# A Case Study for Fostering CIVIC engagement: Theory for Developing Environmental Stewardship in Adolescents through Outdoor Recreation and Student-Driven Long-Term Research in Science Classes

Carolan H. Ziegler

Faculty of Education, Edgewood College, Madison. Wisconsin, USA
Email: caziegler@edgewood.edu
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***Abstract*—This case study explores an application of the theory that practicing science outdoors empowers students to be agents of change and later identify as environmental stewards. Decades of research in the scientific community have contributed to an understanding of the value of nature for child and adult development. However, millennia of research from Indigenous communities around the globe have already identified the value of the human-to-land connection. Scientific exploration that incorporates Traditional Ecological Knowledge could provide an opportunity to connect students to the land in a concrete and sustainable way – encouraging future student involvement in global ecological issues. This case study, from the perspective of a non-Indigenous author in a predominantly non-Indigenous population of adolescents, explores implementation, data collection, and establishment of procedures for student research and long-term data sets in an ever-changing project. In addition, it will discuss the benefit of outdoor place-based education in fostering environmental stewardship in students.**

***Keywords*—place-based education, environmental stewardship, sustainability, indigenous science, outdoor recreation, traditional ecological knowledge, civic action**

## I. Introduction

"If we want children to flourish, to become truly empowered, let us allow them to love the earth before we ask them to save it" [1].

Changing climates, pollution, and biodiversity loss in the 21st century have forced us to consider our place in our community, nation, and planet. As we reflect on next steps, it is important for each educator to ask themselves how their classrooms will inspire the necessary reform. What do we want our youth to gain from being present in our classrooms? What do we hope for them in the future? What role can we play in this journey? Through outdoor recreation, data-driven student-led research projects and a strong connection to ancestral and modern Indigenous ways of knowing, we can influence the future of our youth by asking these complicated questions.

It is well-documented that a connection to nature and wild places can enhance physical and emotional health [2, 3]. But in a rapidly changing climate, how can we empower students to become agents of change and environmental stewards? Educators must first provide students with opportunities to interact with and embrace nature – The fun factor. In conjunction with these activities, educators must provide opportunities for long-term data collection and a respectful study of Traditional Ecological Knowledge. This can be achieved through coupling outdoor recreation and long-term student-driven ecological research.

## II. Literature Review

Wisconsin-born conservation ethicist Aldo Leopold provides one of the best examples of this type of data collection from settler history[1] 1 and how it can inspire policy change [4]. Through careful observation and wildness appreciation, his phenological data spans over half a century. His family turned this type of data collection into a hobby, taking weekends at their famous "Shack" to note relationships amongst species [5]. This multigenerational data collection spanned over 70 years and became one of the most important local documentations of climate change and its effects on the local flora and fauna [4]. Starting first with outdoor joy, Leopold inspires us to expand our classroom walls and make conservation a constant, careful and record-driven practice.

But of course, Aldo Leopold was not the first human to note changes over time amongst species in Wisconsin. Specifically in the land referred to as Wisconsin by settlers, at the very site where this case study occurred, members of the Ho-Chunk (also called Hoocąk) Nation have carefully studied ecological relationships and used this information to make decisions about land use. Evidence of their ancient occupation on ancestral lands, mostly in the form of burial or effigy mounds and fluted points, can be found all over the University of Wisconsin Madison and Edgewood College Campuses, dating back 12,000 years [6]. Prior to settler occupation, this site was named Teejop in Hoocąk (Ho-Chunk language) which translates to "Four Lakes". Native ancestors practiced living in harmony with the land, taking many lessons from the plants and animals that called this land home before them. According to Aaron Bird Bear, Recruitment and Retention Specialist at the School of Education, UW Madison, observation of the landscape near the shores of the lakes influenced their policies and beliefs. "The Ho-Chunk love(d) it because they live(d) alongside this species (bur oak) for so long that they are culturally intertwined with this species of tree" [6]. As non-Indigenous educators, it is important to learn from this careful and

[1] Using ecology to influence decision-making and policy has been happening for millennia through Indigenous traditions. This instance (Aldo Leopold) is one of the first documented examples from settler history. As Leopold was one of the first to write about and document it, he is referred to here, but it is certainly not the first time this has happened in this land's history.

constant practice of observation and emphasize its role as science in understanding the world around us. Students can then move away from only non-Indigenous science (also known as Western Science), which focuses on written records and scientific methods and spans a few hundred years [7] to incorporating aspects of Indigenous science which can be considered a "living knowledge" [8]. Indigenous science emphasizes the journey of discovery and de-emphasizes knowledge sharing exclusively through written books, quantitative data, or journals.

While outdoor education has gained tremendous popularity since the start of the COVID-19 pandemic [3], learning through nature play and the outdoors has been a global tradition for millennia amongst Indigenous communities. Under the umbrella term of Indigenous science sits the term Traditional Ecological Knowledge which has been a key part of this case study. Traditional Ecological Knowledge differs from Indigenous science as it can be defined as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" [9]. Traditional Ecological Knowledge should not be seen as separate from Western non-Indigenous science, however. Instead, it should be explored as a collaborative approach. Whyte [10] explains this collaborative approach:

"It serves to invite diverse populations to continually learn from one another about how each approaches the very question of "knowledge" in the first place, and how these different approaches can work together to better steward and manage the environment and natural resources" [10].

As students of science, we know that long-term datasets make a huge difference in understanding ecosystems at large and tracking changes over time. How can this dream become a classroom reality? What outcomes can you expect? This paper explores the evidence behind this practice and shares tips for success based on a decade-long case study from Madison, Wisconsin, USA in an adolescent learning community.

Richard Louv describes the relationship between 21st-century children and nature as "nature-deficit disorder" [11]. This disorder is characterized by a lack of knowledge about the natural world (including natural processes, food origin, and biodiversity) and insufficient outdoor playtime. Symptoms include diminished senses, attention problems, and physical/emotional illnesses. As future generations of young people are faced with multiple environmental concerns, one could reasonably assume that the next generation will require a deep understanding of, and respect for, the natural world. As outdoor enthusiasts, educators involved with the project outlined in this case study have identified one outcome of the program: The development of a sense of environmental stewardship in students. Stewardship involves more than knowledge of a need or topic; it requires engagement, action and cooperation. It encourages community involvement and promotes a deeper understanding of the natural processes. Although only a small portion of our students may become professional scientists, each one is already a citizen of the Earth. Because of this, it is vital that we continue to foster a sense of environmental stewardship in students.

Doing so requires understanding how environmental stewards are formed and nurtured. Bonnett [12] explores the philosophical and ethical obligations of sustainability and how a sustainable frame of mind is accomplished. This goal does not simply include sustainability in a way that sustains or keeps nature alive and well, but also sustains our own independent existence, which in turn is not independent of nature at all. "For authentic human being the attitude of sustainability is not a bolt on option but a necessity" [12]. He suggests the scope or view of our identity be expanded to include nature and that through this inclusion, we will cease to see ourselves as apart from but instead a part of nature. Sustaining nature, then, becomes an issue of sustaining ourselves, and vice versa.

The Swiss National Science Foundation investigated the relationship between environmental knowledge or experiences and learning and behavior in Swiss adults. In this study, Finger [13] identifies a paradox between the high level of environmental awareness and concern but low or limited social behavior as a response. He attributes this to what he calls the Life-world approach to environmental behavior. This approach relates to the idea that behavior is "related to and derives from significant life experiences, and that learning is less contributing to a developmental process than it constitutes a means of giving meaning to experiences" [13]. To test this approach, Finger gathered empirical data on the life experiences of over one thousand Swiss and French adults and compared them to their activity in environmental behaviors. The in-depth method for this data collection is outside the scope of this paper; suffice to say the research was conducted thoroughly and legitimately. After performing three regression analyses from the data, the author concluded that they found "little causal relationship between environmental value orientations, awareness, concern, information and knowledge acquisition on the one hand, and behavior on the other". Instead, Finger concluded, "Environmental behavior appears to be mainly related to environmental experiences" [13]. Finding a way to incorporate education into nature experiences could potentially result in greater environmental behavior. In other words, there is no replacement for outdoor experiences when fostering environmental stewardship.

These nature and life experiences can come in any format. While to some, it may just be physical activity or an academic-based science class, others see a path with which significant dedication and environmental change is within reach. This path is an opportunity to engage youth in the beauty and joy of the outdoors. Louv explains, "Time in nature is not leisure time; it's an essential investment in our children's health" [11].

Achieving student engagement and fostering a desire to become an agent of change was explored in detail by Cook et al in their 2015 case study in Australia [14]. Members from the art and science community as well as indigenous elders, teamed up to provide an opportunity for adolescents to know and love a local ecological community. They engaged in play, research, and learning from elders and were then invited to discuss possible changes to two neighborhoods to enhance child-friendliness with urban planners. This development of civic voice amongst adolescents demonstrates that youth can enact change, and policymakers are interested in and grateful for their input as they represent the future consumers and users of shared spaces. By valuing the perspective of adolescents and pairing them with urban planners, they saw their work and opinions visualized in their neighborhood landscape.

## III. Materials and Methods

Lake Wingra is 321 acres with an average depth of 9 feet and a shoreline of 3.6 miles, making it the smallest of the Yahara Chain of Lakes in Madison, Wisconsin, USA. Edgewood Campus School sits on the shores of the north side of the lake and offers private schooling for students in 4K through 8th grade (ages 4–13). Since 2014, this school has employed a place-based approach to science education that incorporates lake science and specifically Lake Wingra as well as ancestral Indigenous occupation of the land before the arrival of European settlers. In the greater Madison area, public and private organizations (including Friends of Lake Wingra, the Department of Natural Resources, and the University of Wisconsin-Madison Center for Limnology) have provided research on and resources for the study of the local lakes and their relationship to the human population of this area. Citizens who are active in the community of scientists and policymakers have a history in Madison, Wisconsin; Earth Day celebrations originated here over 50 years ago.

Middle school science standards for the state of Wisconsin reflect a wide range of inquiry-based scientific practices including those in ecology, chemistry, earth sciences, and scientific experimentation. Obstacles to long-term projects in schools center around commitment and buy-in from instructors. Tying projects directly to standards has been fundamental to Edgewood Campus School's success. Students in seventh and eighth grades participate in this study during the introductory unit on Ecology. Seventh-grade students look at the Ecology of the Lake through the biotic components and overall geography – An introduction to limnology. Students in eighth grade take a second look at the lake in a unit on the Ecology of the Lake through the abiotic factors that influence the lake – The lake's chemistry.

The Wisconsin Science Standards (closely linked to the more globally known Next Generation Science Standards, 2013) are:

- SCI.SEP4.m Students extend quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
- SCI.SEP5.m Students identify patterns in large data sets and use mathematical concepts to support explanations and arguments.
- SCI.SEP7.m Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
- SCI.LS1.C.m Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.
- SCI.LS2.A.m Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems but the patterns are shared.
- SCI.LS2.C.m Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.
- SCI.ESS2.A.m Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources [15].

At its birth in 2014, the lake sciences program at Edgewood Campus School required students to survey and gather samples from the lake environment on foot. This included terrestrial and aquatic sampling; boardwalks and piers were used for access to obtain aquatic samples. A map of the campus can be seen in Fig. 1. A roughly .5km walk brings students from their classrooms to the lake shore riparian zone. Within the first year, the program added the use of kayaks and canoes to bring students into the lake to gather samples of water and plant material. A nearby boat outfitter was utilized to help with this. This required a full day of students getting to and on the lake. It was a challenge to have students missing other courses so frequently, as this was only a part of science class curriculum.

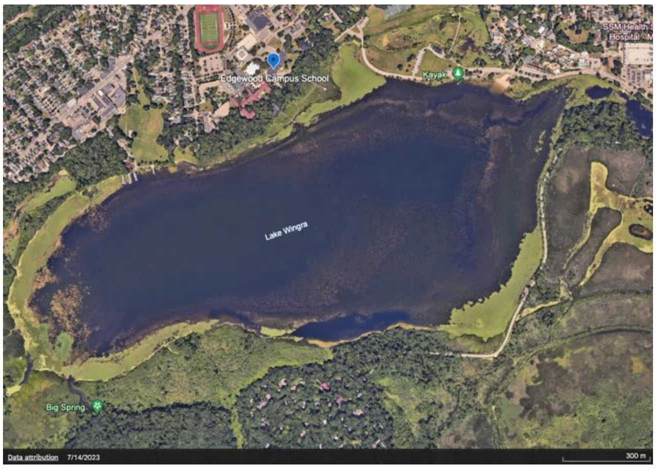


Fig. 1. Google Earth imagery of Lake Wingra marked for Edgewood Campus School [16].

As data collection continued and developed with the help of University Wisconsin Limnology Department experts and Department of Natural Resources guides, Edgewood Campus School teachers began to apply for outside funding to outfit the school with their own fleet of kayaks for student data collection. Currently, the school has enough kayaks to have 19 students on the water at a time. The kayaks are now stored on site near the water, decreasing travel time dramatically and allowing data collection to happen more frequently. Eliminating the time requirement has allowed students to focus on high quality data collection methods, frequency in sampling, and data analysis. A group can get on and off the water for data collection with sufficient time for safety and precision in a 50-minute class period.

Once the initial obstacle of accessibility was eliminated, focus turned to enhancing the research to be student-led and consistent over many years. With support from the Hasler

Laboratory at the University of Wisconsin, protocols were established for data collection including zooplankton analysis, macroinvertebrate sampling, macrophyte sampling, conductivity, pH, dissolved oxygen, carbon dioxide, turbidity, nutrient analysis (phosphorus and nitrogen) and temperature (both surface and at 1 meter depth).

Wisconsin State Standards emphasize the use of the scientific method as the way to gather and report scientific findings [15]. However, because the focus of this research at Edgewood was to celebrate and explore the Indigenous knowledge and science of this sacred space, emphasis was also given to incorporate concepts from Ho-Chunk tribes both historical and current. As literary references are not a part of traditional Indigenous communities, we use alternative sources of information like lectures, podcasts, and guest presenters to learn about the significance of Lake Wingra for both ancestral and modern-day Ho-Chunk people. Lake Wingra is famously a spring-fed lake with roughly two dozen springs still active today [17]. The connection between native Ho-Chunk tribal members and the springs of Lake Wingra can be seen when considering the original name of this lake from Ho-Chunk, Kichunkochheperrah, meaning “Place Where the Turtle Comes Up”. The springs were and still are places of sacred importance for ceremonies to explore pathways between the animal and human worlds [18]. Students begin their year by observing the shorelines of Lake Wingra and exploring the multiple burial mounds along the shorelines. We ask questions about the sacred significance of the land (for example: Why did ancestral Ho-Chunk tribes choose to put effigy mounds in this location?) and look at accounts of the mounds and springs from settlers in the early years of Wisconsin statehood [18]. We also explore the very nature of science as a way of knowing. Most students involved with this case study, at this point in their education, have experienced science to mean only non-Indigenous science. We work as a group to ask what other types of information are valuable and necessary to include an extensive history of this area beyond the temporal scope starting at Wisconsin’s statehood. By beginning the unit of study with the Ho-Chunk people, students are reminded that the land they know as Wisconsin has changed many times throughout human history and will continue to change.

Inquiry continues for students as they are asked to consider the focus question for this unit: What is the health of our lake ecosystem? Lake Wingra is perhaps one of the most studied lakes in the United States due to its multi-use property and presence as an urban lake. University of Wisconsin Arboretum, private golf courses, public and private schools, and residential units sit on its shores. Students explore the multiple uses of the lake for recreation, drainage, and educational opportunities in addition to its value in nature as a wildlife corridor. By making visual observations of this multi-use resource, students begin the process of understanding multiple stakeholders and using civil discourse to explore needs. Their end goal is to be able to answer this initial question with data they have personally taken, compare it to existing data, and participate in a civic engagement activity where they make an effort to influence the health of the lake in the future by practicing environmental stewardship.

Parameters for water sampling are established for lake ecosystems [19]. In our scenario, Lake Wingra provides a home base for students to consider the entire ecological community (aquatic and terrestrial). Students are presented with the tools used (a majority of the tools used come from the LaMotte Water Quality assessment kits), provided opportunities to practice these techniques in a laboratory setting, and then asked to make predictions about the levels of each parameter they explore. Hypotheses are based on local existing research (from student-gathered data over the last ten years) as well as more global data (from lakes throughout the Great Lakes Region of the United States). This process of prediction-making based on existing data is key in helping students explain how these levels impact humans and wildlife alike. Samples are brought back into the classroom and analyzed. Data is recorded on paper first and then input into a freely accessible spreadsheet on the program’s student-driven website. Students regularly look at data to determine statistical analysis appropriate like outliers, standard deviation, averages, and box and whisker plot creation. Mathematical analysis is performed in conjunction with the support of a math teacher during both math and science classes. Teachers reported greater student interest in these findings and were anecdotally attributed to their use in multiple classes (both math and science).

This process of sampling, testing, and analyzing is carried out each month of the year and students sample the same area and parameters each time. While efforts are made to eliminate any additional variables aside from the date change, we acknowledge that there are situations out of our control that might impact our data (namely human error). Students worked in teams to gather data for specific parameters and presented this data in a formal class presentation called “The State of the Lake Address” which informed the community about their analysis of the overall health of Lake Wingra. Influential policymakers and individual scientists who provided support for this opportunity are invited. The city of Madison holds an annual State of the Lakes address, hosted by the Clean Lakes Alliance. Scientists, community members, and policymakers gather to discuss and plan for the future of the Yahara Watershed [20].

It should be noted that to perform the data collections students engage with Lake Wingra through outdoor recreation. As previously mentioned, experiencing joy outdoors and the discovery of nature could be key to enhancing stewardship among students. Although kayak trips are, at first glance, designed to acquire samples for analysis in the lab, their dual purpose is to allow students an opportunity to embrace and experience nature from a new and exciting perspective. While many students have experienced some sort of lake excursion with family, not all students have. In addition to kayaking, the image in Fig. 2 shows students using gas-powered ice augers to reach the lake water for sampling during winter months. As a class, we regularly observe (with the help of binoculars) green heron nests when they return during late spring, float above bluegill nesting sites in the summer, and even identify seemingly magical objects in the lake as freshwater bryozoans. All of these activities combine as a socially joyful experience for adolescents under the guise of science. Fig. 3 demonstrates the value of these experiences during the COVID-19 pandemic when social interactions were limited.

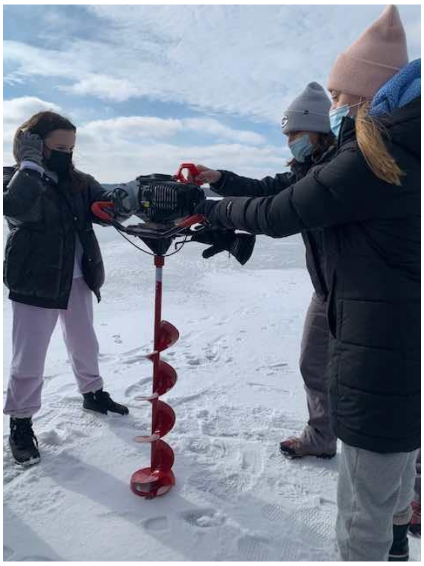

Fig. 2. During winter months, students use ice augers to drill holes when the ice is thick enough (7+ inches) to gather samples to analyze (February 2021).

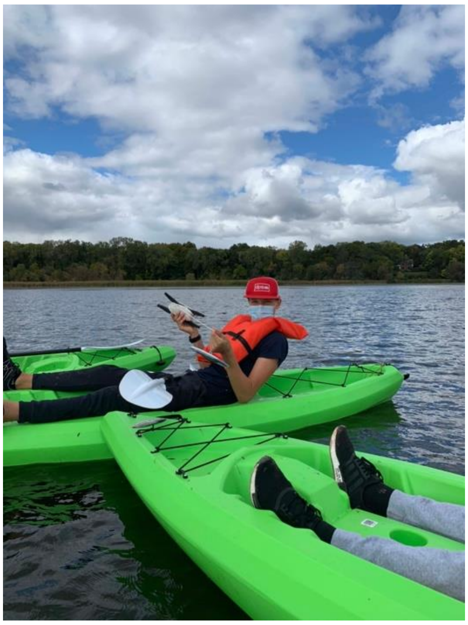

Fig. 3. The pandemic provided a unique opportunity to have students outside and learning instead of learning online or on screen. Students were still able to meet for regular data collection throughout these years following the recommended safety protocol. A student is pictured with a Secchi disk. (October 2021).

The final and perhaps most important component of this unit of study is a student-led civic action project. During this time, students identify an area where they can make a difference in their community based on the information and data they and their teammates have collected. Sample civic action projects have included group and individual activities and ranged from contacting and speaking with local members of government to starting neighborhood campaigns to remove excess leaves from gutters (minimizing nutrient runoff into lakes). The student-driven nature of this process is key. As they have already participated in the six steps above, they are well versed in issues that surround the lake and major stakeholders that can be impacted. Students can take their own interest (social engagement or education, physical activity, written word, art as a message of change) and influence their immediate community. The following is a list of student-driven civic action projects that were carried out during October 2019:

- Help neighbors by volunteering to remove leaves from the street/sidewalks;
- Educate the community with flyers about issues that impact the lake;
- Interview the maintenance staff at schools and churches about their road salt use;
- Educate peers on the effigy mounds on campus and how to treat them with respect;
- Create information warning about invasive species and their removal;
- Assist community members in signing up for Rain Alerts to avoid runoff from leaves into the lake;
- Start or improve a compost pile;
- Write to policymakers about lake pollutant concerns, specifically road salt and nutrient loads from agriculture and leaf runoff.

## IV. Result and Discussion

At the end of the unit, students were required to take formal assessments to demonstrate they had met the goals set forth in the standards at the beginning of the unit. Each student was also asked to reflect on the unit by answering the question "What stands out to you about this unit that you enjoyed?" Responses were recorded in Google Forms. Several responses from October 7, 2021 were as follows:

- "My favorite part was getting to do real research that will help the community we are in. I felt like in this unit we were able to do science that seemed very similar to what real scientists do in their fields. Making our presentations, lab reports, and other projects on what we found in our lake felt good because we were greatly contributing to knowledge on how to help Lake Wingra."
- "I really liked writing my State of the Lakes essay. I liked this because I enjoyed writing about a Lake that I have been to and kayaked in. I thought it was cool that in this unit we were actually doing something to help our planet and lake."
- "We might've helped actual research on the lake, and it feels good to make a difference."
- "My favorite part of the unit was kayaking because I thought it was fun to collect data on the oxygen, turbidity, pH levels, etc. When kayaking, it not only was fun but it also was for a good purpose. It made me feel good to know that I was making a strong impact for the future of Lake Wingra."
- "I liked writing the letter to the mayor because I want to learn more of what people are doing in the real world to prevent lakes from dying. I also liked when we gave the state of lakes addresses because it felt very professional and I enjoyed it."

(Unedited responses from Google Forms by 8th grade students taken on October 7, 2021.)

Although the previous responses are student-written, they are not complete confirmation of fostering stewardship or change agency to last a lifetime. They are, however, confirmation that student interest was sparked. They also tell us that despite the growing number of studies into outdoor education, there is a lot still to be explored. Just as the conversations between Western or non-Indigenous science and Indigenous science encourage us to look at data that is not only qualitative or quantitative, we too must look to our students for indicators of passion and joy when we measure our success in school. Joyful students look to the future of possibilities as something that can be influenced. By giving students a chance to dive into a topic on ecology in their neighborhood and introduce a civic action to help, we are giving students a voice and agency for a future of environmental obstacles.

Educators in the 21st-century have obligations to prepare their students for a changing climate. Understanding the science behind these changes and how to study them is one part of the process. An integral part of this preparation should focus on solutions that can be achieved by collaborating with community members and learning from existing non-Indigenous science and Indigenous science alike. Place-based programs like the one described in the case study above prepare students for a world where they will be making decisions about land use and ecosystem management by first demonstrating the intrinsic value of the landscape and then providing students with the tools necessary to make an impact in local communities.

As Aldo Leopold said in his collection of essays "A Sand County Almanac":

"…there is value in any experience that reminds us of our dependency on the soil-plant-animal-(hu)man food chain, and of the fundamental organization of the biota. Civilization has so cluttered this elemental (hu)man-earth relation with gadgets and middlemen that awareness of it is growing dim" [5].

This case study suggests that this de-cluttering can be achieved through outdoor recreation activities like hiking and kayaking coupled with long-term data collection. By implementing a place-based research program in adolescent formal education, students were able to see long-term impacts and make connections to themselves and their communities. Although data for this research is not quantitative in manner, it demonstrates a need for more place-based education research in fostering environmental stewardship and suggests that perhaps this way of looking at success (written, quantitative, focused on Western science) could be expanded to include, more philosophically, attitudes towards civic engagement projects and individuals self-identified place within the natural world.

## Conflict of Interest

The author declares no conflict of interest.

## Acknowledgment

This endeavor would not have been possible without the generation contributions of research, time, and advising from several local and national non-profit organizations. The Center for Great Lakes Literacy along with the University of Wisconsin chapter of Sea Grant provided a community of educators to share ideas with as well as funding ideas for equipment. Anne Moser, University of Wisconsin Water Resource Librarian, is owed a particularly large thank you for the professional development opportunities that allowed educators to explore limnology in their community so that they might bring the science back to their classrooms.

In addition, the University of Wisconsin Hasler Laboratory of Limnology and the many graduate students who perform research on the lake ecosystem provided many hands-on opportunities and field trips for students in this case study. Their involvement allowed students to connect their classroom work to active, ongoing scientific research. They also provided resources to compare existing lake data to support more accurate analysis.

The National Resources Foundation of Wisconsin granted this program the funding to purchase an entire classroom set of binoculars, allowing students to gather data on bird migration and populations as well as identify bird nesting strategies. Putting real tools into student's hands is integral to making this project exciting and fun for students.

Lastly, this case study and the entire place-based education programming described here was a collaborative effort with the support of the Edgewood Campus School, primary and secondary school educators, and program directors (Dr. Amy Schiebel, Jennifer Koziar, Heidi Pankratz, and Bridget Moylan). The strong community of educators who believe in the vision of outdoor place-based education is vital to the long-term success of this program.

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