Regeneration of Culturally-Significant Conifer Tree Species in the L'Anse Indian Reservation: Impacts From Herbivory by Deer (*Waawaashkeshi*)

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To the Anishinaabe peoples of the Great Lakes region, northern white cedar (Thuja occidentalis; Ojibwa: giizhik) is a particularly sacred plant with numerous medicinal and ceremonial uses. However, cedar populations are threatened across the region due to difficulties with regeneration. Populations of white-tail deer (waawaashkeshi) are above historical norms, due to reductions in natural predators such as the gray wolf (Canis lupus; Ojibwa: ma'iingan). Cedar is a favorite winter food source of deer, and ecologists agree that over-browsing by deer is likely the leading cause of cedar decline. Small cedar seedlings are protected while buried under snowpack, but as they grow, they become susceptible to browsing and often perish before reaching the canopy. Cedar are the dominant species in many riparian (stream-side) wetlands that provide critical links between aquatic and terrestrial ecosystems. Reductions in cedar could result in long-term ecological changes. We examined four conifer tree species of these ecosystems to compare apparent browsing by deer. While we found cedar and hemlock (Tsuga Canadensis; Ojibwa: gaagaaimizh) abundant in the smallest size class, there is a significant decrease of both species in larger size classes compared to the other species. Our findings support the conclusion that cedar and hemlock are being over-browsed by deer, and that both species could face long-term declines with the current populations of deer in the area.

Keywords: environmental science, regeneration, cedar, hemlock, whitetail deer

Introduction

The Native American group known as the Anishinaabe, meaning "original person" (Benton-Banai, 1988), is one of the largest Indigenous groups in North America. Anishinaabe are known by various regional names such as Chippewa or Ojibwa/Ojibwe/Ojibway (same pronunciation), with cultural relatives Ottawa (Odawa) and Potawatomi (Bodewadomi) across much of the same ancestral homeland centered on the Great Lakes region.

Traditional Anishinaabe worldviews include strong environmental ethics. Plants and animals are considered other-than-human relatives who have spirits (manitous) and gifts to share (Callicott & Nelson, 2004; Kimmerer, 2015). Following traditional teachings, humans' relationships with the environment should be respectful and reciprocal as part of *mino-bimaadiziwin* ("living a good life") as well as ensuring the well-being of future generations (Callicott & Nelson, 2004; Geniusz, 2015; Kimmerer, 2015; Rheault, 1999). This worldview certainly applies to individual species, which is often a familiar concept to non-Indigenous observers who are aware of species held sacred by Indigenous groups (e.g., eagles, bears, etc.). However, traditional Anishinaabe worldviews encompass a much broader scope. All of nature is sacred, its balance depends on proper relationships, and there are consequences for disregarding teachings about respect and reciprocity (Callicott & Nelson, 2004). As biologists agree, entire biological communities are made up of numerous species of plants and animals that are dependent on each other (including humans), which in turn depend on a stable physical habitat (i.e., rocks, soil, water). A key difference in Anishinaabe worldviews is that humans are not at the top of a hierarchical arrangement in nature (Callicott & Nelson, 2004; Kimmerer, 2015). Humans are one of many components of complex systems, and our actions, intentional or otherwise, can disrupt the balance of biological communities. The importance of proper relationships with nature has long been recognized and valued by Anishinaabe peoples (Benton-Banai, 1988; Callicott & Nelson, 2004; Danielson, 2002; Geniusz, 2009; Geniusz, 2015; Johnston, 1976; Kimmerer, 2015; Wilson, 2008).

With Anishinaabe environmental worldviews as a foundation, in this paper, we expand on previous research on relationships in forested wetland communities in northern Michigan (Kozich et al., 2021; Wilson, 2008). The northern Great Lakes region is characterized by the abundance of forested wetland ecosystems known as rich conifer swamps. These diverse ecosystems are also commonly called "northern conifer wetlands" (Dickmann & Leefers, 2016), "cedar swamps" (Kost, 2002), and "lowland swamps" (Pregitzer, 1990). They are often adjacent to lakeshores and streams as riparian ecosystems. In these low-lying settings, the swamps are often fed by cold groundwater as it slowly moves down-slope (Kost, 2002). The constant supply of groundwater, and the mineral nutrients it carries, results in rich, peat-accumulating soils that can support high biodiversity (Kost, 2002; Pregitzer, 1990).

Many conifer trees (trees with year-round needles) are adapted to the damp conditions of rich conifer swamps and create dense shade and cool micro-climates that benefit many other organisms. Mosses, lichens, liverworts, and many amphibian species are common in rich conifer swamps, including over 30 plant and animal species that are considered rare (Kost, 2002). The shaded conditions also help keep streams cool by minimizing heat and evaporation due to sun exposure (Johnson, 2004; Kost, 2002). Many fish species, including brook trout (*Salvelinus fontinalis;* Ojibwe: *maazhamegoons*), rely on the cold-water stream habitats common to rich conifer swamps (Jobling, 1981; Nuhfer et al., 2015). The roots of large conifers along stream-banks provide valuable habitat structure and protective cover for fish (Anglin & Grossman, 2013; VanDusen et al., 2005). Downed trunks and branches over streams create shady pools of deeper water required by brook trout (Kost, 2002). The canopy of conifer trees thus plays a key role in the balance of these diverse and intricate systems.

Four conifer species stand out as key components of rich conifer swamps, with northern white cedar (*Thuja occidentalis;* Ojibwe: *giizhik*) as the most characteristic of the group. Cedar belongs to the genus *Arborvitae*, which means "tree of life" in Latin (Barnes & Wagner, 2004; MSU, 2015). It provides critical winter cover and food for white-tail deer (*Odocoileus virginianus*; Ojibwe: *waawaashkeshi*) and many other animal species. It is strong, slow-growing, and shade-tolerant, and it displays remarkable abilities to adapt and survive in otherwise harsh habitat conditions. It is tolerant of saturated, acidic soils and can survive after being tipped or even toppled by wind, which is a common occurrence with trees in wet habitats due to shallow root systems (Barnes & Wagner, 2004; Danielson, 2002; Kost, 2002).

Cedar is one of the most sacred plants in Anishinaabe culture, representing health and the continuity of life and is used for purification of the body and spirit (Geniusz, 2015; Johnston, 1976). Stories and songs about "Grandmother Cedar" illustrate the Anishinaabe view of plants as relatives (Geniusz, 2015). It is present at ceremonies such as sweat lodges, drum circles, and powwows. Its medicinal properties as a tea are helpful in treating coughs, headaches, and blood ailments (Danielson, 2002; Dickmann & Leefers, 2016; Meeker et al., 1993). Cedar leaves are often placed in shoes to ensure safe travels and are hung above doorways to purify homes (Benton-Banai, 1988). Its strong, rot-resistant wood has many uses on lodges, canoes, and utility items. The many gifts cedar provides are summarized in a story by Nancy Jones (2013):

> And then there is the next one. The cedar tree, that was another one that was asked, "How will you help the Anishinaabe?" Nanabosh asked. "Oh there are a lot of ways I can help the Anishinaabe," he said. "When somebody has a child, when a couple has a child, they will use my wood to make the cradleboard," he said. "I will give him all the love that I have to offer to the child. I shall bestow many visions onto him for the duration that he is in the cradleboard. And he shall dream too. The child will have healthy bones, have a straight spine, strong and straight bones just be totally healthy if one uses the cedar. I have many uses that I can give them, when they want to make medicine from my being a tree. When someone is making a canoe that is one use that will be used to make the strips of cedar on the bottom when someone makes it. They can make a cedar bark covering for their shelter when they want to stay warm during the winter." That is the one, the cedar bark, that will be utilized for a roof covering. And also these trees they will make other things like rice knockers, how it was said. This is where it will come from. "There are many ways I can help the Anishinaabe. I shall care for them too" (pp. 106-107).

Stories like the one above illustrate the wide-ranging values of traditional ecological knowledge (TEK) in Anishinaabe culture. Aside from highlighting its variety of human uses, cedar is personified as a relative that can communicate about the gifts it can offer. By presenting non-human species as sovereign beings, foundations for respectful and non-hierarchical relationships can be established (Callicott & Nelson, 2004; Kimmerer, 2015). Cultural worldviews established and shared through traditional stories like this result in the 'balance with nature' that is so often associated with Indigenous peoples (Booth, 2003; Callicott & Nelson, 2004; Geniusz, 2015; Johnston, 1976; Jones, 2013; Kimmerer, 2015).

Like cedar, hemlock (*Tsuga canadensis;* Ojibwa: *gaagaagimizh*) is a slow-growing, long-lived conifer tree historically common to forests of the upper Great Lakes region. Although it is common on drier upland forests, it is also tolerant of the damp, shady conditions of rich conifer swamps (Barnes & Wagner, 2004; Geniusz, 2015; Kost, 2002; Meeker et al., 1993).

Hemlock's dense foliage provides important habitat for many wildlife species, including deer, rabbits, and porcupine (Geniusz, 2015). Like cedar, hemlock has many medicinal properties. For example, Anishinaabe peoples have traditionally used twigs as a treatment for dysentery and needles to make a rich medicinal tea (Meeker et al., 1993). Deer appear aware of the antiseptic properties of hemlock as well; it is believed that they seek refuge in the litter beneath hemlocks to treat impacts from skin injuries and parasites such as worms and insects (Geniusz, 2015).

Balsam fir (*Abies balsamea;* Ojibwa: *aninaadag*) is a short-lived tree that is similarly common to rich conifer swamps, although it appears most often as a shade-tolerant understory tree more often than a canopy-level dominant one (Barnes & Wagner, 2004; Geniusz, 2015; Kost, 2002; Meeker et al., 1993). Balsam fir has numerous medicinal uses, as a treatment for headaches, colds, and ailing joints, among others (Meeker et al., 1993). Its pitch can be used as an effective sealant and water-proofer for canoes and baskets (Dickmann & Leefers, 2016). Nancy Jones re-tells additional stories of its uses:

> Oh me too, I shall help in many ways. For instance, when the Anishinaabe makes camp, they will use my boughs as a floor when they need something to lie on. And for instance these things, the way I look, it is if someone pokes at the lumpy pitch, the blistery part of that tree, from there they will get medicine. The medicine they will get from here, and they will know later on how to use this medicine. There is a reason for why I look like this, when the tree has all this sticky pitch. There are many uses for this. They will use this for flooring, and others will use this when they make medicine. They will have dreams as to how to use it (Jones, 2013, p. 107).

Black spruce (*Picea mariana;* Ojibwe: *gaagaagiwanzh*) is remarkably tolerant to harsh habitat conditions, including cold climates and saturated, acidic bogs (Barnes & Wagner, 2004; Geniusz, 2015; Kost, 2002). Black spruce is also common in rich conifer swamp communities, and Anishinaabe peoples have long known its many important uses. Its roots are strong and pliable and can be used as various-sized cords to tie nearly anything (Dickmann & Leefers, 2016; Geniusz, 2015). Like balsam fir, its pitch is very resinous and makes an effective sealant (Dickmann & Leefers, 2016). The inner bark can be ground up and used as a medicine to treat a wide range of ailments (Dickmann & Leefers, 2016; Geniusz, 2015). Its needles are rich in vitamin C and can be used as a medicinal tea (Geniusz, 2015; Meeker et al., 1993).

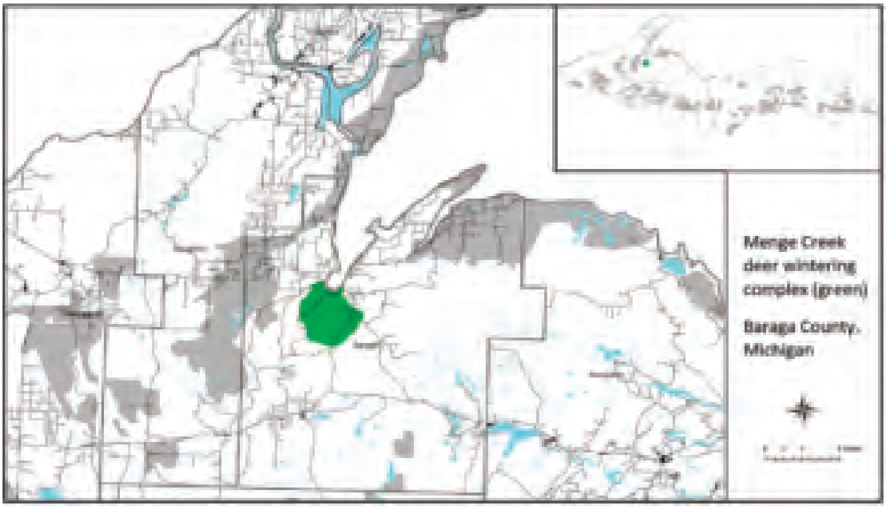
Relationships in rich conifer swamp ecosystems are delicate and complex, with subtle changes capable of disrupting their natural balance. Many disturbances in rich conifer swamps are easily attributable to human activities (e.g., climate change, careless timber harvesting, and hydrological changes). Other disturbances, however, are less obvious and may only be noticeable over long time scales as forest communities undergo gradual changes. A current concern among ecologists is the decline of cedar across the Great Lakes region, and its cause is widely agreed to be a trophic cascade, or a food chain domino effect, involving gray wolves (*Canis lupus;* Ojibwe: *ma'iingan* and white-tail deer (*Odocoileus virginianus*; Ojibwe: *waawaashkeshi*). Wolves are a top predator across the forests of the northern Great Lakes region, and deer are among their preferred prey. Deer, in turn, consume cedar leaves as a primary food source. When wolf populations are not capable of keeping deer populations in balance, deer populations dramatically increase. Their overpopulation, in turn, results in a dramatic decrease of cedar, which has been demonstrated by abundant literature (Cornett et al., 2000; Forester et al., 2009; Reuling et al., 2019; Rooney, 2001; Van Deelen et al., 1996; White, 2012). Other studies have found similar impacts to hemlock, another preferred food source of deer (Anderson & Loucks, 1979; Borgmann et al., 1999; Frelich & Lorimer, 1985; Rooney et al., 2000; Rooney & Walker, 2003; Salk et al., 2011). It appears that the human preference for reduced wolf populations is altering the species composition of rich conifer swamps, which could result in wide-ranging ecological and cultural impacts as other species emerge as dominants in the absence of mature cedar and hemlock (Danielson, 2002; Rooney & Walker, 2003; Salk et al., 2011; Van Deelen et al., 1996; Waller & Alverson, 1997; White, 2012). The common finding across the literature is that small cedar and hemlock seedlings are largely protected under winter snow-pack, but as they grow, they become susceptible to browsing by deer (with few reaching maturity). Our research goal was to quantify survival rates across several tree species in a rich conifer swamp to infer how deer browsing could be affecting species composition of the ecosystem.

Methods

Our objectives with this mixed-methods research were to expand on our previous studies of relationships in floodplain forests involving tree species composition, canopy density, and groundwater inflow (Kozich et al., 2021). In this paper, we explore relationships between the tree community and wildlife species that inhabit them. The study site is within the L'Anse Indian Reservation, home of the Keweenaw Bay Indian Community (KBIC). We compared the regeneration of cedar, hemlock, balsam fir, and black spruce along Menge Creek (Figure 1), a small second-order stream that traverses dense forest communities. Many floodplain areas of Menge Creek feature rich conifer swamps, and the watershed as a whole is recognized as an important deer wintering complex by the Michigan Department of Natural Resources (MDNR, 2015).

Figure 1

Menge Creek deer wintering complex (image: MDNR, 2015)



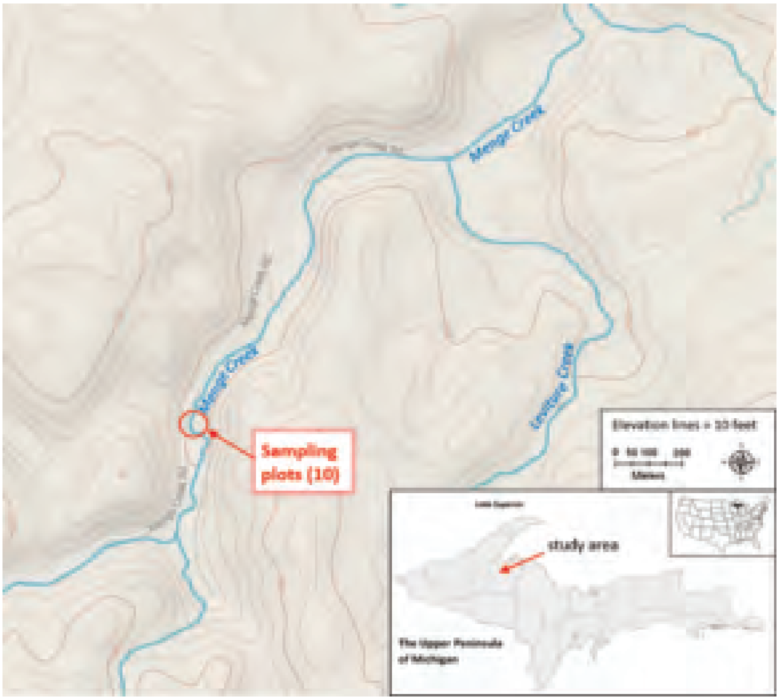
Our research team included faculty from Keweenaw Bay Ojibwa Community College (KBOCC) with a combined background in ecology, forestry, and data analysis. Two KBOCC Environmental Science majors assisted with this project, including one whose contributions served as the foundation of the required Capstone independent research project he successfully defended for his fall 2020 graduation. The research team included KBIC tribal members and descendants.

Following Indigenous research methods, members of the research team gained preliminary community insight through informal discussions with key knowledge-holders (e.g., elders, natural resource personnel, nearby residents), exchanged knowledge with each other throughout all steps of project, and treated all inhabitants of our study site as our relatives (Wilson, 2008). Research protocols were approved by key KBIC personnel, including the KBIC Tribal Council and the KBOCC Institutional Review Board. Preliminary findings were shared with the KBOCC community by a student research assistant in December 2020 as part of his capstone research project. Applications of this work, through this paper, are intended to support Indigenous knowledge, sovereignty, and nation-building.

Our project design was guided by community insight through an online survey conducted in April 2020. The survey was conducted by a student research assistant with the goal of capturing a glimpse of community perspectives on topics such as the importance of cedar, the current state of deer herd management, the role of hunting, and diminished wolf populations in the area. The survey was promoted for two weeks through all KBOCC social media outlets. It contained 15 Likert-scale questions and two open-ended questions for respondents to share any additional knowledge, observations, or opinions (see Appendix 1 for the full list of survey questions). Participation was voluntary and without compensation. All respondents provided their informed consent and were aware that their participation assisted in KBOCC scholarly research.

Figure 2

Location of sampling plots along Menge Creek



In summer 2020, we selected our study area along Menge Creek (Figure 2). We chose a study area within the vicinity of our previous research that we suspected to fit the profile of a rich conifer swamp. After reviewing topographical maps, we examined the site in person to confirm the plant community, floodplain gradients, groundwater seepage, and saturated peat-accumulating soils that are characteristic of rich conifer swamps (Kost, 2002). Downed trees were common across the surface as well as the stream. We documented all four tree species focal to our research (cedar, hemlock, balsam fir, and black spruce) as well as others typical of rich conifer swamps such as yellow birch (*Betula alleghaniensis;* Ojibwe: *wiinizik*), white spruce (*Picea glauca;* Ojibwe: *gaawaandag*), red maple (*Acer rubrum;* Ojibwe: *zhiishiigimiiwanzh*), and mountain maple (*Acer spicatum;* Ojibwe: *zhaashaagobiimag*). All characteristics of this site were determined to represent rich conifer swamps, as described in ecology literature (Kost, 2002). See Figures 3 and 4.

Figure 3

Rich conifer swamp community of Menge Creek

Figure 4

A cedar seedling in sample plot #7

We used transect and quadrat sampling to inventory our four focal species at the study site. We established two parallel transects, one on each side of Menge Creek. Each transect contained five sample plots (quadrats) equally spaced 40 meters apart from each other. Each of the 10 sample plots was 6 meters by 6 meters in area. Within each sample plot, we counted all individual cedar, hemlock, balsam fir, and black spruce trees. Following methods common across the literature, we then separated all individuals into three size classes based on height (Cornett et al., 2000; Frelich & Lorimer, 1985; Reuling et al., 2019; Rooney, 2001; Rooney et al., 2000; White, 2012):

- Class 1 = <0.5m tall (small seedlings protected under snowpack in winter)
- Class 2 = 0.5m to 3m tall (saplings vulnerable to browsing by deer)
- Class 3 = >3m tall (trees not vulnerable to browsing)

For statistical analysis, we separated the four tree species into two groups based on deer feeding preference. We characterized cedar and hemlock as 'browsed' because they are known as preferred food sources. Balsam fir and black spruce were characterized as 'unbrowsed' since they are unpalatable food sources. Our assumption was that if browsing is not affecting recruitment (the progression from seedling to maturity), all four species will demonstrate similar distributions of individuals across all size classes. However, since our study site is in a known deer wintering complex, we hypothesized that the recruitment rates of cedar and hemlock from class 1 to class 2 would be significantly lower than that of balsam fir and black spruce.

We did not monitor actual deer behaviors through field cameras or other such devices. We did not exclude deer from our sample plots through fencing or other deterrents. Since our study area is in a known deer wintering complex, and over-browsing is a well-documented phenomenon in our area, we made a simple but critical assumption that survival rates of individual trees across size classes are reflective of deer browsing behaviors (Cornett et al., 2000; Reuling et al., 2019; Rooney & Walker, 2003; White, 2012).

Results

Thirty-nine KBIC Tribal members and descendants completed our community survey. Among notable trends, respondents expressed the value of cedar, as 82% agreed that cedar is a culturally important tree to them. Respondents appeared less certain about the cultural value of hemlock, with 41% agreeing and 54% expressing no opinion. Respondents appeared fairly aware of potential impacts from deer browsing, as 59% agreed that too many deer could affect cedar and hemlock populations (31% had no opinion); however, only 49% agreed that cedar and hemlock are in decline in our area (48% expressed no opinion). Regarding wolf populations, 62% agreed that wolves are important for keeping deer populations in control. As for the open-ended questions, 24 respondents shared thoughts about deer populations in our area, 17 of whom expressed that the local populations are high. We received fewer comments about cedar and hemlock populations (15), with no discernable trends in responses.

Data from our sampling plots are shown in Table 1. The total individuals and relative abundance across all four species were fairly even in the class 1 size (seedlings), but cedar and hemlock almost disappeared in class 2, where black spruce was clearly dominant.

Table 1

Data from our 10 sampling plots, comparing total individuals and relative abundance across all species and size classes.

	Species		Class 1	Class 2	Class 3
Browsed species	Cedar	N	257	2	50
		%	29.1%	1.2%	64.1%
	Hemlock	N	229	5	13
		%	25.9%	3.0%	16.7%
Unbrowsed species	Balsam fir	N	219	53	9
		%	24.8%	32.3%	11.5%
	Black spruce	N	178	104	6
		%	20.2%	63.4%	7.7%

N = total individuals; % = relative abundance.

We hypothesized that cedar and hemlock are disproportionately experiencing a lack of progression from size class 1 to size class 2. While the evidence in Table 1 seems to make this statement clearly, we used several measures to test the hypothesis statistically. An independent-samples t-test was run to determine if there were differences in populations between classes. There were no outliers in the data, as assessed by inspection of a boxplot. Populations for each class were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$), and there was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = .335$). Between the two groups of tree species, there is a statistically significant difference in the populations of groups between class 1 and class 2 ($p = .001$). Although our methods prevent us from proving that deer are the cause (i.e., no behavioral observations), our hypothesis is supported. Cedar and hemlock are not progressing to larger size classes at a similar rate to balsam fir and black spruce.

Additional analytical steps yielded results consistent with the test results above. For instance, there were no significant differences between the two transects (east bank plots versus west bank plots). Ungrouping the browsed and unbrowsed species made no statistical difference either. It is very clear that in our study plots, something is causing severe mortality in cedar and hemlock seedlings as they grow beyond 0.5 meters in height.

Discussion

Our interests with this ongoing research are to continue learning about relationships between other-than-human species within the setting of the rich conifer swamp communities of Baraga County, Michigan. We began in 2015 by implementing a stream temperature monitoring program for waters of our area that provide critical habitat to cold-water fish species with study sites including Menge Creek. We then expanded the scope of our work to investigate relationships between forest canopy cover and water temperatures in Menge Creek (Kozich et al., 2021). Our current interests, described in this paper, take the next step of examining relationships between the charismatic trees that inhabit rich conifer swamps and the wildlife species that rely on them for food and shelter. Throughout the journey of this work, over 20 KBOCC student assistants have gained hands-on research experience, delivered presentations at conferences, and co-authored publications in scholarly journals. Several have continued their stream-related work through ongoing employment at the KBIC Natural Resources Department, leveraging the familiarity they gained with local stream ecosystems as KBOCC students. While we are very pleased with how our work reflects Indigenous research methods, we also acknowledge that a lot remains to be learned.

Our findings on the decline of cedar and hemlock in our area are not necessarily surprising, as numerous other scholars and practitioners across the Great Lakes region have noted the same phenomena with deer browsing as the apparent explanation (Borgmann et al., 1999; Cornett et al., 2000; Forester et al., 2009; Reuling et al., 2019; Rooney et al., 2000; Rooney, 2001; Rooney & Walker, 2003; Salk et al., 2011; Van Deelen et al., 1996; White, 2012). This appears to be a complex issue to resolve. To restore balance to the area's forest communities, the apparent solution would be to simply reduce deer populations so cedar and hemlock seedlings can successfully reach maturity. Research involving exclosures such as fences has shown that tree populations can dramatically increase without the browsing pressures of deer (Anderson & Loucks, 1979; Cornett et al., 2000; White, 2012).

However, as Waller and Alverson note (1997), deer herd management for reduced populations is feasible in ecological aspects but challenging in human aspects. Many hunters and passive wildlife viewers prefer abundant deer and would likely disapprove of intentionally reduced populations. The restoration of wolf populations to historic levels, as a means to cull deer herds, is similarly problematic among much of the public as well, often due to safety concerns or anticipated impacts on farm animals or pets. The continuation of high deer populations in the Great Lakes region is expected to result in further long-term impacts to the species composition of forest communities due to losses of cedar and hemlock (Frelich & Lorimer, 1985; Salk et al., 2011; Van Deelen et al., 1996; Waller & Alverson, 1997; White, 2012).

Further complicating matters in our research setting, KBIC members may not view increased hunting as a feasible solution for reducing deer herds. In previous research, we described local fishing harvests that have never approached sustainable quotas, and many survey participants cited harassment from the non-Native community as a factor (Kozich et al., 2020). With ongoing controversies surrounding treaty rights, and fears among Tribal members exercising them, it seems reasonable that 'more hunting' may not be a simple solution to restoring ecosystem balance.

In our previous Menge Creek research, we found evidence of forest tracts within the watershed that already appeared to be transitioning towards other dominant tree species as cedar and hemlock have been reduced (Kozich et al., 2021). In all sample plots, cedar was only present in large, mature individuals as midstory layers were dominated by balsam fir, black spruce, or red maple (Kozich et al., 2021). Findings from this updated expansion of our work are very similar, indicating that long-term trends are already in motion and cover an area of the floodplain larger than previously known.

Long-term reductions of cedar and hemlock pose cultural impacts for future generations of Anishinaabe peoples. Respondents to our community survey expressed cultural values associated with these trees as well as concerns about their sustainability. The potential inability of future generations to collect cedar and hemlock could alter long-standing ceremonial traditions and provide fewer medicinal options. Even if cedar populations do remain intact in some areas, access to them could be difficult for elders considering the remote and rugged nature of the region. Although the Anishinaabe are undoubtedly adaptable people, there seems to be a degree of tragedy involved with ecological and cultural impacts that are theoretically preventable. If Anishinaabe worldviews regarding balance, respect, reciprocity, and relations could gain traction with the non-Indigenous public and relevant decision-makers, perhaps the trend of forest community impacts could be reversed and some semblance of natural balance could be restored. Re-examining human roles in nature, following Indigenous teachings, seems to be the critical first step in this regard. Otherwise, due to the ongoing colonization of nature-based on human preferences (i.e., few wolves), permanent changes to forest communities seems inevitable (Fischer-Kowalski & Haberl, 1998).

Our research in this area will continue, and we are excited about many possibilities for expansion. A limitation with our current progress is that we took no measures to definitively prove that deer browsing is the cause of cedar and hemlock mortality. Although our data (and parallel research in the literature) clearly support this notion, an opportunity for follow-up would be to employ field cameras to record deer behaviors in study plots. Partners in the KBIC Natural Resources Department can likely offer assistance and wisdom with this task. With adequate funding, another opportunity would be to replicate a deer exclosure experiment in study plots over a number of years to examine possible changes in cedar and hemlock survival compared to non-enclosed plots. Other studies have found that seedlings' surroundings, including the presence of other species as deer deterrents, can reduce browsing (Borgmann et al., 1999). As wolf-deer-plant relationships appear to be a topic of much interest in our community, we are excited for whatever directions our efforts will involve next.

Conclusion

In keeping with Indigenous research methodology, all KBOCC Environmental Science research is place-based, community-based, and is intended to provide tangible benefits to those who call this sacred area home. All persons involved in this research are from the local community and have vested interests in our study sites and our research findings. To each of us, our research is sacred in our own respective ways. As continuous learners, our projects involving stream, forest, and wetland communities will continue and expand. As we learn more about the complex wetland ecosystems in our area, we will continue sharing what we learn with the local community and all interested scholars and practitioners who can benefit from our efforts.

Acknowledgements

We acknowledge that our study area lies within ancestral, traditional, and contemporary lands and waters of many Indigenous nations, including the Anishinaabe. We also acknowledge our many more-than-human relatives who call this region home and have done so since time immemorial. As the original caretakers of these lands and waters, we are most grateful to all our relatives, and we thank all who practice stewardship and care today in partnership with local, state, federal, tribal, and other governance entities throughout the Great Lakes region.

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Author Biographies

Andrew Kozich is the Environmental Science Department Chair at KBOCC, with a background in forestry, water resources, environmental policy, and Anishinaabe Studies. As the mentor of 20 or more Environmental Science majors per semester, he guided this student-led research project and contributed the majority of the writing.

Karen Colbert is the lead Math faculty at KBOCC and serves as a data analyst and consultant on special research projects (including student-led research). Karen is a PhD student in Computational Science and Engineering at Michigan Technological University, with research grounded in improving data analytics assessments for Indigenous communities.

Gerald (Jerry) Jondreau is a KBOCC adjunct instructor in courses focusing on forest resources and Anishinaabe culture. He has served as the KBIC Tribal Forester and is the owner of Dynamite Hills Farms, where he and his family produce natural foods such as maple syrup. Jerry is an enrolled member of the Keweenaw Bay Indian Community.

John Lusty is a fall 2020 KBOCC Environmental Science graduate (with honors). The research presented in this manuscript represents an expansion of the work John completed for his required capstone independent research project. He and Dr. Kozich designed the project, conducted the literature review, and led the data collection.

Victoria Ripley is a current KBOCC Environmental Science major who assisted with data collection for this project. She is a valuable student assistant in departmental research projects involving stream ecology, fisheries management, and groundwater contamination. Victoria is a descendant of the Keweenaw Bay Indian Community.

Appendix 1: Questions contained in community survey, conducted April 2020.

1. What is your age?
2. Are you a KBIC Tribal member or descendant?
3. How long have you lived in Baraga County?
4. Cedar is a culturally important tree to me.
5. Hemlock is a culturally important tree to me.
6. Wolves are important for helping control deer populations in our area.
7. Conifer tree species such as cedar and hemlock are declining in our area.
8. Our area should consider expanded hunting to help control deer populations.
9. Cedar and hemlock trees are vulnerable to harm from deer over-population.
10. Climate change could threaten cedar and hemlock populations in our area.
11. Logging is negatively affecting cedar and hemlock populations in our area.
12. Other human activities could be harming cedar and hemlock populations in our area.
13. I am concerned about nature being out of balance in our area.
14. Please share any observations you've made about changes in cedar and hemlock populations in our area.
15. Please share any thoughts on current deer populations in our area.

Note: questions 4-13 used a 5-point Likert scale.