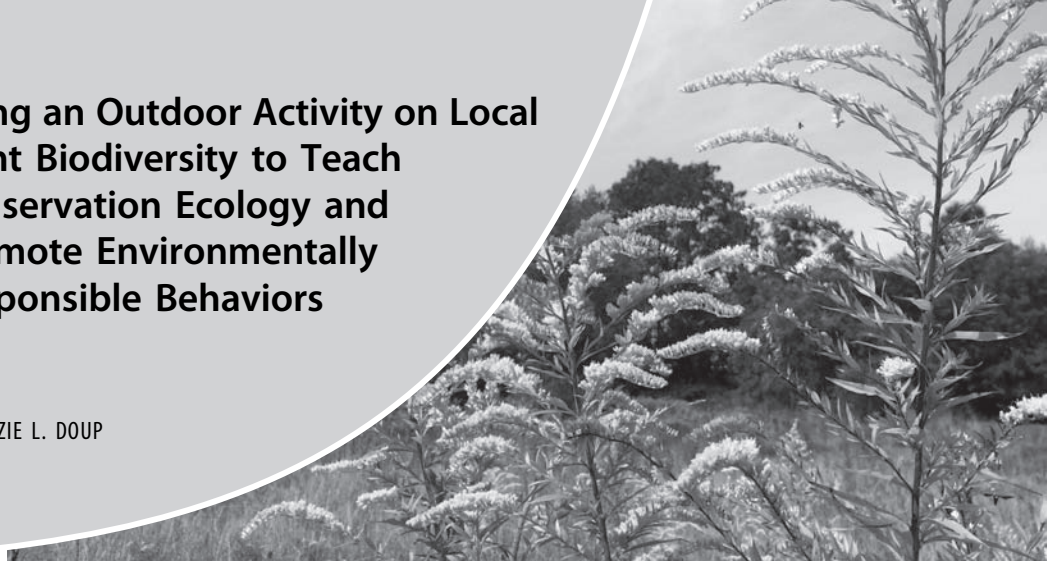
INQUIRY & INVESTIGATION

Using an Outdoor Activity on Local Plant Biodiversity to Teach Conservation Ecology and Promote Environmentally Responsible Behaviors



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Abstract

Children today do not spend as much time outside as they did in previous generations; consequently, they are not building connectedness to nature and are less likely to engage in pro-environmental behaviors. Environmental education is one way to ameliorate this problem. However, teachers are limited by their access to natural habitats, time, and field expertise. To address both of these issues, I present an inquiry-based activity for both Advanced Placement and general high school biology that requires students to spend time in nature, use authentic field methods for collecting data, and apply their findings to pertinent conservation issues. This four-day activity uses a simplified approach, called the meter stick random sampling method, to measure plant biodiversity of different local habitats. Time-efficient and not reliant on species identification, this method is designed so students can repeat this procedure in their backyards or at a local nature preserve. The data can be used to discuss how human disturbance of habitat affects biodiversity, the importance of biodiversity for the stability of ecosystems, and how to restore biodiversity locally.

Key Words: *biodiversity; conservation; ecology; human impacts; biology; environmental science; field methods; plants.*

○ Introduction

Importance of Establishing a Sense of Place in Nature

Human connection with nature is imperative for the conservation of natural resources and general well-being. Not only do direct experiences with nature offer valuable educational experiences (Dettmann-Easler & Pease, 1999; Krasny & Tidball, 2009; Kudryavstev et al., 2012; Wynveen et al., 2014), they also increase self-discipline (Taylor et al., 2002), mitigate attention deficit disorders (Taylor & Kuo, 2009), and promote environmentally responsible behaviors (Duerden & Witt, 2010; Ryan, 2005; Vaske & Korbin, 2001; Wynveen et al., 2014). At this time when the majority of the human population lives in cities and biodiversity is being lost drastically, the detachment between people and nature is extremely evident (Louv, 2011). Therefore, it is essential to foster connectedness with nature in youth, and environmental education is one way this can be achieved.

"Sense of place" is defined as the level of attachment one has for a specific location and what meaning one places on that location (Kudryavstev et al., 2012). This is important for conservation efforts and environmental education, because the stronger sense of place one has for specific natural areas, the more likely they will take action to protect and conserve them (Kudryavstev et al., 2012; Vaske & Korbin, 2001; Wynveen et al., 2014; Ryan, 2005; Wynveen et al., 2011). By measuring how attached visitors were to parks and natural areas in urban Michigan, Ryan (2005) determined that the public had a strong sense of place for these areas; furthermore, this high level of attachment and sense of place could serve as a "powerful force for the preservation and restoration" of those areas (p. 37). The study also concluded that sense of place is affected by the physical appearance of the landscape, the type of experiences people have, and how well people understand the nature of these areas (Ryan, 2005). Another study by Vaske and Korbin (2001) concluded that frequency of visitation and emotional connectedness to a natural area ultimately led to a higher degree of environmentally responsible behaviors. Likewise, past research has proven that environmental education in outdoor, natural areas can help foster a sense of place and increase environmental mindfulness (Kudryavstev et al., 2012; Vaske & Korbin, 2001). Together, these studies emphasize the importance of having a positive connection with nature.

Background

The study of ecosystems and measuring biodiversity poses challenges for the high school teacher, because it requires time, access to natural habitats, field sampling expertise, and species identification (Heard, 2016). Nonetheless, engaging students directly with nature and exposing them to authentic scientific practices are essential for their scientific literacy and their likelihood of making environmentally responsible decisions (Kudryavstev et al., 2012;

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Vaske & Korbin, 2001). Considering these challenges and the importance of understanding ecosystems, I propose an inquiry-based activity aimed at general and Advanced Placement (AP) high school biology classes that engages students directly with local ecosystems through authentic data collection and analysis of plant biodiversity. In addition to teaching ecological concepts, the aim of this lesson is to engage students with outdoor experiences in order to foster a sense of place and to increase pro-environmental behaviors. This activity follows AP Biology standards and Next Generation Science Standards, which identify that students need to do the following: understand how human disturbance of a habitat affects its biodiversity and stability, use mathematical representations to investigate factors that affect biodiversity, and design solutions for minimizing human impacts on the environment (College Board, 2016; NGSS Lead States, 2013).

This activity incorporates technology with Google Maps as a creative way to illustrate the spatial relationship of plant diversity in the local area. Additionally, students are encouraged to explore nature, not only on school grounds, but also in their backyards and local parks. Students evaluate plant biodiversity in local habitats, determine which habitats have low biodiversity, and outline what actions can be taken to remediate these areas. Secondly, they identify which habitats have the highest plant biodiversity and discuss possible explanations for these phenomena. Plants are used for this study because they offer accurate representations of the biodiversity of a given ecosystem (Benavent-Gonzalez et al., 2014; Heinze et al., 2015). Furthermore, plant biodiversity can be easily defined by plant abundance and frequency of distribution (Heinze et al., 2015), and plant communities have been used previously to help prioritize conservation efforts (Benavent-Gonzalez et al., 2014).

○ Activity for Exploring Local Plant Biodiversity

Learning Objectives

- To measure and analyze plant biodiversity in different local ecosystems using mapping technology (Google Maps Service), Microsoft Excel, and field methods.
- To evaluate how human disturbance of habitat affects biodiversity and ecosystem stability.
- To promote environmentally responsible behaviors in students through direct engagement with nature.

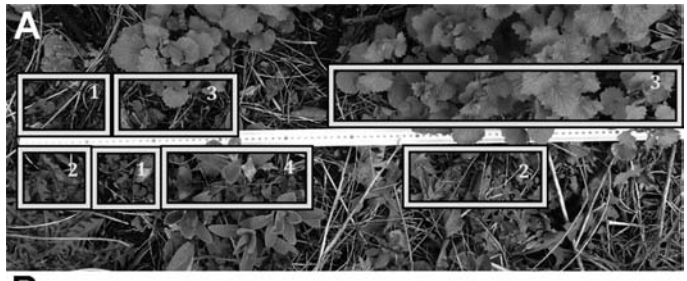
Safety Recommendations

Review with your students how to safely handle plants. I would recommend having your students wear field gloves, long pants, and boots to avoid contact with plants that could cause skin irritation.

○ Methodology

This activity is intended to be part of a larger unit on ecology. Students should have a prior understanding of populations, communities, and ecosystems, biotic and abiotic factors, transfer of matter and energy through trophic levels, and the definitions and importance of biodiversity. This activity requires access to a variety of outdoor habitats. In the following example, the habitats I used were a mowed grassy area, non-mowed grassy area, forest edge, forest (a small fragment), and a cultivated field, all of which were accessible on or near our school grounds. In more urban areas, consider using mowed grassy areas, grassy regions within parking lots, forest edges, vacant lots undergoing ecological succession, non-mowed or longer grassy regions, and any natural areas you have available.

The method I propose for measuring plant biodiversity is similar to a gentry sampling method that biologists utilize to estimate species richness of vegetation (Long-Term Ecological Research Network, 2013). Because only a meter stick is required, I refer to it as the "meter stick random sampling method." For the meter stick random sampling method, a meter stick is randomly tossed into the habitat under study, and the number of different herbaceous plants and trees within a hand's width of the meter stick are recorded (Figure 1). If the meter stick is under the canopy or in contact with a root of a tree, then the tree is also counted. As shown in Figure 1, there are four different types of herbaceous plants and two types of trees (the meter stick is under the canopy of two different trees) in the sample study area. Different plant types that could be assessed include moss, small



B

Plant Category	# Types; # of Individual Plants
Moss	0
Small, herbaceous plants	Plant 1; 5 individuals Plant 2; 2 individuals Plant 3; 6 individuals Plant 4; 3 individuals
Medium, herbaceous plants	0
Woody-stemmed plants/Shrubs	0
Saplings	0
Large trees	Tree 1; 1 individual Tree 2; 1 individual

Figure 1. **(A)** Sample meter stick method illustration for forest edge habitat. The 4 small, herbaceous plants are in the study area are identified as plant 1, plant 2, plant 3, and plant 4. **(B)** Students count the number of each plant type to fill out their data tables. Note that two trees were also included in the data because the canopy of the trees was over the area of study.

herbaceous plants, medium herbaceous plants, woody stemmed plants/shrubs, saplings, and large trees. Note: moss could be excluded if you want to focus only on vascular plants. A handout should be provided on which students record their data and evaluate the class data (Supplemental Material).

Suggested Pacing and Sample Data

I suggest four class days for this activity, and have broken down my proposed pacing in Table 1. For their culminating project, the students added their data to an interactive Google Map, graphed the class data, and analyzed the relationship between plant biodiversity and human disturbance (Figures 2–4).

In the sample data presented in Figures 2–4 and Table 2, I include the Google Maps from my general Biology class and the Excel data from my AP Biology classes. My general Biology class consisted of 25 students who worked in 9 groups, and my AP Biology classes consisted of 35 students who worked in 15 groups. Each group was assigned a specific habitat and gathered two trials of data on the plant biodiversity present. The groups added their total data in the form of pins on the Google My Maps Service (the Map). Color-coded pins based on habitat were dropped on the exact location the data was taken (Figures 2–3). The use of Google My Maps Service allowed for the spatial relationship of the habitats and their diversity to be indicated. Furthermore, this showed the fragmentation of habitats and which habitat types covered the most area. Next, each group totaled the number of plant types they found in their habitat, then found the average total between their two trials. For example, the sample trial shown in 1 includes six total plant types. The groups pooled their data, and the average number of plant types per habitat was determined (Table 2, Figure 4).

An extension of this activity required the students to collect plant biodiversity data at their home or a local park. The students individually added these data points as pins to the class map (Figures 2–3). An interactive form of the map can be found at https://goo.gl/Ym89tq (case sensitive). After all pins were added, the students analyzed the data.

Analysis of Data and Discussion

The students worked cooperatively within their groups to determine if one habitat had consistently higher biodiversity than the other habitats and explained why. Secondly, they looked for habitats with consistently low plant biodiversity and extrapolated possible causes. Furthermore, the students discussed possible actions that could be taken to remediate areas of low plant biodiversity in groups and as a whole class. From whole class discussion and written responses from individuals, the students concluded that high levels of human activity, such as mowing and cultivating, had negative effects on plant biodiversity. Conversely, habitats including the forest, forest edge, and non-mowed grassy area with minimal human interference had high levels of biodiversity (Table 2, Figure 4).

Other research supports this conclusion. Land use and human disturbances, such as mowing, strongly affect plant biodiversity by only allowing plants that are tolerant to specific disturbances to survive

Table 1. Suggested pacing guide for implementing the plant biodiversity analysis activity. The student and teacher roles are defined.

Day	Description of Activity; Student and Teacher Roles
1	Student Role — Students will work in groups of 2–3 to collect data using the meter stick random sampling method in their assigned habitat. At least two trials of data should be taken. The students are assigned to use the same method to collect data in a habitat in their backyard or local park.
	Teacher Role — The teacher will model one sample trial of the method before allowing students to go to their assigned habitat. While the students are collecting data, the teacher will circulate among them to make sure they stay on task and complete the data collection thoroughly.
2	Student Role — Students will average the data collected by the group for the number of plant types they observed in their assigned study site. Then, they will share the data as a pin on the Google My Maps Service (the Map) and as data in a class spreadsheet. Students who took extra data at home or at another natural area will do the same. The students will start to analyze the data by building a graph that best represents the data. This can be done in Excel or by hand.
	Teacher Role — The teacher will have made the Map and the spreadsheet for the students to input their data. Then, the teacher will instruct the students on how to navigate the Map. The teacher will guide students with how to build a graph to represent the data, but this should be student-led.
3	Student Role — The students will independently analyze the data by finishing the graph they started yesterday. Then, they will use the graph and the Map to further analyze the data and evaluate the biodiversity of the various habitats. A guided question sheet (Appendix) is provided by the teacher for the students to fill in.
	Teacher Role — The teacher will answer questions and guide the student progress.
4	Student Role — In their assigned groups, the students will discuss their findings of which habitats are most diverse, least diverse, and why. The students will evaluate the role of human disturbance on plant biodiversity and discuss how to restore biodiversity in areas where it was low.
	Teacher Role — The teacher will facilitate whole group discussion on the role of human activity on ecosystem stability and biodiversity.

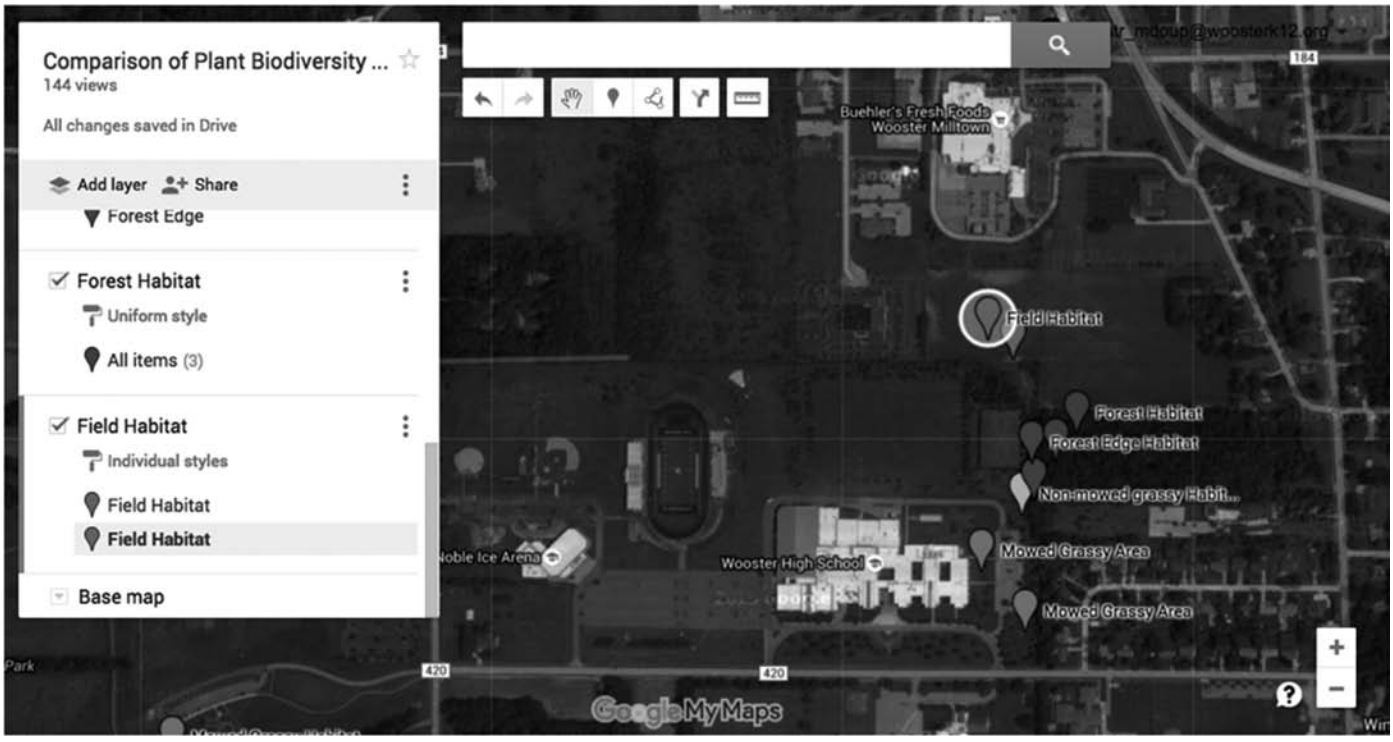


Figure 2. Comparison of Plant Biodiversity in Different Habitats Map, Wooster High School Campus view.

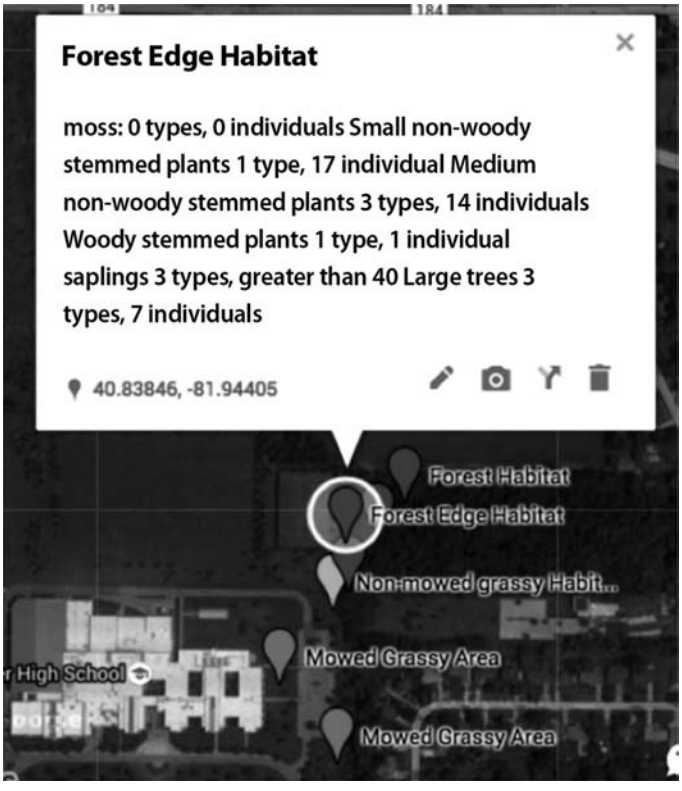


Figure 3. Comparison of Plant Biodiversity of Different Habitats Map with data example of forest edge habitat.

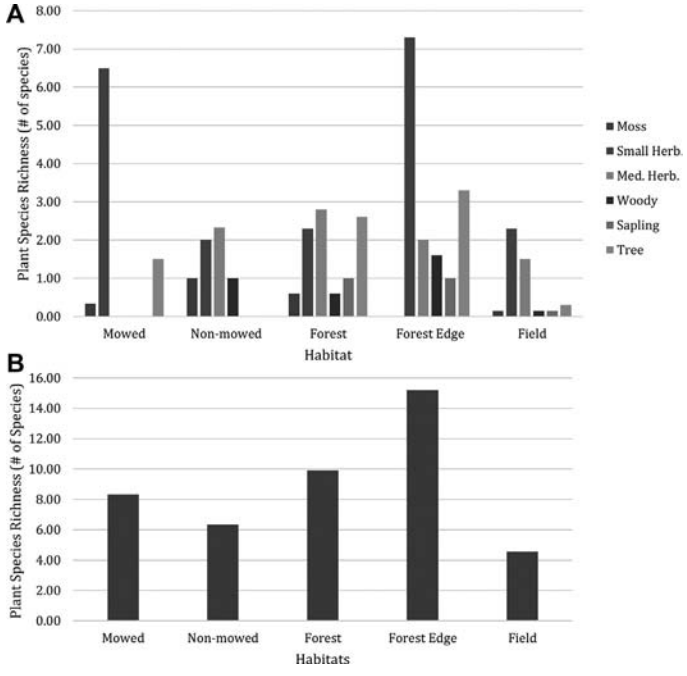


Figure 4. Examples of graphs students made to represent the plant biodiversity data. Students worked in groups to create graphs of the class data in Excel and came up with different ways to represent the data. **(A)** Total number of plant species in a habitat as well as their relative abundance; **(B)** total number of plant species only.

Table 2. Table of class data for plant species richness in different habitats, measured by number of plant types. The number of plant types found in the specified habitat from all student groups was averaged.

Average Number of Each Plant Type in Various Habitats					
Plant Type	**Mowed**	**Non-mowed**	**Forest**	**Forest Edge**	**Field**
Moss	0.33	1.00	0.60	0.00	0.15
Small Herb.	6.50	2.00	2.30	7.30	2.30
Med. Herb.	0.00	2.33	2.80	2.00	1.50
Woody	0.00	1.00	0.60	1.60	0.15
Sapling	0.00	0.00	1.00	1.00	0.15
Tree	1.50	0.00	2.60	3.30	0.30
TOTAL	*8.33*	*6.33*	*9.90*	*15.20*	*4.55*

(Heinze et al., 2015). This led to the discussion about how we can restore biodiversity in threatened areas. Many student responses explained how more than one plant type could be planted and humans could interfere less. Other resolutions focused specifically on mitigating habitat fragmentation and urban sprawl; "build corridors to connect habitats and replant trees that we cut down," one student suggested. Furthermore, another student addressed how the authorities of the city should identify habitats of high biodiversity and avoid building there: "In Wooster, one threat is the expansion of the city. We could combat this threat by avoiding building over forest."

We must be cautious not to oversimplify ecological concepts, as biodiversity is not always negatively affected by disturbance. For advanced biology classes, the intermediate disturbance hypothesis could be discussed in relation to the data collected in the plant study. According to the hypothesis, biodiversity is highest when an area has moderate levels of disturbance, allowing both early and late successional species to coexist (Roxburgh et al., 2004; Yeboah & Chen 2016). This hypothesis can be applied to the human-nature relationship, postulating that moderate disturbance, or use of the environment, can actually allow for increased biodiversity instead of reducing it. (Roxburgh et al. 2004; Yeboah & Chen 2016). This discussion could deepen the students' understanding of biodiversity and the factors that affect it.

Modifications and Enrichment

One of the strengths of this activity is how easily it can be tailored to meet the learning needs of your students. For example, you could make the activity more inquiry-based by challenging your students to design their own random sampling method for measuring plant biodiversity of different habitats on your school grounds. You could provide basic materials, such as marking flags and meter sticks, and go over the different plant types they would be measuring (e.g., herbaceous plants, shrubs, saplings, and trees). At the end of this activity, the groups could present their method and data to the class. Evaluation of limitations and strengths of the method could then be discussed as a whole group. Focusing on experimental design and data analysis, this approach would give your students the opportunity to work in groups to apply the rules of sampling in an inventive way.

In addition to data analysis and graphs, students could also compile an action plan for restoring biodiversity on school grounds or in their backyards. Students could use the plant biodiversity data to analyze which habitats had the lowest number of plant types. From there, students could brainstorm what specific actions they could take to improve biodiversity in these habitats. Possible actions include planting native species, removing invasive species, designating an area to no longer be mowed, or cleaning up trash and other pollution in the habitat. Furthermore, your class could present a comprehensive proposal to the school board on how to increase and protect the biodiversity surrounding the school. This would give the students deadlines and real applications of their data, which would increase their engagement with the activity. With this approach, the objective of promoting environmentally responsible behaviors in students becomes the main focus.

Final Remarks

This activity successfully engages all students—despite their worldviews and previous knowledge—with each other and nature to increase their understanding of biodiversity and its local threats. This is just one activity of many that shows students the value of protecting nature and the benefits of being outside. The students learn random sampling field methods, spend instructional time outside, and are encouraged to explore more of their local natural areas, all of which can foster a sense of place for their local ecosystems and encourage environmentally responsible behaviors. Engaging students with nature and real-world problems through science education is just one way to prepare this generation to solve social and environmental issues.

○ Acknowledgments

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References

Benavent-Gonzalez, A., Lumbreras, A., & Molina, J. (2014). Plant communities as a tool for setting priorities in biodiversity conservation: A novel approach to Iberian aquatic vegetation. *Biodiversity And Conservation*, *23*(9), 2135–2154.

College Board. (2016). AP Biology Curriculum Framework. Retrieved from https://apcommunity.collegeboard.org/group/apbiology/curriculum/

Dettmann-Easler, D., & Pease, J. L. (1999). Evaluating the effectiveness of residential environmental education programs in fostering positive attitudes toward wildlife. *Journal of Environmental Education*, *31*(1), 33–40.

Duerden, M. D., & Witt, P. A. (2010). The impact of direct and indirect experiences on the development of environmental knowledge, attitudes, and behavior. *Journal of Environmental Psychology*, *30*(4), 379–92.

Heard, M. J. (2016). Using a problem-based learning approach to teach students about biodiversity, species distributions & the impact of habitat loss. *American Science Teacher*, *78*(9), 733–738.

Heinze, J., Bergmann, J., Rillig, M. C., & Joshi, J. (2015). Research article: Negative biotic soil-effects enhance biodiversity by restricting potentially dominant plant species in grasslands. *Perspectives in Plant Ecology, Evolution and Systematics*, 17227–235. doi:10.1016/j.ppees.2015.03.002

Krasny, M. E., & Tidball, K. G. (2009). Applying a resilience systems framework to urban environmental education. *Environmental Education Research*, *15*(4), 465–482.

Kudryavstev, A., Stedman, R. C., & Krasny, M. E. (2012). Sense of place in environmental education. *Environmental Education Research*, *18*(2), 229–250.

Louv, R. (2011). Reconnecting to nature in the age of technology. *The Futurist*, *45*(6), 41–45.

Long-Term Ecological Research Network. (2013). *Experimental Macroecology: Effects of Temperature on Biodiversity, Field Sampling*. Retrieved from http://macroeco.lternet.edu/?q=node/13

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States* (Vols. *1, 2*). Washington, DC: National Academies Press.

Ryan, R. L. (2005). Exploring the effects of environmental experience on attachment to urban natural areas. *Environment and Behavior*, *37*(1), 3–42.

Roxburgh, S. H., Shea, K., & Wilson, J. B. (2004). The intermediate disturbance hypothesis: Patch dynamics and mechanisms of species coexistence. *Ecology*, *2*, 359.

Taylor, A. F., & Kuo, F. E. (2009). Children with attention deficits concentrate better after walk in the park. *Journal of Attention Disorders*, *12*(5), 402–409.

Taylor, A. F., Kuo, F. E., & Sullivan, W. C. (2002). Views of nature and self-discipline: Evidence from inner city children. *Journal of Environmental Psychology*, *22*, 49–63.

Vaske, J. J., & Korbin, K. C. (2001). Place attachment and environmentally responsible behavior. *Journal of Environmental Education*, *32*(4), 16–21.

Wynveen, C. J., Kyle, G. T., Absher, J. D., & Theodori, G. L. (2011). The meanings associated with varying degrees of attachment to a natural landscape. *Journal of Leisure Research*, *43*(2), 290–311.

Wynveen, C. J., Kyle, G. T., & Sutton, S. G. (2014). Environmental worldview, place attachment, and awareness of environmental impacts in a marine environment. *Environment & Behavior*, *46*(8), 993–1017.

Yeboah, D., & Chen, H. (2016). Diversity-disturbance relationship in forest landscapes. *Landscape Ecology*, *31*(5), 981–987.

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