



TOPICS 4-6

Integrate Data Science
Investigate Endangered Species

Purpose

Students will investigate information about endangered species and conservation efforts to find patterns and make general observations. They will research, analyze, and interpret data findings and use the math they have learned to answer questions posed or questions of particular interest to them. They will use the data to drive decisions, develop a model, and to make predictions about future extinction rates.

Students have the opportunity to apply all or a subset of the concepts and skills they have learned in Topics 4–6.

Pacing

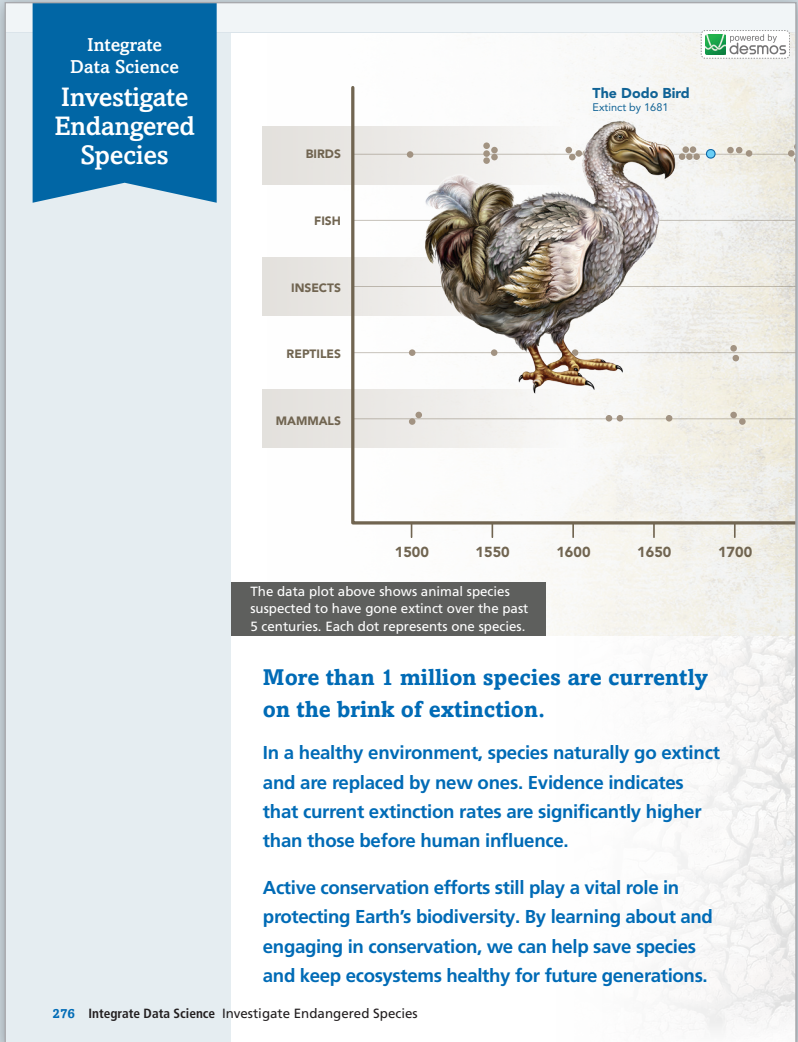
Allow 3–4 days for students to complete the investigation and optional extension.

Invite Student Questions and Conjectures

To engage students in the context and have them bring their own unique experiences and ideas to the situation, consider these prompts:

- Q: Can you think of any animals that have gone extinct?
- Q: Do extinctions seem to happen more often than they did in the past? How do you know?
- Q: What do you think causes extinctions? How might human actions influence animal extinctions?

Interactive version is available at SavvasRealize.com.



English Language Development

MLR2 Collect and Display

Notice and Wonder

WHOLE CLASS

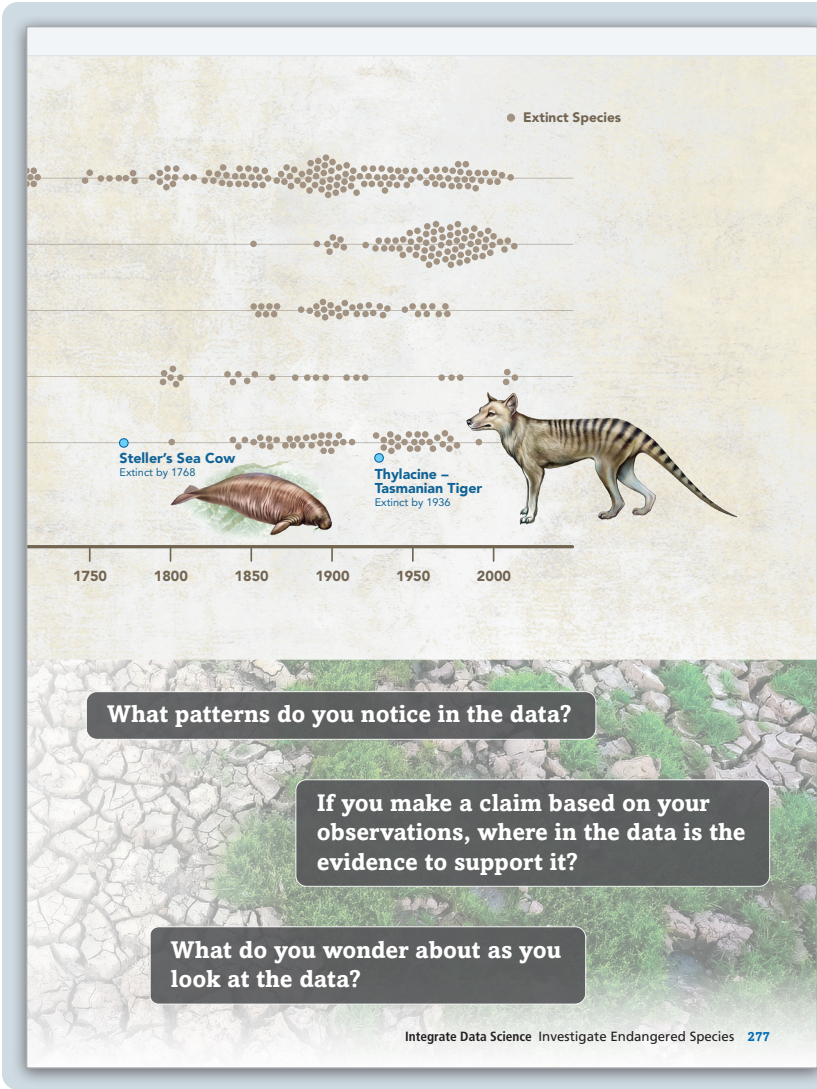
Engage students in classroom discourse as they notice and wonder about the data plot showing extinct species over time.

MLR2 Collect and Display

Record what students notice and wonder, and revisit the lists during the investigation. While recording, listen for informal words students may use, and revise what you record as students refine their terminology.

Notice	Wonder
• There are more extinct birds than extinct reptiles and insects. • Over time, more species became extinct. • More fish have gone extinct in the past hundred years than the centuries before. • Most mammal extenctions happened between 1850 and 2000.	• I wonder why there are more extinctions in the last 200 years than before? • I wonder how the Dodo bird went extict? • I wonder how scientists track extinction data?

Interactive version is available at SavvasRealize.com.





Promote Mathematical Discourse

Before answering questions, have groups discuss factors related to conservation of endangered species. If needed, help them understand conservation and the role of conservation efforts in protecting endangered species. Add to the class notice and wonder display as students share their thinking. **(MLR2)**

Q: What are some other factors that could impact conservation efforts for endangered species? [protected areas, habitat preservation, legal protection and policy, education, etc.]

Q: Are these variables related in some way? How could you tell? [If the species is highly endangered, the population is lower and the cost for conservation might be higher.]

Launch the Investigation SMALL GROUP

You may choose to complete parts 1–4 as a class or in small groups. Facilitate classroom discussion at pause points between each part.

1. Sample response: Since x represents the number of Tiger projects and y the number of Elephant projects, the inequality $30,000x + 9,000y \leq 90,000$ represents the combined cost of both projects can be at most \$90,000. The inequality $100x + 150y \leq 900$ represents the number of worker hours per project and that the combined number of worker hours for both projects can be no more than 900 hours.
2. Students may use graphing technology or graphing paper to plot the system of inequalities.

Ask students to share their work and describe how the impact score can be determined from the solution.

Q: How can you determine the highest possible impact score?

Sample response:

I used the graph of the system to determine the highest possible impact score. Although the intersection (1.5, 5) would maximize the impact score, there cannot be half a conservation project. I chose two values in the solution set (1, 5) and (2, 2) and compared their impact scores:

$$I = 80(1) + 60(5) = 380; I = 80(2) + 60(2) = 280$$

To get the highest impact score, the conservation group could do 1 tiger project and 5 elephant projects for an impact score of 380.

3. Sample response: If I prioritize tigers, the impact score might increase, but I might not stay within my constraints. For example, if I chose 5 tiger projects and 1 elephant project, the impact score is $I = 80(5) + 60(1) = 460$, but I would spend over \$90,000 and use more than 900 worker hours
4. Sample response: If I received extra funding, I could increase the number of projects, as long as the funding does not exceed the new budget constraint.



Interactive version is available at SavvasRealize.com.

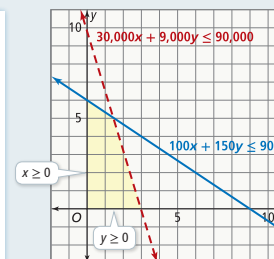
CALIFORNIA'S CONSERVATION BUDGET IS ONE OF THE LARGEST IN THE U.S.

An environmental organization has a \$90,000 budget and 900 worker-hours available for conservation projects. Using the equation $I = 80x + 60y$, where x represents tigers and y represents African savanna elephants, determine the combination of projects that maximizes the impact score while staying within the constraints.

An **impact score** quantifies the effectiveness or significance of an action or project, assessing how well it meets its goal.

Endangered Species	Region	Population Estimate	Cost	Worker-Hours	Impact Score
 Red Wolf	North America	20–30	\$5,000	90	50
 African Savanna Elephant	Africa	415,428	\$9,000	150	60
 Tiger	Asia	2,608–3,905	\$30,000	100	80
 Galapagos Giant Tortoise	South America	15,000	\$35,000	200	80
 Blue Whale	Oceans	5,000–15,000	\$20,000	150	50
 California Condor	North America	93	\$10,000	80	60

1. Given the system of inequalities shown in the graph, explain what each inequality represents. What do the variables represent and what are the constraints?
2. How could you determine the highest possible impact score?
3. If you prioritize one project over the other, how is the impact score affected?
4. How could you adjust your plan if additional resources or constraints are introduced? For example, suppose you receive extra funding or the number of available worker hours is reduced.





DRIVE YOUR INVESTIGATION

Anticipate

As you plan, anticipate ways that students will ...

- choose which endangered species they will investigate
- use tools to graph the constraints
- determine how the variables are related
- make predictions about the impact of conservation efforts

Also anticipate errors that may occur like:

- swapping the variables
- using incorrect inequalities to represent the data and constraints
- misinterpreting the constraints
- drawing conclusions without mathematical evidence to back it up

Monitor

Questions for Students Before Starting the Investigation

Q: What variables will drive your investigation? [cost, worker-hours, impact score, population estimate, etc.]

Questions for You As You Observe

As you monitor students working, ask yourself the following questions:

- **Which students need support with researching the information they need?** Refer students to the data from the guided activity, or data from official websites.
- **Which students need help creating models that represent the data?** Encourage students to use technology tools such as Desmos Graphing Calculator or graphing calculators.

Questions for Students During the Investigation

- Q:** What factors influenced your choice of endangered species for your investigation? Guide students to discuss a strategy for their selection.
- Q:** What constraints do you need to consider when developing your model? Help students model the variables and constraints by first assigning variables, and then determining inequalities for the cost and for worker-hours.
- Q:** How can you determine the maximum impact? If the student chose conservation projects with an impact score, help them write an equation to determine the combination that maximizes the total impact. Otherwise, discuss ways the impact of conservation could be measured.



Interactive version is available at SavvasRealize.com.

DRIVE YOUR INVESTIGATION

Choose an endangered species of interest to you for a new conservation project. To drive your investigation, you can use the conservation projects from the previous page. Alternatively, you could research other variables related to endangered species, using data from an official website.

- 1. Make Sense of the World** What variables did you research related to your chosen endangered species? Develop a model that you could use to describe the relationship between the variables.
- 2. Predict** Over the past 100 years, the rate of animal extinctions has dramatically exceeded the natural extinction rate. Based on your findings, predict how conservation efforts could influence the survival of the species.
- 3. Make An Impact** How could changes in conservation efforts or environmental policies affect the future for endangered species?

REFLECT ON MATH PRACTICES AND PROCESSES

Choose two of the following questions to reflect on how you engaged with the math practices and processes during the investigation.

- 1. Model with Mathematics** Which mathematical model did you use to answer the questions?
- 2. Reason** How might the impact of your conservation project change if new data about the endangered species becomes available? How would you integrate this new information into your existing model?
- 3. Make Sense and Persevere** When you encountered difficulties during the investigation, how did you work through them? What steps did you take to overcome obstacles and stay on track?
- 4. Communicate Precisely** How did you determine the validity of your work? How did you support your findings?

EXTENSION

Investigate conservation efforts of endangered species or habitats in your community.

- What conservation efforts are currently underway in your community to protect endangered species or habitats?
- How effective have these conservation efforts been in preserving endangered species or habitats? Propose improvements to existing efforts, or explain why the efforts are sufficient.
- Support your recommendations with your mathematical findings.

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Questions to Assess Student Understanding (Assessing Questions)

- Q:** What do the variables represent and what are the constraints?
- Q:** How does your model relate to the variables and constraints you researched?

Questions for Students Who Need Help (Assessing Questions)

- Q:** Which endangered species interest you? What are the constraints for those species?
- Q:** Is there an official website that provides more information on the endangered species you are investigating?
- Q:** How can you use technology to help you develop a model?

Questions to Help Students Think More Deeply (Assessing Questions)

- Q:** What mathematical evidence do you have to support your conclusions and predictions?



Select and Sequence Solutions

The following is a possible sequence for the presentation of sample student work with suggested questions. This sequence of solutions does not have a particular coherence and can be reordered in any way. You should select and sequence responses from your own students, using the sample responses provided only as needed.

It is recommended that this part of the lesson take place after the Investigation.

1. **A student used the conservation data from the table in the Student Edition.** (Student Work A)

Q: How did you determine the highest possible impact score?

Q: How does the solution of the system of inequalities support your conclusions?

2. **A student researched the global rhino population over time, and used Desmos Tool(s) to create a linear regression.** (Student Work B)

Q: How does the data support your conclusion?

3. **A student researched global whale populations over time using data in a table.** (Student Work C)

Q: Can you write a function to model the decline in population?

Q: How can you determine if your model is a good fit for the data?

4. **A student researched the movement of a giant tortoise over time using the tracking data from an official website.** (Student Work D)

Q: What tools can you use to help you analyze the tortoise's movement?

Q: What could each unit on your graph represent in real-world distance?

Connect to the Goals of the Investigation

After allowing students to finish the questions for the lesson, return to an all-class discussion to solidify the connection to the goals of the lesson.

Q: How did you use a model to describe the conservation of the endangered species?

Q: Did you have enough information to determine if the extinction rate would change based on conservation efforts?

Q: Using the data you found in your investigation, what conclusions can you draw about conservation projects and their impact on extinction rates?

Q: How is student A's strategy different from student B's? How is it similar?

Q: Could student C use their equation to make a prediction about the population 20 years from now? How confident would you be in that prediction?

Q: Do you think student D could use their method to track the total distance the tortoise covered? What other information might be needed?

REFLECT ON MATH PRACTICES AND PROCESSES

Ask students to choose two of the math practices and processes questions that reflect the ways that they engaged with math practices during the investigation.

You may also assign questions to facilitate discussion about how students demonstrated proficiency with the math practices and processes.

EXTENSION

Q: How will you find what conservation efforts are in place for endangered species in your community?

ANALYZE STUDENT WORK

You may choose to project these individually or together from SavvasRealize.com.

Student Work A

I selected Blue Whale and Galapagos Giant Tortoise species with a budget of \$500,000 and 2,000 hours. I let x be the number of Giant Tortoise projects and y the number of Blue Whale projects.

$I = 80x + 50y$
Budget:
 $35,000x + 20,000y \leq 500,000$
Hours: $200x + 150y \leq 2,000$

$I = 80(0) + 50(13) = 650$ or $I = 80(10) + 50(0) = 800$.

The greatest impact is with 10 giant tortoise projects.

There used to be over 350,000 blue whales, but hunting has reduced their numbers to just 10,000 to 25,000.

The Galápagos Islands have around 15,000 giant tortoises, down from an estimated 200,000 – 300,000 before humans arrived. Without conservation efforts, both species could become extinct. Policies to help reduce pollution and environmental protections could save these species.

Blue whales keep ocean ecosystems balanced by eating up to 6 tons of krill a day. The Giant tortoises keep land ecosystems balanced since their movement is crucial for the survival of trees and plants.

To review content, refer students to Topic 5, Lessons 1 to 3.

Student Work B

x_1	y_1
0	25
10	30
15	50
20	60
25	60
30	50
35	45
40	40
42	49
44	44
45	40
47	40
48	57
50	63
53	73
56	76

Linear Regression

EQUATION

 $y = 0.4906x + 32.953$

STATISTICS

 $R^2 = 0.3325$
 $r = 0.5767$

RESIDUALS

 e_1 plot

The Javan Rhino population is one of the most endangered species in the world. The population of the Javan Rhino was below 30 in 1965 but conservation efforts have increased that population to about 70 in 2021. Although the points are scattered, there is a positive correlation in the data which shows the population is increasing. I used linear regression calculate the line of best fit to model the growth, $f(x) = 0.4906x + 32.953$. The correlation coefficient is 0.57 which indicates a positive correlation but it is not very strong nor very weak. I expect this trend to continue as long as conservation efforts continue.

To review content, refer students to Topic 6, Lessons 5 to 6.



ANALYZE STUDENT WORK You may choose to project these individually or together from SavvasRealize.com.

Student Work C

I researched global whale populations and learned that modern whaling reduced Blue Whale populations by 98.5%.

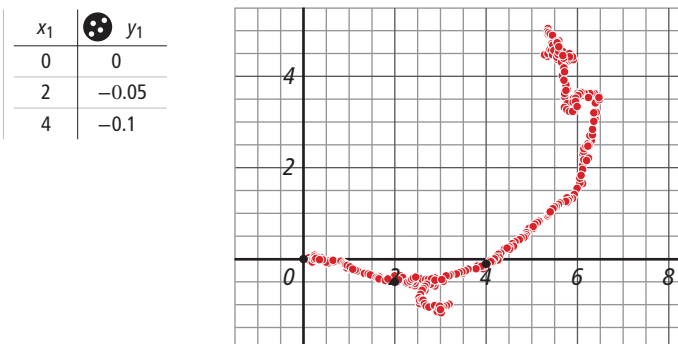
Global Whale Populations		
Whale Species	Population in 1890	Population in 2001
Fin	762,400	109,600
Minke	637,000	506,900
Blue	340,280	4,727
Humpback	231,700	42,070
Gray	24,600	15,936

Data source: Pershing et al. (2010); Christensen (2006)

Using 1890 as year 0 and 2001 as year 111. I used the function $f(x) = 340,280 - 3023x$ to model the decline in the population of blue whales. This means there was a decline of 3,023 blue whales per year. This model shows the species going extinct at year 2000. However, likely due to conservation efforts, there are still currently about 15,000 blue whales in the world. In order to save the species, there should be more impactful conservation efforts until there is a positive trend in the population over time.

To review content, refer students to Topic 6, Lessons 5 and 6.

Student Work D



I used the data from an official website to investigate the movement of Birgit the Giant Tortoise in the Galapagos Islands. I started with the points (0, 0), (2, -0.5) and (4, -0.1). I used the distance formula to find the distance traveled between each point.

$$d_1 = \sqrt{(-0.5 - 0)^2 + (2 - 0)^2} = \sqrt{4.25} \approx 2.1$$

$$d_2 = \sqrt{(-0.5 + 0.1)^2 + (2 - 4)^2} = \sqrt{4.16} \approx 2.01$$

The total distance is 4.11 units. If each unit = 100 m, then the total distance is 411 m. To keep the tortoises safe, the land around the tortoises path should continue to be protected.

To review content, refer students to Topic 4, Lesson 3.

You can use the space below to reflect on the Integrate Data Science. The questions can be used as a guide, or you can write freely as you reflect on the investigation.

Integrate Data Science Teacher Reflection

Instructional Strategies	Resources and Tools
- Which instructional strategies were most effective? - Which instructional strategies were less effective?	- Which resources and/or tools best supported learning and/or data analysis? - Are there additional resources and/or tools that could be utilized next time?

Key Moments	Review
- What were some memorable insights or unique approaches to the investigation? - Were there any surprising outcomes or shifts in students' thinking?	What skills or concepts need to be reviewed?

Investigate Endangered Species: Key Takeaways