The Relationship Between Biodiversity Loss and Invasive Species

Robert C. McDowell

This curricular unit is designed especially with AP Environmental Science students in mind, although this unit could also easily modified and used with any high school or middle school level ecology or environmental science class to teach and emphasize both the importance and fragility of ecosystem biodiversity.

The diversity of life on Earth shapes and nourishes every part of our existence. But because these connections are seldom obvious, human beings have often pursued short term interests with little regard to the effects we are having on surrounding ecosystems. As a result, biodiversity is rapidly declining. If we want to ensure our survival and the long-term health of Earth itself, we need to develop an informed and educated populace that understands what biodiversity is, and is willing to do something to protect it. Climate change has accelerated the change in biodiversity of ecosystems, making the problems even more acute. [1]By developing this curriculum for my students, I hope to emphasize the problems associated with biodiversity loss, and to have the students come to some understanding about the need to preserve the biodiversity of the world and their local ecosystems. I also hope to instill a desire in my students to become active in efforts to help preserve biodiversity, both worldwide and locally.

To connect with students while teaching this unit I will emphasize the environmental impacts of human introductions of non-native species to various ecosystems, as well as the associated social and economic costs of non-native species introduction. The Convention on Biological Diversity lists invasive species as one of the direct drivers of biodiversity loss. In fact, introduced species are a greater threat to native biodiversity than pollution, harvest, and disease combined. For example, when the Asian chestnut blight fungus virtually eliminated American chestnut from over 180 million acres of eastern United States forests in the first half of the 20th century, it was a disaster for many animals that were highly adapted to live in forests dominated by this tree species. For example, ten moth species that could live only on chestnut trees became extinct.[2]

I will emphasize the symbiotic relationships in nature because often invaders interact with one another to generate a problem where either species alone would be harmless. For example, ornamental fig trees in the Miami area for over a century stayed where planted, in people's yards, because they were sterile. Each fig species requires a particular wasp to pollinate it, and the wasps were absent. About fifteen years ago, the pollinating wasps for three fig species arrived independently in the region, and now these fig species are reproducing. At least one has become invasive, with seedlings and saplings being found many miles from any planted figs.[3]

The overall theme for this curricular unit will be diversity, both environmentally and culturally, and mans effect on the biodiversity of the Earth's ecosystems. The conceptual framework for this unit is as follows:

Overall Theme: Cultural Impact on Diversity

Throughout Earth, there is a great diversity of habitats, organisms, and cultures. This great diversity gives resilience and strength to the ecosystems and cultures, and the organisms within them.[4]

The ecological and cultural systems are interactive and interdependent. Humans create differing cultural systems to meet their needs, and this causes changes in the ecosystems surrounding them. Organisms are dependent on the ecological systems and the biotic and abiotic factors within those systems. Altering the ecological systems affects all life and the interrelationships between them.The quality of resources within an ecosystem affects the standard of living of human cultures. Cultural perspectives influence the attitudes toward the use of resources and environmental protection. Populations of organisms within an ecosystem exhibit interrelated patterns of growth and decline. Ecosystems can be evaluated for their environmental health. Human intervention with the ecosystem can have a positive or negative impact on the ecosystem. Cultural values and economic factors will shape the human interaction with ecosystems.

Curriculum Unit 1: Defining and Measuring Biodiversity

The lessons that make up this unit will begin with the exploration of what biodiversity actually is, what it looks like, and why it is vitally important, not just for the environment, but for also for human well being. In order to generate student's interest in helping to preserve biodiversity, I will first have to educate them in what biodiversity really is, and what it looks like in nature. Once students have been grounded in the real nature of biodiversity, and the problems associated with biodiversity loss, they will be able to explore ways to help increase the biodiversity of their local ecosystems.

Biodiversity can be defined as the variation in living organisms, viewed in the world as a whole, within an ecosystem, or a given localized habitat. Biodiversity also includes the Earth's diversity of ecosystems, such as the tropical rain forests, savannas, the oceans, marshes, deserts, and all of the other environments where organisms live and for which they are uniquely adapted.[5] The students taking this class would have already had a grounding in the various biomes of Earth, and researched some of the organisms that inhabit those biomes. My students do an internet research project where they make a poster about some of the Earth's biomes, as well as any major environmental problems associated with those biomes. Some of the lessons that students will have already been

presented include the great diversity of ecosystems, and an introduction to some key terms that they will need to understand in order to move forward. These include the definition of an ecosystem and a species, as well as the understanding of what a keystone species is.

Maintenance of biodiversity is vital, since intact ecosystems are more resilient and healthy, and are essential for provision of the ecological needs of humans, including pollination, clean water, flood control, and pest control. While scientists agree that the maintenance of biodiversity is critical in some of our most unique ecosystems, many also agree that it is equally important to conserve the biodiversity remaining in our most settled or disturbed regions, such as city lots and suburban backyards. [6]

Students will start to explore the concept of biodiversity within the boundaries of the school property. We have several areas set aside as natural areas, and have purposefully let them remain as areas where students can measure the diversity of species. They will compare these two areas of the school property that have been maintained in a more traditional manner. The traditionally maintained areas will serve as a basis for the comparison of the species richness of the two areas.

There are some basics and limitations that the students and I will need to discuss before they venture outside to do their measurements.

From the definition of biodiversity alone, which is fairly broad, it is clear that no single measure of biodiversity will be adequate. Biodiversity cannot be easily denoted by a single number. Measurements typically have two components:

> The number of variables. For example, the number of individuals, the number of species, the number of different habitats etc.
>
> The degree of difference between those variables.

Species richness (the number of species) describes the number of elements but will not capture information on the number of individuals of the species. Rarity can also provide a measure of biodiversity. While biodiversity can be measured in a number of ways, in practice it tends to be measured in terms of species richness; the number of species.

There are two methods that my students will follow. They will determine the biodiversity of a given area by the number of different species in that area, as compared to the total population of that area. The first method will involve a simple calculation, while the second method is slightly more involved.

The following is the method that my students will use to measure the relative biodiversity of the various plots around our school. Students will be assigned to a team of 3-4 students to perform their field measurements.
Students will be instructed that they are to act as actual field biologists, and are to be as objective and careful as any real scientist would be in the field.

I have made my own 1 meter square sampling grids out of PVC plastic tubing and plastic elbows, and I have 6 grids for the students to use and share.

Student Activity 1: Biodiversity Measurement

Materials Needed (per group):
I meter square plastic grid
notebook
calculator
digital camera or cell phone camera
field guides

Duration:
This exercise will require 3 days to complete. Two habitats per team will be sampled, each requiring one class period to sample completely. The 3rd day will be used for calculation of biodiversity indexes, answering questions, and discussion.
Instructions:
Selecting a sampling location
These steps are to be followed at each habitat
Randomly drop the 1 meter square plastic grid onto your selected habitat. If the grid lands partially on a paved surface, pick it up and drop it again.

Sampling biodiversity
For this exercise, you will be measuring two types of organisms; plants and insects on the surface of the ground.
Count how many individuals there are of every species in the plot.
While you are in the field, you may categorize organisms together without identifying them. (For example, thin grass, leafy clover, etc.)
Using your digital cameras, take as many pictures as you feel necessary to properly identify the organisms that you found. You should also take pictures of the habitat as a whole to use as an illustration in your eventual report.
Record all data in your field notebook. See example table below.

Organism Type	Number of Individuals
Leafy clover	15
Small black cricket	10

Large Grasshopper	2

When we return to the classroom, use our Field Guides to attempt to identify the specific species of organisms that you found. Compare your species identification with other groups to confirm.

Calculating a Biodiversity Score
We will use 2 different methods to estimate biodiversity in the habitats that you sampled.

Basic Biodiversity Index

This method is very simple. First, count the total number of species you found in your plot.

Now, divide this number by the total number of individuals of all species found in your plot.

This is your basic biodiversity index, record this value in your field notebook.

Share your data with all other groups in your class, and calculate the average basic biodiversity index for this habitat.

Method 2 – Simpson Index of Diversity
This method is a little more complicated than method 1- we will be solving this equation:

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)} \right)$$

D is the biodiversity index we are calculating
n is the number of individuals of a given species
N is the total number of individuals present in your sample
It is helpful to construct a table to aid you in calculating this index- on the next page is a sample table that gives an example of how to perform the calculation

Species	n (number of individuals)	n(n-1)
Species A	4	7
Species B	5	20
Species C	7	42

Total N (add up next column)	16	
Total n(n-1)		69

In this example, to calculate the index, plug in the numbers, and you should get the following result:

$D = 1 – (69/240) = 0.287$

This index ranges from 0 (no diversity) to 1 (maximum diversity).

Using the above example as a guide, calculate the Simpson biodiversity index for your own data.

Record this number in your lab notebook as the "Simpson Diversity Index"

Share your data with all other groups in your class, and calculate the average basic biodiversity index for this habitat

Comparing Habitats

Once you have visited both sites, calculated your biodiversity indexes for both sites (separately), and shared data with other groups, calculate an average biodiversity for each habitat

You will have 2 different average indexes for each habitat, the "basic biodiversity index," and the "Simpson biodiversity index"

Compare the results for both habitats with your colleagues, and write a brief explanation as to why you believe one habit was more diverse than another.

Curriculum Lesson 2: Invasive Species and Their Impacts

Once students have a good grounding in what biodiversity actually means, we will start to explore the effects of non-native introductions on the biodiversity of ecosystems. Although students already have a fairly good understanding, or at least some pre-knowledge of the effects of pollution, overharvesting, and population growth, they are usually fairly ignorant of the effects of non-native species introduction on biodiversity.

One of the largest misconceptions that students have is that "This has always been this way". They simply don't understand that the forest or grassy area that they are now studying is not the ecosystem that was here before mankind changed it. They see woods, and it must be good just because it is green. They don't yet understand the profound changes that have occurred. At this point in the curriculum I will show a presentation of some non-native species in our region. I will include some that are surprising to students, such as Japanese Honeysuckle (Lonicera japonica) and Multiflora Rose (Rosa

multiflora). These species are ubiquitous to our area, and students are surprised to find that what they thought was part of the natural landscape is in fact an invasive plant.

We will then discuss what definition we could attach to the term invasive species. The Convention on Biodiversity identifies invasive species as any foreign species that threatens the balance of an ecosystem through its introduction and proliferation. Such non-native species generally arrive in one of two ways: unintentional introduction (such as microorganisms transported in a ship's ballast water) and intentional introduction (such as nursery plants or food crops).

Environmental Impacts of Non-Native Species

The introduction of invasive species can result in the extinction of local species and negative changes to the habitat and biodiversity of invaded ecosystems. These species lead to the killing or crowding out of native species through predation, parasitism, disease, and competition. They also alter ecological processes such as the water, nutrient, and energy cycles, thus completely changing how ecosystems function. Compared to other threats to biodiversity, invasive introduced species rank second only to habitat destruction. Of all 1,880 endangered species in the United States, 49% are endangered because of introduced species.[7] The zebra mussel, accidentally brought to the United States from the Baltic, transforms aquatic habitats by settling in dense masses over vast areas. At least thirty freshwater mussel species are threatened with extinction by the zebra mussel. A parasite can be similarly devastating. The sea lamprey reached the Great Lakes through a series of canals and, in combination with overfishing, led to the extinction of three native fish species.

Economic Impacts of Non-Native Species

The economic impact of invasive species is derived from direct and indirect costs. Direct costs are those related to controlling the spread of invasive species, such as the use of pesticides applied in an attempt to contain the spread of pests. Indirect costs relate to the ecosystem services lost through such destruction. Through damage to agriculture, forestry, and fisheries, introduced species inflict an enormous economic cost, estimated at $137 billion per year to the U.S. economy alone.

The Role of Globalization

Globalization has greatly increased long-distance travel and commerce, and the speed at which non-native organisms can be spread. These and other factors have increased the frequency by which non-native plants and animals are introduced to new areas. Some of the methods of introduction that will be discussed in this unit are listed below.

Past Government Programs: The establishment of a new invader is sometimes an unanticipated outcome of a government program; kudzu, for example, was originally introduced through a government-sponsored erosion control program.

Escaped Ornamental Plants, Nurseries Sales, or Disposals: Many invasive plant problems began as ornamental plantings for sale in nurseries and garden shops. Purple loosestrife, for example, is sold as an ornamental plant but takes over native vegetation in wetlands, and can clog western streams preventing water withdrawal and recreational uses.

Intentional Introductions: The introduction of non-indigenous species into ecosystems with few controls on reproduction or distribution.
Live Food Industry: The import of live, exotic foods and the release of those organisms can result in significant control costs, e.g. the snakehead fish in Maryland, and the mitten crab in Virginia.

Aquaria Releases: Escapes or intentional release of unwanted pets can be a source of new non-native species in all parts of the country. The invasive algae Caulerpa is thought to have been introduced to U.S. waterways after being discarded from aquaria.

Control of Invasive Species

Keeping potentially invasive organisms out is the most cost-effective way to deal with introduced species. Targeting common pathways by which invaders reach our shores can slow or stop their entry. Ship ballast water, wooden packing material, and horticultural plants are three pathways for invasion that could all be monitored.

A species that is introduced despite precautions can sometimes be eradicated, especially if discovered quickly. In the Florida, a Giant African snail population was eliminated by a long campaign.

Chemical control involves using a pesticide, such as an herbicide or insecticide. Although chemicals can effectively control some species (such as water hyacinth in Florida), they may have nontarget impacts, they are often expensive, and pests can evolve resistance to them.

Biological control involves introducing a natural enemy usually from the native range of the introduced pest. A disadvantage of biological control is that some agents attack nontarget species, and it is very difficult to remove a troublesome introduced natural enemy once it is established. Biological control agents need to undergo rigorous testing before being released into the environment, lest they themselves become an invasive pest.

In mechanical control, hand pulling or various kinds of machinery are employed to physically remove the invasive pest. For example, in Delaware there is a program to physically remove Burning Bush Euonymus (Euonymus alata) from susceptible areas state forests. [8]

I will give students a short quiz to evaluate their knowledge of invasive species and their introductions. This will be a formative evaluation, so I know where they stand before I give them their major assignment for the lesson.

Student Activity 2: Formative Evaluation

Formative Evaluation –Answer the questions fully and to the best of your ability. For each answer, use a specific invasive species as an example. Do not duplicate examples.

1) Define invasive species:

2) Explain why not all non-native organisms are considered invasive:

3) Describe two intentional and two unintentional pathways for the introduction of invasive species to the United States.

4) Describe the effects of an invasive species on the biodiversity of an ecosystem, and explain why those effects are possible.

5) Describe three things an ordinary homeowner or consumer could do to prevent the spread or introduction of invasive species.

6) Describe three ways that invasive species could be controlled, their benefits and drawbacks.

7) Explain why the control of non-native invaders sometimes needs to be coordinated internationally.

Student Activity 2: Informational Brochure

In this activity students will be assigned to produce an informational brochure that could be handed out to highlight the methods that could be used to prevent or control invasive species in Delaware.

Invasive Species Brochure Assignment

Introduction

Congratulations! You have been named by the Delaware branch of the Environmental Protection Agency to research and publicize the potential effects of some of the most pernicious invasive plants in Delaware. Your mission is to research the invasives, including their original source, their environmental effects on the habitats in Delaware, and the potential social and economic consequences of their presence in the ecosystem.

In this assignment, you will need to create an informative brochure on the impact of what you consider the top 5 invasive species in Delaware. In order to successfully complete the assignment you will need to fully describe the problem associated with your chosen invasives, and explain to a common homeowner how they can avoid the problem or remove the problem if it is already established.

From a list of invasive species in Delaware, choose the five that you consider the worst offenders, or that you think you can do the most about.

Create a table that gives a brief description of the five organisms you are focusing on. For example:

Common Name	Kind of plant (grass, vine, etc.)	Origin: (where did it come from?)	Benefit: (Is it useful in any way?)	Damage
Japanese Honeysuckle	Climbing vine	Japan: introduced to U.S. in 1862 in Long Island	Does provide some food and nectar	Crowds out native plants, especially in sunny areas. Becomes a monoculture rapidly.

In your brochure, make sure to include the following:

- A picture of every plant for easy identification
- The common name and scientific name of each species
- The preferred environment for the species
- The physical features of the species
- A description of the particular problem that the species causes (environmental, social, human health, economic)
- A potential list of organisms that will be harmed by the species.
- A list of potential actions that could be taken by a homeowner to eliminate the problem, and their benefits/drawbacks
- Any potential organizations that could be contacted for further information or help.

The brochure should be the three-fold variety, and should be easy to read for a consumer.

Curriculum Unit 3: Student Centered Local Action Plan

Now understanding why biodiversity is vital, and how non-native species affect biodiversity, students will be expected to be able to formulate a plan to help our local ecosystems. By exposing students to many different types of non-native species, in habitats around the world, and then focusing them on our local ecosystems, they will have a greater understanding of the problems that we face locally. It is my hope that they will be energized to take action beyond their actual class assignment, and become active in preserving local ecosystems and habitats. I also hope to encourage them to increase the biodiversity within their own backyards, and thus help the ecosystem as a whole.

This curricular unit will have two main activities for students. The first will be for them to go out into the local ecosystem, pick an area, have it approved by me, and then to measure the biodiversity of the habitat. They will attempt to identify and non-native invasives, formulate a plan to help remediate the problem, and report back to the class with their results. The class will act as town representatives, etc., and rate the remediation plans according to agreed upon criteria.

The second activity will be for the students to develop a plan for their own backyard, or to cooperate on a yard if they do not have a suitable yard. They will develop plans to increase the habitat worthiness of their own small part of the local ecosystem, and write a report on the progress they have made in the development of the plans.

By tying their efforts all the way back to their own backyards, I hope the lesson of biodiversity and non-native invasives will be deeply rooted. I also am hoping that the students will take their understanding and spread it to their parents, neighbors, and colleagues, thereby helping our local ecosystem in a way that a simple lesson would not.

I will have the students focus on non-native plants, as they are the easiest for them to work with, and ultimately will have the biggest return on investment of the students time. Non-native plants are exotic, and are typically pioneers and colonizers. They are plants that, once established, can rapidly reduce the suitability of a habitat for native organisms. Because they are exotic, invasive plants rarely have any beneficial properties in the new habitat. They also lack the natural predators and diseases that would reduce their population and keep it in check. Invasive plants have become recognized as a major threat to the integrity of natural habitats. They often proliferate and dominate a habitat community to the detriment and sometimes exclusion of endemic species. This is the reason to target them in our efforts to restore natural ecosystems biodiversity. [9]

It is important to recognize that not all non-native species become invasive. Many plant species that have been introduced by humans have not become invasive. This is because they are not entirely well adapted to our local climate, and do not spread out to become monocultures in the ecosystem.

Some of the factors that students will report back on to their student peers will include the importance of the local habitat to be restored, the importance of that habitat to the wider ecosystem, the costs involved in remediation, the environmental considerations of remediation, and any social impacts of the remediation. They will develop a list of shareholders, such as property owners, local government, and environmental groups. Students will be expected to develop a coordination plan

If feasible, students will coordinate their efforts in order to cover a wider area. For example, if two different groups take different areas of a watershed for a stream, their efforts will be multiplied and the results will be greater. Most of my students live within either the White Clay Creek watershed, or the Christina River watershed. Healthy ecosystems are vital to the maintenance of a watershed, and contribute to the overall health of large bodies of water. [10]We will target more critical habitats within those watersheds to achieve a greater total effect.

Students will scout habitats on their own time, and I will also organize trail walks through the most promising habitats on weekends. Students will be encouraged to come on at least one trail walk so they can get a good idea of the scope of the undertaking.

Students will be responsible to get written permission from property owners, who will either be private land owners, the State of Delaware, or the City of Newark. Students will also need to coordinate to have any debris properly removed from the habitat cleanup.

Student Activity 3, Part 1: Student Centered Local Action Plan

In this activity students will develop a plan to coordinate the remediation of one or more local habitats of high importance.

Habitat Restoration Plan

Your team has been assigned a very import task from the Habitat Restoration Coordinator from the State of Delaware. You will need to develop a Local Action Plan for a small local habitat, and present your plan to the Habitat Restoration Coordinator (me) and the Comprehensive Ecosystem Team (the rest of the class). Your Local Action Plan will be reviewed and the Comprehensive Ecosystem Team (CET) will determine which, if any of the proposals should be acted upon.

In order for your plan to have the best chance of being chosen, you will need to consider all of the ramifications of your plan, including the environment, the economic aspects, as well as any social issues that may arise. For example, if your site involves private property, will it disturb the homeowners or cause them harm? What if the invasive is part of a person's garden? How will you get them to remove the invader?

Grade Requirements

There are some critical issues that need to be addressed before the work can even begin. Each team will be given a notebook to record their findings and pertinent information.

You may also include an educational portion to your action plan. How will you educate the landowners or others about the need to prevent and/or remove invasive plants?

You will need to get the site approved by the Habitat Restoration Coordinator before you take any steps toward remediation. All site plans and written permission will need to be documented, and safety considerations will need to be discussed on a site-by-site basis.

Photographs of the site, and a site map should be included in your proposal for a Local Action Plan.

Habitat Restoration Notes

Notebook Owner: **Team Members:**

Area of Concern and Location:

Primary Habitat (Forest, grassland, etc.):

Preliminary Biodiversity Index:

List all Native Organisms of Particular Importance:

Watershed Location:

Reason for Concern:

Primary Types of Invasive Species:

Property Owners:

Other Parties:

Primary Interests of Stakeholders (list all stakeholders):

Safety Considerations:

Possible Remediation Actions:

Student Activity 3, Part 2: Membership on Comprehensive Ecosystem Team

As a member of the overall Comprehensive Ecosystem Team (CET), your task is to evaluate other team's presentations to make sure that they have fully documented all of the required aspects of the site remediation. You will need to ask questions, and your job is to see that their team has thoroughly addressed all of the stakeholders concerns, as well as any safety issues. You will discuss with other members of the CET the relative merits and drawbacks of the proposed plans, and ask the team presenting the plans for answers to your concerns. You will either give the team a "Permit for Remediation" or ask them to return and answer specific concerns that you have about their plan. If they do not have specific answers right away, it is within your purview to have them return at a later time when they have addressed your concerns. If they do not have proper documentation and permissions, you may not give them a permit.

The purpose of being on the CET is twofold. First, you will help others develop their site plans more completely. Second, you will see how it is to be on a governing body, and to develop comprehensive plans.

Grade Requirements. As part of the CET you will keep notes on the meeting. You will keep track of proposals, questions asked, questions answered, counter proposals, etc. You will turn this in to the Habitat Restoration Coordinator as a part of your overall grade.

The CET will determine the overall merit of the proposals, and will determine which, if any of the proposals merits further consideration for remediation work. If the CET decides to move forward on a proposal, we will discuss at that time the possibility of doing some remediation work as a class.

Curriculum Unit 4: Backyard Habitat Creation

As development by humans continues to expand, wildlife habitats in the affected areas are altered and may become unable to support the needs of species that previously occupied those areas. Alternatively, many non-native species, such as Starlings (*Sturmus vulgaris*) that are better adapted to metropolitan conditions may increase their presence and abundance as a direct result of this development.

The actions that students take on their own properties can have a significant effect on the various species that share this habitat. One way they can enhance the natural features

they have in their yards and neighborhoods would be to create environmentally friendly backyard habitats.

Many plants, shrubs, and trees that benefit wildlife also are attractive to people, and are often non-native species. Each species has different requirements and will provide the biodiversity in a habitat. Further, wildlife will fare better where habitats provide most of the food, water, and cover they require in one area, minimizing the amount of travel they need to do.

Well-managed backyard habitats can save energy, protect the soil, and improve water and air quality. Trees and other plants hold soils in place during rain and wind, reducing the amount of sediment and contaminants that enter water bodies. Plants improve air quality by filtering particulates and removing carbon dioxide from the air, replacing it with oxygen.

Diversity or variety in a backyard habitat promotes a healthy landscape and attracts a more diverse wildlife community. Habitat diversity includes both species and structural diversity of the plants that form habitat, as well as a variety of nonliving materials.

The presence of a very diverse number of plant species makes it less likely that insects or disease will cause severe problems.[11] Having a variety of trees, shrubs, perennial and annual flowers, and grasses in a yard also may attract a more varied wildlife community. With careful planning, a diverse plant community can provide a wide selection of food and cover options for wildlife, as well as provide a year-round variety of aesthetically pleasing views as the plants flower or fruit at different times.

Since native plants are adapted to local weather and soil conditions, they better resist local insects and diseases, and they provide foods that are familiar. Using native plants also reduces the potential for introducing other invasive exotics, such as the Wooly Adelgid (*Adelges tsugae*) that can cause serious problems to existing native populations.[12] As invasive non-native plants spread, they will crowd out and compete with natives, causing some wildlife to lose their preferred food sources. A good example of this is English Ivy (*Hedera helix*) which is a very common garden invader.

By encouraging students to work on their own Backyard Habitat, or to help with our own Schoolyard Habitat, I hope to empower them to be a part of the solution to biodiversity loss, and to encourage others through their actions. In this way I hope to not only educate the students about biodiversity loss and invasive species, but to also instill in them a desire to do something positive about the issue.

Getting a Backyard Habitat certified is an easy step for students and their parents to take to help with the issue of biodiversity loss. The National Wildlife Federation has a program where a homeowner can find information about the benefits and requirements of

a Backyard Habitat, and for a small fee, get their yard certified as Habitat Friendly. I am hoping that students will take this extra step, but I cannot require it since it involves a fee. But certification would be a good way to show others that the program is easy and very beneficial to our local ecosystem.

Student Activity 4: Backyard Habitat Design

In this activity students will develop a plan for a Backyard habitat

Backyard Habitat Plan

For this assignment you are going to bring the concept of biodiversity directly to your backyard. The National Wildlife Federation has a lot of information on their website about the benefits and requirements of a Backyard Habitat.

Your assignment is to go to the National Wildlife Federation website (www.NWF.org) and to download the certification requirements for having a habitat. Fill in the questionnaire to the best of your knowledge. If your parents can help with some questions, ask them. If you live in an apartment or otherwise do not have a backyard, you will use the dimensions and characteristics of our Schoolyard Habitat as your model.

Eventually I will ask you to go home and to propose a Backyard Habitat to your parents. You will discuss the benefits and advantages of having one. You may already have a large portion of the requirements completed, but you should explain to your parents the need for biodiversity, and the role that you can take in our ecosystem to help preserve biodiversity within your local habitat.

Grade Requirements: For your grade, you need to develop a plan for a Backyard Habitat in your yard. Even if it is not implemented, you should develop a site plan, describe any potentially invasive plants that you currently have, and some non invasive plants that could replace them. Use a similar technique as the Local Action Plan that you developed earlier, but focus on your property rather than a natural area. Devise a plan that would increase the biodiversity of your yard, and draw a site plan similar to the one in the Local Action Plan.

Actual implementation of the plan is entirely voluntary, but I hope that you would at least incorporate some of the plan. How could you achieve your plan incrementally? Is there some way to encourage your parents to allow you to work on the plan a little at a time? By now you understand the vital importance of biodiversity and the need to reduce the number of invasive organisms in our environment. Now is your chance to take ownership of your small part of the world and make it a better place.

Appendix A

Standards Addressed

The Following National Science standards have been incorporated into the unit curriculum provided.

Unifying Concepts and Processes Standard
• Evidence, models, and explanation.
• Change, constancy, and measurement

Science as Inquiry Standards
• Skills necessary to become independent inquirers about the natural world.
• An appreciation of "how we know" what we know in science.
• Understanding of scientific concepts—Biological diversity, and biogeography
• Planning and conducting investigations
• Using appropriate tools and techniques to gather data
• Thinking critically and logically about relationships between evidence and explanations
• Diversity and adaptation of organisms
• Links to direct student observations of the natural world—to the ecoregions they live in
• Organisms and environments
• Emphasis on learning subject matter in the context of inquiry, technology
• Emphasis on groups of students analyzing and synthesizing data

Learning Map

The Relationship between Biodiversity Loss and Invasive Species

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Enduring Understandings:

1) Biodiversity is critical to the health of ecosystems
2) Biodiversity can be measured and calculated to ecosystems or parts of ecosystems
3) Invasive species have been introduced through human actions into almost every ecosystem.
4) Invasive species degrade ecosystems by reducing the level of biodiversity

Unit 1: Biodiversity Measurement
Time: Approximately 2-3 blocks (85 minutes per block)

Activity: Biodiversity Measurement: Students participate in the species characterization of various plots of land within school property boundaries. (1 block)
Students calculate the relative biodiversity of the various plots of land in the classroom setting (1 block)
Students finish calculations and report out to the class on their findings (1 block)

Unit 2: Invasive Species and Their Impacts
Time: Approximately 1-2 Blocks

Activity: Informational Brochure: Students design and produce an informational brochure on five invasive species that they feel are causing the most harm in Delaware.
Research in library (1 block)
Students prepare the brochure on their own time
Report back to class, and class discussion (2 blocks)

Unit 3: Student Centered Local Action Plan
Time: Approximately 2-3 blocks

Activity (Part 1) : Habitat Restoration Plan: Students prepare and defend a habitat restoration plan based on a local ecosystem. Students work in collaborative groups.
(Part 2) Students also act as a part of the Comprehensive Ecosystem Team (CET), which oversees all plans as a government body.

Unit 4: Backyard Evaluation and Habitat Creation
Time: Highly variable, depending on student needs.

Activity: Backyard habitat Design: Students evaluate their own backyard for biodiversity and the presence of invasive organisms. Based on their evaluation and needs, they are asked to implement some recommendations to make their backyard more resilient and healthy by increasing its biodiversity.

Notes

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