The Bioenergy Alliance Network of the Rockies:

A "Next Generation" Approach to Forest Management

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Authorization to Submit Thesis

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Abstract

Western forests have become fuels-laden due to decades of wildfire suppression policy. Fuels-laden forests are then stressed by both the direct and indirect effects of climate change including increased severity and frequency of wildfires, and increased insect and disease outbreaks due to rising temperatures and drought. Longer and more severe fire seasons are then threatening humans in the expanding wildland urban interface. However, American environmental policy has been gridlocked due to the American "green state" making implementing forest management policy that addresses current climatic and social conditions difficult. To address this complex environmental problem, a "next generation" approach to forest management was introduced in 2013. The Bioenergy Alliance Network of the Rockies (BANR) is a multi-faceted Coordinated Agriculture Project funded by the United States Department of Agriculture to address the most recent outbreak of bark beetles in the western United States by harvesting beetle-killed trees to improve forest health and provide a renewable source of energy. To determine the potential for BANR as a "next generation" approach to avoid gridlock a mixed-methods procedure that included conceptual mapping, interviews, and a spatial analysis were done. Results from this procedure indicated that the innovative approach will have the most potential to avoid gridlock in the wildland urban interface where social considerations outweigh ecological concerns.

Keywords: bark beetle, political gridlock, wildland urban interface, wildfire, climate change

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Dedication

To my father: *for your eternal love and support, I will forever be your only daughter*

To my mother: *for your unfaltering love and support*

To my brothers: *for always having my back*

To my friends: *for the joy and happiness you bring to my life*

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1. INTRODUCTION: A "NEXT GENERATION" APPROACH

One hundred years after the 1910 Big Burn, a century of fire suppression and other management practices have led to a fuels-laden landscape contributing to high-intensity fires threatening property, natural resources, and people (United States Forest Service [USFS], 2012) (Busenberg, 2004). The threat of increasing severity and frequency of wildfire is then likely intensified in certain regions by the direct effects of climate change such as persistent drought and increasing temperatures (Brown, Hall, & Westerling, 2004). Since the 1970s, the fire season has increased from an average of five months to an average of seven months as of 2014 (Cleetus & Mulik, 2014). In addition the direct effects of climate change there are indirect effects such as increasing disease and insect outbreaks. The most recent outbreaks of bark beetle in western forests is an indirect effect of climate change. Bark beetles have been a natural part of the ecosystem for millennia (Black, 2010). They appear cyclically and play a role in nutrient cycling in an otherwise nutrient poor system. The beetles employ a "mass attack" strategy to overwhelm a single tree while simultaneously introducing harmful fungi and bacteria as they move throughout the tree, then lay their eggs within the tree's phloem where the larvae go through a maturation process and eventually leave to attack another host tree (Raffa et al., 2008). Since 1996, about forty-two million acres of United States' (US) forests have been significantly affected by large beetle infestations, with the major outbreaks occurring during the last decade (Meddens, Hicke, & Ferguson, 2012). This phenomenon is concurrent with warming temperatures and drought in the western US (Bentz et al., 2010).

The bark beetle utilizes diapause and developmental timing for reproduction and growth which are directly influenced by climate as they both depend on temperature (Bentz et al., 2010). Therefore, when there are fewer colder days, there is less cold-induced beetle mortality (Bentz et al., 2010). Additionally, the trees are increasingly vulnerable to beetle attack due to the indirect effects of climate change that include community associates (fungal symbionts), host-tree vigor (reduced defense mechanisms due to climatic water stress), and host-tree abundance (Bentz et al., 2010). This suggests a strong correlation between warming temperatures and drought and widespread bark beetle outbreaks (Bentz et al., 2010).

The most recent outbreaks of bark beetle are the largest and most severe in recorded history (Bentz et al., 2010) having a direct effect on net carbon fluxes. From 1997 to 2010, the amount of carbon released from beetle-killed trees was similar to the amount of carbon released from wildfires (Hicke, Meddens, Allen, & Kolden, 2013). Together, they have killed trees that contained greater than 100 Tg C (Hicke et al., 2013). Although carbon releases can be offset by new growth in following decades, the subsequent replacement of beetle-killed trees can be other tree species or plant associations (Bentz et al., 2010). There are locations in British Colombia, Canada that have switched from being a slight carbon sink to a carbon source immediately following beetle outbreaks (Kurz et al., 2008). These beetle-affected forests are comprised of dry fuels that are likely susceptible to more severe wildfires at certain phases following beetle attack and under certain environmental conditions (CSU, BANR) (Hicke, Johnson, Hayes, & Preisler, 2012). During the early phase of a beetle-affected tree when the tree is dry but still has needles, the probability of dangerous crown fires increases but, this phase does not change surface fire behavior (Hicke et al., 2012). During the later phases when the tree is dry but has lost needles, the probability of surface fire increases due to increased surface fuel-loads and the probability of crown fires is reduced (Hicke et al., 2012). Although the changing phases are significant to wildfire behavior, other important factors include climate, weather, topography, and forest type (Hicke et al., 2012).

The Bioenergy Alliance Network of the Rockies (BANR) is an innovative response to forest management designed to address the threat of wildfire from fuels-laden forests made worse by the direct and indirect effects of climate change. The collaborative project "aims to explore the use of beetle-killed and other forest biomass as a bioenergy feedstock, and provide rigorous scientific underpinnings to support a sustainable regional renewable energy industry" (Colorado State University [CSU], BANR). The dead trees are a potential source of a vast woody biomass resource as they require no cultivation, are not used for food, and have a potential favorable carbon balance (CSU, BANR). BANR is a Coordinated Agricultural Project (CAP) funded by the Agriculture and Food Research Initiative (AFRI) Competitive Grant from the US Department of Agriculture (USDA), National Institute of Food and Agriculture (NIFA). In addition to the University of Idaho, there are four other universities working on this project including Colorado State University, Montana State University, the University of Montana, and the University of Wyoming. The project is separated into task groups including feedstock supply, feedstock logistics and processing, system performance and sustainability, education, extension and outreach, and health and safety (CSU, BANR). Within the system performance and sustainability task group, there are six subgroups including field-scale environmental impacts, impacts of biochar use on biofuel sustainability, life cycle assessment, financial analysis, socioeconomic and policy analysis, and decision support system. The task group encompassing this research is system performance and sustainability, and socioeconomic and policy analysis. The goal of the task group is to analyze economic, sociocultural, and policy constraints for beetle-killed and other forest biomass as biofuel feedstock and to develop options for understanding, clarifying, mitigating, or overcoming socioeconomic and policy barriers to the production of carbon-negative biofuel and biochar (CSU, BANR). Additional goals of this group include cost-benefit analyses, the social acceptability of biomass removal and biofuel/biochar production, and public policy analyses (CSU, BANR). However, measuring success of this project, in terms of traditional success measures such as acres treated or kilowatt hours of energy produced, is not possible until it is fully implemented with quantifiable results. Therefore, an alternative method of determining success might begin by asking the question, “what is BANR?”

From a policy perspective, BANR is an approach that aligns with what Christopher Klyza and David Sousa (2010, 2013) label the “next generation” agenda to environmental policymaking. An approach that follows the “next generation” agenda is an alternative method to environmental policymaking that provides an innovative response to a complex environmental problem to avoid the current political structure caused by the American “green state” (Klyza & Sousa, 2013). The “green state,” of which the top layer is the “golden era” of environmentalism, is the build-up of outdated environmental laws and the commitments to these statutes by federal agencies, creating American environmental policy gridlock (Klyza & Sousa, 2013). The “golden era” was the period between 1964 and 1980 when environmental groups had a series of victories that “privileged their interests” (Klyza & Sousa, 2010). Legislation that was passed during this time included, but was not limited to, the Endangered Species Act (ESA), the National Environmental Policy Act (NEPA), Clean Water Act, and the Wilderness Act. Environmental policy in the U.S. has since been characterized by the resilience of these basic policy commitments (Klyza & Sousa, 2010). The “green state” has made implementing environmental policies that address the current climatic and social conditions in the U.S. futile (Klyza & Sousa, 2010). According to Klyza and Sousa (2010), "institutional reconstruction is always extraordinarily difficult; legislative gridlock preserved the victories of the golden era, which do privilege environmental interests" (p. 445).

In order for environmental groups to have favorable policy outcomes, they must only "play defense" to protect the commitments of the "golden era" (Klyza & Sousa, 2010). This is the setting for the historical conflict between environmental and utilitarian values (Wilson, 2008). There are a few past victories for utilitarian interests, one of which was the 1995 "Salvage Rider" attached as an appropriation to a rescissions bill for the federal governments' 1995 fiscal year budget. However, the Rider was met with intense legal battles by environmentalists because of the vague language and threat to old growth forests (Dorn, 1996). The Rider has since created a lasting mistrust of the USFS and utilitarian interests by environmentalists. Therefore, if a federal agency wants to implement a new environmental policy, or change an old policy, they must either pass new legislation, which has proven to be extraordinarily difficult, or use an alternative method of policymaking to avoid gridlock. Today, the "golden era" legislation victories continue to have an immense importance on influencing environmental policy change in the US (Klyza & Sousa, 2013).

The "next generation" agenda draws on the shared knowledge that the laws of the "golden era" are ineffective at solving current environmental management problems (Klyza & Sousa, 2013). Klyza and Sousa (2013) suggest advocates of this agenda "seek more efficient, results-oriented policy and processes that will contribute to a better balancing of the many values at play in the environmental arena" and have a goal of improving the "performance of old objectives" and "modernizing current policies to address emerging concerns" (p. 4-5). The "next generation" agenda is about discovering new ways to tackle the increasingly complex past, present, and future environmental problems in an efficient manner with the least political opposition as possible (Kettl, 2004).

Forest management is an increasingly complex environmental problem due to both fuels build-up from a century of wildfire suppression and the direct and indirect effects of climate change enhancing the vulnerability of forests to more severe and frequent wildfires. Ecological concerns are stressed by social considerations including an increasing population in the wildland urban interface (WUI), the transitional areas that lie between wildlands and urbanized spaces (Galiana-Martin, Herrero, & Solana, 2011), and continued environmental policy gridlock. The Bioenergy Alliance Network of the Rockies is a "next generation" approach to forest management as it is an innovative response that attempts to balance the many interests involved to tackle a complex environmental problem. Since measuring the success of BANR will not be possible for another several decades, an alternative method for determining the success of BANR is the potential for the "next-generation" approach to avoid gridlock. A mixed-methods procedure that included conceptual mapping, key informant semi-structured interviews, and a spatial analysis, was used to assess the potential for BANR to avoid gridlock

A mixed-methods procedure designed to address complex research problems, offers deeper insight and an expanded understanding of a topic (Creswell, 2009). This research uses a sequential exploratory mixed-method procedure which uses quantitative data to assist in contextualizing the qualitative data (Creswell, 2009). The purpose of this procedure is first, to explore the research topic, and secondly, to apply it in a practical manner (Creswell, 2009). Furthermore, a mixed-methods procedure can provide strengths where there are weaknesses in only using quantitative or qualitative data (Creswell & Clark, 2007). Following a mixed-methods procedure, this research is designed to use the data collected during the first qualitative analysis to inform the second qualitative analysis, and then use the data collected during the second qualitative analysis to inform the final quantitative analysis. The mixed-methods approach findings suggest that the WUI is the place on the landscape where a "next generation" approach to forest management will avoid gridlock. Since the WUI is a place on the landscape where gridlock will be avoided it will be a place where future success could be measured using traditional measures of success.

2. CONCEPTUAL MAP: A COMPLEX ENVIRONMENTAL PROBLEM

Conceptual mapping is a graphic organizational tool that is used to visualize, explain, and explore complex problems and understandings of a topic (Hay & Kinchin, 2006). The process of building a concept map allows the researcher to better understand the complexities of the problem by creating a simplification of reality (Heemskerk, Wilson, & Pavao-Zuckerman, 2003). This process allows for connections to be drawn that, at first, are not realized, providing a tool to create new knowledge (McAleese, 1994). Creative production of new knowledge is enabled by the availability of numerous potential linkage sites (Hay & Kinchin, 2006) (Cañas & Novak, 2010). Although conceptual maps may lack the ability to provide an answer to a research question, they are effective tools to help answer research questions by generating new knowledge once connections are realized (Heemskerk et al., 2003).

The completed concept map provides a visualization of the knowledge and understanding of a topic (Hay & Kinchin, 2006). When interrupting the visual representation of a topic, the researcher engages in the information, ideas, and concepts (McAleese, 1994). Engagement of the topic occurs at two levels, the operational level and the cognitive level (McAleese, 1994). The operational level is the moving of nodes and linkages when creating the conceptual map. The cognitive level is the interrupting of the conceptual map. However, the two levels are not necessarily sequential, the processes can interact, informing one another (McAleese, 1994). Engagement at the two levels leads to the final visualization through a comprehensive process of checking the nodes and the linkages (McAleese, 1994). This process provides a better understanding and comprehension of a complex problem (Hartley, 2014). When the visualization is complete, it can be used to help answer complex research questions. The completed conceptual map is then used to “reach an agreement on how to proceed” (Kane & Trochim, 2007, p. 1) with a research question. The completed visualization can then be used for teaching or for sharing information (Hay & Kinchin, 2006). Ultimately, the conceptual map is aimed to place new perspectives on previous knowledge (Hartley, 2014).

2.1 Methods

Conceptual mapping using CMaps software was used in this research to first operationally visualize and then cognitively analyze the complex nature of a forest management approach that follows the “next generation” agenda. The map was based off of three primary nodes. These nodes included, socio-political considerations, socio-ecological considerations, and relevant ideas that shape a forest management approach that follows the “next generation” agenda. The primary nodes were chosen as the BANR task group that encompasses this research has interests in the socio-political area of the project. However, in order to effectively understand the entire complexity of a “next generation” approach, the other two primary nodes were included.

Linkages made between nodes were decided based on American forest policy, the goals of a “next generation” approach to forest management, and assessing previous understandings, while creating new understandings of the topic when they emerged. When an understanding or topic emerged from a primary node, it was added with a link as a secondary node. This process was completed though the final quaternary node. When a specific topic or idea emerged when linking the two nodes, a node along the link was created. Since conceptual mapping is used as a way to organize the understanding of a complex problem, the nodes and linkages reflect the previous and current knowledge of the research interest (Hartley, 2014).

When the conceptual map was completed, the visualization was used to define where there was the most potential for gridlock to occur based on where the nodes and linkages congregated. This complex area of the map was determined to be the place where there was the greatest potential for a "next generation" approach to forest management to become gridlocked.

2.2 Results

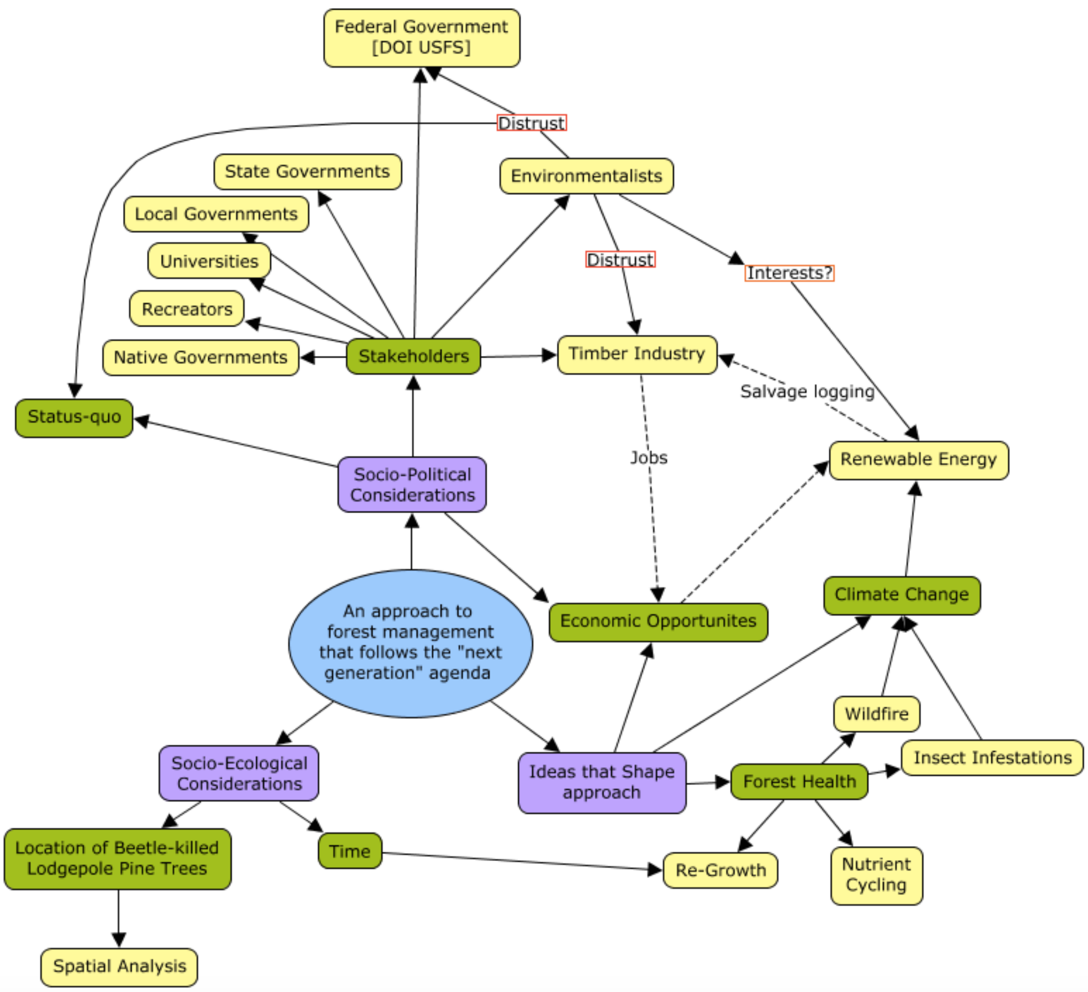

Figure 2.1: Conceptual map portraying the complex nature of a "next generation" approach to forest management.

(Levels of Complexity: Blue – Primary node; Purple - Secondary node; Green - Tertiary node; Yellow - Quaternary node)

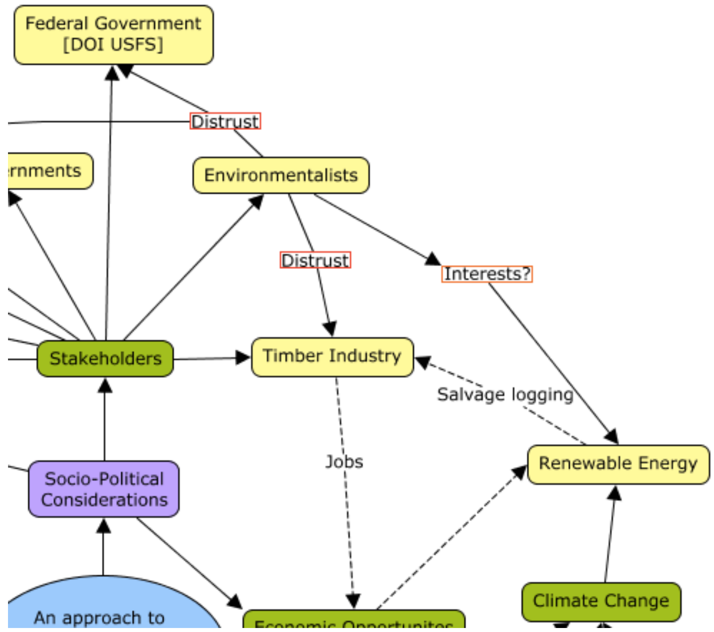

Figure 2.2: Area of the concept map where there was the highest potential for continued gridlock with an approach that follows the "next generation" agenda.

The area on the conceptual map where the linkages and nodes congregated was in the upper right hand corner. The nodes and linkages congregated around the "interests?" node that connected the "environmentalists" node to the "renewable energy" node, which was also connected to the "timber industry" node and the "climate change" node. The "environmentalists" node was also connected to both the "timber industry" node and the "USFS" node through a "distrust" node. Although there were other areas on the conceptual map where there were clusters of nodes, there were no other areas where both nodes and linkages congregated. The place where nodes and linkages congregated portrayed the greatest potential for a "next generation" approach to forest management to become gridlocked because of the historical relationships between environmentalists, the USFS, and the timber industry, and the addition of renewable energy, which is different from a traditional fuels management approach.

2.1.1 Environmentalists, USFS, and Timber Industry

The historical clashing of interests of the environmentalists, the timber industry, and the USFS in the national forest system create potential for "next generation" approach to forest management to become gridlocked. Historically, the clashing of interests on how natural resources should be managed or protected created environmental political conflict (Smith & Freemuth, 2007). Political conflict between environmental groups and the USFS, were cemented in the "late 1980's with the listing of the Spotted Owl as an endangered species" (Carlson & Wilson, 2004). Environmental groups lobbied the U.S. Fish and Wildlife Service (USFWS) to list the Northern Spotted Owl under the ESA to ensure habitat protection for the threatened species. Since this event, the timber industry has blamed environmentalists for the extensive reductions in the availability of USFS timber resources and economic hardships that followed.

Fifteen years later, the timber industry had a victory of its own. The 1995 Salvage Rider suspended laws created during the "golden era" of environmentalism, allowing unrestrained "salvage" logging on USFS land (Dorn, 1996). The Salvage Rider met intense legal battles by environmentalists due to the vague language of the term "salvage" and the suspension of laws (Dorn, 1996). The Rider has created a lasting mistrust of the USFS and the timber industry by environmentalists. The addition of a renewable energy source is what makes BANR different from a traditional forest management approach. The innovative approach is designed to reduce the historical feelings that environmentalists have of salvage logging by appealing to concerns of the increasingly detrimental direct and indirect effects of climate change on the forests.

2.1.2 Renewable Energy

The "renewable energy" node linked the "environmentalists" node to the "climate change" node through the "interests?" node. These nodes were all linked because climate change is at the center of the modern environmental movement (Giddens, 2009). However, the techniques for mitigation such as wind, solar, and hydropower have created other environmental issues. Wind turbines, large solar farms, and dams have had negative impacts on wildlife habitat and conservation, especially on birds, bats, and salmonid fish species (Kuvlesky et al., 2007). Mitigating the consequences of climate change using renewable energies has caused an ideological polarization among environmentalists because of the effects on wildlife conservation.

Polarization among environmentalists has created an uncertainty about the interests they have about using traditional sources of renewable energies. The “interests?” node had question mark punctuation because it was unclear if the recent effects of climate change in western forests have altered perspectives on using salvage logging to produce a form of bioenergy. Therefore, this area on the conceptual map portrayed that the interests of environmentalists could halt the successful implementation of a “next generation” approach to forest management if they showed disdain toward woody biomass as a renewable energy source. Environmentalists could use old policy commitments and play defense to protect the status-quo. Instead, if the interests of environmentalists aligned with a forest management approach that uses salvage logging to produce a form of bioenergy, there would be higher potential of gridlock avoidance.

2.3 Summary

Conceptual maps are graphical tools used to organize and analyze a complex problem. A conceptual map is used to actively engage with a research topic, create new knowledge, and help with reaching an agreement on how to proceed with answering a complex research question. In this research, a conceptual map was used to visually organize the complexity of a “next generation” approach to forest management. The place where there was the highest level of complexity was where the nodes and linkages congregated. This area on the conceptual map represented where there was the greatest potential for gridlock to occur.

Including a renewable energy element is aimed at reducing conflict and mistrust by appealing to the interests of environmentalists. However, due to the polarization of environmentalists, the addition of a renewable energy source may not be positively received. Consequently, this area portrayed that if environmentalist interests were better understood, then the potential of a “next generation” approach to forest management to avoid gridlock could be determined.

3. INTERVIEWS: ENGAGING ENVIRONMENTALISTS

The conceptual map portrayed the ambiguous nature of environmental interests. Ambiguity of interests emerges from the idea that if a carbon neutral source of bioenergy is included in a forest management decision, then environmentalists will approve as it could provide a climate change mitigation technique. However, even if bioenergy is included in a forest management approach, environmentalists may still be more concerned with a management decision that uses a form of salvage logging. There may be concern due to the historical decisions of forest management that have utilized salvage logging in ecologically sensitive areas. This is portrayed by the “distrust” nodes on the conceptual map between environmentalists and the timber industry, and environmentalists and the USFS. Therefore, understanding the interests of environmentalists is essential to determine the potential for a “next generation” approach to forest management to effectively avoid gridlock.

Interviews were used as a research tool to gain an understanding of the assumption that if a “next generation” approach to forest management includes a bioenergy aspect, then there will be minimized political opposition to implementing the approach. Environmentalists should be accepting of an approach that includes a climate change mitigation technique.

3.1 Methods

Data was obtained using purposive sampling of key informants as the research interest was on the specific phenomenon of utilizing beetle-killed trees as a source of bioenergy (Creswell & Clark, 2007). Purposive sampling was used as there was a central research problem that required participants to have experience in the subject matter (Creswell, 2009). Purposive sampling was used to identify appropriate environmental organizations. Environmental organizations were chosen based on the criteria of geographic location and a natural resources conservation specific mission statement. Thirty-two organizations were identified that fit these criteria. The geographic location of groups included the BANR study region (Colorado, Idaho, Montana, and Wyoming). National groups that were identified either had a presence or interest in the BANR study region. The environmental groups sampled consisted of local city government organizations and non-profit organizations to gain more variation within the environmental organizations (Creswell & Clark, 2007). Once environmental groups were identified, a key-informant from each organization was interviewed. From the original thirty-two organizations selected, twelve key-informants from twelve different environmental organizations were interviewed.

Key-informants typically have defined sample selection criteria depending on the research interest. As this research was attempting to understand the general interests of environmentalists, a key informant was chosen based on their seniority within the environmental organization. Out of the twelve interviews conducted, ten of the participants had the title of "Director." In the cases when the Director believed that there was a more qualified participant within the organization, a Specialist was interviewed. This occurred for the other two interviews. This criteria was used to increase the probability that the participant was providing information representative of the environmental organization.

Semi-structured interviews were selected as they are "well suited for studies in which researchers have a relatively clear sense of their interests and the kinds of questions they wish to pursue" (Taylor, Bogdan, & DeVault, 2015, p. 104). Furthermore, semi-structured interviews are flexible and allow for new ideas to emerge from the participant (Bennett et al., 2015) providing the opportunity for creating valuable new information. A total of thirty-two individuals within environmental organizations were selected as key informants. Out of the thirty-two organizations selected, twelve full interviews were conducted. Since only twelve key-informant interviews were conducted there were possible limitations of generalization of interests across all environmental groups. However, upon completion of the twelfth interview, no new information emerged, therefore, it was determined that saturation was reached. Typically, when more detail is warranted and specific contexts of participants views are of interest, a limited number of participants are necessary (Creswell & Clark, 2007). According to Creswell and Clark (2007) a typical sample size in this case is between "four and ten" (p. 112).

Depending on the preferred primary line of communication, an email or phone call was made to participants describing the BANR project, the purpose of this research and the reason for contact. The initial email sent was as follows:

> Dear ___,
>
> My name is Faith Sugerman and I am currently a graduate student at the University of Idaho receiving my MS in environmental science in the College of Natural Resources. I am reaching out to you/your organization regarding the graduate research I am conducting with Dr. Patrick Wilson on the Bioenergy Alliance Network of the Rockies (BANR).
>
> If you are not familiar with BANR, BANR is a USDA funded Coordinated Agriculture Project aimed at exploring the use of beetle-killed lodgepole pine trees in the Rocky Mountain inland northwest region of the United States as a source of bioenergy. Ultimately, the project hopes to harvest these trees as a potential source of renewable energy while reducing fuel loads and restoring ecosystem health.
>
> My research focuses on examining the potential success of BANR. Conceptual mapping was used to determine essential nodes and linkages to identify possible areas prone to gridlock. My findings have determined that support from environmental organizations is essential for success.

Therefore, I was wondering if you would have some time to set up a phone or Skype call in the near future to speak about if the goals of BANR are something you would accept or reject. Or, if you would like, we can correspond over email.

I will only be asking two leading questions which are posted below as this is an open discussion to gain initial insight into the current values of environmental and conservation groups regarding utilizing beetle-killed lodgepole pine trees as a source of bioenergy:

1. Do you think this project is feasible?

2. If yes, do you think it has success potential?

Thank you for your time and I hope to speak to you soon!

Kind regards,

Faith Sugerman

If a call was made, the initial following script was read:

Hi ____!

My name is Faith Sugerman and I am currently a graduate student at the University of Idaho receiving my MS in environmental science in the College of Natural Resources. I am reaching out to you/your organization regarding my graduate research on the Bioenergy Alliance Network of the Rockies, BANR. Have you heard about it?

No.: BANR is a USDA funded Coordinated Agriculture Project aimed at exploring the use of beetle-killed lodgepole pine trees in the Rocky Mountain inland northwest region of the United States as a source of bioenergy. Ultimately, the project hopes to harvest these trees as a potential source of renewable energy while reducing fuel loads and restoring ecosystem health.

Yes.: (Continue below)

My research focuses on examining the potential success of BANR. Conceptual mapping was used to determine essential nodes and linkages to identify possible areas prone to gridlock. My findings have determined that support from environmental organizations is essential for success.

Therefore, I am reaching out to you to gain insight into if the goals of BANR are something you would accept or reject by asking two questions:

1. Do you think this project is feasible?

2. If yes, do you think it has success potential?

Thank you for your time you have taken to speak with me about my research.

Following initial contact, a time, a day, and a location were specified. Two of the twelve interviews conducted were in-person in Missoula, Montana. One of the twelve interviews was conducted through email as the participant was exceptionally busy. The other nine interviews were telephone interviews. Telephone interviews were chosen as the main mode of administration due to convenience, cost-effectiveness, and timeliness (Crano & Brewer, 2002). All interviews were between twenty minutes to an hour and were transcribed utilizing researcher notes. Interviews were not recorded. Prior to beginning the interview, the participant was sent an International Review Board (IRB) approved consent form for their review and was given the opportunity to provide any additional questions or concerns about the research. A follow-up email was then sent to the participant thanking them for their time and participation and were again asked to provide any additional questions or concerns. No negative responses were recorded.

Lastly, Microsoft Excel was used to thematically code interview data. To thematically code data, Column A in an Excel workbook was populated with the organization the participant was affiliated with. Next, the adjacent row was populated with words or short phrases noted during interviews for each group in Column A. After, repeated words or phrases were highlighted if repeated more than three times across participants. Lastly, the repeated words and phrases were placed into thematic categories to interpret common interests among participants.

Participants Interviewed

Cascade Forest Conservancy

Center for Biological Diversity

City of Missoula: Conservation Lands Management

Conservation Colorado: Aspen Center for Environmental Studies

Missoula Department of Natural Resources

Northern Rockies Conservation Cooperative

Pinchot Institute for Conservation

The Nature Conservancy

The Wilderness Society

USDA-NIFA Northwest Advanced Renewables Alliance Project

Western Colorado Conservation Corps of Partners

Western Resource Advocates

3.2 Results

Thematic coding of interview data resulted in several findings. Firstly, seven of the twelve participants agreed that location is an important factor in determining the potential success. Five of the twelve participants agreed that the WUI is the place where beetle-killed trees, and other fuels, pose the greatest threat to humans. Therefore, perhaps the WUI is a place on the landscape where a "next-generation" approach to forest management will be most accepted. Secondly, five of the twelve participants agreed that any management decision to harvest woody biomass for bioenergy must be scientifically sound. Thirdly, six of the twelve participants agreed that there must be economic feasibility and social accountability. These findings suggest that the initial assumption that "the effects of climate change have made the interests of environmental groups ambiguous" was imprecise. In fact, the effects of climate change on the extent and severity of beetle-killed trees was not the main interest. The main interests were the extent and severity of wildfire and its effects on humans, the supporting science, and the economic feasibility of biomass. The bioenergy aspect of the forest management approach seemed to have created positive interest, but also generated other concerns.

3.2.1 The Wildland Urban Interface

A distinct theme was that implementing a "next generation" approach to forest management will be most likely be accepted by environmentalists in the WUI. As the WUI was a place where a "next generation" approach to forest management will be most accepted, it will be the place where there could be the greatest potential to avoid gridlock. Therefore, the WUI could be a place to measure the future success of a "next generation" approach to forest management. As the WUI continues to expand, the threat of wildfire on property, natural resources, and humans and infrastructure have increased (Radeloff, 2005) (USFS, 2012). For this reason, the main interest of environmentalists included wildfire and its effects on humans. The participant with the Western Resource Advocates said "an approach such as BANR makes sense" and suggested to "target the WUI from a conservation standpoint." This was supported by the participant with the Center of Biological Diversity (CBD) who at first questioned the premises of BANR and asked, "does it need to be done?" After posing this question, the participant mentioned the importance of "defensible space that is immediately within the boundaries of the home" to mitigate the threats of wildfire. Therefore, from the perspective of a conservationist from the CBD, the WUI seems as though it would be the only option where a "next generation" approach to forests management could occur without the threat of conservationists questioning whether or not a forest management project is just "propaganda by the timber industry." Moreover, the participant with the Montana Department of Natural Resources (MDNR) suggested to "go after the low-hanging fruit" such as a "clean-up effort and fuels mitigation in the WUI." Even though this participant suggested that "there is success potential" for this forest management approach, the "conflict [with salvage logging] is still alive and well in Montana." However, the participant suggested that by being "open with the process," gaining "public support," and allowing the process to be "interactive," would make "groups that want to shut [the project] down think twice." The idea of the importance of community support in the WUI was supported by a participant with the Cascade Forest Conservancy. This participant believed that salvage logging dead trees in the WUI for bioenergy was a "good use" of fuels, but there should be accountability with the process by explaining to the community the "motivation behind [the management decision]."

Even though the WUI was suggested as a place on the landscape where a "next generation" approach to forest management could succeed, there were still obvious trust issues regarding the motivation behind the approach. The mistrust comes from the historical relationship between environmentalists and the USFS dating back to the 1995 Salvage Rider. The participant from the CBD asked if "they just want to log more and get environmental regulations out of the way?" showing lack of trust in whomever "they" are. The participant seemed to group the timber industry and the USFS together. Additionally, the participant referred to the most recent legislative attempt to improve forest health, the Resilient Federal Forests Act of Cong. (H.R. 2936, 115th Cong. (2017)) as a "disaster." The bill reduces the use of environmental impact statements in accordance with NEPA using categorical exclusions (CEs). The participant from the Cascade Forest Conservancy mentioned that the introduction of H.R. 2936 has the “environmental community in shock” because of the extent of CE’s. The participant from the MDNR had opposite views. The participant stated that there are “problems with lawsuits all the time” when harvesting timber off of USFS land. Therefore, the participant believed that H.R. 2936 could “make life more stable for industry and biomass” by reducing problems with lawsuits and “could allow for some of these projects to occur.” The concerns over the introduction of H.R. 2936 portray the continued mistrust that push groups such as the CBD to use the laws created during the “golden era” of environmentalism to continue the status-quo of environmental policy gridlock.

3.2.2 Science and Climate Change

Science was an important aspect of the success potential of harvesting woody biomass for bioenergy. Although the majority of the participants believed an approach that harvests woody biomass to reduce fuel loads and provides a source of bioenergy was feasible, there were apprehensions about the success potential. Apprehensions about the success potential were based on 1) if using beetle-killed trees as a source of bioenergy will be socially beneficial, and, 2) the need for harvesting dead trees in the first place. The participant from The Wilderness Society said that an approach such as BANR is a “cool way to address a problem,” but in order for there to be success potential, the scientific research must be “conducted by qualified scientists and also be transparent to overcome skepticism on the part of interested parties.” Additionally, the same participant said that from their “experience, efforts that are successful are those that rely on science where the entire group identifies the problem and research that needs to be done is done in order to address uncertainties.” The participant with Conservation Colorado – Aspen Center for Environmental Studies referenced the availability of the outcomes of a lifecycle assessment (LCA) as an important aspect for success feasibility. The participant believed a project that includes a bioenergy aspect "is feasible with caveats" and would "want to see a full picture, perhaps with the use of an LCA." This participant also believed that "pulling hazard trees from various areas so that there is a decent amount of biomass would be ideal if it could be used in some sort of beneficial way" but, was unsure about the "lifespan of the bioenergy facility."

These responses portray the importance of providing scientifically grounded evidence of utilizing dead trees for bioenergy. However, according to the participant from the Northern Rockies Conservation Cooperative (NRCC), "the fundamental premise of the BANR project is wrong, ecologically speaking." One of the main hurdles to avoid gridlock is the science conservationists cite about the natural cycles of beetle outbreaks in western forests and the importance of these dead trees in habitat creation. For example, the participant from the NRCC said,

> "Rocky Mountain forests have evolved with bark beetles for thousands of years. Periodic bark beetle eruptions are a natural part of this ecosystem and the forests are adapted to them (I realize climate change is affecting extent and severity of the outbreaks). Ecologically literate conservationists and scientists know that dead trees are an essential component of forests. Numerous birds, mammals, insects, and fish depend on habitat created by standing and fallen snags. Removal of downed wood and snags eliminates the habitats needed to maintain populations of generalist insects and pathogen predators that control pest outbreaks."

This portrays the apprehensions of conservationists due to the ecological importance of dead trees. This was echoed by the participant from the CBD who mentioned that "any program that reports to improve forest health, we must first question the science on it." However, ecological considerations in the WUI become less important because of the social implications of the increased risk of wildfire on people. There is consensus between environmentalists that the WUI is a place on the landscape where a “next generation” approach to forest management could avoid gridlock.

Although science was an important aspect for success potential, there was surprisingly only one mention of the effects of climate change on western forests. The NRCC participant was the only participant that referenced the current literature regarding the effects of climate change on the lifecycles of beetles. Participants from preservation-oriented environmental groups were more concerned with the ecological implications of removing woody biomass and participants from conservation-oriented environmental groups were more concerned about the social implications of using woody biomass for bioenergy. Participants from conservation-oriented environmental groups did not mention climate change as a concern. However, there were conservation-oriented environmentalists that had positive reactions such as, “I like the thought,” “good approach”, “makes sense”, “open to the idea”, and “good idea,” that were perhaps due to the use of woody biomass as a climate change mitigation technique. Possibly because there was no specific question regarding climate change, participants did not acknowledge it as a main concern, but because the approach involved a climate change mitigation technique, some were more open to this type of management decision.

3.2.3 Economic Feasibility and Social Accountability

In addition to strong scientific support, economic feasibility and social accountability was an important aspect for the success potential of a “next generation” approach to forest management. There was concern from the participant with The Nature Conservancy (TNC) about “how to pay for [active management]” but suggested that “finding a market for the biomass would be a cool outcome.” This concern about the economic feasibility was echoed by the participant from the Pinchot Institute stating that “economic feasibility could pose a significant challenge" to implementing this type of forest management approach. The participant from the Western Colorado Conservation Corps of Partners (WCCC) stated that "although it is expensive to go through and treat forests…if biofuels could be make it financially feasible, then people will be cooperative." A suggestion made by the participant from the Cascade Forest Conservancy was that "private companies shouldn't profit" and proposed that "the money go back into the community" to enhance accountability. Therefore, economic feasibility was a concern only because of the aspect of utilizing woody biomass as a source of bioenergy not because of reducing fuel loads. Most of the economic feasibility concerns emerged from the "lifespan of a bioenergy facility" and its ability to sustain a "steady log flow supply." The participant from the Western Resource Advocates posed the question, "are there biofuel operations to purchase this work?" This participant suggested that,

> "From an economic standpoint, there must be a set of buyers and infrastructure in place. Without these two aspects, it will be too expensive to ship. This seems to be the most vulnerable aspect because without it, this project sounds expensive. For me, I would have to have this piece before getting involved…the solution is interesting and the possibility of a mobile biofuel plant is interesting because it could eliminate cost, the need for infrastructure, and eliminate a carbon footprint."

The concern of economic feasibility was reiterated by the participant from TNC who suggested that the "ecological, social and economic problem is going to be huge" but, also suggested that "integrating these three problems" could make a project that uses bioenergy from woody biomass "possible."

The participant who was involved in another USDA NIFA CAP, the Northwest Advanced Renewables Alliance (NARA), suggested that "before we go running off to what we think is the next brilliant idea, let's make sure we aren't stepping into a hornet's nest." To avoid “stepping into a hornet’s nest,” this participant suggested, based on their experience working on the NARA CAP, to “get to people beforehand to address concerns in order to avoid legal intervention and mistrust.” This participant was in agreement with the importance of understanding the interests of environmentalists who have historically used legal tools, such as the “golden era” laws, in the courts to continue gridlock due to the mistrust of utilitarian interests.

3.3 Summary

Interviews were conducted to better understand the “interests?” node that connected the “environmentalists” node to the “renewable energy” node on the conceptual map. In order for an approach that follows a “next generation” approach to avoid gridlock, it was necessary to understand the interests of environmentalists. If there was disdain for harvesting beetle-killed trees as a source of bioenergy, then there was a high potential for gridlock to occur. This is a result of the distrust between environmentalists and the USFS and environmentalists and the timber industry.

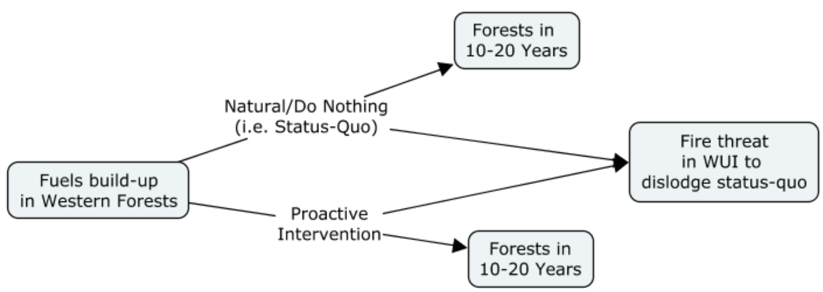

Figure 3.1: Flow Chart of Strategies for Addressing Fuels Build-Up in Western Forests

Findings portrayed that harvesting woody biomass to use as a source of bioenergy to both improve forest health and provide a renewable source of energy, led to two strategies that must be recognized: proactive intervention and no intervention at all. Even if conservation-oriented environmentalists were interested in using beetle-killed trees as a source of bioenergy, preservation-oriented environmentalists were more in favor of the status-quo. Each of these strategies will have different outcomes both on forests and the availability of bioenergy. Historically, the strategy of no intervention has taken precedence to the strategy of proactive intervention because of gridlock. Preservation-oriented environmental groups could use the “golden era” of environmentalism to continue the status-quo. If gridlock persists, then no intervention would occur, and there will be a different outcome in the forests than if proactive intervention would have occurred.

Most importantly, findings suggest that the threat of wildfire in the WUI could dislodge the status-quo. Therefore, the place on the landscape where success of a “next generation” approach to forest management could be measured in the future is in the WUI. The WUI is a place on the landscape where proactive intervention could take precedence to the status-quo and avoid gridlock due to the threat of wildfire to people. However, according to these findings, in order for proactive intervention to occur in the WUI, it must be coupled with scientific evidence and economic feasibility. Ultimately, the place on the landscape where success of a “next generation” approach to forest management could be measured in the future approach is in the WUI, where there is the greatest potential to avoid gridlock.

4. SPATIAL ANALYSIS: BEETLE-AFFECTED AREAS IN BANR STATES

The “next generation” agenda is about discovering new ways to tackle increasingly complex past, present, and future environmental problems in an efficient manner with the least political opposition as possible (Kettl, 2004). Interview results revealed that a “next generation” approach to forest management will have the most potential to avoid gridlock in the WUI. This is the place where social considerations outweigh ecological concerns because of the imminent threat of wildfire to humans and, therefore, acceptance by environmentalists. Using the Environmental Systems Research Institute’s (ESRI) geographic information system (GIS) ArcMap, a spatial analysis was conducted to determine these specific areas on the landscape where success will be measurable in the future.

Location and space can be a powerful tool for mixing qualitative data and quantitative data (Goodchild & Janelle, 2004). In social science, space can be used to bind social variables to spatial variables (Haining, 1990). This is most commonly done using a GIS. A GIS is a computer software based tool that facilitates a spatial analysis. According to Goodchild & Janelle (2004), spatial analyses can “reveal patterns and anomalies” (p. 8) in social variables that may have not been revealed by just using conventional mapping techniques. Using GIS tools is a popular technique in multiple social science fields including resource management (Goodchild & Janelle, 2004). GIS in resource management usually includes the mapping of ecological phenomenon based on social variables (Meddens et al., 2012). By mapping ecological phenomenon’s based on social variables management responses can be better informed (Meddens et al., 2012). Using map algebra in ArcMap, a spatial analysis was used to visualize the ecological phenomenon of beetle-killed trees based on the social variable of acceptance. Results from the spatial analysis were used to calculate the beetle-affected (BA) WUI area in the BANR states.

The visualizations portray the BA WUI area in the BANR states (Figure 4.3 and Figure 4.4). BA area is different from beetle mortality (BM) area. BM area only includes dead trees and BA area includes both live and dead trees (Meddens et al., 2012). The BA WUI areas were calculated for Colorado, Idaho, Montana, and Wyoming and the combined BANR states.

4.1 Methods

4.1.1 Data

The data used for BM area was created by Meddens et al. (2012). A grid with 1-km^2 cells was overlaid on aerial images from the USFS Aerial Detection Survey (ADS) database from 1997 to 2012. The aerial images were recorded by observers in an aircraft creating polygons of tree mortality. The images recorded forest type and number of trees killed. Next, Meddens et al. (2012) applied a fishnet over the polygons to convert the ADS images into 1-km^2 grids. Then, the areas of the intersected polygons within each 1-km^2 grid were calculated. The number of killed trees per hectare (ha) in that cell was multiplied by the intersected area of the polygon within the cell to provide the area (ha) of killed trees within each cell (Meddens et al., 2012). Because the ADS polygon data was overlaid with a fishnet, there were numerous possibilities of land cover within each cell. For example, if a cell had a value of "5," then there was 5 ha of BM area in the entire 1-km^2 cell. However, the 1-km^2 cell could have 100% forest or 25% forest, 75% other land cover. This process was done for each year from 1997 to 2012 resulting in seventeen individual images with 1-km^2 cell values.

The data used for the 2010 WUI came from SILVIS Lab public data source. The data was originally created by Radeloff et al. (2005) and has since been updated to include 2010 land cover data. The data used fine resolution housing density and land cover data to create polygons of land class covers. The housing density data was created from the U.S. 2000 decennial census at the census block level. The land cover data were created by classifying 30-m resolution Landsat TM satellite data into fourteen categories: high/medium/low density interface, high/medium/low density intermix, high/med/low/very low density with no vegetation, very low density with vegetation, uninhabited with vegetation, uninhabited with no vegetation, and water. The wildland urban intermix was defined as having 6.17 housing units/ km^2 with greater than 50% wildland vegetation. The wildland urban interface was defined as having greater than having 6.17 housing units/km^2 with less than 50% wildland vegetation, but within 2.4-km of an area that has greater than 75% vegetation with an area of 5-km^2 (Radeloff et al., 2005).

4.1.2 Analysis

Map algebra uses algebraic operations with raster map layers to create a new raster output. Using the *raster calculator* tool in ArcMap, map algebra was used to create Figures 4.3 and 4.4. The rasters that were created for Figures 4.3 and 4.3 were also used to calculate the BA area in Tables 4.1 and 4.2. The two steps that did not use the *raster calculator,* were converting the WUI polygon data to a raster (STATEWUIrast) and converting the state shapefiles for Colorado, Idaho, Montana, and Wyoming to rasters (StateRast). Both of these steps used the *polygon to raster* tool. The full workflow is shown in Figure 4.1.

First, for all seventeen rasters, the 1-km^2 grid cells with -9999 values were converted to 0. To convert the values from -9999 to 0 a conditional equation was used. The condition set was ‘if the value of a 1-km^2 cell in a given year is equal to -9999, then convert the value to 0, if the value is not equal to -9999, then keep the original cell value.’ This created a new raster for each year (BkYear) that had the lowest cell value set at 0 and the highest value set at 100. These values represent the area in ha of BM in each 1-km^2 grid cell. Additionally, because 100 ha is equal to 1-km^2, the value of the cell is equivalent to the percentage of the value of the beetle-mortality area within the cell. Next, the sum of the seventeen rasters was calculated. This created a new raster (BkSum) with cell values from 0 to 100 representative of BM from 1997 to 2013 for the entire western U.S. Then, the values in the “BkSum” greater than 0 were calculated to remove the 0 values from the “BkSum” raster. This created a raster (BkSumNo0) of the BA area in the entire western U.S.

Next, the *polygon to raster* tool was used to convert the SILVIS Labs Colorado, Idaho, Montana, and Wyoming WUI data from polygon data to raster data (StateWuiRast). The cell size was set to 1000-m to match the resolution of the BM area data. The cell assignment was set to “maxiumum_combined_data.” The area of a cell would be combined if there was more than one feature in a cell that had the same value. If the features in a cell had different values, then the cell assignment would use the combined feature with the largest area within the cell to determine the assigned value to the cell (ArcGIS, Tool Reference).

Once the land cover data were converted from raster to polygon, the *raster calculator* tool was used to distinguish the wildland urban interface and wildland urban intermix from the other unique land cover identifiers in the state, called attributes. To remove the other land cover attributes and combine the interface and intermix data, the “StateWuiRast” raster was set equal to the value given for the interface and intermix attributes. This created a new raster

(StateWuiRast2) that removed the other land cover attributes and combined the wildland urban interface and wildland urban intermix into a single WUI attribute.

The *raster calculator* tool was then used to determine where on the landscape there was both WUI and BA area (Figure 4.3 and Figure 4.4). The “BkSumNo0” raster and “StateWuiRast2” were used to create a new raster output (StateBKSumWui) that coded the state’s BA WUI area as “1” and all other area in the state as “0.”

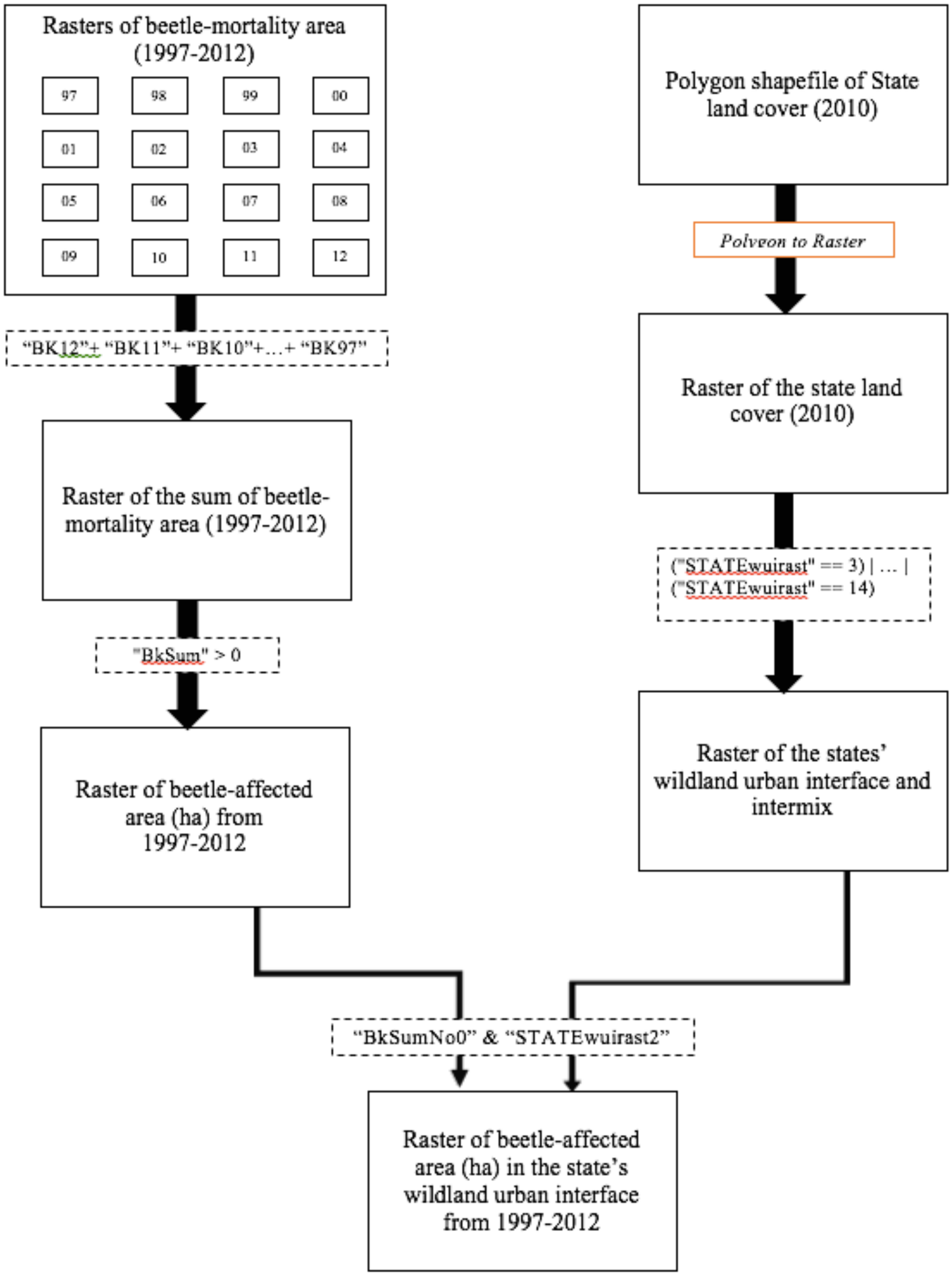

Figure 4.1 Workflow of Spatial Analysis: Workflow showing the beginning/intermediate outputs and the final output used to create Figures 4.3 and 4.4. The solid boxes are the outputs and the dotted boxes are the equations used in the *raster calculator* tool in ArcMap. Note, the *polygon to raster* tool is denoted separately.

After completing the raster analysis, the “BkSumNo0” raster and the “StateWUiRast2” raster were used to calculate the BA WUI area in the BANR states. Since each cell was 1-km^2 and was coded to either be “1” (BA area and WUI) or “0” (neither), the actual BM area in each cell was unclear. Therefore, instead of reporting the BA area with BM area as only BA without the corresponding BM area, BM area threshold rasters were created for each state (#State#). The thresholds provide a more accurate representation of the amount of BM area in each state. Additionally, using the *Mask (Environment*) setting for raster analyses, the “BkSum” raster was used to create independent threshold rasters for the entire BA area in the BANR states. BM area threshold rasters included 0.000001 – 10%, 10.000001 – 20%, 20.000001 – 30%, 30.000001 – 40%, 40.000001 – 50%, 50.000001 – 60%, 60.000001 – 70%, 70.000001 – 80%, 80.000001 – 90%, and 90.000001 – 100%. The minimum threshold was taken out to the sixth decimal point to account for fractions of BM area in a 1-km^2 cell. The cells that met the criteria of the threshold were coded as “1” and the cells that did not meet the criteria of the threshold were coded as “0.” The number of cells that were coded as “1” in each threshold was the amount of BA area at that threshold. The area was converted from km^2 to ha by multiplying the amount of cells coded as “1” by one-hundred. As the BM area thresholds increased, the BA WUI area in the BANR states decreased (Figure 4.4). This provides a more accurate representation of the amount of BM WUI area within the BANR states. The BA WUI area in the BANR states was the sum of the BA area within each increasing BM area threshold for the individual state. The BA WUI area in the BANR states was the sum of the BA area at each threshold across the BANR states. The total BA WUI area in the BANR states was the sum of the BA WUI area in each state.

After finding the BA area within the BM area thresholds, the total BA WUI area of each state and the total BA WUI area in the BANR states were calculated. Additionally, using the BA area calculations, percentages of the BA area were found. Equation 4.1 is the equation used to find the percentage of WUI area affected by beetles in each BANR state. Equation 4.2 is the equation used to find the percentage of the total BA WUI area in BANR states. Equation 4.3 is the equation used to find the percentage of the total BA WUI area in each BANR state.

Equation 4.1: $$P_{BA} = \frac{Total\ BA\ WUI\ Area}{Total\ WUI\ Area\ in\ State} \times 100\%$$

Equation 4.2: $$P_{BA} = \frac{Total\ BA\ WUI\ Area\ in\ BANR\ States'}{Total\ BA\ Area} \times 100\%$$

Equation 4.3: $$P_{BA} = \frac{Total\ BA\ WUI\ Area\ in\ State}{Total\ BA\ WUI\ Area} \times 100\%$$

4.2 Results

The BA WUI area is the potential place on the landscape where success of a "next generation" approach to forest management could be measurable in the future. However, the total BA WUI area is minimal and only continues to decrease as the threshold of BM area increases (Figure 4.1). Colorado had both the largest BA WUI area and the most WUI area affected by beetles. The BA WUI area in Colorado accounted for almost half of all the BA WUI area in all BANR states and about 39% of the WUI had been affected by beetles (Table 4.1).

Overall, the total percentage of BA WUI area in the combined BANR states was 2.3%. The total BA WUI area in the BANR states was 692,100 ha (Table 4.1). The total BA area in the BANR state's, regardless of WUI or not WUI, was calculated at each threshold and then summed. The total BA area in the BANR states was 30,042,300 ha (Table 4.2). In the entire BA area in the BANR states, only 2.3% of the BA area was in the WUI (Table 4.3).

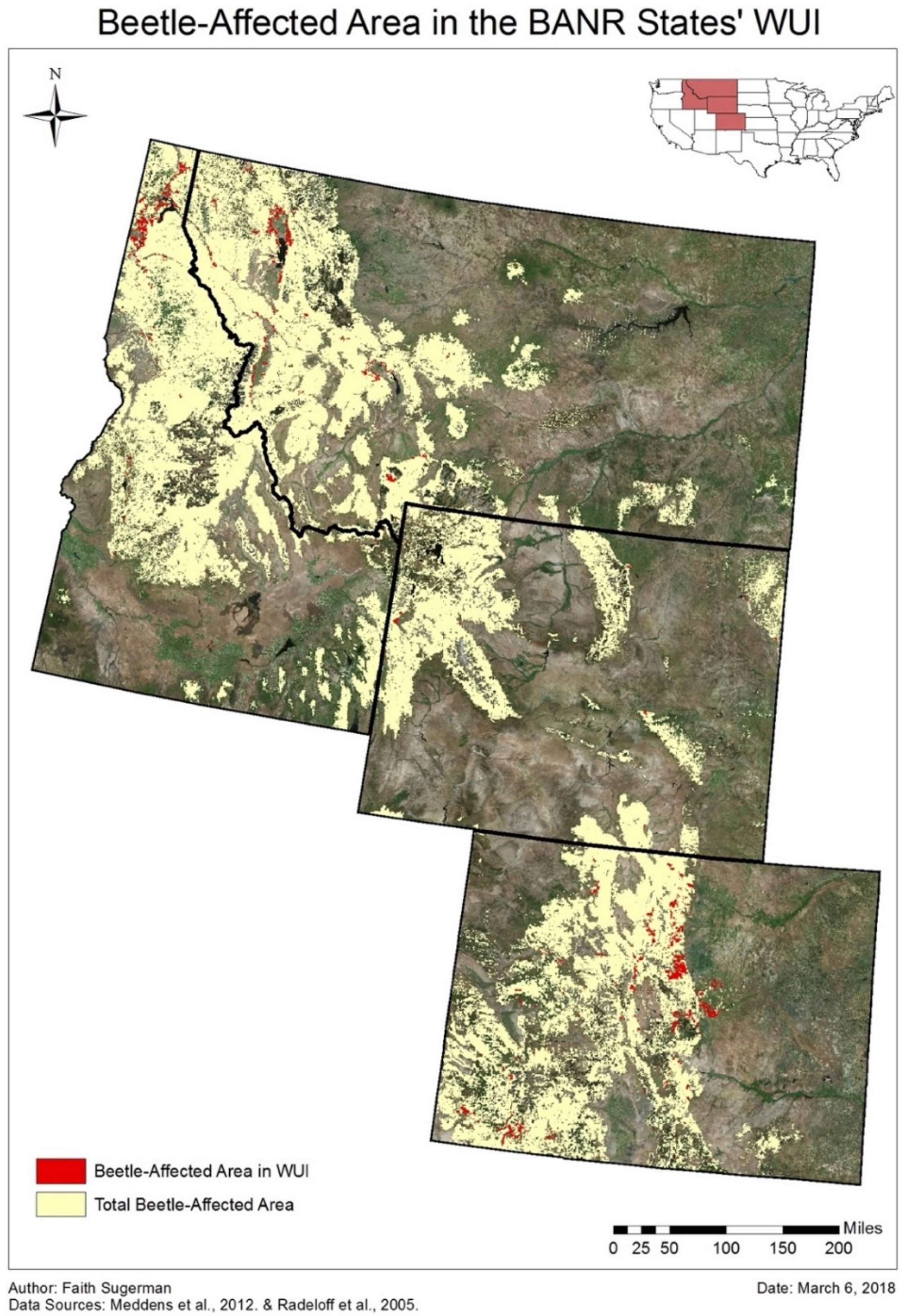

Figure 4.2 Beetle-Affected Area in the BANR States' WUI: Map of the BA WUI area and the total BA areas in all of the BANR states. This visualization represents the findings in Table 4.3 where Colorado had the highest percentage of BA WUI area compared to the other states. Overall, only 2.3% of the BA area is within the WUI.

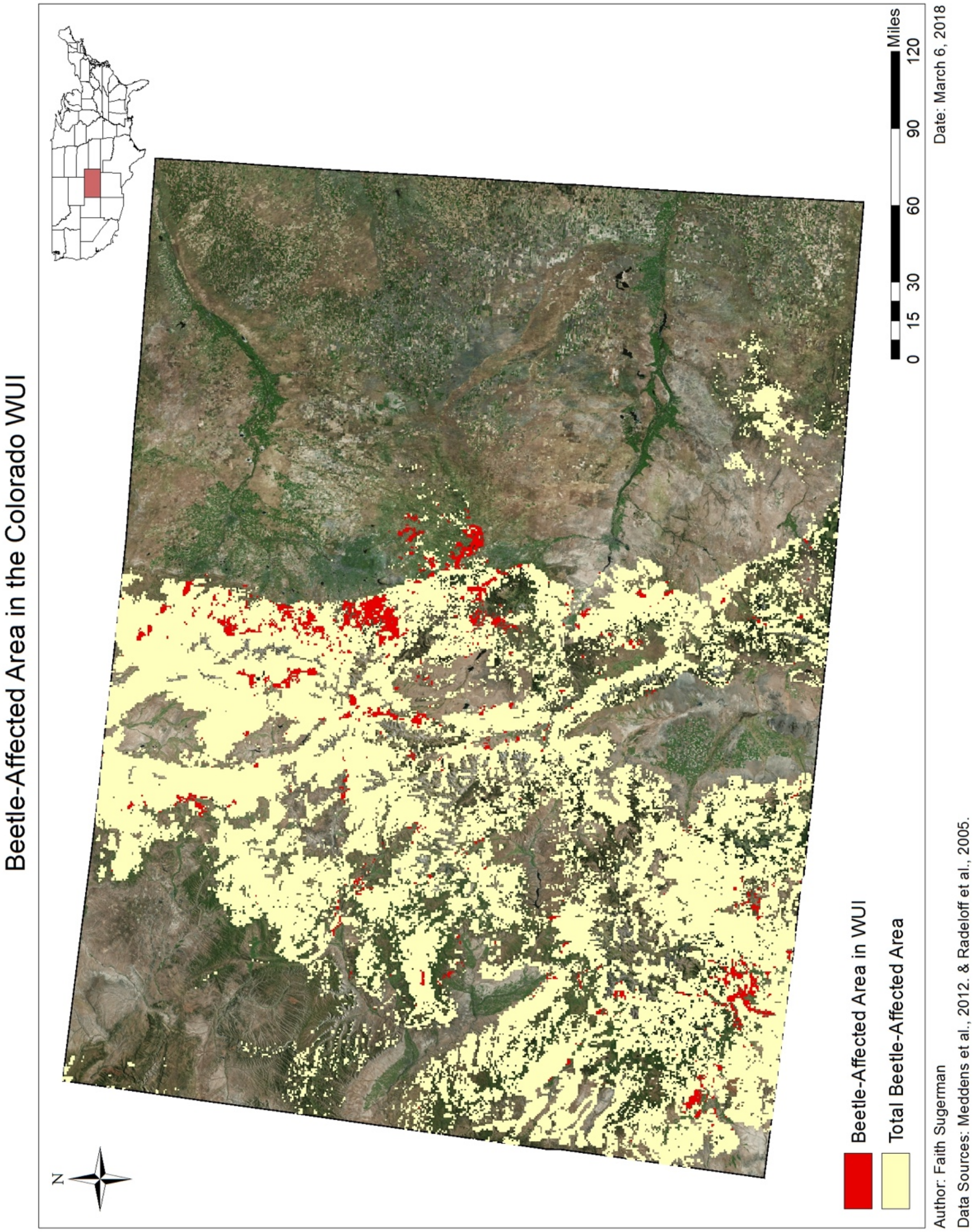

Figure 4.3 Beetle-Affected Area in the Colorado WUI: Map of the BA WUI area and the total BA area in Colorado. Colorado contained almost half of the area out of the area that was both WUI and BA area in the BANR states.

	BA WUI Area (BANR States) (ha)				
BM Area Thresholds (%)	**Colorado**	**Idaho**	**Montana**	**Wyoming**	Total BA WUI Area
0-10	269,900	151,300	163,100	20,400	604,700
10-20	20,800	1,800	8,600	800	32,000
20-30	15,100	200	4,000	900	20,200
30-40	8,400	300	1,800	200	10,700
40-50	6,500	0	600	0	7,100
50-60	3,400	0	1,100	400	4,900
60-70	2,800	100	400	500	3,800
70-80	1,800	200	100	100	2,200
80-90	1,200	200	100	100	1,600
90-100	4,300	100	100	400	4,900
Total BA WUI Area (ha)	334,200	154,200	179,900	23,800	692,100
Total WUI Area (ha)	864,100	377,000	475,600	211,200	1,927,900
% of WUI Area Affected by Beetles	38.68	40.90	37.83	11.27	35.90

BM Area Thresholds (%)	BA Area BANR States (Includes WUI & Non-WUI) (ha)
0-10	22,848,700
10-20	2,623,700
20-30	1,340,600
30-40	849,700
40-50	570,200
50-60	411,600
60-70	301,700
70-80	225,900
80-90	171,900
90-100	698,300
Total (ha)	30,042,300

Table 4.1 Beetle-Affected WUI Area in BANR States (Above): Table 4.1 outlines the BA WUI area in Colorado, Idaho, Montana, and Wyoming. The total BA area within the state's WUI is the sum of the BA area at each threshold for the individual state. The total BA area within the BANR states' WUI is the sum of the BA area within the BANR states' WUI at each threshold.

Table 4.2 BA Area in BANR States (Left): Table 4.2 outlines the total BA area within the BANR states. The total BA area within the BANR states is the sum of the BA area at each BM area threshold.

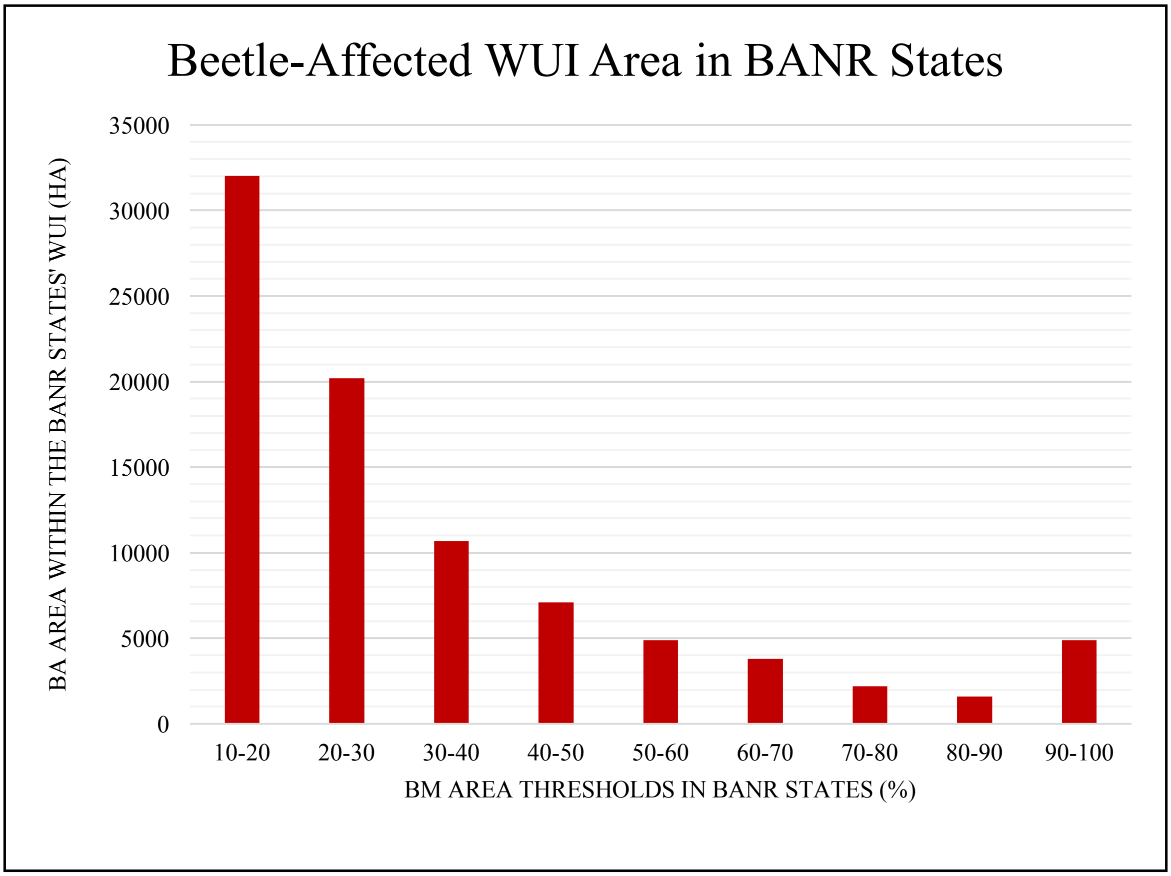

Figure 4.4: Histogram of the BA WUI area in the BANR states. The histogram does not include the 0-10 BM area threshold as it had significantly greater BA WUI area than the rest of the BA areas. Although the majority of BA WUI area occurred between 0-10 BM area threshold, the other areas where BA WUI area occurred was at the 10-20 BM area threshold and the 20-30 BM area threshold.

Table 4.3 Percentage of Beetle-Affected Area: Table of the percentages of beetle-affected area in the BANR states. 2.3% of the BA area was in the WUI. 48.29% of the BA area within the WUI in the BANR states was in Colorado.

% of Total BA WUI Area in BANR States	2.3			
	Colorado	**Idaho**	**Montana**	**Wyoming**
% of Total BA WUI Area in Individual BANR state	48.29	22.28	25.99	3.44

4.3 Summary

GIS is commonly used in natural resources management to facilitate a spatial analysis that combines both quantitative data and qualitative data. The spatial analysis can take into account social variables that may have an impact on physical variables. Findings from interviews with environmentalists indicated that the WUI was the place on the landscape where social considerations will outweigh ecological concerns. Groups that would historically utilize the laws created during the "golden era" in the courts to create environmental policy gridlock would be less inclined to use them in this area. The WUI is therefore a place on the landscape where gridlock will be avoided, and success of a "next generation" approach to forest management could most likely be measurable in the future. Using ESRI's ArcMap, a spatial analysis was done to visualize the places on the landscape where there was both WUI and BA area in the BANR study region.

The spatial analysis used the *raster calculator* tool to perform map algebra to create new rasters from the data provided by Meddens et al. (2012) and Radeloff et al. (2005). The new raster of the sum of the BM area and the new rasters of the WUI in the BANR states were used to visualize the BA area within the WUI in each of the BANR states. The visualizations portrayed the extensive BA area in the BANR states and the minimal area where the WUI intersects the BA area. Since the raster output coded each cell as either "1" (BA area and WUI) or "0" (neither), the cells coded as "1" was the area in km^2 that was affected by beetles. Additionally, because the values of each 1-km^2 cell were known, the raster of the sum of BM area was used to create thresholds to organize the BM area in the BANR states. These values were used to gain a more accurate estimation of the amount of BA area in the WUI in the BANR states.

At the 0.000001 – 10% BM area threshold, the BA area within the WUI was greatest. After this threshold, the BA area within the WUI decreased. Additionally, there was minimal BA area within the WUI in the BANR states compared to the total BA area in the BANR states. Lastly, only 2.3% of the overall BA area in Colorado, Idaho, Montana, and Wyoming is in the WUI.

Almost half of all of the BA area within the WUI in the BANR states occurred in Colorado. Colorado was expected to have a higher percentage than the other three states. The state has major WUI areas along the Front Range (Radeloff et al., 2005) where there is severe tree mortality from bark beetle. Although the WUI is the place on the landscape where the success of a "next generation" approach to forest management will most likely be measurable in the future, the percentage of BA area within the WUI was minimal. Because the percentage was minimal and most of the BM area was less than 10%, there is little potential for a "next generation" approach to forest management to avoid environmental policy gridlock.

5. CONCLUSION: THE FUTURE OF BANR

American environmental policy gridlock is created by an American "green state," of which the top layer is the "golden era" of environmentalism (Klyza & Sousa, 2010). Gridlock has made creating new environmental policy difficult because the laws of the "golden era" which, according to Klyza and Sousa (2010), "do privilege environmental interests" (p. 4-5). In order for environmental groups to have favorable policy outcomes, they must only "play defense" to protect the commitments made during the "golden era." (Klyza and Sousa, 2010). Therefore, alternative methods of policymaking are required to implement environmental policy that is reflective of current social and climatic conditions.

To avoid gridlock, alternative methods are used to solve complex environmental problems and dislodge the status-quo. Alternative methods of policymaking follow the "next generation" agenda, which aims to discover new ways to tackle the increasingly complex past, present, and future environmental problems in an efficient manner with the least political opposition as possible (Kettl, 2004). The agenda draws on the shared knowledge that the laws of the "golden era" are ineffective at solving current environmental management problems (Klyza & Sousa, 2013).

In 2003, emerging concerns about the extensive bark-beetle outbreak sparked a "next-generation" approach to forest management in the environmental policy community. The approach included tackling concerns about the decades of fuels build-up and the direct and indirect effects of climate change on forests. The Bioenergy Alliance Network of the Rockies was a "next generation" approach to forest management as it was an innovative response to a complex environmental problem that aimed to harvest beetle-killed lodgepole pine trees to improve forest health by reducing fuel loads and providing a source of bioenergy. Using dead trees as a source of bioenergy provides a favorable carbon balance, as it uses the carbon that would have naturally returned to the carbon cycle and turns it into bioenergy. Due to the extent of the recent outbreak, some areas that were severely affected had shifted from a carbon sink, to a slight carbon source (Kurz et al., 2008), likely increasing the severity of wildfire from dry woody biomass at certain stages of following a beetle-attack and under certain conditions (Hicke et al., 2012).

However, due to the time lag in information, the outcomes of the BANR project cannot be measured for another several decades. Therefore, a mixed-methods procedure that included conceptual mapping, key informant semi-structured interviews, and a spatial analysis was used to determine the potential for a “next generation” approach to avoid environmental policy gridlock. The concept map indicated that if the addition of a renewable energy aspect to a forest management approach could appeal to the interests of environmentalists, the approach could avoid gridlock. Alternatively, due to historical relationship between environmentalists, the timber industry, and the USFS, made more complex by the polarization within the environmental community, there may be disdain from environmentalists due to the use of salvage logging. If environmentalists opposed a “next generation” approach to forest management, then the approach may face an unsuitable legal future and encounter gridlock, the very problem the approach was designed to avoid.

Two strategies emerged after gaining a better understanding of the interests of environmentalists: proactive intervention and no intervention. Proactive intervention is implementing a “next generation” approach to forest management. Since a “next generation” approach aims to reduce political opposition, the approach should be effective at avoiding gridlock. No intervention is continued gridlock due to environmentalists opposing an attempt of a “next generation” approach since the approach uses a form of salvage logging. Since the 1995 Salvage Rider, environmentalists are skeptical of utilitarian interests that aim to improve forest health using salvage logging. Therefore, environmentalists could use the victories of the “golden era” in the courts to prevent proactive intervention and continue gridlock.

The use of the courts is what Klyza and Sousa (2010, 2013) call adversarial legalism. Adversarial legalism is another alternative method of policymaking that is characterized by high degrees of legal contestation and uncertainty (Kagen, 1991). Environmentalists commonly use the method to protect the commitments made during the “golden era” to maintain the status-quo. Interviews revealed that the place where proactive intervention and the implementation of a “next-generation” approach to forest management will take precedence to the status-quo of no intervention, and avoid gridlock, could be in the WUI. The WUI is place where social considerations outweigh ecological concerns and could be a place on the landscape where success can be measured in the future.

After performing the spatial analysis, it was found that the BA area within the WUI in the BANR states was minimal. The total BA area in the BANR states was 30,042,300 ha. Out of the 30,042,300 ha of BA area in the BANR states, only 692,100 ha were within the WUI. Additionally, the majority of the BA area within the WUI had less than 10% BM area. Therefore, not only is the BA area within the WUI minimal, there is also less BM area. Overall, only 2.3% of the total BA area in the BANR states was within the WUI. The state that had the greatest BA area within the WUI was Colorado. Colorado had almost half of the BA area within the WUI out of all of the BA area within the WUI across all of the three other BANR states. Despite the investment as a “next generation” approach, if the WUI is where there is the most potential to avoid gridlock, and provides a place on the landscape where success of a “next generation” approach to forest management could be measured in the future, then there is slight potential for the approach to have an effect.

However, the BANR project has discovered valuable forest management information that reflects the current social and ecological conditions. As a research endeavor, the project has helped explore the complexities of the ecological and social implications of harvesting beetle-killed trees for bioenergy. If a similar bark-beetle outbreak occurs again, researchers can use the information gathered by the participants of the BANR project to inform a different management decision in the future. Perhaps, the next management decision could be made using a different “next generation” approach to avoid gridlock. In fact, Klyza and Sousa suggest “next generation” approaches could be made along five alternative pathways. The pathways include, increasing the use of appropriations politics, executive-branch policymaking, the courts, collaboration-based politics, and state-focused policymaking. These five pathways have previously proved to be successful in avoiding American environmental policy gridlock.

The BANR project was a collaborative-based attempt to implement a “next generation” approach to forest management. The project included federal agencies, state representatives, private-sector actors, universities, and environmental organizations, to attempt to resolve a natural resources issue. The approach included objectives that embraced the various stakeholder interests in a forest management policy such as forest health, climate change, and economic opportunity. However, because of the complex nature of a “next generation” approach to fuels reduction, a collaborative-based process may only be successful in the WUI, where there could be compromise between the diverse group of stakeholders.

An alternative pathway that is currently being pursued is increasing the use of appropriations politics. To avoid a similar outcome to the 1995 Salvage Rider, the current appropriation politics could use the information gathered by the BANR project participants to write less contested legislation. In the most recent Omnibus Bill for fiscal year 2018, the Interior and Environment, Agriculture and Rural Development, Commerce, Justice, Science, Financial Services and General Government, Homeland Security, Labor, Health and Human Services, Education, State and Foreign Operations, Transportation, Housing and Urban Development, Defense, Military Construction and Veterans Affairs, Legislative Branch, and Energy and Water Development Appropriations Act (H.R. 3354, 115th Cong. (2017-2018)) recognizes the use of biomass for bioenergy. H.R. 3354 requires bioenergy policy to be consistent across the Department of Energy, the Environmental Protection Agency, and the USDA, and also requires the recognition of the benefits of forest biomass for energy, conservation, and responsible forest management (H.R. 3354, 115th Cong. (2017-2018)). BANR and H.R. 3354 are just two examples of the types of "next generation" approaches to forest management currently being used to avoid gridlock.

Forest management is a complex environmental problem due to fuels build-up from decades of fire suppression policy, the indirect and direct effects of climate change, an expanding WUI, and environmental policy gridlock. To address a complex environmental problem and avoid gridlock, an approach that follows the "next generation" agenda could be used as an alternative method to environmental policymaking (Klyza & Sousa, 2013). The BANR project was a "next generation" approach to forest management. Although the approach may not succeed as a "next generation" approach, as a research endeavor, the project provided a foundation for future "next generation" approaches to forest management that may utilize a different alternative pathway for avoiding American environmental policy gridlock.

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Appendix A: University of Idaho International Review Board Approval

University of Idaho
Office of Research Assurances
Institutional Review Board
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To:	Patrick R. Wilson
Cc:	Faith Sugerman
From:	Jennifer Walker, IRB Coordinator
Approval Date:	June 27, 2017
Title:	The Bioenergy Alliance Network of the Rockies as a way around wildland forest policy gridlock in the United States
Project:	17-151
Certified:	Certified as exempt under category 2 at 45 CFR 46.101(b)(2).

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the protocol for the research project The Bioenergy Alliance Network of the Rockies as a way around wildland forest policy gridlock in the United States has been certified as exempt under the category and reference number listed above.

This certification is valid only for the study protocol as it was submitted. Studies certified as Exempt are not subject to continuing review and this certification does not expire. However, if changes are made to the study protocol, you must submit the changes through VERAS for review before implementing the changes. Amendments may include but are not limited to, changes in study population, study personnel, study instruments, consent documents, recruitment materials, sites of research, etc. If you have any additional questions, please contact me through the VERAS messaging system by clicking the 'Reply' button.

As Principal Investigator, you are responsible for ensuring compliance with all applicable FERPA regulations, University of Idaho policies, state and federal regulations. Every effort should be made to ensure that the project is conducted in a manner consistent with the three fundamental principles identified in the Belmont Report: respect for persons; beneficence; and justice. The Principal Investigator is responsible for ensuring that all study personnel have completed the online human subjects training requirement.

You are required to timely notify the IRB if any unanticipated or adverse events occur during the study, if you experience and increased risk to the participants, or if you have participants withdraw or register complaints about the study.