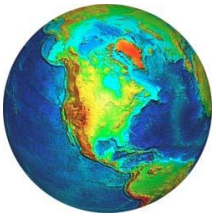


# Climate Change and Invasive Species
# Double Whammy in a Bag

## Overview:

- The task is for students to create a game about the double whammy of climate change and invasive species and how together they will affect biodiversity, the economy, the environment, and the inhabitants in your region.

**Objectives:** At the conclusion, students will be able to:

- Provide examples of potential impacts caused by climate change
- Discuss various interpretations of the role that climate change can play in the establishment and spread of invasive species in the Great Lakes
- Recognize some common native and invasive species in the Great Lakes
- Increase cooperation skills among group members
- Provide a setting for individuals to practice the skills necessary for appropriate decision making in a small group
- Increase appropriate communication skills between members of the group

**Duration:** This lesson can be completed in two class periods. Ideally students should play multiple times and trade games with other groups so they can observe different outcomes depending on students' knowledge, game design, etc.

Warm-up: 5 -10 minutes
Activity: 30 – 50 minutes
Wrap-up: 10 - 20 minutes
Setting – you can decide if the game will be played in an open area indoors or outdoors or in the classroom.

## Standards:

Subject Areas:
Science, Social Studies, and Language Arts
Life Science:
Analyze the roles of organisms as part of interconnected food webs, populations, communities, and ecosystems

- Assess survival needs and interactions between organisms and the environment
- Assess the requirements for sustaining healthy local ecosystems
- Evaluate human impacts on local ecosystems

Earth and Space Science

- Explain how the Earth's surface changes over time

Language Arts
Oral Language
Reading and Viewing
Writing and Representing
Social Studies
Human and Physical Environment

**Keywords**

- Climate change, weather, region, predictability, organisms, agriculture, crops, tourism, economy, infrastructure, adaptation, interdependence, abiotic, biotic, invasive, native

## Materials and Preparation

- A paper bag filled with photo cards of both invasive and native species, and cards with climate change scenarios (both scientific and social impacts) for your region. The bag should also include a writing utensil and piece of paper for development of rules, objects that can be used as game pieces, and a larger piece of paper should also be available for a game board if the group chooses to use them.

- Possible Climate Change Scenarios: more precipitation (rain or snowfall), less precipitation, more sunshine, less sunshine, higher daytime temps, lower daytime temps, higher wind speeds, more storms, flooding, drought etc. Ask students to consider the following questions when designing their game:

    1. How would the above changes affect me? How would they affect my community?
    2. How would they affect local ecosystems? How would they affect native plants/animals?
    3. How could they aid the spread of invasive species?

## Description/Procedure

The group is given the bag of supplies and then given simple instructions of the task they are to complete. Participants are instructed to use objects in the bag to create a new game that they will have the opportunity to play during subsequent activity groups.

Their first task is to develop the type of game they will create and give it a name. They are then to develop a list of rules (each person must suggest and have accepted one rule, and each rule must be agreed on by 75 percent of the group). It is left to the group to make necessary decisions with little intervention from the leader. Once the game is completed (named, rules developed, and a game board and pieces are finished). Processing the experience with the group is important. Take the time needed for this step.

For example, discussion could focus on whether the group cooperated toward the common goal of creating an invasive species/climate change game, how decisions were made and by whom, and how much the group communicated with one another. The discussion may also cover whether the new game resembles any real life issues about invasive species and climate change.

**Leadership Considerations:**
-More intervention may be necessary depending on the ages and involvement in prior learning about invasive species and climate change.
-Encourage processing of each situation as it may occur in real life.
-Types and numbers of photos in bag should reflect the level and abilities of the participants.

**Variations:**
When working with larger groups, the leader may divide the group in half, giving each group identical bags, and then allowing each group to play the other group's game at the end.

## Prerequisite Teacher Knowledge:

Aquatic invasive species (AIS) are species that are found outside of their native habitat and cause harm to their new environment. They are highly competitive and persistent. There are over 185 non-native species in the Great Lakes, and the trend has been one new species every 6-8 months. As the climate continues to warm, and the Great Lakes experience additional stressors, AIS may become an even bigger problem as warming temperatures, changing water quality, and disturbance may allow new AIS to expand their ranges and make their home in the Great Lakes. This illustrates the need to be vigilant and step-up efforts to prevent AIS introductions into the country. Most of those responsible for fighting AIS infestations realize that it is less expensive to prevent their introduction in the first place than to try to control or eradicate them once an infestation has occurred.
To prevent future invasions it would be helpful to know the answers to a few questions: Are there characteristics that are common between different invasive species? How can we tell which habitats are most at risk?

Aquatic invasive species have certain characteristics that tend to make them successful:

- Rapid growth and reproduction: tend to grow quickly and produce a lot of offspring; many reproduce multiple times in one season.
- Asexual reproduction: some species need only one individual to reproduce; especially plants, which may need only a small plant fragment to start a completely new population.
- Adaptability: typically hardy and able to tolerate a wide range of environmental conditions, including degraded and polluted habitats and rapidly changing conditions that native species can't tolerate.
- No predators: Since these species are non-native, they often lack the natural predators that would keep their population numbers in check.

Global climate change may make conditions more suitable for invasive species. Warming temperatures, increased precipitation, and other climate change impacts predicted by scientists present a whole new challenge to invasive species management. While it is unknown exactly how AIS may respond to a changing climate, it is predicted that many species will benefit from these changes, expand their ranges, and have exacerbated negative impacts. Due to the characteristics that allow AIS to become successful, these species will most likely have the upper hand at trying to adapt to changing conditions, which may allow them to further outcompete existing native species.

**CLIMATE CHANGE/AIS MAY IMPACT**

| | | |
|---|---|---|
| Evaporation | Income | Crop production |
| Snow | Extinction | Cooperation |
| Drinking water | Lake levels | Warm water fish |
| Severe storms | Lakefront property | Wetlands |
| Insect pests | Rain | Tourism |
| Recreation | Toxic air pollution | Forests |
| Water pollution | Electricity | Drought |
| Flooding | Fear | Debate |
| Biological diversity | Shipping | Summer |
| Winter | Disease | Air conditioning |
| Birds | Soil moisture | Weeds |
| Fertilizer use | Pesticide use | Dredging |
| Invasive fish | Invasive plants | Invasive invertebrates |
| Invasive reptiles | Invasive pathogens | Cold-water fish |
| Shoreline development | People | Water diversion |
| Algal blooms | | |

**Introduction:**
Ask students about their prior knowledge about climate change and invasive species.

- Can they name any invasive species? Do they know the issues caused by those species or what people are doing to control them?
- Ask students how they think a changing climate might impact these species? What changes are expected? What kind of species will do better after these changes? What kinds of species might do worse?
- Repeat the activity after students gain more knowledge about climate change and invasive species. Point out to students how the outcomes differ games.

## Review Questions

1. List and discuss potential scientific and social factors which may be affected by climate change.

2. Those who deny climate change insist that climate scientists prove beyond any reasonable doubt that climate change poses an imminent danger before we take action as a society. Who should policy makers believe and why and how should they deal with such dilemmas?

**Evaluation**
Ask the students to answer the following questions:
1. What are the four main habitat components?
2. What are some of the impacts of climate change on habitat? Give four examples.

## Answers to Review Questions

1. Accept a large variety of answers for this question. Jobs would be created to help develop new crop seeds that could tolerate warmer, dryer conditions. Farmers would need to adjust their crops and farming practices to respond to the changing conditions. Recreational facilities would need to change their structure for the longer summer season, lowered water levels, and warmer temperatures. Anglers and manufacturers of fishing gear would need to be flexible because spawning grounds for fish would decrease and new species would become abundant. Companies that use toxic chemicals may need to adjust their procedures because increased temperatures and incidence of severe storm would cause airborne pollutants to travel further. The lowered lake and river levels would also greatly impact the shipping industry because boats would either be unable to pass through certain areas or would be required to carry a lighter load. This would have repercussions on the companies that use this method to transport goods.

Most scientists believe that invasive species (plants, fish, and other animals) would increase due to a wider range of temperatures in the Great Lakes. This would allow for range expansion and changes in habitats that would be more suitable for invading species. Many species that may be limited due to colder water temperatures would be able to survive in the new warmer water temperatures. Invasive plants ordinarily found in southern areas could move up to the Great Lakes region. Also, the growing season would be extended, so invasive plants would have a better chance to grow and propagate. The increased rainfall or, conversely, droughts that could occur with climate change may also shift the ranges of invasive species and provide new opportunities for invasion.

**2.** Insisting that climate scientists prove beyond any reasonable doubt that climate change poses an imminent danger before we take action as a society is like saying we shouldn't buy car insurance unless there is absolute proof that we will be involved in an accident. There are uncertainties in climate projections, and possible outcomes range from benign to catastrophic, but doing nothing puts all life at unnecessary risk.

Scientific societies and scientists have released statements and studies showing the growing consensus on climate change science. A common objection to taking action to reduce our heat-trapping emissions has been uncertainty within the scientific community on whether or not global warming is happening or if humans cause it. However, there is now an overwhelming scientific consensus that global warming is indeed happening and humans are contributing to it.

Our understanding of the particulars of climate change continues to evolve, and predictions of specific impacts may be revised upward or downward. However, the majority (97%) of climate scientists who specialize in understanding the complex interactions of our atmosphere, Earth, and Sun have concluded that:

"There is unequivocal evidence that Earth's lower atmosphere, ocean, and land surface are warming; sea level is rising; and snow cover, mountain glaciers, and Arctic sea ice are shrinking. The dominant cause of the warming since the 1950s is human activities. This scientific finding is based on a large and persuasive body of research. The observed warming will be irreversible for many years into the future, and even larger temperature increases will occur as greenhouse gases continue to accumulate in the atmosphere. Avoiding this future warming will require a large and rapid reduction in global greenhouse gas emissions. The ongoing warming will increase risks and stresses to human societies, economies, ecosystems, and wildlife through the 21st century and beyond, making it imperative that society respond to a changing climate. To inform decisions on adaptation and mitigation, it is critical that we improve our understanding of the global climate system and our ability to project future climate

through continued and improved monitoring and research. This is especially true for smaller (seasonal and regional) scales and weather and climate extremes, and for important hydroclimatic variables such as precipitation and water availability.

Technological, economic, and policy choices in the near future will determine the extent of future impacts of climate change. Science-based decisions are seldom made in a context of absolute certainty. National and international policy discussions should include consideration of the best ways to both adapt to and mitigate climate change. Mitigation will reduce the amount of future climate change and the risk of impacts that are potentially large and dangerous. At the same time, some continued climate change is inevitable, and policy responses should include adaptation to climate change. Prudence dictates extreme care in accounting for our relationship with the only planet known to be capable of sustaining human life."
[This statement is considered in force until August 2017 unless superseded by a new statement issued by the American Meteorological Society Council before this date.]

To most of us, uncertainty means not knowing. To scientists, however, uncertainty is how well something is known. And, therein lies an important difference, especially when trying to understand what is known about climate change. In science, there's often not absolute certainty. But, research reduces uncertainty. In many cases, theories have been tested and analyzed and examined so thoroughly that their chance of being wrong is infinitesimal. Other times, uncertainties linger despite lengthy research. In those cases, scientists make it their job to explain how well something is known. When gaps in knowledge exist, scientists qualify the evidence to ensure others don't form conclusions that go beyond what is known. Even though it may seem counterintuitive, scientists like to point out the level of uncertainty. Why? Because they want to be as transparent as possible and it shows how well certain phenomena are understood.

Decision makers in our society use scientific input all the time. But they could make a critically wrong choice if the unknowns aren't taken into account. For instance, city planners could build a levee too low or not evacuate enough coastal communities along an expected landfall zone of a hurricane if uncertainty is understated. For these reasons, uncertainty plays a key role in informing public policy.

Taking into account the many sources of scientific understanding, climate scientists have sought to provide decision-makers with careful language regarding uncertainty. A "very likely" outcome, for example, is one that has a greater than 90 percent chance of occurring. Climate data or model projections in which we have "very high confidence" have at least a 9 out of 10 chance of being correct.

However, in this culture of transparency where climate scientists describe degrees of certainty and confidence in their findings, climate change deniers have linked less than complete certainty with not knowing anything. The truth is, scientists know a great deal about climate change. We have learned, for example, that the burning of fossil fuels and the clearing of forests release carbon dioxide ($CO_2$) into the atmosphere. There is no uncertainty about this. We have learned that carbon dioxide and other greenhouse gases in the atmosphere trap heat through the greenhouse effect. Again, there is no uncertainty about this.

Earth is warming because these gasses are being released faster than natural processes can absorb them. It is very likely (greater than 90 percent probability) that human activities are the main reason for the world's temperature increase in the past 50 years.

Scientists know with very high confidence, or even greater certainty, that:

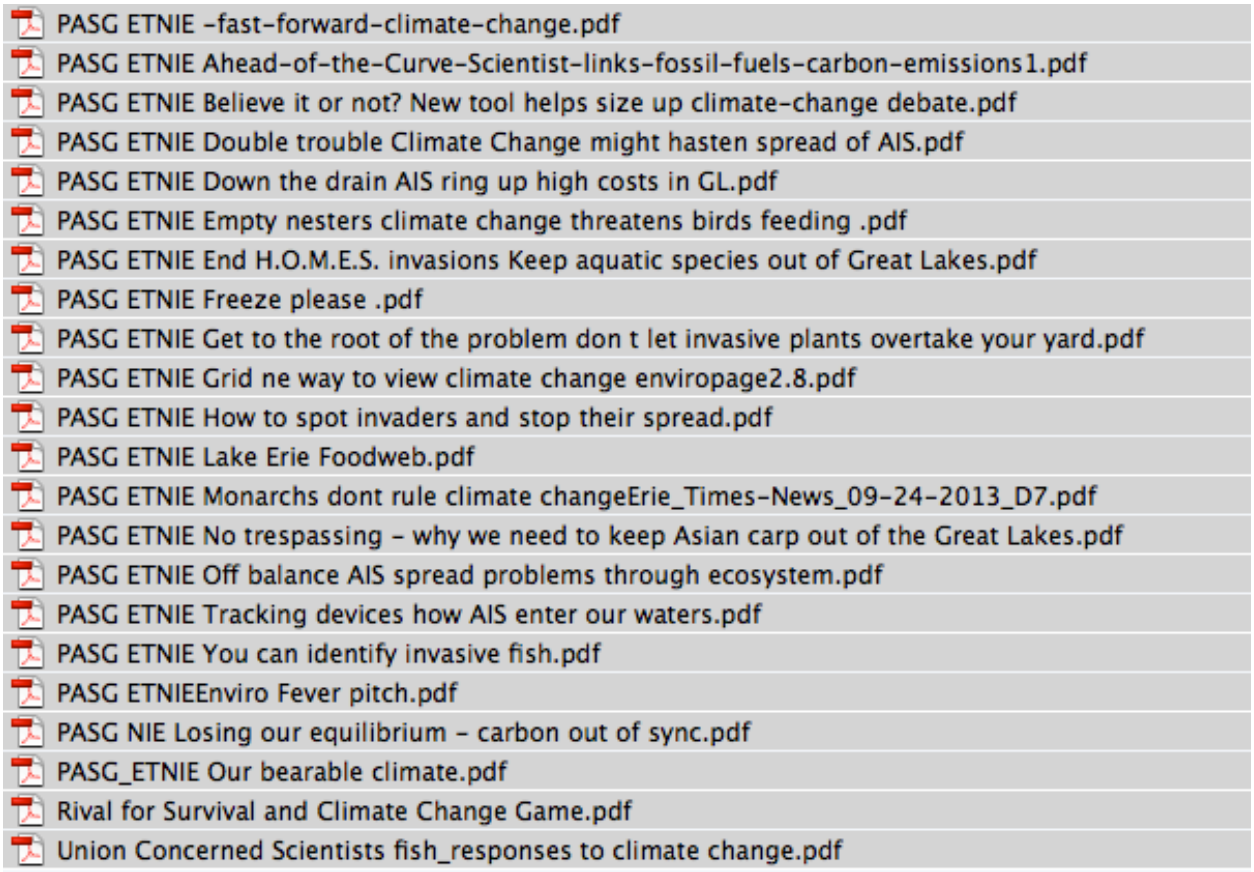
- Human-induced warming influences physical and biological systems throughout the world
- Sea levels are rising
- Glaciers and permafrost are shrinking
- Oceans are becoming more acidic
- Ranges of plants and animals are shifting

Scientists are uncertain, however, about how much global warming will occur in the future (between 2.1 degrees and 11 degrees Fahrenheit by 2100). They are also uncertain how soon the summer sea ice habitat where the ringed seal lives will disappear. Curiously, much of this uncertainty has to do with—are you ready? —humans. The choices we make in the next decade, or so, to reduce emissions of heat-trapping gasses could prevent catastrophic climate change.

So, what's the bottom line? Science has learned much about climate change. It tells us what is more or less likely to be true. We know that acting now to deeply reduce heat-trapping emissions will limit the scope and severity of further impacts – and that is virtually certain.

## Resources:

- Union of Concern Scientists - http://www.ucsusa.org/global_warming/
- PA Sea Grant fact sheet- http://www.paseagrant.org/fact_sheet_group/invasive-species/
- PA Sea Grant/Erie Times-News in Education pages Climate change/AIS pages listed below can be found in the resource folder.




**This lesson is one of 10 lessons that focus on climate change and invasive species prepared by the Pennsylvania and New York Sea Grant programs as part of a larger Great Lakes Sea Grant Network initiative funded by the Great Lakes Restoration Initiative.**

Sea Grant Great Lakes

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