presence of hazards, pollutants, or contaminants. This includes mine scarred lands.	Eligible sites include those that meet the CERCLA definition of a brownfield.	Liable parties include owners and operators, any person responsible for disposal or a disposal facility, any person responsible for transport of hazardous waste. CERCLA protects knowing purchasers, contiguous property owners, innocent land owners, and creditors from liability.	CERCLA authorizes a number of grants and loans for brownfield redevelopment, the most significant being EPA'S Brownfields and Land Revitalization Program.	CERCLA response actions are not required to obtain federal, state, or local permits for activities conducted exclusively on site.	**HIGH**

2017, Tax Cuts and Jobs Act *P.L. 115-97*	U.S. Treasury and IRS	Subject to CERCLA brownfield definition.	All real property composing a brownfield site satisfies the IRS's original use requirement. Investments in the site must be made to ensure basic safety standards for human health and the environment.	-	Investors who invest capital gains into qualified opportunity zones can defer and reduce their tax burden.	-	**HIGH**
2021, Infrastructure Investment and Jobs Act *P.L. 117-58*	U.S. EPA, U.S. Dept of Interior Office of Surface Mine Reclamation and Enforcement (DOI)	-	Subject to CERCLA eligibility requirements for specific sites, funding	-	Provides funding for brownfield activities and funding to both EPA and DOI.	Enables the Secretary to consult EPA and DOI to determine its regulations or guidance to prioritize and expedite clean energy siting on former mine sites.	**HIGH**
2022, Inflation Reduction Act (IRA) *P.L. 117-169*	U.S. Treasury and IRS	An energy community can be defined, in part, as a brownfield site defined under CERCLA.	Qualified facilities must be located in an energy community.	-	ITC shall be increased by 10%	-	**MEDIUM**

Michigan law addresses brownfield redevelopment on a more cursory level than U.S. federal law and displays an overall medium level of alignment within itself. State legislation such as the 1994 Natural Resources and Environmental Protection Act (NREPA) and the 1996 Brownfield Redevelopment Financing Act (BRFA) work in conjunction to define brownfield sites, their eligibility for initiatives, liability considerations, financial support, and site permitting. Michigan's brownfield definitions are somewhat consistent, with their sweeping definitions of brownfield sites, financial resources, and robust liability protections. Michigan's eligibility criteria between acts varies, with NREPA eligibility focusing on site eligibility and BRFA focusing on eligible authorities. However, BRFA does additionally refer back to NREPA's definition of site eligibility. Permitting requirements are seemingly only a concern for specific brownfield projects who wish to access particular incentives. These issues do not directly cause conflict between these policies. Michigan falls victim to the same issues federal legislation does, failing to properly consider renewable energy developments or community priorities. EGLE, similar to EPA, discusses the potential for renewable energy development on brownfield sites, but these projects appear to happen infrequently in the state. The results of this analysis can be found in Table 6.

While both state and federal law boast relatively high levels of horizontal alignment, they fail to show this alignment between themselves. Federal and state legislation mostly fails to conflict with or support the others, leading to a medium degree of vertical alignment. Definitions, eligibility criteria, liability definitions and protections, and financial opportunities are similar enough not to conflict, though their failure to agree with each other is also apparent. Permitting requirements between the two bodies conflict, as CERCLA exempts response actions on a brownfield site from permitting, while Michigan requires projects seeking specific types of state funding to submit work plans. The issues that exist for these bodies horizontally continue to exist vertically, and the results of this analysis can be found in Table 7.

Table 6. Michigan Horizontal Alignment

Legislation	Agency	Definition	Eligibility	Liability	Financial	Permitting	Alignment
1994, Natural Resources and Environmental Protection Act (NREPA) *1994 PA 451*	Michigan Department of Natural Resources (DNR)	An eligible property [brownfield] is any area, place, parcel(s), or portion of a parcel where a hazardous substance in excess of satisfactory concentrations has been released, deposited, disposed of, or otherwise is located. It may additionally or otherwise be a historic resource or blighted property.	A brownfield project means the entire project, including site remediation and further economic development.	NREPA protects buyers of contaminated properties, so long as they did not cause contamination and follow specific provisions. Lenders, fiduciaries, etc. are protected from liability.	Provides grant and loan funding for qualified brownfield projects, including repeated awards.	-	**MEDIUM**
1996, Brownfield Redevelopment Financing Act (BRFA) *1996 PA 381*	Michigan Strategic Fund (MSF), Michigan Economic Development Corporation (MEDC), Michigan Department of Environment, Great Lakes, and Energy (EGLE)	An eligible property is as defined by *1994 PA 451,* a historic resource, tax reverted, functionally obsolete, or a blighted property.	A brownfield redevelopment authority (BRA) or a developer working via a BRA.	-	Authorizes Tax Increment Financing (TIF) for state brownfields, as well as creates a state brownfield revolving fund from which brownfield grants and loans are distributed. Additionally allows the creation of local BRA and establishment of local brownfield revolving funds.	Projects that seek to capture state education and school operating taxes must submit work plans to EGLE or MEDC, depending on the project's associated environmental activities.	**MEDIUM**

Table 7. Vertical Alignment between U.S. Federal Law and Michigan Law

Level	Legislation	Agency	Definition	Eligibility	Liability	Financial	Permitting
Federal	CERCLA *P.L. 96-510*	U.S. EPA, U.S. Coast Guard	A brownfield site is real property that expansion, redevelopment, or reuse of is complicated by the presence or possible presence of hazards, pollutants, or contaminants. This includes mine scarred lands.	Eligible sites include those that meet the CERCLA definition of a brownfield.	Liable parties include owners and operators, any person responsible for disposal or a disposal facility, any person responsible for transport of hazardous waste. CERCLA protects knowing purchasers, contiguous property owners, innocent land owners, and creditors from liability.	CERCLA authorizes a number of grants and loans for brownfield redevelopment, the most significant being EPA'S Brownfields and Land Revitalization Program.	CERCLA response actions are not required to obtain federal, state, or local permits for activities conducted exclusively on site.
State	NREPA *1994 PA 451*	Michigan Department of Natural Resources (DNR)	An eligible property [brownfield] is any area, place, parcel(s), or portion of a parcel where a hazardous substance in excess of satisfactory concentrations has	A brownfield project means the entire project, including site remediation and further economic development.	NREPA protects buyers of contaminated properties, so long as they did not cause contamination and follow specific provisions. Lenders, fiduciaries, etc. are protected from liability.	Provides grant and loan funding for qualified brownfield projects, including repeated awards.	-

			been released, deposited, disposed of, or otherwise is located. It may additionally or otherwise be a historic resource or blighted property.				
State	Brownfield Redevelopment Financing Act *1996 PA 381*	Michigan Strategic Fund (MSF), Michigan Economic Dev. Corporation (MEDC), Michigan Department of Env., Great Lakes, and Energy (EGLE)	An eligible property is as defined by *1994 PA 451,* a historic resource, tax reverted, functionally obsolete, or a blighted property.	A brownfield redevelopment authority (BRA) or a developer working via a BRA is eligible to access funds.	-	Authorizes Tax Increment Financing (TIF) for state brownfields, as well as creates a state brownfield revolving fund from which brownfield grants and loans are distributed. Additionally allows the creation of local BRA and establishment of local brownfield revolving funds.	Projects that seek to capture state education and school operating taxes must submit work plans to EGLE or MEDC, depending on the project's associated environmental activities.
Federal	Tax Cuts and Jobs Act *P.L. 115-97*	U.S. Treasury and IRS	Subject to CERCLA brownfield definition.	All real property composing a brownfield site satisfies the IRS's original use requirement.	-	Investors who invest capital gains into qualified opportunity zones can defer and	-

				Investments in the site must be made to ensure basic safety standards for human health and the environment.		reduce their tax burden.	
Federal	Infrastructure Investment and Jobs Act *P.L. 117-58*	U.S. EPA, U.S. Dept of Interior Office of Surface Mine Reclamation and Enforcement (DOI)	-	Subject to CERCLA eligibility requirements for specific sites, funding	-	Provides funding for brownfield activities and funding to both EPA and DOI.	Enables the Secretary to consult EPA and DOI to determine its regulations or guidance to prioritize and expedite clean energy siting on former mine sites.
Federal	IRA *P.L. 117-169*	U.S. Treasury and IRS	An energy community can be defined, in part, as a brownfield site defined under CERCLA.	Qualified facilities must be located in an energy community.	-	Solar ITC shall be increased by 10%	-
Align.			**MEDIUM**	**MEDIUM**	**MEDIUM**	**MEDIUM**	**LOW**

3.7 Discussion

Existing brownfield redevelopment legislation may not prohibit community-centric RE projects, but it also fails to support or encourage them. Results of this analysis identify potential areas for improvement or inclusion of RE incentives and community-focused efforts within existing state and federal law. Additional modifications for existing programs at the state and federal levels are also discussed.

Federal law does a commendable job defining brownfields and their eligibility, however, both Federal and Michigan law could expand liability protections such that they are more sweeping. In addition, it would be beneficial to expand existing brownfield legislation to directly accommodate RE developments rather than simply recommending ways to access funding for a joint project, like EPA currently does. Programs like EPA's RE-powering could be integrated into brownfield redevelopment legislation to encourage and support RE redevelopment. This likely includes making brownfield funds accessible for site improvement rather than solely for remediation efforts.

Michigan law works to address its surplus of brownfields, but the limited state legislation highlights a need for more resources for brownfield developers considering RE projects. Michigan could benefit from expanding access to brownfield development funds to use them for site improvements rather than simply site remediation. Current projects, like the Mitchell Bentley Solar Garden, are only possible with significant support from utilities or other outside funders due to limitations on accessing brownfield funds. Michigan could use aspects inspired by Massachusetts's policy on developing brownfields to adapt its legislation to make it friendlier for these developments. Michigan's existing use of tax incentive financing (TIF) under BRFA does make brownfields more appealing as a resource to developers and could easily be integrated into future legislation to continue supporting new developments.

While this study did not address local law in Michigan, some consideration is required for a complete understanding of policy alignment. Local governments are granted the ability to form their own brownfield redevelopment authority (BRA) under Michigan's BRFA and to form local brownfield revolving funds. Additional consideration will be required under each locality's BRA to assess local redevelopment laws and regulations. While not addressed within existing law or policy, there is potential that the BRA may also be given the responsibility to assess acceptance and SLO surrounding the project. The BRA is likely made up of community members who have established relationships with other relevant stakeholders in the area, making it better equipped for this task than outside entities.

Existing legislation certainly has room to enable the use of brownfields for RE projects. Expanding existing programs, like RE-powering, and integrating concepts from places that successfully deploy renewables on contaminated lands, like in Massachusetts, can support a brownfield to brightfield boom. Federal and state law is predominantly indifferent to this type of development, neither encouraging nor discouraging it, leaving ample room for federal, state, and even local governments to shape the socio-politics of the situation moving forward. Suggestions for a legal framework that would better enable brownfields to be redeveloped into RE sites can be found in Table 8.

Table 8. Legal framework for community-centered renewable energy brownfield redevelopment

Level of Government	Recommendation	Suggested Tools
Federal	Expansion of EPAs RE-Powering to allow the program to provide grants and loans to renewable energy brownfield developments	Legislation, Grants, Loans
	Expansion of brownfield fund eligibility requirements to support certain types of new development on brownfield sites	Legislation, Grants, Loans
	Expansion of ITC to make non-solar projects eligible for 10% adder	IRS ITC
	Inclusion of provisions in grants and loans requiring certain measures of community engagement and ensuring SLO	Information
State	Adopt SMART-inspired program to support renewables on brownfield sites and accelerate permitting process	Generation Tariff, Virtual Net Metering
	Expansion of brownfield fund eligibility requirements to allow certain types of new development on brownfield sites	Legislation, Grants, Loans
	Provide developer guide for renewable energy brownfield redevelopment with provisions for community engagement and ensuring SLO	Information

3.8 Conclusion

This study used LFA to analyze federal and Michigan law related to community-centric RE brownfield redevelopment. Its findings indicate that existing law supports brownfield redevelopment but fails to make considerations for communities or to support RE development. RE development on brownfield sites often requires SLO, as seen in Cadillac's Mitchell Bentley Solar Garden, highlighting its importance as a consideration. The existing law and policy allow for RE development on brownfield sites. However, it requires a piecemeal approach to funding the remediation and installation aspects of the project due to limitations on the use of brownfield funds.

Aligning existing state and federal legislation is achievable and could help support future green energy efforts at contaminated sites throughout Michigan and the U.S. A legal framework for community-centric, RE projects on brownfields can be built around existing state and federal legislation with the addition of tools to identify community priorities and include them in project development. In doing so, these projects can work to protect justice and communities throughout their process.

U.S. federal law displays overall high to medium levels of alignment regarding brownfield redevelopment. Limited consideration is given to RE development or community priorities. Brownfield definitions, eligibility for redevelopment funds, and liability considerations are highly consistent between pieces of federal legislation, including the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Tax Cuts and Jobs Act, the Infrastructure Investment and Jobs Act, and the 2022 IRA. Financial and permitting considerations exhibit slightly less coherency, however, do not conflict or impede one another.

Michigan displays a medium degree of alignment. It falls victim to similar issues that are seen at the federal level. Michigan legislation fails to address RE and community priorities within their brownfield redevelopment law. Michigan brownfield definitions, eligibility of sites, and permitting exhibit little consistency between pieces of legislation but do not necessarily contradict or impede one another. Michigan boasts robust liability protections for brownfield sites and provides financial resources, such as grants, loans, and TIF, that can be used in conjunction with each other, indicating a higher level of alignment.

Overall, state and federal law exhibit a medium degree of vertical alignment for brownfield redevelopment, with both failing to adequately consider RE brownfield redevelopment or provide adequate consideration for community priorities when it comes to redevelopment. Brownfield definitions, eligibility of sites, liability, and financial incentives do not necessarily function in conjunction but do not interfere with one another. However, brownfield permitting conflicts do exist, indicating a low level of alignment between this aspect of the law.

This study concludes that while brownfield redevelopment legislation largely does not clash at the state and federal levels, it fails to support redeveloping brownfields for RE and with community priorities in mind. While brownfield redevelopment and remediation are supported, and RE development is supported, there needs to be more support between policies that encourage the explicit redevelopment of brownfields for RE. In addition, existing brownfield policy makes minimal consideration of community priorities, raising justice concerns for these redevelopment projects. Redeveloping brownfields for RE is a way to reutilize existing spaces to support future development and generations, but this is only possible with supportive policy. Given the variety in state-level brownfield policy, the state-level findings of this study are difficult to apply outside of Michigan. However, the technique and federal findings can be used to understand policy alignment between federal law and other states.

This research indicates a need for comprehensive, aligned brownfield and energy law and policy built around principles of justice and engagement. Enabling RE development on brownfield sites can help support the world's growing demand for energy without compromising existing green spaces. Redeveloping brownfield sites can help rebuild communities that may suffer due to their proximity to contaminated sites and improve access to green energy in a world where it is the only path forward.

Future research should further consider the justice implications of redeveloping brownfield sites for renewable energy. In addition, it should examine the need to balance development needs with community priorities when the two may not align. While community priorities should remain paramount for each development project, conflict is likely unavoidable. Local governments and stakeholders are operating with more limited resources than state or federal governments, which requires examining how this resource gap can be minimized to support community needs and desires. This paper introduces brownfield legislative alignment between Michigan and the federal government that is absent from existing literature.

3.9 References

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Chapter 4: Conclusions

4.1 Implications and Recommendations

This thesis explored different dimensions of social acceptance within two distinct types of sustainable redevelopment to characterize the role that acceptance can play within policymaking and broader redevelopment efforts. While genetically improved forests and brownfield redevelopment contribute to different spheres of redevelopment, both stand to benefit from a marked inclusion of community priorities and the acquisition of SLO, which can contribute to environmental justice in terms of both procedural and distributional issues. The work conducted here is intended to set a stage for inclusion of social acceptance issues in redevelopment by providing information about what characterizes acceptance and how it may be included within policy moving forward.

Chapter 2 analyzes viewpoints of GITs among FFOs in three midwestern states with significant forest cover to contribute a new perspective to conversations on GIT adoption and acceptance. Survey results indicate that respondent FFOs hold varying levels of perceived risks and benefits for different species of trees and different levels of genetic improvement. Respondents associated lower levels of risk and higher levels of benefit with lower levels of genetic improvement that can be perceived as more “natural,” which other field studies support (Hajjar & Kozak, 2015; Hajjar et al., 2014; Fuller et al., 2016). FFO respondents tended to believe that the benefits of GIT outweigh the potential risks and show a greater willingness to plant GITs of species they are concerned about. These findings indicate that GIT science and policy should focus on improvement methods that are perceived as more “natural” among adopting populations. In addition, policymakers and scientists alike should focus on protecting local ecologies and bolstering native species’ genetics before introducing foreign genetic matter or introducing new species. This paper demonstrates the need to consider the perspective of technology adopters to ensure science and policy can support the factors important to adoption instead of focusing on factors important to non-adopting populations such as the general public.

Chapter 3 reviews federal and Michigan law pertaining to brownfield redevelopment and assesses policy alignment before recommending a supportive legal framework for redevelopment. Analysis reveals overall medium to high levels of vertical and horizontal policy alignment regarding brownfield redevelopment, however, limited to no consideration is made within these policies for community priorities or RE siting. Policies are supportive of brownfield remediation, with funding often limited to these efforts and barred from use for site improvement (such as installing new technology). In addition, policies do not make explicit considerations or support RE developments, as seen in some other states, like Massachusetts. Recommendations on community engagement are limited to best practices and are not codified or required by brownfield redevelopment policy. These findings indicate a need for redevelopment policy to consider community priorities and SLO to ensure community buy-in as well as just processes and outcomes. A legal framework for community-centric RE development can be built around existing state and federal policy with the addition of tools that prioritize SLO and adoption by community members.

4.2 Limitations

The findings of this thesis have their limitations, which has several implications for future work. Chapter 2 is limited by survey non-response error and a small sample size. In addition, it fails to provide an understanding of forest property specifics among respondents, which may be necessary to truly understand their opinions on GITs. This chapter and survey could be improved by gathering more responses, which could be achieved by tailoring surveys to different ecological areas of the study region. Additionally, Chapter 2 may benefit from in-person surveying to improve response rates. While these factors should be considered when interpreting the findings, Chapter 2 still provides value to the field of study by surveying an adopting population that has been excluded from existing GIT acceptance research.

Chapter 3 is limited by its study region, focusing only on one state's policy alongside the U.S. federal law and a limited number of analyzed documents, aspolicy documents were limited to brownfield redevelopment-specific documents. This chapter and its analysis could be improved by including additional state policies and by expanding the documents in the alignment analysis to include RE policy and legislation. However, while these limitations are important to remember, Chapter 3 still provides valuable insights into brownfield redevelopment for RE developments that are currently missing from the field. It additionally works to connect community acceptance and SLO to this type of brownfield redevelopment at the policy level, which has seldom been done in the existing literature.

Lastly, my own positionality limits this thesis and its components. While I have worked to expand my understanding of these topics, the fact remains that my work carries an inherently Western perspective, and my research here has focused on the Midwestern U.S. What constitutes sustainable redevelopment is likely to look quite different in other regions of the world and will require studies to address the uniqueness of diverse policy environments and community needs across regions and nations.

4.3 Future Work

The work presented here introduces two approaches to sustainable redevelopment, including redeveloping brownfield sites for RE and planting GIT on FFO land, that each indicate a need for more extensive work in sustainable redevelopment at large to understand acceptance of varying technologies. There is room for work examining the socio-political dimensions of sustainable development and the design of community-centric, SLO-oriented approaches to redevelopment. In a world where sustainability can be considered the only path forward (Ditlev-Simonsen, 2021; Pintér et al., 2005), it becomes imperative to examine how community priorities can be integrated to ensure justice within redevelopment efforts.

Next steps include designing templates or standard processes for prioritizing community and adopter acceptance that can be applied to different types of sustainable redevelopment to make the inclusion of acceptance criteria easier. This could include approaches to engagement with different communities and best practices to ensure the prioritization of community needs and desires. This guide would need significant flexibility given the variations between dimensions of sustainable redevelopment, however, it could offer example applications and highlight sections where additional project-specific considerations are required. It could include additional considerations to be made by policymakers versus developers to allow more tailored approaches to different types of redevelopment or among different communities depending on their role within the project as implementers of a project or technology as opposed to those that are simply impacted by a project or technology.

Future research related to GITs should generally focus on acceptance among adopting populations as opposed to potentially impacted populations. Future research regarding the redevelopment of brownfields into RE sites should examine how the history of a site and its role in a community can influence the acceptance of its operation and the SLO a community grants site developers. Each instance has the potential to contribute to acceptance-centered policy and create more just redevelopment spaces that give power back to communities.

4.4 Final Thoughts

Acceptance-informed redevelopment policy is, regardless of context, non-negotiable for true and long-lasting sustainability. Current research and policy lack sufficient acceptance considerations, contributing to a gap between policy formulation and policy implementation that can harm communities and development efforts alike. The scale at which acceptance is considered and integrated into development plans and policies is relevant to establishing long-term, sustainable change in policy making. In addition, and perhaps more importantly, whose acceptance or SLO is considered should be treated as an overriding consideration in each effort or policy. The acceptance of those who will influence implementation of policy through technology adoption versus those who are impacted by policy and technology will influence policy design and failure potential. When policy focuses on acceptance among impacted populations instead of implementing populations, the likelihood of policy gaps grows due to the different considerations likely to be made by adopters that other populations cannot fully consider.

This thesis relied on concepts of acceptance, justice, power, and inclusive decision-making to assess the importance and inclusion of acceptance within two subsects of sustainable redevelopment and their policy. Sustainable redevelopment is a far-reaching field that necessitates continued and repeated discussion surrounding its issues. Still, this thesis contributes new understandings of the importance of acceptance-informed sustainable redevelopment. Both chapters attempt to assess acceptance from a unique perspective while reconciling the greater theme of acceptance in sustainable redevelopment. Each chapter works to address current limitations in science and policy implementation within its own sphere.

Not every redevelopment effort will be acceptable to every population, nor must they be. Some efforts will be contrary to a community's core values or will be underdeveloped to the point where a community cannot offer SLO due to a lack of information. However, every redevelopment effort must *consider* acceptance. The same is true for policy making. Including acceptance in all conversations of sustainable redevelopment opens the door for more just developments that give back power to communities historically omitted from these spaces.

Policy that is formulated with acceptance among adopters as distinct from those who are impacted in mind is policy that communities are more likely to implement. These research findings focus on the importance of including acceptance in policymaking to ensure justice, manage power, and reduce the formulation-implementation gap. Redevelopment for its own sake is not an inherently ethical pursuit. Redevelopment should be pursued such that it is in the best interest of the people and the communities that are impacted by it. To do so, these communities and their approval must be paramount to the development and policy process to ensure their voices are preserved along the way.

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Appendix A

A.1 Chapter 2: Survey Instrument

<u>Introductory Questions</u>

We'd like to start by asking you about your forestland in Michigan, Wisconsin, and Minnesota.

1. What is the total acreage of the forestland that you own?

☐	☐	☐	☐	☐	☐
0-20 acres	20-40 acres	40-60 acres	60-80 acres	80-100 acres	100+ acres

2. How many parcels of forestland do you own?
   Note: We are referring to parcels as they are taxed. For example, if you purchased 80 acres of continuous forest land but receive 2 tax bills for 40 acres each, you have 2 parcels.

☐	☐	☐
1 parcel	2-5 parcels	6+ parcels

3. How long has this land been in your family?

☐	☐	☐	☐
0-10 years	11-50 years	50-100 years	100+ years

4. Is the house that you reside in for at least 6 months of the year located on your forestland?

☐	☐
Yes	No

5. To what extent are you concerned about the following issues, if they are ecologically relevant to your property?

	Very nconcerned	Somewhat nconcerned	either	omewhat oncerned	Very oncerned	Not cologically Relevant
e presence d effects of nerald ash borer	☐	☐	☐	☐	☐	☐
he loss of ard maples	☐	☐	☐	☐	☐	☐
e threat of udden oak death	☐	☐	☐	☐	☐	☐
he loss of ritical jack ine habitat	☐	☐	☐	☐	☐	☐

<u>Assessment of Tree Genetic Improvement Techniques</u>

_*You will be introduced to three levels of genetic improvement that can be used in tree species as a tool of forest management. These questions will help researchers understand how you think about the risks and benefits associated with these general techniques.*

6. Level 1 genetic improvement of trees involves traditional breeding techniques. Trees from either the same species or different species are crossed to produce

and select trees that are better than either parent tree in regard to disease or pest resistance, stress tolerance, or product yield (e.g. timber, maple syrup, etc.). *Example: The apple variety 'Gala' was bred from apple varieties 'Golden Delicious' and 'Kidd's Orange Red' in the 1930s*

Please indicate to what extent you agree or disagree with the following statements for Level 1.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Unsure**
There is potential risk to myself.	☐	☐	☐	☐	☐	☐
There is potential risk to my forest property.	☐	☐	☐	☐	☐	☐
There is potential benefit to myself.	☐	☐	☐	☐	☐	☐
There is potential benefit to my forest property.	☐	☐	☐	☐	☐	☐
There is potential risk to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential benefit to society as a whole.	☐	☐	☐	☐	☐	☐

There is potential risk to trees and forests in my region.	☐	☐	☐	☐	☐	☐
There is potential benefit to trees and forests in my region.	☐	☐	☐	☐	☐	☐

7. Level 2 genetic improvement of trees involves traditional breeding like in the Level 1 description, but in Level 2, tree DNA is used to predict the traits of the bred offspring. This avoids having to wait for the trees to mature, saving time and money. *Example: Cacao production is threatened by black pod disease. Cacao breeding uses molecular markers to select for plants resistant to this disease. Resistant trees are identified at the seedling stage and do not need to be exposed to the disease.*

Please indicate to what extent you agree or disagree with the following statements for Level 2.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Unsure**
There is potential risk to myself.	☐	☐	☐	☐	☐	☐
There is potential risk to my forest property.	☐	☐	☐	☐	☐	☐
There is potential benefit to myself.	☐	☐	☐	☐	☐	☐

There is potential benefit to my forest property.	☐	☐	☐	☐	☐	☐
There is potential risk to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential benefit to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential risk to trees and forests in my region.	☐	☐	☐	☐	☐	☐
There is potential benefit to trees and forests in my region.	☐	☐	☐	☐	☐	☐

9. Level 3 genetic improvement of trees involves the introduction of foreign genes (genes from different plants) to local tree species, making them genetically modified organisms. Foreign genes are selected in response to a single trait, e.g. to create resistance in one tree species to an existing disease or improve a forest product (e.g. fiber quality in timber, maple syrup yield, etc.). *Example: A gene from wheat was introduced into American chestnut trees that allows them to survive chestnut blight.*

    Please indicate to what extent you agree or disagree with the following statements for Level 3.

	Strongl y Disagre e	**Disagre e**	**Neutral**	**Agree**	**Strongl y Agree**	**Unsure**

There is potential risk to myself.	☐	☐	☐	☐	☐	☐
There is potential risk to my forest property.	☐	☐	☐	☐	☐	☐
There is potential benefit to myself.	☐	☐	☐	☐	☐	☐
There is potential benefit to my forest property.	☐	☐	☐	☐	☐	☐
There is potential risk to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential benefit to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential risk to trees and forests in my region.	☐	☐	☐	☐	☐	☐
There is potential benefit to trees and forests in my region.	☐	☐	☐	☐	☐	☐

Specific Genetic Improvement Scenarios

_*We will now present to you four specific scenarios of potential genetic improvement of tree species. We want to better understand how you think about the potential risks and benefits of genetic improvement in each individual scenario.*

9. Scenario 1 – The Jack Pine and Kirtland's Warbler Populations: The jack pine is vital to the survival of the Kirtland's Warbler, a bird that will only build its nests under the tree. Loss of jack pines would also mean the loss of the Kirtland's Warbler. Researchers have shown that it is possible to make genetic improvements to improve a tree's heat tolerance, one critical factor endangering jack pine. If scientists provided a genetically improved jack pine through local nurseries, what do you think about the relative risks versus benefits of doing so?

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Unsure**
There is potential risk to myself.	☐	☐	☐	☐	☐	☐
There is potential risk to my forest property.	☐	☐	☐	☐	☐	☐
There is potential benefit to myself.	☐	☐	☐	☐	☐	☐
There is potential benefit to my forest property.	☐	☐	☐	☐	☐	☐
There is potential risk to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential benefit to society as a whole.	☐	☐	☐	☐	☐	☐

There is potential risk to trees and forests in my region.	☐	☐	☐	☐	☐	☐
There is potential benefit to trees and forests in my region.	☐	☐	☐	☐	☐	☐
The benefit of protecting the Kirtland's Warbler outweighs the risks associated with genetic improvement.	☐	☐	☐	☐	☐	☐

10. How likely are you to consider planting these genetically improved trees?

☐	☐	☐	☐	☐	☐
Very Unlikely	Unlikely	Uncertain	Likely	Very Likely	Species isn't suitable to my land

11. Scenario 2 – The Timber Value of Oak Trees: The northern red oak holds significant economic value in local and regional timber markets. Genetically improved northern red oaks would see improved growth, increasing the value of your harvested trees in these markets. If scientists selected northern red oaks for improved growth and provided them through local nurseries, what do you think about the relative risks versus benefits of doing so?

	Strongly	**Disagree**	**Neutral**	**Agree**	**Strongly**	**Unsure**

	Disagree				Agree	
There is potential risk to myself.	☐	☐	☐	☐	☐	☐
There is potential risk to my forest property.	☐	☐	☐	☐	☐	☐
There is potential benefit to myself.	☐	☐	☐	☐	☐	☐
There is potential benefit to my forest property.	☐	☐	☐	☐	☐	☐
There is potential risk to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential benefit to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential risk to trees and forests in my region.	☐	☐	☐	☐	☐	☐
There is potential benefit to trees and forests in my region.	☐	☐	☐	☐	☐	☐

The benefit of increased economic value outweighs the risks associated with genetic improvement.	☐	☐	☐	☐	☐	☐

12. How likely are you to consider planting these genetically improved trees?

☐	☐	☐	☐	☐	☐
Very Unlikely	Unlikely	Uncertain	Likely	Very Likely	Species isn't suitable to my land

13. Scenario 3 – The Emerald Ash Borer and Ash Trees: The emerald ash borer has devastated ash populations throughout regions of the United States. Genetic improvement could provide ash trees that are resistant to the emerald ash borer, allowing populations to recover. If scientists provided a genetically improved ash that was resistant to emerald ash borer through local nurseries, what do you think about the relative risks versus benefits of doing so?

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Unsure**
There is potential risk to myself.	☐	☐	☐	☐	☐	☐
There is potential risk to my forest property.	☐	☐	☐	☐	☐	☐

There is potential benefit to myself.	☐	☐	☐	☐	☐	☐
There is potential benefit to my forest property.	☐	☐	☐	☐	☐	☐
There is potential risk to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential benefit to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential risk to trees and forests in my region.	☐	☐	☐	☐	☐	☐
There is potential benefit to trees and forests in my region.	☐	☐	☐	☐	☐	☐
The benefit of emerald ash borer resistance outweighs the risks associated with genetic improvement.	☐	☐	☐	☐	☐	☐

14. How likely are you to consider planting these genetically improved trees?

☐ ☐ ☐ ☐ ☐ ☐

Very Unlikely	Unlikely	Uncertain	Likely	Very Likely	Species isn't suitable to my land

<u>15. Scenario 4 – Climate Changes and Maple Trees:</u> The hard maple is economically and culturally significant throughout the northern midwestern United States. Given changes to climatic conditions in the region in the coming 50-100 years, maple trees may be unable to survive in this region unless they are bred and selected to survive these environmental changes. If scientists provided hard maple through local nurseries that could continue to thrive in the Midwest, what do you think about the relative risks versus benefits of doing so?

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Unsure**
There is potential risk to myself.	☐	☐	☐	☐	☐	☐
There is potential risk to my forest property.	☐	☐	☐	☐	☐	☐
There is potential benefit to myself.	☐	☐	☐	☐	☐	☐
There is potential benefit to my forest property.	☐	☐	☐	☐	☐	☐
There is potential risk to society as a whole.	☐	☐	☐	☐	☐	☐

There is potential benefit to society as a whole.	☐	☐	☐	☐	☐	☐
There is potential risk to trees and forests in my region.	☐	☐	☐	☐	☐	☐
There is potential benefit to trees and forests in my region.	☐	☐	☐	☐	☐	☐
The benefit of protecting hard maples outweighs the risks associated with genetic improvement.	☐	☐	☐	☐	☐	☐

16. How likely are you to consider planting these genetically improved trees?

☐	☐	☐	☐	☐	☐
Very Unlikely	Unlikely	Uncertain	Likely	Very Likely	Species isn't suitable to my land

Values & Beliefs

Please indicate the extent to which you agree or disagree with the following statements.

Strongly Disagree Neutral Agree Strongly

		Disagree				Agree
17.	*The primary value of forests is to provide benefits to humans.*	☐	☐	☐	☐	☐
18.	*The balance of nature is delicate and easily upset.*	☐	☐	☐	☐	☐
19.	*Forests should be protected for their own sake rather than to meet the needs of humans.*	☐	☐	☐	☐	☐
20.	*Forests are only valuable if they provide jobs or income for people.*	☐	☐	☐	☐	☐
21.	*Humans were meant to rule over nature.*	☐	☐	☐	☐	☐
22.	*Humans should manage forests primarily for human benefit.*	☐	☐	☐	☐	☐
23.	*Humans will eventually learn enough about nature that they will be able to control it.*	☐	☐	☐	☐	☐
24.	*We are approaching the limit of the number of people the Earth can support.*	☐	☐	☐	☐	☐

25.	*The needs of humans are more important than the needs of forests.*	☐	☐	☐	☐	☐
26.	*Human interference with nature often produces disastrous* consequences.	☐	☐	☐	☐	☐

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
27.	*Humans are seriously abusing the environment.*	☐	☐	☐	☐	☐
28.	*Nature is strong enough to cope with the impacts of modern industrial nations.*	☐	☐	☐	☐	☐
29.	*It is pointless to come up with solutions to environmental problems because nature is unpredictable.*	☐	☐	☐	☐	☐
30.	*If humankind continues on its present course, we will soon experience a major ecological catastrophe.*	☐	☐	☐	☐	☐

31.	*Forests have value whether humans are present or not.*	☐	☐	☐	☐	☐
32.	*Human ingenuity will prevent us from making the Earth unlivable.*	☐	☐	☐	☐	☐
33.	*The Earth has very limited room and resources.*	☐	☐	☐	☐	☐
34.	*We can develop technologies to solve our most pressing environmental problems.*	☐	☐	☐	☐	☐
35.	*Humans have the right to modify the natural environment to suit their needs.*	☐	☐	☐	☐	☐
36.	*Forests exist primarily to be used by humans.*	☐	☐	☐	☐	☐
37.	*Forests have the same right to exist that humans do.*	☐	☐	☐	☐	☐
38.	*Humans are still subject to the laws of nature.*	☐	☐	☐	☐	☐
39.	*We must change human behavior to manage environmental problems.*	☐	☐	☐	☐	☐

Demographics

The following information will ask for your demographic information.

40. How old are you? ___

41. What is your gender?

☐	☐	☐	☐
Female	Male	Other	Decline to Say

42. What is your highest level of education?

☐	☐	☐	☐	☐	☐
Less than High School	High School	Associate's Degree	Bachelor's Degree	Graduate Degree	Decline to Say

43. Please indicate your total household income.

☐	☐	☐	☐
0-$50,000	$50-$100,000	$100,000+	Decline to Say

44. Please rank how important the following reasons are to you for owning forest land from "least important" to "most important."

	Least Important	**Somewhat Unimportant**	**Neither**	**Somewhat Important**	**Most Important**

Economic	☐	☐	☐	☐	☐
Conservation	☐	☐	☐	☐	☐
Family Legacy	☐	☐	☐	☐	☐
Personal Enjoyment	☐	☐	☐	☐	☐
Natural Beauty	☐	☐	☐	☐	☐

45. What is your political ideology?

☐	☐	☐	☐	☐	☐
Very Liberal	Liberal	Neutral	Conservative	Very Conservative	Decline to Answer

Thank you for taking the time to complete this survey. Is there anything else you would like us to know?

____

__

A.2 Chapter 2: Reliability Analysis

Table 1. Reliability Analysis Results

Question Sets	**Scale Components**	**Cronbach's Alpha**	**Resulting Scale Variable**
Level 1 GIT Risk/Benefits		0.461	-
Please indicate to what extent you agree or disagree with the following statements for Level 1:			
	There is potential risk to myself.		
	There is potential risk to my forest property.		
	There is potential benefit to myself.		
	There is potential benefit to my forest property.		

	There is potential risk to society as a whole.		
	There is potential benefit to society as a whole.		
	There is potential risk to trees and forests in my region.		
	There is potential benefit to trees and forests in my region.		
Level 2 GIT Risk/Benefits		0.333	-
Please indicate to what extent you agree or disagree with the following statements for Level 2:			
	There is potential risk to myself.		

	There is potential risk to my forest property.		
	There is potential benefit to myself.		
	There is potential benefit to my forest property.		
	There is potential risk to society as a whole.		
	There is potential benefit to society as a whole.		
	There is potential risk to trees and forests in my region.		
	There is potential benefit to trees and forests in my region.		
Level 3 GIT Risk/Benefits		0.368	-

Please indicate to what extent you agree or disagree with the following statements for Level 3:			
	There is potential risk to myself.		
	There is potential risk to my forest property.		
	There is potential benefit to myself.		
	There is potential benefit to my forest property.		
	There is potential risk to society as a whole.		
	There is potential benefit to society as a whole.		
	There is potential risk to trees and forests in my region.		

	There is potential benefit to trees and forests in my region.		
Level 1-3 GIT Benefits		0.946	BenefitScale
Please indicate to what extent you agree or disagree with the following statements for Level 1/2/3:			
	There is potential risk to myself.		
	There is potential risk to my forest property.		
	There is potential benefit to myself.		
	There is potential benefit to my forest property.		
	There is potential risk to society as a whole.		

	There is potential benefit to society as a whole.		
	There is potential risk to trees and forests in my region.		
	There is potential benefit to trees and forests in my region.		
Level 1-3 GIT Risks		0.948	RiskScale
Please indicate to what extent you agree or disagree with the following statements for Level 1/2/3:			
	There is potential risk to myself.		
	There is potential risk to my forest property.		

	There is potential risk to society as a whole.		
	There is potential risk to trees and forests in my region.		
Level 1-3 GIT Risk/Benefits Scale		0.695*	RiskBenefitFULL*
Please indicate to what extent you agree or disagree with the following statements for Level 1/2/3:			
	There is potential benefit to myself.		
	There is potential benefit to my forest property.		
	There is potential benefit to society as a whole.		
	There is potential benefit to trees and		

	forests in my region.		
Level 1 Benefits		0.824	Level1Benefit
Level 1 Risks		0.884	Level1Risks
Level 2 Benefits		0.912	Level2Benefits
Level 2 Risks		0.924	Level2Risks
Level 3 Benefits		0.932	Level3Benefits
Level 3 Risks		0.93	Level3Risks
VBN		0.324	-
Modified NEP		0.269	-
Forest Values		0.122	-

** While the reliability analysis of the Level 1-3 GIT Risk/Benefit responses returned a Cronbach's alpha of 0.695 after omitting one question, it was combined into an index variable given the high Cronbach's alpha values that BenefitScale and RiskScale achieved independently as well as its proximity to the accepted value of 0.7. In addition, correlation analysis of the Risk & Benefit scales revealed a Pearson coefficient of -0.613.*