THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

Species Populations and Biodiversity

How can species population data for _____ indicate changes in the biodiversity of its ecosystem?

GRADES 9–12

Life Science

VAN ANDEL EDUCATION INSTITUTE

VAEI.ORG

INQUIRY-BASED SCIENCE

Life Science

Species Populations and Biodiversity

Grade Level/Content	9–12/Life Science
Lesson Summary	Students will identify an ecosystem and species of interest to analyze factors positively or negatively impacting the population size of the chosen species and the biodiversity of the broader ecosystem.
Estimated Time	3, 45-minute class periods
Materials	Population data of various species in different ecosystems (see suggested Secondary Resources); graphing software (optional); Investigation Plan; calculator; Internet access
Secondary Resources	Data.gov species reports and datasets International Biogeographical Society NatureServe – Data, Maps & Tools NatureServe – Explorer® NatureServe – At-Risk Species Yellowstone Wolves Wolf Reintroduction Changes Ecosystem 2014 Wolf Project Annual Report Effect of Climate Change on Plant Population Growth Rate
NGSS Connection	**HS-LS2-2** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
Learning Objectives	• Students will devise a plan to obtain information for a species population size of interest. • Students will collect and analyze data to identify trends in this population size over time. • Students will develop mathematical representations of changes in species populations based on analyzed data and related scientific research of population size changes in species of interest, as well as broader biodiversity indicators.

How can species population data for _____ indicate changes in the biodiversity of its ecosystem?

Ecosystems are always in flux. Many things happen within an ecosystem that can cause changes to species' populations. Changes might be as simple as not having enough food to eat, which would impact a particular population of organisms. A change could also create a larger problem, such as climate change that leads to elevated sea surface temperatures that negatively impact species' reproductive abilities. Whatever the cause, organism populations are always changing as a result of biotic and abiotic factors.

Sometimes one species serves a special environmental role or niche. If something were to happen to the population size of this species, its increase or decrease would be felt throughout the ecosystem. Its absence, in particular, would have an impact on the ecosystem's biodiversity. In this lesson, students research information and data trends in different species' population sizes. They also relate these trends to environmental conditions within the ecosystems inhabited by these species to determine likely causes for these changes in population.

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science. In all investigations:

Students don't know the "answer" they are supposed to get.

Students play a driving role in determining the process for learning.

Teachers and students construct meaning together by journaling.

Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

Students will devise a plan to research and obtain population data about a chosen species in an ecosystem of interest to them. Students will use credible resources shared by you or found during Internet research to quantify population size changes over time and the likely reasons for these changes.

- Investigation Plan
- Calculator
- Internet
- Available reference books, reports or literature (as available)
- Graphing software (optional)

Part 2

INVESTIGATION FACILITATION

Question

Introduce the investigation question.

How can species population data for _____ indicate changes in the biodiversity of its ecosystem?

Personal Knowledge

Students capture what they already know about population sizes, biodiversity, and ecosystems.

Part 1

- Find out what students know about populations and species interactions, as well as living and non-living factors that influence population sizes.
- Generate a concept or idea web with the class that shows factors students identify as biotic or abiotic. Determine which seem to have the greatest impact and work with your students to identify a way to represent the relative impact of these factors.
- Ask students to record their interpretation of this concept web in their journal.

Part 2

- Ask students to identify 2–3 species (and their ecosystems) of interest that they have seen or heard about from past classes, recent media coverage, or general interest. Remind students to consider plants and fungi along with animals.
- Explain to your students that they will have a research partner to work with for this lesson. Determine the best way for students to communicate which species interest them, and how to go about pairing students for the lesson.
- Ask students to record their chosen species and ecosystem for this investigation in their journal.

DISCOURSE

Encourage students to discuss with each other how factors such as food availability, space, predation, sunlight, temperature, and water supply influence different species' population sizes. Ask them to consider and describe what would happen to individual species and the ecosystem as a whole if one of these factors were to become scarce or vary drastically from their current state.

RISK-TAKING

Encourage them to work with a peer that is genuinely interested in the same species and (possibly) ecosystem, even if they have not worked together in the past. If necessary, conduct a *Blind Card Sort* to team students based on their choice of species. For the first round, have students write their first species choice on an index card and pass it in for you to sort into like pairs. Call out species pairs to assign students to research teams for the lesson. Continue 2 or 3 more rounds while keeping the unpaired cards from previous rounds to increase possible matches. For the last round, work with remaining students to identify a species of mutual interest to assign remaining research teams.

Prediction

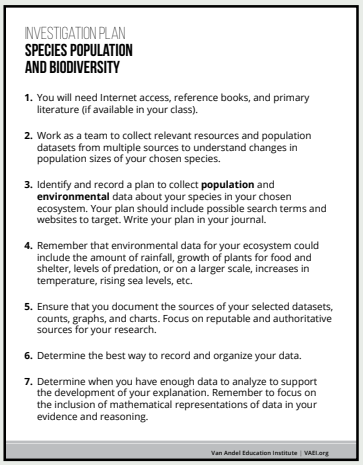
Students communicate an expected outcome, based on prior knowledge

- Students present their predictions in the format: *I predict that populations for (insert species name) in the (insert ecosystem name) _____ because _____.*

Investigation Plan

Students determine a plan to research the population size of the selected species and how it relates to environmental conditions in its ecosystem.

- Students will determine a plan to identify relevant resources and collect multiple population datasets about their selected species within a given ecosystem.
- Encourage students to record their plan (including possible search terms and websites to target) in their journal.
- Remind them that they also need to collect relevant environmental data for the ecosystem. A wide variety of possible factors should be considered, including: rainfall, growth of plants for food and shelter, levels of predation, or, on a larger scale, increases in temperature, ecosystem nutrient loads, rising sea levels, etc.
- Encourage students to look for authoritative resources during the course of their research. Excellent online resources for species data and maps as well as environmental data include species reports and datasets from Data.gov, a list of species websites and databases from the International Biogeographical Society, and the NatureServe website. The NatureServe website includes a variety of tools you may want to highlight, including NatureServe – Data, Maps & Tools, NatureServe – Explorer®, and NatureServe – At-Risk Species maps.



INVESTIGATION PLAN

SPECIES POPULATION AND BIODIVERSITY

1. You will need Internet access, reference books, and primary literature (if available in your class).
2. Work as a team to collect relevant resources and population datasets from multiple sources to understand changes in population sizes of your chosen species.
3. Identify and record a plan to collect **population** and **environmental** data about your species in your chosen ecosystem. Your plan should include possible search terms and websites to target. Write your plan in your journal.
4. Remember that environmental data for your ecosystem could include the amount of rainfall, growth of plants for food and shelter, levels of predation, or on a larger scale, increases in temperature, rising sea levels, etc.
5. Ensure that you document the sources of your selected datasets, counts, graphs, and charts. Focus on reputable and authoritative sources for your research.
6. Determine the best way to record and organize your data.
7. Determine when you have enough data to analyze to support the development of your explanation. Remember to focus on the inclusion of mathematical representations of data in your evidence and reasoning.

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Investigation Plan

CRITICAL THINKING

Use the Fair Test checklist to help students think critically about the investigation plan. Help them understand that a good investigation plan must include a process that is repeatable, generates quality data, and minimizes error. The more critically students think about their investigation plan, the more confident they can be in their results.

Observation

Students record population size data and ecosystem/habitat conditions for their selected species.

- Have students determine the best way to record their data (scientific explanations, images, tables, and graphs) in their journal.
- Students should also document the websites and report sources for their collected data.
- If students determine that there is not enough data to support an analysis of two or more datasets, work with them to quickly identify a different species of interest.

INTEGRITY

Remind students that a significant portion of scientific work is research to understand what is already known by others. Check that students are not plagiarizing and have collected and recorded the sources of their data correctly and ethically.

Part 3

INVESTIGATION ANALYSIS AND DEVELOPMENT OF CLAIM

Data Analysis

Students make sense of their data by organizing it and representing it visually.

- Have students analyze their data. They may wish to use the Data Analysis prompt as a guide.
- Have students **evaluate** their data for trustworthiness.
- Then, have them analyze their data to find patterns and trends. They may **organize** the data and/or **represent** it visually to construct meaning.
- Focus student analysis on mathematical comparisons of populations and the factors influencing the researched species and the ecosystem as a whole. Have them look for connections between the population sizes of their chosen species and any related environmental conditions that may have changed and been documented by scientists.
- Students should calculate averages, quantify long-term trends and identify discrepancies/commonalities across multiple sets of data.
- Encourage students to create graphs and charts that show population changes and relate these changes to the changing environmental conditions. Push them to consider combining data from multiple sources into a single visual representation or to develop a series of representations to communicate meaning in one infographic.
- Have students **interpret** what the identified patterns or trends mean.
- Ensure they have enough data that it can be used as evidence to support a claim.

CRITICAL THINKING

Have students dig deeper into their data to flesh out all of the relationships that exist between the population size of interest and changes in the environment. They should consider both local (niche, community, ecosystem) and global changes that may impact the species. They should also consider similar species in the same or different ecosystems that may shed light on the species being investigated.

Secondary Knowledge

Students use secondary sources to understand relationships between a species' population size and how changes in the environment can alter it.

- Use these secondary resources (or your own) to further develop students' understanding of how population sizes are affected by changes (large and small) in the environment.
  - Yellowstone Wolves
  - Wolf Reintroduction Changes Ecosystem
  - Effect of Climate Change on Plant Population Growth Rate
  - Impact of Density on Population Size
- Have students review these and similar resources that highlight specific case studies and broader relationships between species populations and environmental conditions. Students then should better understand how changes to environmental conditions on local, regional, and global scales can impact a particular species' population size, as well as the overall biodiversity of an ecosystem.

Explanation

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've researched to write an explanation that answers their investigation question.
- Students may wish to use the Explanation prompt as a guide. Have them write their explanation in their journal.
- Have students develop a **Claim** to answer the question: How can species population data for _____ indicate changes in the biodiversity of its ecosystem?
- Then, have them add **Evidence** (the analyzed data) to support their claim.
- Finally, have them add **Reasoning** to their claim. Reasoning should include the information obtained from this investigation as well as science principles they have learned.

Claim

The population of wolves in the greater Yellowstone ecosystem provides indications of biodiversity changes within the broader ecosystem among multiple plant and animal species.

Evidence

Yellowstone presents an interesting case study for the reintroduction of a key species. Since the return of 31 Canadian wolves in fall and winter of 1995, the population peaked at 173 in 2003 and has since fallen back down to a range of between 85 and 100 for the last twelve years.

This represents an average increase of nearly 18 wolves during the first 8 years after reintroduction. After this highpoint, wolf populations rapidly fell and averaged 92 wolves between 2003 and 2015.

Reasoning

Investigation: Our research indicates that many scientists believe the carrying capacity for wolves in the Yellowstone ecosystem is approximately 100 wolves. The carrying capacity is a function of the ecosystem's available food, water, shelter, temperature, and competition for available resources. Changes in wolf populations help in understanding and possibly forecasting changes in biodiversity of the Yellowstone ecosystem as increased predation of elk by wolves has brought elk populations in check. Lower elk populations have resulted in increased aspen growth due to decreased browsing pressure on young aspen in the winter months. This has resulted in higher aspen productivity that has improved ecosystem carrying capacity for beavers which depend on aspen for food and shelter.

Science: There is a direct correlation between the environment in which a species lives and how large the population of that species can be. Many factors keep populations in check but can also cause increases or decreases in their numbers. These factors, called limiting factors, include space, water, temperature, and predation. Changes in these, and many other factors, can be shown graphically and compared with population sizes to see how species react. The ripple effect or trophic cascade of the wolf's return has changed the outlook of numerous plant and animal species across the greater Yellowstone ecosystem.

- Once the explanation is written, have students discuss their results using a Present and Defend.

DISCOURSE

Select 4-5 representative species and ecosystem groups to conduct a Present and Defend. This helps develop presentation and audience participation skills. Research teams present a summary of their investigation to the class. The class analyzes the information presented and asks clarifying questions, challenges and/or supports the arguments made, and even presents alternative explanations as appropriate. Research teams defend their explanation with evidence and reasoning.

Evaluation

Students reflect on the investigation.

Have students discuss:

- What surprised me?
- What question would I like to investigate next?
- What alternative explanations should be considered for the data I collected?

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION

Application

Students demonstrate understanding of how environmental conditions impact population sizes of species.

- Have students apply their learning by asking them to consider how environmental conditions affect biodiversity on a global level. Ask students to describe climate change and the dramatic impacts it is having on the world's species (*water temperature increase on coral reefs, loss of rainforest habitat due to clear cutting, etc.*).

Assessment

Evaluate each group's explanation on how well students:

- devise a plan to obtain information for a species population size of interest.
- collect and analyze data to identify trends in this population size over time.
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