**DEP Environmental Education Curricula**

**Lesson Plan**

**GRADE: High School**

**LESSON TITLE: Invasive Species**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Next Generation Science Standards** |  |  | | |
| **HS-LS2-7** | **HS-LS2-7** | *Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity*. | | |
|  | **Science and Engineering Practices** | [**Constructing Explanations and Designing Solutions**](http://www.nap.edu/openbook.php?record_id=13165&page=67)  [Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.](http://www.nap.edu/openbook.php?record_id=13165&page=67)  [Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.](http://www.nap.edu/openbook.php?record_id=13165&page=67) | | |
|  | **Disciplinary Core Ideas** | [Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.](http://www.nap.edu/openbook.php?record_id=13165&page=154) | | |
|  | **Crosscutting Concepts** | [**Stability and Change**](http://www.nap.edu/openbook.php?record_id=13165&page=98)  [Much of science deals with constructing explanations of how things change and how they remain stable.](http://www.nap.edu/openbook.php?record_id=13165&page=98) | | |
| **Objectives** | | | | |
|  |  | **Objective 1:** Learn how to define invasive species.  **Objective 2:** Discuss how invasive species have historically spread.  **Objective 3:** Discuss actions that can be taken to reduce the spread of invasive species.  **Objective 4:** Discuss what effects might occur in an ecosystem after an invasive species has been introduced. | | |
| **Vocabulary** |  |  | | |
|  | **Extirpation** | To destroy totally. | | |
|  | **Introduced, (also Alien, Exotic)** | Deliberate or accidental release of a species into an area in which it has not occurred in historical times. | | |
|  | **Invasive species** | * With respect to a particular ecosystem, a species whose presence in the environment causes economic or environmental harm or harm to human health. Native species or non-native species may show invasive traits, although this is rare for native species and relatively common for non-native species. | | |
|  | **Native, Indigenous** | * Species naturally occurring or originating in a geographical region since prehistorical time. | | |
|  | **Non-indigenous (non-native) species** | * With respect to a particular ecosystem, any species that is not native to that ecosystem. For aquatic species it may be meaningful to consider whether a given species is native to a specific watershed. Species introduced or spread from one region of the US to another outside their normal range are non-indigenous, as are species introduced from other continents. | | |
|  | **Nuisance (also Noxious), Weed** | * Any plant, either native or introduced, with a harmful or destructive influence on existing natural communities, interfering with the objectives or requirements of people. | | |
|  | **Pathogen** | * A bacterium, virus, or other microorganism that can cause disease. | | |
|  | **Status** | * Represents the reproductive population status of the species in that particular location. | | |
| **Background** |  |  | | |
| **Teacher Version**  Selected Materials from … | | **Source:**  <https://www.epa.gov/watershedacademy/invasive-non-native-species>, <https://www.anstaskforce.gov/ans.php> | | |
| **Invasive Species**  Not all non-native species become pests, or even survive, in new locations. But when they do, they often displace a whole suite of native species to become dominant. They then take on new labels: invasive exotics, or non-native nuisance species, or simply, invasive species.  Invasive species are any species or other viable biological material (including its seeds, eggs, spores) that is transported into an ecosystem beyond its historical range, either intentionally or accidentally, and reproduces and spreads rapidly into new locations, causing economic or environmental harm or harm to human health. Synonyms for invasive species include introduced, foreign, exotic, alien, non-native, immigrant and transplants.  **Impacts**  Their impacts vary depending on the location but may be insidious because they often invade the open space areas we have preserved for native flora and fauna. Invasive species may be prevalent in areas we have significantly altered including farmlands, forests and suburbs. Their traits are as follows:   * capable of doing significant harm to ecosystems, economy or public health; * capable of spreading without apparent natural controls (natural predators, disease); * population levels that are unchecked; * causing major change faster than native ecosystems can accommodate; * changing major ecological processes (nutrient cycling, hydrology, fire regime, energy); * destabilizing environmental (physical or community) structure; * forming undesirable monotypic stands of vegetation that replace diverse communities; * reducing biodiversity/integrity, causing extirpations and extinctions; * reducing or eliminating a natural product, ecological service or other valued attribute.   **How big is the problem?**  Consider the following:   * Damages from invasive species, including only those damages that can be expressed in monetary terms, have been estimated as high as $ 138 billion per year. These damages affect agriculture, rangeland, forests, people's homes and yards, human and animal health, food supplies, fishing and boating, outdoor recreation, and many other areas; * Invasive species are thought to have been involved in 70% of this century's extinctions of native aquatic species, and 42% of current endangered species are impacted significantly by invasive species; * In January 2003, the Director of the US Fish and Wildlife Service called invasive species "the biggest environmental threat to this country... it's something everyone needs to take very, very seriously."   Image result for mapping invasive species versus cost of control  **Image Source: California Department of Fish and Wildlife**  ***Crosscutting Concepts***  [***Stability and Change***](http://www.nap.edu/openbook.php?record_id=13165&page=98) ***-*** [*Much of science deals with constructing explanations of how things change and how they remain stable.*](http://www.nap.edu/openbook.php?record_id=13165&page=98)  Discuss with the students how the invasive species brings change into a previously stable ecosystem, often quite quickly and with devastating effects. Changes can be environmental, economic, and/or public health.  **Aquatic Nuisance Species (ANS)**  ANS may:   * displace native species * degrade native habitats * spread disease * disrupt human social and economic activities that depend on water resources.   **ANS Travel**   * Stocking - Species was intentionally planted in the new location; i.e., stocked for sport, storage, stock contamination, bio-control; includes legal and illegal stocking. * Shipping - Ballast water discharge and/or hull fouling. Ballast water from ships can transport a large volume of water into various geographical areas. Ballast is now regulated (In the United States and many other countries) in terms of treatment. Ships may do a ballast water exchange (swapping out water taken near shore with other water mid-ocean; changing temperatures and salinity levels reduce transfer of organisms) or treat ballast water onboard (there are several commercial disinfection treatments used and approved). This reduces but does not eliminate the threat of invasives traveling via ballast waters. * Aquarium Release - Species released in the wild by owners who no longer want them. * Bait Release - Species introduced as discarded bait. * Aquaculture - Species that escaped from aquaculture facilities. * Canals - Species that gained access to new areas via canals. * Pet Escape - Species that were released by pet owners, used mostly to designate amphibian and reptile escapes.   **ANS Status**  “Status” represents the reproductive population status of the species in that particular location and includes many categories…   * Collected-species was collected or observed from the site; reproduction is not known - this is the default status; many of these are actually established populations * Established-population is reproducing and overwintering * Eradicated-population was eliminated by human activity e.g., Rotenone to kill introduced fish for subsequent native fishery restoration. * Extirpated-population died out on its own, without human interference, e.g., cold winter * Failed-population was stocked but died out; failed to reproduce * Stocked- species was introduced, as opposed to being caught * Unknown - used when all other categories do not fit   **Invasives Programs**  Maine Department of Inland Fisheries and Wildlife (IF&W) – Invasive Fish  Department of Marine Resources (DMR) – Marine Invaders  Maine DEP – Invasive Aquatic Plants   * Invasive aquatic species are introduced exotic flora and fauna that displace native plant and animal communities. * Infestations may result in   + habitat disruption,   + lower of property values and tax revenue,   + diminished water quality,   + reduced fishing and water recreation opportunities and   + significant expense for mitigating these environmental costs.   + Maine DEP's Invasive Aquatic Species Program addresses invasive aquatic species - primarily plants - in three ways:   + prevention,   + early detection and   + control.   **Threats to Trees and Forests**   * [Wood Borers:](http://www.maine.gov/dacf/mfs/forest_health/invasive_threats/index.htm) These insects' worm-like larvae develop beneath the bark or within the wood leaving tunnels as evidence; emerging adults leave holes in the bark. * [Piercing-Sucking Insects:](http://www.maine.gov/dacf/mfs/forest_health/invasive_threats/index.htm) These insects feed on fluids of the host plant. Many spend a significant part of their lives attached to the host plant * [Defoliators](http://www.maine.gov/dacf/mfs/forest_health/invasive_threats/index.htm): These insects consume the foliage of host plants. * [Disease:](http://www.maine.gov/dacf/mfs/forest_health/invasive_threats/index.htm) Disease can have devastating effects in parts of the United States and has a broad host range.   **Invasive Plants**   * An invasive plant is defined as a plant that is not native to a particular ecosystem, whose introduction does or is likely to cause economic or environmental harm or harm to human health. * There are currently approximately 2,100 plant species recorded from Maine.   + *Approximately one third of those are not native.*   + Of those plants that are not native, *only a small fraction is considered invasive*, but these have the potential to cause great harm to our landscape.   How do these plants reach our landscape?   * In many cases, people have imported invasive species for ornamental and landscaping purposes because many of these species are very attractive. * In other cases, these plant species are purposely planted because they have strong root systems and can provide soil stabilization and prevent erosion. * Accidental introduction through tagging along with other plants purchased at garden shops and through soil contamination are also possible.   Why are invasive plants so successful on our landscape?   * Invasive plant species often lack natural predators, diseases, and other pathogens that keep them in check in their native habitats. * They have competitive adaptations including   + early leaf-out,   + aggressive reproductive strategies, and   + efficient dispersal methods. * In many cases, they take advantage of disturbances, like road construction, and establish themselves before native species can get a foothold.   What Can You do To Help?   * When buying plants or moving them from place to place consider whether the plants are likely to escape. * Verify that plants you buy for your yard or garden are not invasive. Ask your local garden supplier to include more native species. * Replace invasive plants in your garden with non-invasive alternatives. * When boating, clean your boat thoroughly before transporting it to a different body of water. * Don't release aquarium plants, fish, live bait, or other exotic animals into the wild. * Volunteer at your local park, refuge, or other wildlife area to help remove invasive species. Help educate others about the problem. | | | | |
| **2nd topic source**  **Invasive Mussels** | | Source https://www.nwf.org/Wildlife/Threats-to-Wildlife/Invasive-Species/Invasive-Mussels.aspx | | |
| **Zebra mussels** and **quagga mussels** are virtually identical both physically and behaviorally. Originally from Eastern Europe, these tiny trespassers were picked up in the ballast water of ocean-going ships and brought to the Great Lakes in the 1980s. By 1990 zebra mussels and quagga mussels had infested all of the Great Lakes.  Zebra mussels on a stick  Now, both quagga mussels and zebra mussels have spread to 29 states by hitching rides on boats moving between the Great Lakes and Mississippi River Basins.  **Reproduction**  In her five-year lifetime, a single quagga or zebra mussel will produce about five million eggs, 100,000 of which reach adulthood. The offspring of a single mussel will in turn produce a total of half a billion adult offspring. It’s easy to see why there are an estimated 10 trillion quagga and zebra mussels in the Great Lakes today!        **Diet**  Zebra and quagga mussels feed on small organisms called plankton that drift in the water. The 10 trillion quagga and zebra mussels blanketing the bottom of the Great Lakes filter water as they eat plankton and have succeeded in doubling water clarity during the past decade. Clear water may look nice to us, but the lack of plankton floating in the water means less food for native fish.  **Prevention**  It is imperative to prevent zebra and quagga mussels from spreading further, and to keep new invasive species out of the Great Lakes. Regulators support stronger ballast water regulation as well as improved methods of ensuring recreational boats are cleaned of invasive species before moving between bodies of water.  Zebra and quagga mussels harm native fish populations, ruin beaches and attach to boats, water intake pipes, and other structures causing the Great Lakes economy billions of dollars a year in damage.  They devastate native species by stripping the food web of plankton, which has a cascading effect throughout the ecosystem. Lack of food has caused populations of alewives, salmon, whitefish and native mussel species to plummet.  Zebra and quagga mussels promote water clarity by filter feeding. Clearer water allows sunlight to penetrate to the lake bottom, creating ideal conditions for algae to grow. In this way, zebra and quagga mussels have promoted the growth and spread of potentially harmful algae blooms. Algae foul beaches and cause botulism outbreaks that have killed countless fish and more than 70,000 aquatic birds in the last ten years.  **Control**  Once zebra and quagga mussels become established in a water body they are impossible to fully eradicate. Scientists have not found solutions that kill zebra and quagga mussels without also harming other wildlife. | | | | |
| **Projects**  **Educational Poster or e-media presentation – Invasive Aquatic Species** | | | **Materials taken from Source:**  **Original Projects** | |
| **Project Option 1 - Poster Project/School Newsletter Outreach**  Each group shall choose either a Maine invasive species, or a method of transport of these species. Groups shall create informational posters (1 page – 11” x 17”) highlighting the following issues:   * Name of the species/method of transport * Estimate of introduction to Maine * Issues related to this invasion – environmental, health, economic * Attempts to halt growth/transfer of species * Maine state agency that works with your issue * How others may find out more information regarding this species * How to report invasive species to the appropriate authorities   Students may start their search for information here: <http://www.maine.gov/portal/about_me/invasives.html>  These posters may be displayed in classrooms or school hallways to raise awareness of this important issue. In addition, for those schools that send out weekly e-newsletters, these posters could be shared electronically with the greater school community.  **Project Option 2 – e - Media Presentation**  Each group shall choose either a Maine invasive species, or a method of transport of these species. Groups shall create informational media presentation highlighting the following issues:   * Name of the species/method of transport * Estimate of introduction to Maine * Issues related to this invasion – environmental, health, economic * Attempts to halt growth/transfer of species * Maine state agency that works with your issue * How others may find out more information regarding this species * How to report invasive species to the appropriate authorities   Students may start their search for information here: <http://www.maine.gov/portal/about_me/invasives.html>  These presentations may be shared in classrooms or schools to raise awareness of this important issue.  Remind students to always follow school rules regarding internet access and materials viewed. | | | | |
| **Teacher Prep** |  |  | | |
|  | **Advanced Preparation Steps &**  **Duration** | 1. Read and consider associated background material (1 hour) 2. Review video clip (9:55 minutes) 3. Review PowerPoint (15 minutes) | | |
| **Needed Materials** |  |  | | |
|  |  | Video Clip Introduced Species and Biodiversity (Run Time 9:55) <https://www.youtube.com/watch?v=J-ftiWffNTc>  1. Invasive Species Teacher background material and student material. 2. Internet access | | |
|  | **Duration of activities** | 60 minutes | | |
|  | **Safety notes** | Always follow school computer safety rules when going on the internet to obtain information for this project. | | |
| **Procedures for instruction** |  |  | | |
|  |  | Introduce the class to the idea of invasive species. | | ~2 minutes |
|  |  | Introduction to Invasive Aquatic Species (with embedded YouTube Film) | | ~30 minutes  (PowerPoint) |
|  |  | Invasive Species Projects | | ~25 minutes |
| **Student Materials** |  |  | | |
|  | Background Informational Sheet | Reading assignment prior to the demonstration day. | | |
|  | Vocabulary List | Available for clarification of terminology as students read their Background Informational Sheet | | |

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| **Student Background Information Sheet – Invasive Aquatic Species** | | |
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| **Source https://www.nwf.org/Wildlife/Threats-to-Wildlife/Invasive-Species/Invasive-Mussels.aspx**  **Zebra mussels** and **quagga mussels** are virtually identical both physically and behaviorally. Originally from Eastern Europe, these tiny trespassers were picked up in the ballast water of ocean-going ships and brought to the Great Lakes in the 1980s. By 1990 zebra mussels and quagga mussels had infested all of the Great Lakes.  Zebra mussels on a stick  Now, both quagga mussels and zebra mussels have spread to 29 states by hitching rides on boats moving between the Great Lakes and Mississippi River Basins.  **Reproduction**  In her five-year lifetime, a single quagga or zebra mussel will produce about five million eggs, 100,000 of which reach adulthood. The offspring of a single mussel will in turn produce a total of half a billion adult offspring. It’s easy to see why there are an estimated 10 trillion quagga and zebra mussels in the Great Lakes today!        Once zebra and quagga mussels become established in a water body they are impossible to fully eradicate. Scientists have not found solutions that kills zebra and quagga mussels without also harming other wildlife. | | |
| **Student Vocabulary List– Invasive Aquatic Species** | | |
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**Project Assessment**

**Project Title:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Instructor/School/Grade:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_/\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_/\_\_\_\_\_\_\_\_

**Instructor Contact Information:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Date assigned to your class:** \_\_\_\_\_\_\_\_\_\_\_ **Number of Students Participating** \_\_\_\_\_\_

The following questions are intended to help us understand your feelings regarding the presentation and materials. Your sincerity in answering these questions is appreciated. Please feel free to use the space at the end of the form for any additional comments that you may have. *This form has been left in Microsoft Word format so that you may fill it in electronically. Please fill out the form completely and email your assessment to* [david.madore@maine.gov](mailto:david.madore@maine.gov).

**Ranking System**

1 ~ Excellent / Strongly agree

2 ~ Good – Above average / Moderately agree

3 ~ Average – ok / Neutral in agree or disagree

4 ~ Poor – below average / Moderately disagree

4 ~ Very poor – not acceptable / Strongly disagree

NA / not applicable

*Please continue on the second pagee…*

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| **1** | **2** | **3** | **4** | **5** | **NA** | **Questions** |
|  |  |  |  |  |  | **Course Content** |
|  |  |  |  |  |  | 1. Value of course content to you. |
|  |  |  |  |  |  | 1. Importance of course content given your teaching topic. |
|  |  |  |  |  |  | 1. Overall rating of course content. |
|  |  |  |  |  |  | 1. Ease of implementing materials into daily lessons. |
|  |  |  |  |  |  | **Materials/Project** |
|  |  |  |  |  |  | 1. Movie (if applicable) was easy to present. |
|  |  |  |  |  |  | 1. Student worksheet was useful and easy to follow. |
|  |  |  |  |  |  | 1. Student project stimulated thinking & conversation. |
|  |  |  |  |  |  | 1. The project put ideas across effectively. |
|  |  |  |  |  |  | 1. Teacher materials were useful and easy to follow. |
|  |  |  |  |  |  | 1. The method of material presentation encouraged students feel free to ask questions, disagree, express ideas, etc. |
|  |  |  |  |  |  | **Self-Evaluation (Instructor)** |
|  |  |  |  |  |  | 1. What was your level of knowledge concerning this topic prior to this presentation? |
| **Please share any recommendations you feel would be helpful.** | | | | | | |

**Thank you for providing your feedback!**

Please email your assessment to david.madore@maine.gov.