



POPULATION MANAGEMENT

Subject Area: Science – Environmental Science, Population Studies

Grade Levels: 6th – 8th

Time: This lesson can be completed in two 45-minute sessions. (Three sessions if the optional hands-on activity is conducted. Additional time will be needed for the growth and observation of the grass.)



Essential Questions:

- What issues do ranchers face when trying to maintain healthy herds?
- How does knowing about population dynamics help ranchers and conservationists balance the needs of cattle and wildlife that live in the same space?

Overview:

In this lesson plan, students learn about the necessity of managing the herd size and grazing rights of the cattle in East Africa. Students learn how ranchers balance their cattle management with wildlife needs. Overgrazing, water use and habitat degradation by cattle reduces the resources available for the East Africa’s wildlife. Wildlife conservation and management has sound economic benefits for ranchers. The challenge for ranchers is to optimize herd size while supporting the needs of wildlife.

Nature Works Everywhere Themes:



Nature provides grazing habitat that ranchers use to raise cattle for milk and meat. The grazing habit also supports wildlife that can serve as an additional source of meat.



Nature provides grazing habitat for cattle, which supply goods such as leather, horn and dung for fertilizer, and enables wildlife populations to thrive, which supports the economy of emerging nations in East Africa.

Introduction:

Cattle play a central role among Kenya’s rural people. Cattle herds needs overlap with the needs of East African wildlife. East African wildlife populations are a valued resource that attract tourists and provide much-needed income. Cattle are a valued resource and are an integral part of the traditional culture in East Africa. When ranchers carefully manage herds it helps balance the needs of these populations.

Cattle owners are concerned with the availability of water, safety from predators, access to pasture and the incidence of disease in their herds. Cattle need a lot of land, forage and water. These demands overlap with those of wildlife.

Therefore, ranchers can see wild animals that compete with their cattle for forage and water as a threat. Research conducted by conservationists is being used to help ranchers see the value of carefully managing herds to enable both cattle and wildlife populations to thrive on their land.

Mathematical calculations based on relevant variables can help ranchers prevent overgrazing and determine the right number of cattle for the amount of resources available. Conservationists study population dynamics to determine the relevant variables based on the vital statistics of populations, and the interactions within and between populations that influence survival and reproduction. For example, if herds are too big for the available land or grazing is not managed properly, overgrazing will degrade the land and the herds will starve.

Cattle ranchers and conservationists share the responsibility for developing and implementing plans to balance the water/land needs of the cattle and wildlife populations. The perspectives of ranchers and conservationists are considered when decisions are being made regarding managing wildlife populations infected with disease.

In Kenya, ranchers and conservationists support the needs of wildlife, while at the same time ensuring cattle herds are able to thrive. The key principle is that the environment benefits from multiple land uses.

Objectives:

The student will...

- Describe the lives of people in rural Kenya, including the importance of cattle in daily life.
- Identify factors that challenge herders to maintain healthy cattle.
- Describe habitat and food requirements of various Kenyan wildlife species.
- Decide if a rancher's management plan is likely to prevent overgrazing.
- Interpret different scenarios to determine if herd size is appropriate for land space.
- Calculate the number of cattle that can be grazed on a given area of land.
- Hypothesize ecological factors that could cause a rancher's herd to be smaller than the land can theoretically support.
- Construct a simple lab experiment that illustrates effects of overgrazing on forage production.
- Identify how Kenya's wildlife and cattle populations are dependent on the grasslands.
- Analyze data to determine the benefits of combining sustainable grazing with wildlife management.
- Calculate the effects of overgrazing using a simple lab set-up.
- Summarize basic concepts of population dynamics.
- Describe how knowing about population dynamics helps herders maintain the right number of cattle for grazing.

Standards:

Next Generation Science Standards:

Disciplinary Core Ideas:

- LS2.A: Interdependent Relationships in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- LS4.C: Adaptation
- LS4.D: Biodiversity and Humans
- ESS3.A Natural Resources
- ESS3.B Natural Hazards
- ESS3.C Human impacts on Earth Systems
- ETS1.B: Developing Possible Solutions
- ETS1.A: Defining and Delimiting Engineering Problems

Crosscutting Concepts:

- Cause and Effect
- Patterns
- Energy and Matter
- Stability and Change
- Systems

Science and Engineering Practices:

- Analyzing and interpreting data
- Constructing explanations and designing solutions
- Engaging in argument from evidence

Performance Expectations:

- LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- LS4-5: Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.
- ES3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- ES3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- ES3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Common Core

English and Language Arts Standards for Speaking and Listening Grade 6 (see also grades 7 and 8):

- CCSS.ELA-LITERACY.SL.6.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.
- CCSS.ELA-LITERACY.SL.6.2: Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.
- CCSS.ELA-LITERACY.SL.6.4: Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

Vocabulary:

Carrying capacity: The number of animals that a given area of land can support. If the population is greater than the carrying capacity, the population will get smaller until it is at or below the carrying capacity.

Conservationist: A scientist who advocates for natural resources.

Exponential growth: The growth of a population in an area with no limits; a J-shaped curve results when population size increases at a constant rate.

Logistic growth: The growth of a population in an area of fixed limits; an S-shaped curve results when the growth of a population slows as it reaches the carrying capacity.

Forage: Plant matter consumed by plant-eating animals. For cattle, forage is mostly grass or hay. Also called fodder or feed.

Grazing: Activity of plant-eating animals such as cattle and horses. Most grazing is consumption of low-growing plants, typically grasses.

Grazing Rights: Legal term referring to the right of a user to allow their livestock to graze in a given area.

Overgrazing: Animals/cattle graze excessively, to the point that it damages vegetation/grass

Population density: The size of the population within a particular unit of space.

Population dynamics: The study of the vital statistics of populations, and the interactions within and between populations that influence survival and reproduction

Population Ecology: A sub-field of ecology that deals with the dynamics of species populations and how these populations interact with the environment.

Trade-off: A situation in which one thing is given up to obtain another.

Materials:

For the teacher:

- Access to computer, projector, Internet

Nature Works Everywhere videos that support this lesson plan:

- Introductory video: *The Value of Grasslands* <http://vimeo.com/77808155>
- Scientist interview videos:
 - *Population Management #1: Cattle Health* <http://vimeo.com/78371203>
 - *Population Management #2: Drought* <http://vimeo.com/78371206>
 - *Population Management #3: Seasonality* <http://vimeo.com/78371204>
 - *Population Management #4: Science* <http://vimeo.com/78371208>
- Meet the Scientist: M. Sanjayan <http://vimeo.com/77229010>

For each individual or group of students:

Activity 1:

- Computer with Internet access
- Notebook paper
- Pencil
- Copy of 3-2-1 Chart Handout
(<https://www.natureworkseverywhere.org/resources/population-management/>)

Activity 2:

- Computer with Internet access
- Poster Paper
- Marker

Activity 3:

- 3 flat seed trays
- Rye grass seed
- Potting soil
- Scissors
- Balance with 0.1 g weight increments
- Measuring jug
- Plastic wrap

Classroom Activities:

Activity 1: Managing Cattle Herds

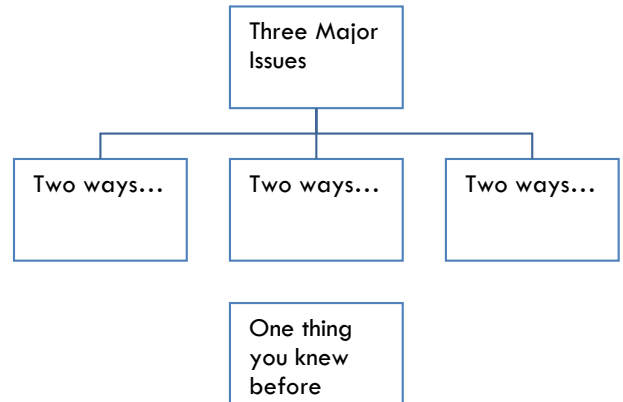
Part 1: Engage

1. Explain to students that life among rural East African people revolves around cattle. Explain that some of the roles cattle serve in the East African traditional culture are:
 - a. Cow dung provides fertilizer
 - b. Cows serve as work animals
 - c. Cows provide meat and milk
 - d. Cow skins are used to produce leather goods
 - e. Bridal dowries are paid in cattle
2. Pose the question, “What do East African cattle and wildlife have in common?” Show the students [The Value of Grasslands](http://vimeo.com/77808155) (<http://vimeo.com/77808155>) introductory video. Discuss student ideas.
3. Explain to students that the cattle and wildlife in East Africa rely on grasslands for survival.
4. Explain that wildlife populations are a valued resource in East Africa because the ecotourism industry boosts the economy.
5. Clarify that with proper management of cattle herd size and grazing rights both populations can thrive in the East African grassland habitat.
6. Explain to students that the aim of this lesson is to understand:
 - What issues do rancher’s face when trying to maintain healthy herds?
 - How does knowing about population dynamics help ranchers and conservationists balance the needs of cattle and wildlife that live in the same space?

Part 2: Explore

1. Show students the [Meet the Scientist: M. Sanjayan](https://vimeo.com/77229010) (https://vimeo.com/77229010) video. Explain that Sanjayan will provide information throughout the lesson.
2. Have each student create a 3-2-1 chart to record what they learn about how ranchers address common issues in an attempt to maintain healthy cattle populations/herds.

3-2-1 Chart: The purpose is to give students a chance to capture some key ideas and make a personal connection to the information.



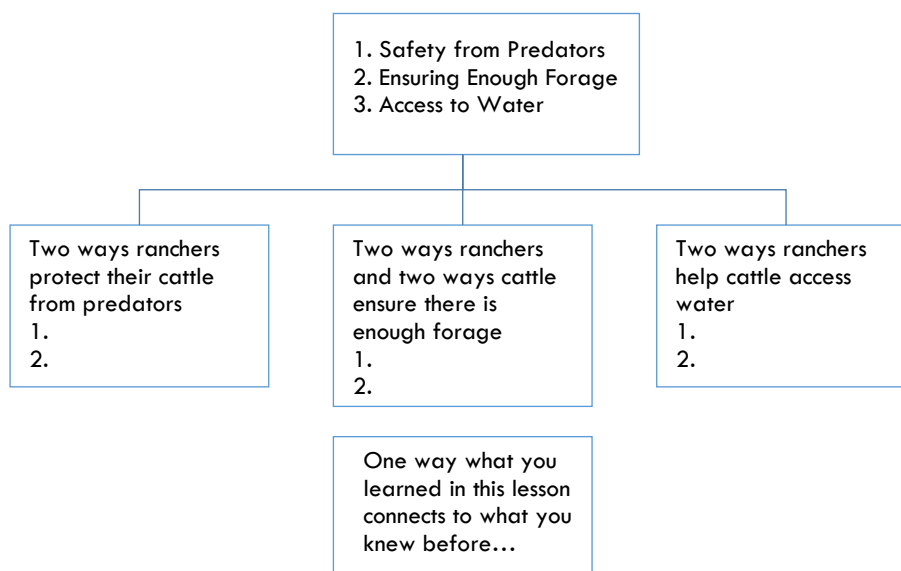
Directions for Completing 3-2-1 Chart:

Top Box: Have students add each of the **three major issues** ranchers face as each issue is presented in lesson

Middle Row: Each time students add an issue have them reflect on information presented and capture **two ways ranchers address the issue** (see below for clarification of how information might be organized, the second row can be recorded in any order, **in the forage issue box students are asked to list two ways ranchers and two ways cattle address/help the issue**)

Bottom Row: Students write one way the content in this lesson relates to what they knew before.

Example of structure:



3. Have students add the issue of predators to their 3-2-1 charts. Describe the predator-safe methods ranchers can implement to help keep their cattle healthy by protecting them from predators:
 - Identify the predators on their land so proper methods are used to keep their cattle safe;
 - Install kraals to keep cattle in and wildlife out – cattle are let out in the day for grazing and returned to the kraal at night; typically, these are constructed of thorny branches, but wicker, wire fencing, wood, or stone walls can be used;
 - Installation of wire fencing with electrical wires around the grazing area -- This method is not practical but can be effective in keeping predators out;
 - Use guard animals such as dogs or donkeys to protect the herds;
 - Keep someone with the herds to scare predators off;
 - Practice good herd management -- Predators are opportunistic, so when cattle are in good health they are less likely to be attacked;
 - Balance the grass/food consumption between cattle and wildlife -- Predators are more likely to turn to eating cattle if the primary herbivores in their food chain are unable to survive.
4. Have students record two ways ranchers deal with predators on their 3-2-1 charts.
5. Now introduce students to the two other major issues ranchers face”. Show the [Population Management #1: Cattle Health](http://vimeo.com/78371203) (<http://vimeo.com/78371203>) that answers the question, “What are the main concerns of local ranchers regarding cattle’s health?” Allow students time to reflect and add the other major issues (access to water, ensure enough forage) ranchers face to their 3-2-1 charts. Have students discuss the issues they have identified with a partner.
6. Clarify that cattle ranchers have three main concerns when trying to maintain healthy cattle populations: making sure grass is healthy and abundant, accessing water frequently and keeping cattle safe from predators.
7. Explain that if ranchers maintain cattle populations that are the appropriate size for the amount of land and rotate to cattle to graze (allowing plants recovery time) there is a better chance of having enough forage for their cattle.
8. Have students add two ways ranchers ensure there is enough forage for their herds to their 3-2-1 charts.
9. Clarify that cattle are grazers and eat grass. Introduce the terms grazing rights and overgrazing. Grazing rights is a legal term referring to the right of a user to allow their livestock to graze in a given area. Overgrazing happens when animals or cattle graze excessively, to the point that it damages the vegetation/grass. It is important for students to realize that when grazing is managed properly grazers help the grassland ecosystem thrive. Say, “Even though cattle eat grass they actually play a key role in keeping grassland ecosystems healthy. Ask, “How do you think cattle help keep the grass/grasslands healthy?” Have table teams use Round Robin strategy to list ways they think cattle might benefit the grass/grasslands.

Round Robin: First student starts with a blank piece of paper and records an idea then passes it on to the teammate to the left. The paper travels around the circle until each team member has at least one idea recorded.

Post the list of ways cattle help keep the grass/grasslands healthy. Have student groups compare their lists to the one provided. Grazers/cattle benefit the grasslands in the following ways:

- Their hooves make seed-to-soil contact which helps dormant seeds to germinate and establish
- They break soil crusts that keep seeds from growing
- They trample standing vegetation into mulch to protect soil and keep it moist
- They turn vegetation into high-quality fertilizer
- They prune stale growth keeping forage plants at peak production (also leaves more suitable parts of grasses for wildlife)
- They prune plants which causes roots to self-prune and become soil

10. Have students list two ways cattle help maintain the food supply in a grassland habitat on their 3-2-1 charts.
11. Ask, “Why do you think ranchers are concerned about accessing water?” Elicit student responses to the question. Show the [Population Management #2: Drought](http://vimeo.com/78371206) (<http://vimeo.com/78371206>) video, which discusses how ranchers cope with drought. Reflect on initial student responses and explain that April and November are the only rainy seasons in East Africa so drought is a big threat. Explain that some ranchers move around based on the weather to access water for the cattle and some utilize grass banks/areas of grass that have been reserved for the dry season. Show the [Population Management #3: Seasonality](http://vimeo.com/78371204) (<http://vimeo.com/78371204>) video that helps to explain how the seasons affect cattle ranching.
12. Have students record two methods ranchers use to try to provide their herds with access to water.
13. Allow students time to reflect and write a sentence on their 3-2-1 charts about how this information relates to something they already knew.

Part 3: Explain

1. Explain to students that to maintain healthy cattle and wildlife populations on their land, ranchers have to balance their desire for bigger herds with what the land can support. To find this balance, the ranchers must use information from conservationist’s research to evaluate population dynamics and figure out the right number of cattle for the amount of land, water and forage available.
2. Introduce the term “carry capacity” – The number of animals that a given area of land can support. If the population is greater than the carrying capacity, the population will get smaller until it is at or below carrying capacity.
3. Show the [Population Management #4: Science](http://vimeo.com/78371208) (<http://vimeo.com/78371208>) video that answers the question, “How can science help land managers work with cattle owners to balance the water needs of their cattle, wildlife, and irrigated agriculture?”

4. Explain that conservationists have developed formulas based on relevant variables that ranchers can use to determine how many cattle their land can support. To determine carry capacity of land and figure out appropriate herd size a rancher must consider:
 - How much food each cow needs based on weight;
 - Total amount of grass on land;
 - How much grass is available for forage (based on take-half, leave-half rule).

Part 4: Extend

1. Have each student research one of the following:
 - How scientists use the principles of *population dynamics* to model how numbers of organisms (such as herds of cattle) change over time
 - What is likely to happen to a population if there are no limiting factors
 - How the death of individuals and other factors (e.g. emigration, immigration, birth rates, fertility of the breed) can limit population growth/size
2. Ask select students to present their findings to the rest of the class.

Part 5: Evaluate

1. Have students get out a piece of paper and a pencil. Model how they should fold paper into three columns. In the first column, have students write why the cattle populations are important to the people in East Africa. In the second column, ask students to describe the issues cattle ranchers face when trying to maintain healthy herds. In the third column, have them summarize what a rancher needs to consider when calculating appropriate herd size.
2. See answer key on the next page.

Answer key for evaluation

Why cattle populations are important in East Africa	Issues for cattle ranchers	Considerations for calculating herd size
<ul style="list-style-type: none"> • Cow dung provides fertilizer • Cows serve as work animals • Cows provide meat and milk • Cow skins are used to produce leather goods • Bridal dowries are paid in cattle • Cattle benefit the land in the following ways: <ul style="list-style-type: none"> • Their hooves make seed-to-soil contact which helps dormant seeds to germinate and establish • They break soil crusts that keep seeds from growing • They trample standing vegetation into mulch to protect soil and keep it moist • They turn vegetation into high-quality fertilizer • They prune stale growth keeping forage plants at peak production (also leaves more suitable parts of grasses for wildlife) • They prune plants which causes roots to self-prune and become soil 	<p>Ensuring their cattle</p> <ul style="list-style-type: none"> • are safe from predators • have access to enough forage • have access to enough water 	<p>Ranchers and scientists must establish the carry capacity of the ranch area by calculating</p> <ul style="list-style-type: none"> • How much food each cow needs based on weight; • Total amount of grass on land; • How much grass is available for forage (based on take-half, leave-half rule)

Activity 2: Population Dynamics of Wildlife and Cattle in East Africa

Part 1: Engage

1. Ask students to consider how the increasing population in East Africa, and the increased amount of land needed for housing and agriculture, might impact the grassland habitat cattle and wildlife populations need to survive. Allow students time to share their ideas. Encourage students to understand that the amount of land available for cattle and wildlife is diminishing. At the same time, more cattle are needed for food and more tourists are visiting to see wildlife.
2. In this section students will explore how knowing about population dynamics can help ranchers and conservationists effectively manage cattle and wildlife populations in the valued grassland environment.

Part 2: Explore

1. Have students form small groups to brainstorm the various resources grazing cattle populations and wildlife populations share.
2. Encourage the groups to think about how various species of wildlife in Africa that share habitat with cattle might be affected by overlapping needs. Assign each group three species to research. Have students document the food and habitat requirements for each of their species.

- | | | |
|----------------|---------------------|------------------|
| • Elephant | • Thomson’s Gazelle | • Fish |
| • Zebra | • Impala | • Lion |
| • Wildebeest | • Warthog | • Cheetah |
| • Hippopotamus | • Baboon | • Leopard |
| • Rhinoceros | • Locust | • Hyena |
| • Cape Buffalo | • Termite | • Crocodile |
| • Giraffe | | • Monitor Lizard |

They do not need much detail – just to distinguish between the main categories:

- Habitat requirements: Grassland, Woodland, River
- Food requirements: Browser, Grazer, Predator

3. Have each group create a table with four columns on chart paper:

Competition

Species	Habitat	Food	Competition with Cattle

4. After a group has documented the habitat and food requirements, have them complete the “Competition with Cattle” column to indicate the species’ competition with cattle. Use categories High, Low and None. If they need help, remind them that cattle are grazers and require a grassland habitat. They also need plenty of water. If they share all needs with a wildlife species, then competition will be high.

Provide time for student groups to conduct a Gallery Walk to share their findings. A Gallery Walk is where students explore multiple sources of information posted around the classroom.

5. Ask if they see any patterns between wildlife species’ basic needs and the degree of competition with cattle.
6. Have students brainstorm reasons ranchers benefit from having both cattle and wildlife populations on their land. Have students draw up a list to show the findings of their brainstorm. The list should include:
 - Reduced impact on grasslands (taking half and leaving half for wildlife prevents overgrazing)
 - Alternative meat source from hunting
 - Additional income from ecotourism
7. Explain that with the benefits of wildlife, ranchers need to consider stewardship of wildlife as well as their herds.
8. Tell students that just like cattle herds, wildlife populations need to be managed.
9. Tell students ranchers and conservationists have to learn about these populations to manage them. Have students explore a chart that compares wildlife and cattle population dynamics. What are the challenges of studying wildlife vs. cattle populations? Guide them to identifying the following:

Wildlife	Cattle
Hard to count	Easy to count
Variables differ greatly among species	Variables are the same
Multiple sampling methods needed	Few sampling methods needed
Difficult to conduct genetics studies	Easy to conduct genetics studies

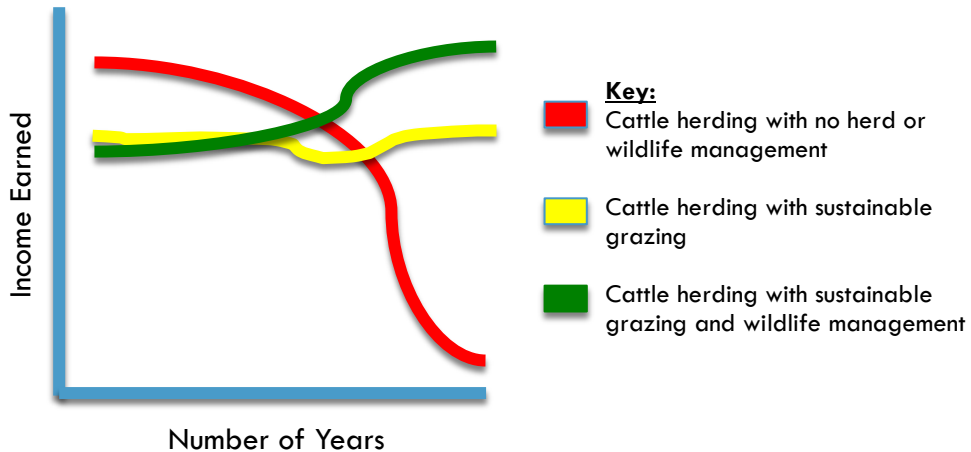
10. Tell students that, now that they have explored what factors ranchers consider when managing cattle herd size, they are going to explore ways that *wildlife populations* can be managed. Have students brainstorm methods to manage wildlife populations. Reveal the following concepts with the pros and cons of each for them to discuss.

Goal	Method	Pros	Cons
Population control	Culling	Cheap	Ethical questions
	Licensed hunting	Provides income	Ethical questions
	Contraceptive methods	May be ineffective, not applicable to all species	Expensive
Habitat limitation	Fencing	Effective. Deters poachers.	Expensive. Unsightly. Interferes with natural migration.
	Natural barriers	Cheap. Needs little maintenance.	May be ineffective

Part 3: Explain

1. To have students show that they understand the concept of how rancher’s benefit from having controlled grazing and managed wildlife populations on their land, have them analyze the graph below on rancher’s earnings. The basic scenarios are to show the rancher’s income over time:

- Cattle herding with no herd or wildlife management
- Cattle herding with sustainable grazing
- Cattle herding with sustainable grazing and wildlife management



2. The amounts of the income are not as important as students understanding the general trends:
 - Cattle herding with no herd management or wildlife management may provide more income initially, but results in overgrazing and risks herd declines, yielding least income over time.
 - Cattle herding with sustainable grazing provides stable income, although less income initially.
 - Cattle herding with sustainable grazing and wildlife management provides more income than managed herding alone.
3. Assign students to groups and have them participate in a Socratic Seminar. Present the question, “Can cattle and wildlife be managed so that both populations can thrive in Kenya’s grassland ecosystem?” During the seminar, groups share and support their ideas in response to the question.

In a Socratic Seminar, students need to frequently contribute to the discussion, explain ideas thoroughly, support their opinions/claims, build on another’s point of view, initiate new ideas, and pay attention and make direct references to points made by other students. See Additional Resources and Further Reading at the end of this lesson plan for information on Socratic Seminars.

Part 5: Evaluate

One Sentence Summary: Write one sentence in a science journal that summarizes how managing both cattle and wildlife populations benefits ranchers and the grassland ecosystem.

One Sentence Summary Strategy: Gauges the extent to which students can summarize a large amount of information concisely and completely. Students are constrained by the rules of sentence construction and must think creatively about the content learned. Students practice the ability to condense information into smaller, interrelated bits that are more easily processed and recalled.

Sample One Sentence:

Cattle herding with sustainable grazing and wildlife management balances the food, water, and land needs of cattle and wildlife and provides ranchers with more income.

Part 6: Optional Hands-on Activity - MODELING EFFECTS OF GRAZING

Note to teacher: This may take an additional class session to set-up and more class time to conduct the experiments.

Procedure

1. Fill the flat seed trays with potting soil to 1 cm below the edge of the trays.
2. Weigh out three equal amounts of rye grass seed, 10 grams each.
3. Sow one lot of the seed evenly in one of three trays. Repeat for the other two trays.
4. Cover the seed with a layer of the soil, about 0.5 cm.
5. Move the tray to a brightly lit location, but avoid direct sun.

6. Water each tray with about the same amount of water (about 0.5 liter each), ensuring the soil is damp throughout, but not soaking.
7. Cover each tray with plastic wrap.
8. When seeds begin to sprout, remove plastic wrap.
9. Allow seedlings to grow. If soil dries out on top, water each tray. Do not allow plants to wilt, and do not allow trays to sit in water.
10. Wait until grass is about 15 cm high.
11. Label trays A, B and C.
12. Use the scissors to cut the grass in Tray A to just above ground level.
13. Use the scissors to cut the grass in Tray B to half way up the stem (about 7 cm high).
14. Leave the grass in Tray C uncut.
15. Remove the cuttings and allow them to dry on sheets of newspaper.
16. Weigh each sample of grass and record the weight in a notebook.
17. Continue to cut the grass until one or more of the grasses produces seed.
18. When one of the grasses set seed, remove all the grass from each tray, keeping them separate.
19. Wash the grasses thoroughly, including the roots.
20. As before, allow the plant material to dry, and weigh the grass.
21. Add the dry weight of all clippings and the dry weight of plants at the end.

Results

1. What is the hypothesis? If cutting does not affect growth, then all plants will have the same total weight.
2. Compare the total dry weights of plants at the end of the experiment.

Conclusion

1. Does the data from the results support the hypothesis?
2. If the grass in Tray A represents over-grazing in a real situation, what can you conclude about the effect of over-grazing on grass growth?

Additional Resources and Further Reading:

Websites

- The Nature Conservancy's Africa Program
<http://www.nature.org/ourinitiatives/regions/africa/index.htm>
- Strengthening Community-led Conservation (The Nature Conservancy)
<https://www.nature.org/ourinitiatives/regions/africa/wherewework/northern-kenya-rangelands.xml>
- Doing the Math: Calculating a Sustainable Stocking Rate (North Dakota Agricultural Experiment Station)
<https://www.ag.ndsu.edu/archive/streeter/2006report/aums/Doing%20the%20Math.htm>
- When the Water Ends: Africa's Climate Conflicts (Yale Environment 360)
http://e360.yale.edu/feature/when_the_water_ends_africas_climate_conflicts/2331

- The Basics of Wildlife Management (Montana State University Extension)
<http://animalrange.montana.edu/documents/extension/thebasicsofwildlifemgmt.pdf>

To learn more about Socratic Seminars, check out the following resources:

- National Paideia Center website: <http://www.paideia.org/>
- NSTA article on Socratic Seminars by Jeanne Ting Chowning:
http://common.nsta.org/resource/?id=10.2505/4/tst09_076_07_36
- To see a Socratic Seminar in action in the science classroom and hear advice from a teacher:
 - Socratic Seminars: Patience and Practice by the Teaching Channel
<https://www.teachingchannel.org/videos/bring-socratic-seminars-to-the-classroom>
 - Socratic Seminar in Science by Northwest Association for Biomedical Research (NWABR) <https://www.youtube.com/watch?v=9TckVl4e3Y0>

Journal Articles

Bernardo, D.J., G.W. Boudreau and T.C. Bidwell (1994) Economic tradeoffs between livestock grazing and wildlife habitat: a ranch-level analysis. *Wildlife Society Bulletin* 22: 393-402

Doran, M.H., A.R.C. Low and R.L. Kemp (1979) Cattle as a store of wealth in Swaziland: implications for livestock development and overgrazing in Eastern and Southern Africa. *American Journal of Agricultural Economics* 61: 41-47

Ilyin, S. (2011) The Looming Threat of Overgrazing: Effects and Recommendations

<http://www.hungercenter.org/wp-content/uploads/2011/09/Looming-Threat-of-Overgrazing-Ilyin.pdf>

Jarvis, L. S. (1991) Overgrazing and Range Degradation in Africa: The Need and the Scope for Government Control of Livestock Numbers. *East Africa Economic Review*, Vol. 7, No. 1.

http://files.oregonstate.edu/uploads/filer_public/2014/06/19/overgrazing_jarvis.pdf