Photos: Steven Braun

From Removal to Restoration

Invasive species activities should include the restoration of native habitat

By **Steven Braun**

THE IMPACT OF invasive species are numerous and far reaching. Thankfully, many educators recognize the problems associated with invasive species and engage their students with environmental service-learning to remove them. Activities like weed pulls, litter removal, spreading mulch, and planting trees are becoming commonplace in formal and informal environmental education. But it is necessary that educators further their efforts and move towards restoration; this often goes beyond planting native species and spreading mulch.

Schoolyard restoration projects should not only remove invasive species, but plant native species, improve soils, and create a native habitat. These extra activities can provide authentic service-learning experiences for children and provide positive benefits to the local environment. These projects also have the power to nurture a sense of connection to the site, facilitate locus of control, teach to different learning modalities and develop skills. A successful schoolyard restoration site will not only improve ecological conditions but support a community, long-term, that acts as a constituency for the area.

What follows is an overview of a restoration project that extends activities past rehabilitation to include long-term monitoring, continued stewardship and community support (see Table 1). The restoration site at Evergreen Middle School in Hillsboro, Oregon was originally an English ivy desert, covered entirely with *Hedera helix*. Eighth grade students and two teachers, aided by the district's facilities personnel, removed the ivy and root stock, added commercial top soil, planted native trees, shrubs and herbaceous plants with a follow-up planting in the spring. The restored area, laid out with a clear scientific design, creates an outdoor field laboratory. This long-term experiment facilitates student understanding of scientific methodology and ecological concepts. Furthermore, the outdoor laboratory permits ongoing monitoring where forthcoming science classes add to a long-term dataset so children may analyze change at the site over time.

Site Design

The outdoor lab consisted of multiple plots with different native planting arrangements and different soil amendments. It used a 2 x 3 design, yielding six total treatments: two different soil amendment applications and three native plant arrangements. The two soil amendments, both laid over a 40-60 cm layer of commercial topsoil, were a 15-20 cm

Infiltrometer constructed from sturdy sewer piping with beveled bottom. Infiltrometer is pounded into the ground, either by twisting it down or pounding a wood block with a sledge-hammer, deep enough to ensure water enters soil and does flow out from the bottom onto the adjacent soil, usually 3-10 cm. Less durable infiltrometers can be constructed from 5 gallon plastic buckets or large tin cans.

layer of either fir mulch or compost over the plot. The three plant arrangements were designed according to structural characteristics and varied composition of herbaceous plants, shrubs and small trees. All plants were evenly distributed throughout the plots. Control plots were created with no soil amendments and no native planting. In total, 21 2 x 2 m^2 plots were created: 18 treatment and 3 control plots. Plot arrangement was random. Interpretive signs labeled the plots and communicated the scientific design and field monitoring techniques we used to assess the ecological value of this restoration site.

Ecological Conditions

When we began the project, the restoration site was covered in English ivy. Now, the site is full of mulched or composted plots with native plants, compacted walkways and informational signs. Originally, students were going to remove English ivy and root wads. However, the project garnered substantial support from administration, neighbors, and teachers that district personnel mechanically removed ivy and root wads. This sped up the restoration and exemplifies the value of community support for restoration projects. Students may not have physically removed the English ivy, but they were familiar with the site when the ivy was rampant.

We left an area adjacent to the restoration site unmodified, still covered in ivy, as a control reference site. If our restoration was successful, ecological conditions would move, or traject, away from this non-restoration reference site. Ideally, we wanted the ecological conditions to traject towards our desired target reference sites. Our students visited three target references sites: an urban nature preserve, a nearby active restoration site and a local forest center. However, one undisturbed or restored natural area will suffice as a target reference site.

Ecological parameters at restoration, target reference and control reference sites were measured before the restoration project by teachers to provide an ecological baseline. After initial restoration (invasive removal, native planting and soil amendments) students measured ecological parameters to construct a long-term data set, allowing for scientific inquiry. Parameters included:

1. % plant cover
2. water infiltration rate
3. % soil moisture
4. soil chemistry: phosphorus and nitrogen
5. soil bulk density

Inquiry Activities

Environmental monitoring and environmental service-learning, discussed thus far in this project, are valuable learning activities. However it is possible to engage students in inquiry-based activities that involve higher levels of cognition than monitoring or service-learning. Below are two inquiry activities we used to add value to the restoration outdoor learning lab.

Activity 1

Essential question: What is the ideal soil amendment for restoration areas needing to minimize flooding and maximize water infiltration?

Students measured soil water infiltration response as a function of different soil amendments. We taught students necessary background information regarding soils and hydrology (porosity, soil texture, hydraulic conductivity – see Table 2) and asked our students to test what soil amendments would allow water to infiltrate soil quicker: mulch, compost or topsoil. Topsoil for this purpose acted as a control but was within our restoration site. We scaffolded the experiment, helping students identify the research question, independent and dependent variables, hypothesis and rationale for hypothesis. This was our first inquiry, so we designed the experiment for the students. In groups of four, students used infiltrometers to find the rate which water entered the soil. Students find a length over time (cm/min) rate for each of the three treatments. In order to get infiltration rate, students:

1. pound the infiltrometer into the soil at a depth of 2 – 6 cm
2. insert a ruler in the infiltrometer with 0 cm at the soil surface
3. pour water (roughly 4 liters) in the infiltrometer
4. record the initial height of water in the infiltrometer as seen on the ruler
5. record the total elapsed time for all water to enter the soil

Infiltration rates will vary according to several factors: degrees of compaction, amount of water poured into infiltrometer, initial water content of the soil, and porosity. This variation—implicit in environmental monitoring—should be accounted for in data analysis, yet the differences between amendments were clear. Moreover, this variation promoted discussion about complex relationships in soils and hydrology.

Students recorded infiltration rates for all three soil amendments: compost, mulch and our control topsoil. This yielded a large data set which all students used to answer their research question. The data was first reviewed by teachers to assure that no inaccurate and confusing data was given to the students. Students then organized this quality-controlled data to construct three box and whisker plots[1] that show variation in infiltration rates among the three soil amendments. Using the box and whisker plots[1], students assessed their hypothesis and wrote a two-paragraph scientific conclusion.

Activity 2

Essential question: What is the ideal planting composition or soil amendment for preventing invasive species from recurring in our restoration site?

Students measured percent plant cover in the restoration site and made comparisons. They chose to compare among soil amendments, native species planting compositions or between the entire restoration site and nearby unrestored control reference site. We taught our students necessary background information regarding plant ecology, soils and species identification. We scaffolded the experiment helping students identify the research question, independent and dependent variables, hypothesis and rationale for hypothesis. Recognizing students struggle with full inquiry, we provided some structure to the experiment (how and when to measure percent cover of plants) while providing some choice (what they chose to compare). In groups of four, students measured percent plant cover by species. Specifically, they:

1. randomly chose a plot from a number generator
2. randomly chose a quadrant (back-left, back-right, front-left, front-right) from the plot
3. laid their PVC 1x1 m^2 quadrat down in the randomly chosen quadrant of the plot
4. collectively estimated the percent of area covered by each species
5. recorded percent cover for each species

Each group took between five to 10 replicates for each of their treatment groups and a control. The replicates were necessary to capture variation and present data in a meaningful way. Data analysis was the same for each inquiry activity, involving box and whisker plots with a written conclusion of results.

Alternatively, students can measure plant recruitment, which some of our students did. They counted the number of new plant shoots in plots with different soil amendments (mulch, compost and our control, topsoil). They took three replicates at each of the three different plots. These data were combined and students compared plant recruitment among plots. This required less materials and plant ID training than measuring percent cover.

The restoration site provided several opportunities for additional inquiry. At the site, students could study the relationship between soil compaction and infiltration rates, the differences in terrestrial invertebrates' richness among the restoration and reference sites, and how soil chemistry or moisture varies among the restoration and reference sites. The inquiry process, facilitated in these experiments, is promoted when students must understand and report their results. At the end of each inquiry activity, students wrote a conclusion and recorded their results in a meaningful figure, often a box and whisker plot. Moreover, several students attended a professional conference, the Joint Aquatic Sciences Meeting, to present posters of their work, adding meaning and authenticity to the endeavor.

Advice for Similar Projects

Several lessons emerged during the process from initial planning and restoration to continued stewardship and subsequent learning activities. Garnering social support for the project is crucial – any barriers to project implementation I perceived were removed by collaborating with district and school personnel. The district mechanically removed ivy root stock from the site, the principal uploaded pictures of the project to the school website and local media featured us as well. In this regard, relationship building was pivotal. I had already established a positive reputation at the school the year prior to project implementation. Asking for help yielded financial contributions, planting donations, discounts on soil amendments, and necessary tools (shovels, rakes, buckets). Rely on common procedures with students. Organizing and quality controlling student data allowed students to answer their research questions and not get confused by inaccurate values. Moreover, if you store reliable data for future generations, you can allow students to ask long-term questions and analyze the success of restoration over time. Finally, plan for obsolescence. Restoring a site and implementing ongoing educational activities permits you to trust the ecological integrity of the site will remain without your continued involvement in the project.

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Endnotes

1. Advice for constructing box and whisker plots: review and compile all student data in a simple table, have students sort the data in ascending order in a second table, make a 5 number summary from the organized table (min, Q1, median, Q3, max), create a box and whisker plot with values on the y-axis for each soil amendment. Provide example.

Table 1

Is it Restoration?	
Restoration:	process of assisting an ecosystem that has been degraded damaged or destroyed,
Rehabilitation:	reparation of ecosystem processes, productivity and services
Mitigation:	compensates for environmental damage
Society for Ecological Restoration International Science & Policy Working Group. 2004. *The SER International Primer on Ecological Restoration.*	

Table 2

Soil, Hydrology and Plant Vocabulary	
Porosity	percentage of void space (air or water) in a soil sample; there are macropores (created by soil aggregation and plant roots), mesopores (stores water accessible to plants) and micropores (too small for plants)
Soil Texture	composition of soil based on relative amounts of soil particle size classified as clay, sand and silt
Hydraulic Conductivity	property in which water (or other fluids) moves through pore spaces
Saturated Hydraulic Conductivity	property in which water (or other fluids) moves through saturated (already filled with water) pore spaces
Plant Recruitment	survival of juvenile plants so that they are added to the existing plant community
Quadrat	square device used for measuring plant cover
Richness	number of different species
Abundance	total number of individuals

Table 3

Desired Environmental Literacy Outcomes	
Environmental Literacy Strand (Hollweg et al. 2011)	**Detail**
Knowledge (Based on Next Generation Science Standards) www.nextgenscience.org/	• Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. • Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. • Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. • Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
Dispositions	• Enhance students' locus of control by collectively implementing schoolyard restoration site • Promote motivation to act by demonstrating successful activities • Instill personal responsibility for restoration site
Competencies	• Use evidence to defend position to resolve issues (ex. Restoration strategy to minimize invasive plant recruitment). • Create and evaluate restoration plan
Environmental Responsible Behaviors	• Involvement in environmental restoration • Involvement in environmental monitoring and adaptive management
Hollweg, K. S., Taylor, J. R., Bybee, R. W., Marcinkowski, T. J., McBeth, W. C., & Zoido, P. (2011). Developing a framework for assessing environmental literacy. Washington, DC: North American Association for Environmental Education. Available at www.naaee.net.	