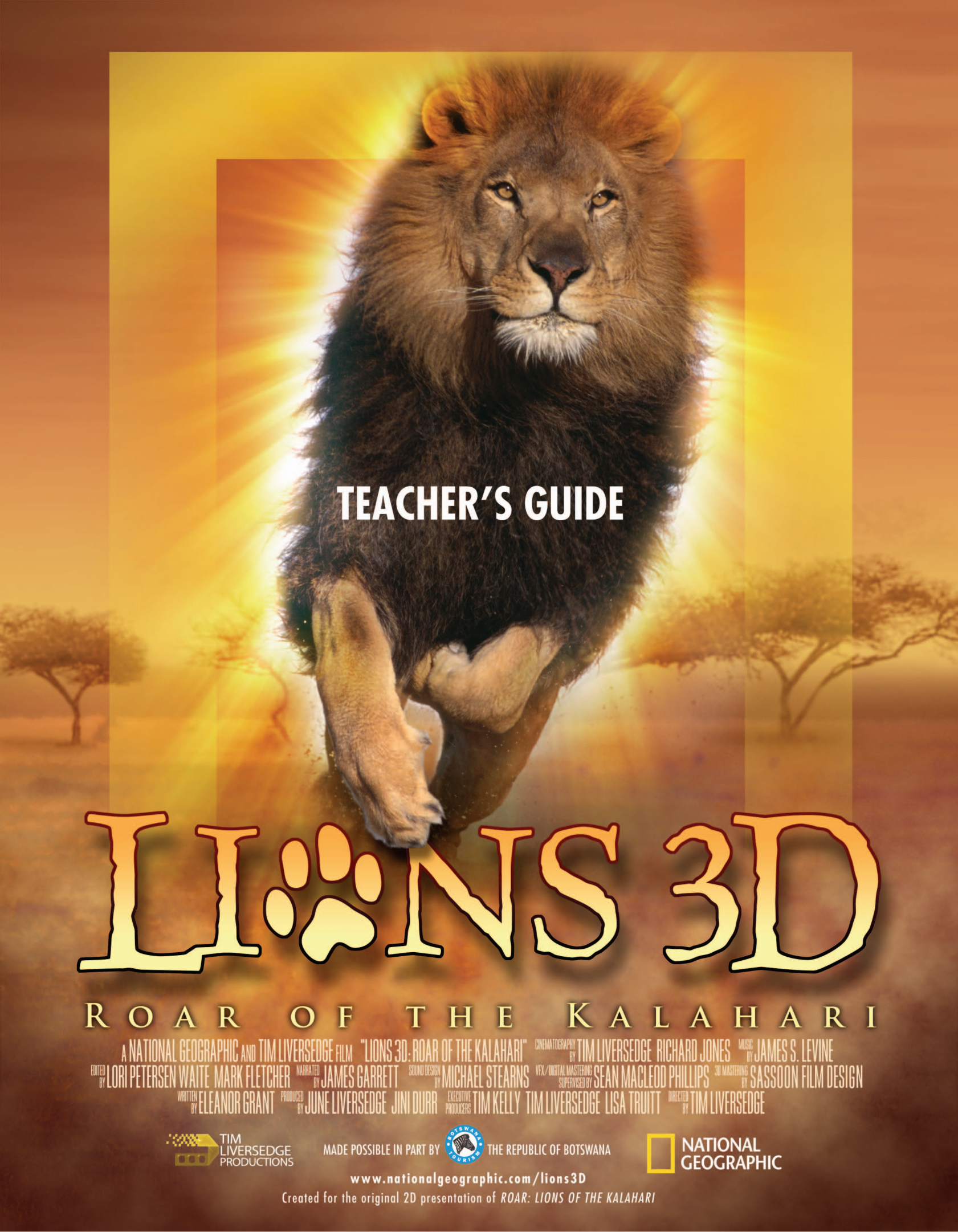
TEACHER'S GUIDE
LIONS 3D
ROAR OF THE KALAHARI
A NATIONAL GEOGRAPHIC AND TIM LIVERSEDGE FILM "LIONS 3D: ROAR OF THE KALAHARI"
CINEMATOGRAPHY BY TIM LIVERSEDGE RICHARD JONES
MUSIC BY JAMES S. LEVINE
EDITED BY LORI PETERSEN WAITE MARK FLETCHER
NARRATED BY JAMES GARRETT
SOUND DESIGN BY MICHAEL STEARNS
VFX/DIGITAL MASTERING SUPERVISED BY SEAN MACLEOD PHILLIPS
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TIM LIVERSEDGE PRODUCTIONS
MADE POSSIBLE IN PART BY BOTSWANA TOURISM THE REPUBLIC OF BOTSWANA
NATIONAL GEOGRAPHIC
www.nationalgeographic.com/lions3D
Created for the original 2D presentation of ROAR: LIONS OF THE KALAHARI

Introduction to *Roar: Lions of the Kalahari* Teacher's Guide

The giant-screen film *Roar: Lions of the Kalahari* captures lion behavior never before presented on the giant screen. It offers unparalleled detail of the natural behavior of lions, their prey, and the incredible profusion of life congregated at a water hole in Botswana, the single water source for some 100 miles. Combining breakthrough cinematography with suspense and action, the film weaves real-life events, as well as scientific and geographic information, into the arc of a compelling story.

About the Lessons

The lessons in this Teacher's Guide were created especially for the film. They were designed to expand students' knowledge of and appreciation for lions and the geographic regions they occupy in Africa, and to engage students in the real-world issues of lion conservation.

Lessons 1, 2, 3, and 4 are for grades 3–5.

Lessons 5, 6, 7, and 8 are for grades 5–8.

—Lessons 1 and 5 teach science curriculum standards within the context of the film.

—Lessons 2 and 6 examine lions and address the life-science content featured in the film.

—Lessons 3 and 7 center on the Kalahari, the geographic region featured in the film.

—Lessons 4 and 8 focus on the conflict between lions and humans, investigate the alarming threat to lion populations and ecosystems, explore the underlying causes, and present scientists' proposals for conservation of lions.

The lessons can be adapted for other grade levels. All lessons were written and evaluated by educators, and align with the U.S. National Geography Standards and the National Science Education Standards. Each lesson combines content and critical thinking skills in science and geography with applications for other content areas. Collectively, the lessons offer a variety of integrated content and classroom strategies—individual, small group, discussion, brainstorming, problem solving, presentation, and more. Each lesson is constructed with objectives and an assessment component, and includes extensions and online resources for educators and students.

The Hawaii Geographic Alliance lists the understandings and performance indicators for the three grade levels of the National Geography Standards — K–4, 5–8, and 9–12.
University of Hawaii, Hawaii Geographic Alliance: **http://www.hawaii.edu/hga/Standard/Standard.html**

About the Film

The footage in *Roar: Lions of the Kalahari* is arranged to tell the story of lion succession and pride takeovers that is both specific to the filmed lions and recurrent in the lives of lions everywhere.

"My mission with *Roar: Lions of the Kalahari* was not to adhere to the pure strictures of documentary filmmaking," said filmmaker Tim Liversedge. "I wanted something . . . that would move my audience emotionally as well as intellectually. The end product combines the highlights of several years of observation, crafted with the arc of a powerful story."

For more information about the making of this unique film, see *The Big Frame:*
http://www.destinationcinema.com/our_films/roar/documents/bigframe.pdf (Destination Cinema, Inc.)

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Handouts: Grades 5–8

Handouts: Maps

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at http://www.destinationcinema.com/our_films/roar/educators.asp

Teacher's Guide Matrix Grades 3-5

Grades 3–5 Lessons	See Film	Don't Need To See Film	Handouts *Optional	Map Handouts *Optional	National Geography Standards *Connected to an optional activity
Lesson 1: Teaching Standards With *Roar: Lions of the Kalahari*	x		1, 2, 3, 5, 6, 7, 8, 9	A, C	4, 8
Lesson 2: Lion Life and Groups		x	1*, 4, 5, 6, 7, 8, 9	B, F	1
Lesson 3: The Kalahari: A Thirsty Land		x	10, 11	B, C, E	1, 4, 5*, 7, 8, 14*, 15, 18*
Lesson 4: African Lions in Trouble		x	11*, 12	A, C, D	1, 3, 4, 6, 8, 13, 14, 18

National Geography Standards

1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

2: How to use mental maps to organize information about people, places, and environments in a spatial context

3: How to analyze the spatial organization of people, places, and environments on Earth's surface

4: The physical and human characteristics of places

5: That people create regions to interpret Earth's complexity

6: How culture and experience influence people's perceptions of places and regions

7: The physical processes that shape the patterns of Earth's surface

8: The characteristics and spatial distribution of ecosystems on Earth's surface

9: The characteristics, distribution, and migration of human populations on Earth's surface

10: The characteristics, distribution, and complexity of Earth's cultural mosaics

11: The patterns and networks of economic interdependence on Earth's surface

12: The processes, patterns, and functions of human settlement

13: How the forces of cooperation and conflict among people influence the division and control of Earth's surface

14: How human actions modify the physical environment

15: How physical systems affect human systems

16: The changes that occur in the meaning, use, distribution, and importance of resources

17: How to apply geography to interpret the past

18: How to apply geography to interpret the present and plan for the future

National Science Education Standards Content Standards for Grades 3–5 for These Lessons

Lesson 1:

A. Science as Inquiry: Abilities necessary to do scientific inquiry
B. Physical Science: Properties of objects and materials, Position and motion of objects
C. Life Science: Characteristics of organisms, Life cycles of organisms, Organisms and environments
D. Earth and Space Science: Changes in the earth and sky
E. Science and Technology: Abilities of technological design, Understanding about science and technology
F. Science in Personal and Social Perspectives: Changes in environments, Science and technology in local challenges
G. History and Nature of Science: Science as a human endeavor

Lesson 2:

A. Science as Inquiry: Abilities necessary to do scientific inquiry
B. Physical Science: Position and motion of objects
C. Life Science: Characteristics of organisms, Life cycles of organisms, Organisms and environments
D. Earth and Space Science: Properties of earth materials, Changes in earth and sky

Lesson 3:

A. Science as Inquiry: Abilities necessary to do scientific inquiry
B. Physical Science: Properties of objects and materials
C. Life Science: Characteristics of organisms, Organisms and environments
D. Earth and Space Science: Changes in earth and sky

Lesson 4:

A. Science as Inquiry: Abilities necessary to do scientific inquiry, Understanding about scientific inquiry
C. Life Science: Characteristics of organisms, Life cycles of organisms, Organisms and environments
E. Science and Technology: Abilities of technological design, Understanding about science and technology
F. Science in Personal and Social Perspectives: Personal health, Characteristics and changes in populations, Changes in environments, Science and technology in local challenges
G. History and Nature of Science: Science as a human endeavour

Teacher's Guide Matrix Grades 5-8

Grades 5–8 Lessons	See Film	Don't Need To See Film	Handouts *Optional	Map Handouts *Optional	National Geography Standards *Connected to an optional activity
Lesson 5: Teaching Standards With *Roar: Lions of the Kalahari*	x		13, 14, 15, 16, 17, 18, 19, 20	A, B*, C	4, 8
Lesson 6: Lion Life and Society		x	13*, 16, 17, 18, 19, 20	B, F	1
Lesson 7: The Kalahari: A Vast Thirstland		x	21, 22	B, C, E	1, 4, 5, 7, 11*, 14, 15, 16*, 18
Lesson 8: African Lion Populations and Ecosystems in Trouble		x	22*, 23	A, C, D	1, 3, 4, 6, 8, 13, 14, 18

National Geography Standards

1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

2: How to use mental maps to organize information about people, places, and environments in a spatial context

3: How to analyze the spatial organization of people, places, and environments on Earth's surface

4: The physical and human characteristics of places

5: That people create regions to interpret Earth's complexity

6: How culture and experience influence people's perceptions of places and regions

7: The physical processes that shape the patterns of Earth's surface

8: The characteristics and spatial distribution of ecosystems on Earth's surface

9: The characteristics, distribution, and migration of human populations on Earth's surface

10: The characteristics, distribution, and complexity of Earth's cultural mosaics

11: The patterns and networks of economic interdependence on Earth's surface

12: The processes, patterns, and functions of human settlement

13: How the forces of cooperation and conflict among people influence the division and control of Earth's surface

14: How human actions modify the physical environment

15: How physical systems affect human systems

16: The changes that occur in the meaning, use, distribution, and importance of resources

17: How to apply geography to interpret the past

18: How to apply geography to interpret the present and plan for the future

National Science Education Standards Content Standards for Grades 5–8 for These Lessons

Lesson 5:

A. Science as Inquiry: Abilities necessary to do scientific inquiry, Understandings about scientific inquiry
B. Physical Science: Transfer of energy
C. Life Science: Structure and function in living systems, Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptations of organisms
E. Science and Technology: Understandings about science and technology
F. Science in Personal and Social Perspectives: Personal health, Risks and benefits, Science and technology in society
G. History and Nature of Science: Nature of science

Lesson 6:

A. Science as Inquiry: Abilities necessary to do scientific inquiry
B. Physical Science: Transfer of energy
C. Life Science: Structure and function in living systems, Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptations of organisms
D. Earth and Space Science: Earth's history

Lesson 7:

C. Life Science: Populations and ecosystems
D. Earth and Space Science: Structure of the earth system, Earth's history, Earth in the solar system

Lesson 8:

A. Science as Inquiry: Understandings about scientific inquiry
C. Life Science: Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptations of organisms
E. Science and Technology: Understandings about science and technology
F. Science in Personal and Social Perspectives: Risks and benefits, Science and technology in society
G. History and Nature of Science: Science as a human endeavor, Nature of science

Lesson 1:

Teaching Standards With *Roar: Lions of the Kalahari*

Resting near the water hole, the male waits for a lioness to hunt his food.

Overview:

In this activity students will learn about lions, the Kalahari, Kalahari wildlife, filmmaking, and technology that supports filmmakers and scientists. They will integrate what they have learned about lions as they interpret the powerful story in the giant-screen film Roar: Lions of the Kalahari*, of a lion "king" in Africa that must fight the battle of his life against a young nomadic challenger, with the fate of two lionesses and the king's litter of cubs hanging in the balance.*

This activity is an accompaniment to the film Roar: Lions of the Kalahari*. Students will watch for specific standards-related information as they view the film. It is recommended that part of this activity be conducted before students see the film to build background and enhance their interest, and the rest conducted after they see the film.*

Information about the film: ***http://www.destinationcinema.com/our_films/roar/roar.asp***

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Connections to the Curriculum:

Geography, life science, language arts, technology, arts, media

Connections to the National Geography Standards: ***http://www.nationalgeographic.com/xpeditions/standards***

Standard 4: "The physical and human characteristics of places"

Standard 8: "The characteristics and spatial distribution of ecosystems on Earth's surface"

Connections to the National Science Education Standards: ***http://www.nap.edu/readingroom/books/nses/html***

Grades K–4 Content Standard A. Science as Inquiry: Abilities necessary to do scientific inquiry

Grades K–4 Content Standard B. Physical Science: Properties of objects and materials, Position and motion of objects

Grades K–4 Content Standard C. Life Science: Characteristics of organisms, Life cycles of organisms, Organisms and environments

Grades K–4 Content Standard D. Earth and Space Science: Changes in earth and sky

Grades K–4 Content Standard E. Science and Technology: Abilities of technological design, Understanding about science and technology

Grades K–4 Content Standard F. Science in Personal and Social Perspectives: Changes in environments, Science and technology in local challenges

Grades K–4 Content Standard G. History and Nature of Science: Science as a human endeavor

Time: Will vary; minimum three class hours, plus time for travel to and from the film.

Materials Required:

- Computer with Internet access
- Writing materials
- Wall map of Africa or the world, or a globe

Photocopies of the following:

- Handout 1: Beliefs About Lions (Handout1Beliefs.pdf)
- Handout 2: Making a Wildlife Film (Handout2WildlifeFilm.pdf)
- Handout 3: Worksheet for *Roar: Lions of the Kalahari* (Handout3Worksheet.pdf)
- Handout 5: Physical Characteristics of Lions (Handout5Characteristics.pdf)
- Handout 6: Lion Family Life (Handout6FamilyLife.pdf)
- Handout 7: Hunting and Feeding Behavior (Handout7HuntFeed.pdf)
- Handout 8: The Lion Life Cycle (Handout8LifeCycle.pdf)
- Handout 9: Takeovers (Handout9Takeovers.pdf)
- Map Handout A: Political Outline Map of Africa (MapAOutline.pdf)
- Map Handout C: Physical Map of Africa (MapCPhysical.pdf)

Objectives:

Students will

- view and discuss a giant-screen film to better understand lions;
- examine the different structures (body parts) that serve different functions in growth, survival, and reproduction for lions and cats in general;
- relate the unique social behavior of lions to reproduction, hunting, and feeding behavior;
- discuss tools and techniques a wildlife filmmaker used to solve problems;
- analyze how lions' unique social behavior formed the basis for the plot in *Roar: Lions of the Kalahari;* and
- analyze how the physical characteristics of the Kalahari influenced the setting of the film and the location and activities of lions.

Geographic Skills:

- Acquiring Geographic Information
- Analyzing Geographic Information

Suggested Procedure

Opening:

Tell students they will view a giant-screen film, *Roar: Lions of the Kalahari*. Explain that it weaves actual events into a story.

The Big Frame gives an overview of the making of the film:
http://www.destinationcinema.com/our_films/roar/documents/bigframe.pdf (Destination Cinema, Inc.)

Ask students what they think lions might do in the film. What other animals might they see? The film was shot in Botswana. Give students Map Handout A: Political Outline Map of Africa (MapAOutline.pdf). Ask them to speculate on the locations of Botswana and the Kalahari and point to those locations on the map. Show students a transparency or give them handouts of Map Handout C: Physical Map of Africa (MapCPhysical.pdf), or other map that indicates Botswana and the Kalahari. (Map C is in color, but can be printed in black and white for students.) How accurate were students' speculations?

Print and distribute Handout 1: Beliefs About Lions (Handout1Beliefs.pdf). Ask students to predict whether or not each statement will be supported by the information provided in the film and their study of lions. If they think the statement will be supported, they should mark an X to the left of the statement. When students have finished, read each statement aloud and ask them to raise their hand if they marked the statement. Invite volunteers to explain why they believe the statement to be true and where they acquired the information or belief. Encourage them to elaborate on their knowledge of and experience with lions. Tell them to save the handout.

Explain that in Africa, lions and other big cats occupy the same or similar habitats. Write the two questions below on the chalkboard. Tell students to use these questions to guide later research and viewing of the film (see Assessment section for answers):

- Why did the filmmaker film lions for this story instead of another type of big cat?
- Could the filmmaker have used another type of big cat to tell the story he wanted to tell?

Development:

Notes:

— *Lesson 2 (RoarLesson2.pdf) also includes this activity.*

— *Younger students may enjoy topics in "Cats! Mild to Wild," such as (under Biology) My, What Big Teeth You Have! and Sound Effects; and (under Behavior) Here Comes the Pride.*

Natural History Museum of Los Angeles County: Cats! Mild to Wild: ***http://www.nhm.org/cats/home.html***

Build Background for Viewing the Film. Use students' responses to Handout 1 and the ensuing discussion to assess their knowledge of and misconceptions about lions. Based on your assessment, you may wish to have students read some or all of Handouts 5–9. The statements on Handout 1 can guide students' reading, as can these three questions, which you may want to write on the chalkboard:

- What structures (body parts) and behavior set lions apart from other cats?
- How do male lions' lives and behavior change during their lifetimes?
- What must most male lions do in order to mate and reproduce?

Students can read the handouts in groups of five, with each member reading one handout. Each student should then report to the group in one of two ways: 1) Answer the questions that appear in the handout; or 2) Write three statements that capture the essence of the handout. After students finish reading and reporting within their groups, discuss the three questions above as a class.

Introduce Handout 2: Making a Wildlife Film (Handout2WildlifeFilm.pdf). Much of the footage in *Roar: Lions of the Kalahari* was filmed up close, with the filmmaker standing just feet or sometimes inches away from lions and other large animals. Assign students to read Handout 2. These questions, which appear on the handout, can guide their reading. Discuss these questions when they finish reading.

1. What was the filmmaker's purpose in making *Roar: Lions of the Kalahari*?
2. What is the theme of the story in the film?
3. What tools and methods did the filmmaker use? How did these tools and methods help solve some of the problems the filmmaker described?
4. What were some of the difficulties in making this film?
5. How did the physical environment make it hard to create the film?
6. How did the filmmaker combine real events and elements of fiction to create this story?
7. What part did scientists play in the production of the film?

Introduce Handout 3: Worksheet for *Roar: Lions of the Kalahari* (Handout3Worksheet.pdf). Give each student Handout 3. They should bring the handout to the film. Review each item under "Watch for These!" Students should pay special attention to the map and the aerial views of Africa featured near the beginning of the film; make a record of the different animals they see; and watch for measurements given in the film and make notes about the tools that would be used to make these measurements.

Assign different groups, pairs, or students to watch for the answers to these standards-based questions on the handout. If more than one question is listed after a number, assign the questions to the same student or group. Have students write down their answers soon after they see the film.

1. What physical processes created the pans described in the film? (The pans in the film are flat-bottomed depressions in the desert.)
2. How would you describe the places you see in the film? How would you describe the region? Why is the water hole an excellent territory for the lions? Why does the rival lion want to take over the water hole?
3. How do the physical features and climate of the region make it possible to film so many different African animals in one place?
4. What does the film show about weather changes from day to day and over the seasons near the water hole?
5. What changes take place in the environment while the water hole is being filmed? Which animals move to new locations?
6. What changes do the elephants make in this environment? Which animals are harmed? Which are helped?

7. How close are the springbok to the water hole when the lions charge them? How do the lions try to position themselves for the charge?
8. In this film what cues cause behavior such as running or taking flight?
9. According to the narrator, how are the cubs likely to be like their parents? What happens to the cubs at the end? Why?

See the Film.

Discuss the Film. After students have seen the film, allow time for students to report to the class their answers to their assigned questions. Discuss the maps and aerial views in the film as well as the measurements given and the measuring tools that would be used. What do the aerial views and maps reveal about the environment of the Kalahari? How does the Kalahari environment influence the location of lion habitats and their activities? Ask students what animals they saw and list their responses on the board. Some students may describe an animal—a meerkat, for example—without knowing its name. Help students identify unknown animals, and teach English language learners the English names for familiar animals such as giraffes and zebras.

Closing:

Encourage students to discuss their reactions to the film. Ask them to imagine what it might be like to film such animals and action from so close. Have them discuss their favorite scenes. How did they feel about viewing real-life events? What did they think about the story? Invite them to speculate on the future of the wildlife "characters" in the film.

Refer to Handout 1: Beliefs About Lions (Handout1Beliefs.pdf). Ask students to consider which, if any, of their original responses do not seem to apply to the film content or their research findings. Would they reconsider any of their original responses? Tell them to mark X's to the right of any statements supported by the film or the research. Invite volunteers to explain any changes between their initial and final speculations about the statements. Ask students to identify statements that may apply some, but not all, of the time. Encourage them to modify all statements so that they are completely accurate. They may do so by adding qualifiers such as usually, sometimes, or some.

Suggested Student Assessment:

In one or two paragraphs, ask students to answer these questions:

- Why did the filmmaker film lions for this story instead of another type of big cat?
- Could the filmmaker have used another type of big cat to tell the story he wanted to tell?

Discussion may center on the social behavior and organization that provide the theme, lion succession, as well as on the conflicts in the story (in the main plot, resident male versus nomadic male; and in the subplot, victorious challenger's genetic survival versus survival of the defeated male's cubs). As the only social cats, lions are the only ones about whom such a story could be filmed.

Ask students to generate a list of questions for a quiz about the events and scientific facts presented in the film. Encourage them to write questions about the geographic setting of the film. Questions can examine cause and effect; e.g., "When the Kalahari dried up and heated up, what happened at the water hole?" Students can write questions that compare and contrast; e.g., "Are lion hunts usually more successful at night or during the day?" Choose between 10 and 20 questions from different lists, read them aloud, and assign each a number. Have students write the answers on a sheet of paper and discuss their answers when all the questions have been asked and answered.

Give students Map Handout A: Political Outline Map of Africa (MapAOutline.pdf) and have them locate Botswana and the Kalahari region. Direct students to answer the following question: How does the physical environment of the Kalahari influence the location of lions and their behavior?

Extending the Lesson:

Print and distribute or have pairs of students read "Filmmakers Use High-Tech Gear to Stalk Lions." After students read the article, have them discuss in pairs what the high-tech gear is and does. Then have them discuss and write their answers to these questions:

- What does this technology allow filmmakers to film that they could not film without it?
- How could this technology be useful to scientists?

Encourage a pair of students to assume the roles of filmmakers or scientists making a presentation to a group of colleagues. They should describe the gear, methods, and the advantages of using them.

National Geographic News: Filmmakers Use High-Tech Gear to Stalk Lions:
http://news.nationalgeographic.com/news/2003/01/0103_030103_lions.html

Have a group of students go online to learn about Crittercam, an instrument worn by wild animals used to gather information. Ask them to report to the class how Crittercam might be helpful to filmmakers, and to scientists studying wildlife.

National Geographic: Crittercam Chronicles: ***http://www.nationalgeographic.com/crittercam***

Invite a representative from a local zoo, natural history museum, or university zoology department to speak to the class and answer their questions about lions, elephants, giraffes, or other animals featured in *Roar: Lions of the Kalahari*.

The American Zoo and Aquarium Association: ***http://www.aza.org/FindZooAquarium***

American Association of Museums: ***http://www.aam-us.org/resources/reference_library/sitesstate.cfm***

Invite students to use reference books or the Internet to research one or more of the animals featured in the film. Encourage them to write and illustrate a report, and put it in the classroom reference section. Numerous photos are available at Game-Reserve.com: African Wildlife & Landscape Photography Gallery (scroll to the bottom of the screen): ***http://www.game-reserve.com/index.html***.

Related Links:

African Wildlife Foundation
http://www.awf.org

Destination Cinema: *Roar: Lions of the Kalahari*
http://www.destinationcinema.com/our_films/roar/roar.asp

Lion Research Center
http://www.lionresearch.org/main.html

National Geographic: Be the Creature: Lion
http://www.nationalgeographic.com/channel/btc/lions.html

National Geographic: Lion Ghosts of Africa
http://www.nationalgeographic.com/ngkids/0206/ws_main.html

National Geographic: Maps and Geography
http://www.nationalgeographic.com/maps

Nationmaster.com: Encyclopedia: Kalahari Desert
http://www.nationmaster.com/encyclopedia/Kalahari-Desert

Natural History Museum of Los Angeles County: Cats! Wild to Mild
http://www.nhm.org/cats/home.html

Oakland Zoo: Africa: African Lion
http://www.oaklandzoo.org/atoz/azlion.html

PBS NATURE: Intimate Enemies
http://www.pbs.org/wnet/nature/enemies

PBS NATURE: Serengeti Photo Safari
http://www.pbs.org/wnet/nature/fun/serengeti_flash.html

US Geological Survey: Water Science for Schools—The water cycle
http://wwwga.usgs.gov/edu/watercycle.html

Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Activity—A Reason for the Season
http://www.nationalgeographic.com/xpeditions/activities/07/season.html

National Geographic: Xpeditions Lesson—Lions and People—Uneasy Neighbors
http://www.nationalgeographic.com/xpeditions/lessons/18/g35/cclions.html

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at http://www.destinationcinema.com/our_films/roar/educators.asp

Lesson 2:
Lion Life and Groups

Swirling dust storms are helpful cover for the lionesses when springbok come to the water hole.

Overview:

In this activity students will examine structures (body parts) that serve different functions in growth, survival, and reproduction for lions and for the cat family in general. They will focus on the social, reproductive, hunting, and feeding behaviors of lions and of cats in general, and compare and contrast elements of lions with other cats. They will observe and analyze maps of spatial distribution. Then they will integrate what they have learned about lions into the powerful story of a lion "king" that must fight the battle of his life against a young nomadic challenger, with the fate of two lionesses and the king's litter of cubs hanging in the balance.

This activity, which can be adapted for different ages, abilities, and instructional goals, is a good accompaniment to the giant-screen film Roar: Lions of the Kalahari. *This activity can be conducted before or after students see the film; however, it is not necessary that students see the film to implement the activity.*

Information about the film: ***http://www.destinationcinema.com/our_films/roar/roar.asp***

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Connections to the Curriculum: Geography, life science, reading

Connections to the National Geography Standards: ***http://www.nationalgeographic.com/xpeditions/standards***

Standard 1: "How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective"

Connections to the National Science Education Standards: ***http://www.nap.edu/readingroom/books/nses/html***

Grades K–4 Content Standard A. Science as Inquiry: Abilities necessary to do scientific inquiry

Grades K–4 Content Standard B. Physical Science: Position and motion of objects

Grades K–4 Content Standard C. Life Science: Characteristics of organisms, Life cycles of organisms, Organisms and environments

Grades K–4 Content Standard D: Earth and Space Science: Properties of earth materials, Changes in earth and sky

Time: Will vary; minimum two class hours

Materials Required:

- Computer with Internet access
- Writing materials

Photocopies of the following:

- Handout 4: "All Cats" and "Lions Only" Chart (Handout4LionsCats.pdf)
- Handout 5: Physical Characteristics of Lions (Handout5Characteristics.pdf)
- Handout 6: Lion Family Life (Handout6FamilyLife.pdf)
- Handout 7: Hunting and Feeding Behavior (Handout7HuntFeed.pdf)
- Handout 8: The Lion Life Cycle (Handout8LifeCycle.pdf)
- Handout 9: Takeovers (Handout9Takeovers.pdf)
- Map Handout B: Political Map of Africa (MapBPolitical.pdf)
- Map Handout F: Lion Habitats and Range of Cheetahs

Optional: Photocopies of the following:

- Handout 1: Beliefs About Lions (Handout1Beliefs.pdf)
- African Wildlife Foundation fact sheet: Lions: ***http://www.awf.org/wildlives/148***
- African Wildlife Foundation fact sheet: Cheetahs: ***http://www.awf.org/wildlives/65***
- **Color** printouts or transparency of Natural Vegetation in Africa Map: ***http://library.berkeley.edu/EART/maps/africa-veg.gif*** (University of California, Berkeley)
  Note*: Handouts or a transparency of this map* ***must*** *be in color.*

Objectives:

Students will

- read and discuss fact sheets, student handouts, and Web documents to better understand lions and cats in general;
- examine the different structures (body parts) that serve different functions in growth, survival, and reproduction for lions and cats in general;
- relate the unique social behavior of lions to reproduction, hunting, and feeding behavior;
- compare and contrast the location of lions and cheetahs by observing and analyzing maps showing their spatial distribution, and make inferences about their distribution; and
- if students have seen the film *Roar: Lions of the Kalahari*, discuss how lions' unique social behavior formed the basis for the film's plot.

Geographic Skills:

- Asking Geographic Questions
- Analyzing Geographic Information
- Answering Geographic Questions

Suggested Procedure

Opening:

STEP 1

If you have conducted Lesson 1 (RoarLesson1.pdf), proceed to the next step. If not, print and distribute Handout 1: Beliefs About Lions (Handout1Beliefs.pdf). Ask students to predict whether or not each statement will be supported by what they learn in this lesson. If so, they should mark an X to the left of the statement. Read each statement aloud and ask students to raise their hands if they marked the statement. Invite volunteers to explain why they believe the statement to be true and where they acquired the information or belief. Use their responses as a springboard for discussion about their experiences with lions. Tell them to save the handout.

STEP 2

If students have seen the giant-screen film *Roar: Lions of the Kalahari*, call on volunteers to summarize the plot including the major conflict.

If they have **not** seen the film, read aloud this summary:

> As the film opens, a giant male lion and two lionesses make up a pride. Their territory centers on an unnamed water hole in the dry Kalahari. Another male prowls the outer edges of the pride territory. He is nomadic, meaning he has no permanent home. The nomadic male would like to make this territory his home and this pride his own. From a distance, he is "roaring" his challenge to the pride male. The pride male is roaring back, keeping him away. A few months later the elder lioness gives birth to cubs. The nomadic male lurks at the edges of the territory, moving into the territory. If the nomadic male finds the cubs, he will kill them. When the cubs are a little older, the two males fight. The pride male holds his territory—for the time being.

Stop here if students will view the film. Otherwise, read to the end.

> Later in the film, the nomadic male challenges and defeats the pride male. The younger lioness mates with the new pride male. The older female and her cubs leave their territory to avoid the new male, who will kill the cubs if he finds them.

STEP 3

If you have **not** conducted Lesson 1 (RoarLesson1.pdf), tell students they will decide why the filmmaker filmed lions for this story instead of another type of big cat, and whether or not the filmmaker could have used another type of big cat to tell the story he wanted to tell. These and other questions will guide their readings and investigations (see Closing for answers).

If students will not see the film, the online feature "Be the Creature: Lion" is a good introduction to lions.

National Geographic: Be the Creature: Lion: ***http://www.nationalgeographic.com/channel/btc/lions.html***

Development:

Option: *This lesson may be taught as described below, or as an extended lesson or unit over several days. Directions for extending the activity are given in the text.*

Examine Habitats. Explain that in Africa, lions and other big cats occupy the same or similar habitats. Give students Map Handout B: Political Map of Africa (MapBPolitical.pdf). Ask them to speculate where lions and cheetahs might be located, then shade in those areas on the map. Then give them Map Handout F: Lion Habitats and Range of Cheetahs (MapFLionsCheetahs.pdf). (Map F is in color, but handouts or a transparency can be in black and white.) Have students compare their maps of predicted locations with the actual locations. How accurate were their predictions? Ask them to compare the two range maps with each other, and with their own maps. As a class, compare the maps, noting the similarities and differences in the spatial distribution.

Option: *Have students compare the spatial distributions of lions and cheetahs with the Natural Vegetation in Africa Map. Ask students how the natural environment might influence the location and activities of lions and cheetahs. Handouts or a transparency of this map* ***must*** *be in color.*

University of California, Berkeley: Natural Vegetation in Africa Map:
http://library.berkeley.edu/EART/maps/africa-veg.gif

Note: *To introduce the activity below to younger students, ask if they've seen kittens playing—chasing each other or scratching furniture. In this activity they will study how big cats act, and parts of big cats' bodies. Some of the Topics in "Cats! Mild to Wild" could be used to introduce concepts (see Biology and Behavior sections).*

Natural History Museum of Los Angeles County: Cats! Mild to Wild: ***http://www.nhm.org/cats/home.html***

Investigate the Characteristics of Cats. In class or as a homework assignment the day before you conduct this lesson, have students individually read and take notes on "Cats: Plans for Perfection." (If students don't have Internet access, educators can choose some, or all, of this feature and print those pages for students.) Tell students that first they will compare structures (body parts) of different types of cats with the *sabertooth*, an ancestor. Review each feature on the main menu (skeleton, muscles, coat) and note 1) how it enhances cats' survival as predators and 2) how it has changed (adapted) over time. They should then note how the behavior of lions and other cats enhances their survival as predators. The next day have students work in pairs or small groups and write one or two descriptive statements about each structure (skull, claw, spine, teeth, etc.) and about each behavior. Include comparisons with the sabertooth. Students should save their notes.

National Geographic: Cats: Plans for Perfection: ***http://www.nationalgeographic.com/cats/index.html***

As a class, discuss these science standards-based questions:

- What structures (parts) of their body help cats, in general, survive?
- What lion behavior enhances their survival as predators?
- What cats are now extinct? How do fossils such as bones help scientists learn about them?

Research Using Handouts 5–9. Have students work in groups of five. Give each group one copy of handouts 5, 6, 7, 8, and 9. Each group member should receive one handout. If a group has four members, the first student to finish reading should read the extra handout. If a group has six members, have two students read Handout 5. *(**Option:** If you extend the lesson over several days, each student can study each handout.)* You may wish to pair English language learners or challenged readers with proficient, English-dominant readers to work on one topic. The standards-based questions listed on the handouts (and on the final page of this lesson) can guide student reading and/or be used for later assessment.

Have each student write three key sentences that capture the essence of their handout and then share their sentences with their group. They will note some overlap in content, because physical structures and family life influence hunting and feeding behavior, takeovers influence family life, and so forth. When group members have finished reporting to one another, discuss these questions as a class:

- How are lions' bodies like or different from the bodies of most cats?
- How is lions' behavior like or different from the behavior of other cats?

Option: *If you extend the lesson, at this point students could reflect on the questions on the handouts as they read an online story and take a quiz.*

National Geographic: Lion Ghosts of Africa: ***http://www.nationalgeographic.com/ngkids/0206/ws_main.html***

Compare Lions and Other Cats. Give each group Handout 4: "All Cats" and "Lions Only" Chart (Handout4LionsCats.pdf). Under each heading, students should list appropriate structures (body parts), abilities (how cats perform) and behaviors (what cats do). Students should use what they learned online and in the handouts. Students should list roaring structures and behaviors at the bottom of the chart under "Anything Else?"

Elements to compare or contrast include manes; hunting and feeding behavior; family life; top speeds; vocalization; and structures associated with behaviors or capabilities. After their research, each group should make a table, Venn diagram (with illustrations, if desired), or illustrate in another way (a) the similarities between lions and other cats and (b) the differences between lions and other cats. The Graphic Organizer includes a model of a comparison matrix: ***http://www.graphic.org/commat.html***.

Option: Compare Lions and Cheetahs. *Following the guidelines in the activity above, have older or more capable students compare lions and cheetahs. Print handouts or have students review online:*

- *African Wildlife Foundation fact sheet:* ***Lions: http://www.awf.org/wildlives/148***
- *African Wildlife Foundation fact sheet: Cheetahs:* ***http://www.awf.org/wildlives/65***
- ***Color*** *Natural Vegetation in Africa Map:* ***http://library.berkeley.edu/EART/maps/africa-veg.gif*** *(Handouts of this map* ***must*** *be in color.)*

Students with online access can review:

- *National Geographic: Be the Creature: Lion:* ***http://www.nationalgeographic.com/channel/btc/lions.html***
- *National Geographic Creature Feature: Cheetahs:* ***http://www.nationalgeographic.com/kids/creature_feature/0003/cheetah.html***

Closing:

If students marked Handout 1 (Handout1Beliefs.pdf) for this lesson, refer to it. Ask students to consider which, if any, of their original responses do not seem to apply to their research findings. Would they reconsider any of their original responses? Tell them to mark X's to the right of any statements supported by the research. Invite volunteers to explain any changes between their initial and final speculations about the statement. Ask students to identify statements that apply some, but not all, of the time. Encourage them to modify all statements so that they are completely accurate. They may do so by adding qualifiers such as *usually*, *sometimes*, or *some*.

In groups have students reflect on what they've learned about the similarities and differences between lions and other cats, or lions and cheetahs. Based on their research, ask each group to write three general statements about lions and other cats. (e.g., "All cats, including lions, have claws" and "Only lions live in prides.") Have groups share their statements with the class.

If you did not conduct Lesson 1, refer to the opening discussion about what would guide students' research. Then pose these questions:

- Why did the filmmaker film lions for this story instead of another type of big cat?
- Could the filmmaker have used another type of big cat to tell the story he wanted to tell?

Discussion may center on the social behavior and organization that provide the theme, lion succession, as well as on the conflicts in the story (in the main plot, resident male versus nomadic male; and in the subplot, victorious challenger's genetic survival versus survival of the defeated male's cubs). As the only social cats, lions are the only ones about whom such a story could be filmed.

Suggested Student Assessment:

Have students work in pairs. One partner should write five questions about the cat family in general, while another partner writes five questions that apply only to lions. Partners should then exchange papers, answer each other's questions in writing, and discuss the answers.

Select a few of the Questions to Guide and Assess Reading and Understanding of Handouts 5, 6, 7, 8, and 9 (on the last page of this lesson). Have volunteers write them on the chalkboard. Or, print out and distribute the page with all the questions. Have students write brief answers, then pair up and discuss their answers.

Extending the Lesson:

Select some of the questions students wrote for the assessment or some of the Questions to Guide and Assess Reading and Understanding of Handouts 5, 6, 7, 8, and 9 (on the last page of this lesson). Ask volunteers to write the questions on index cards. Keep these "Lion or Cat Fact Cards" to use when students play card or board games. Before they take a turn at a traditional game, a student must draw a "Lion or Cat Fact Card" and answer it correctly.

Ask volunteers to create a poster for the classroom with a large illustration of a lion. Students should label body parts and include interesting facts about them, as well as interesting facts about lions.

Ask students to write a "biography" of a female or male lion in the wild. In groups, have students brainstorm possible life courses and events for male and female lions, then work individually to write realistic life stories.

Related Links:

African Lion Working Group
http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html

African Wildlife Foundation
http://www.awf.org

Destination Cinema: *Roar: Lions of the Kalahari*
http://www.destinationcinema.com/our_films/roar/roar.asp

Lion Research Center
http://www.lionresearch.org/main.html

National Geographic: Be the Creature: Lion
http://www.nationalgeographic.com/channel/btc/lions.html

National Geographic: Cats: Plans for Perfection
http://www.nationalgeographic.com/cats/index.html

National Geographic Creature Feature: Cheetahs
http://www.nationalgeographic.com/kids/creature_feature/0003/cheetah.html

National Geographic: Lion Ghosts of Africa
http://www.nationalgeographic.com/ngkids/0206/ws_main.html

National Geographic: Maps and Geography
http://www.nationalgeographic.com/maps

Natural History Museum of Los Angeles County: Cats! Wild to Mild
http://www.nhm.org/cats/home.html

Oakland Zoo: Africa: African Lion
http://www.oaklandzoo.org/atoz/azlion.html

PBS NATURE: Intimate Enemies
http://www.pbs.org/wnet/nature/enemies

Seaworld/Busch Gardens: AnimalBytes: Lion
http://www.seaworld.org/AnimalBytes/lionab.html

Species Survival Commission: Cat Specialist Group
http://lynx.uio.no/catfolk

Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Lesson—Lions and People—Uneasy Neighbors
http://www.nationalgeographic.com/xpeditions/lessons/18/g35/cclions.html

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at http://www.destinationcinema.com/our_films/roar/educators.asp

Questions to Guide and Assess Reading and Understanding of Handouts 5, 6, 7, 8, and 9

Handout 5: Physical Characteristics of Lions

1. Which structure (body part) helps make cats good night hunters? How does its structure help a cat hunt at night?
2. What happens to light after it enters the eye of a lion or other cat?
3. What structures make lions good hunters and fighters?
4. Besides their size, what makes adult male lions look different from other adult male cats?
5. Which structures make lions able to roar? What causes lions to make sound?

Handout 6: Lion Family Life

1. What behavior sets lions apart from all other cats?
2. What is a pride? What is a coalition?
3. Over a lifetime, how does the family life of most female lions differ from the family life of most male lions?
4. In most prides, how do males and females usually help the pride survive?
5. How does living in a pride help its members survive?

Handout 7: Hunting and Feeding Behavior

1. In a pride, which members do most of the hunting? How does social behavior make it easier for individual lions to have enough food?
2. Besides hunting, what behaviors do lions use to feed themselves?
3. According to filmmaker Tim Liversedge, how have the lions in *Roar: Lions of the Kalahari* adapted their hunting behavior to the environment near the water hole in the film?
4. How do lion experts explain the reason most lion hunts fail?
5. In what order do pride members usually feed? How does this order affect cub survival?

Handout 8: The Lion Life Cycle

1. Which characteristics of their parents would you expect cubs to inherit? Which abilities would they need to learn?
2. What happens when a lioness comes into estrus?
3. How do females in large prides raise their cubs?
4. How would you describe the social behavior of young males after they leave their pride of birth?
5. At about what age can lions start breeding?

Handout 9: Takeovers

1. Which members of a pride are temporary, and which are usually permanent?
2. What is a male lion's main goal? How does it compare to the main goal of a female lion?
3. What must nomadic males do in order to join a pride?
4. Why do males kill cubs after they take over a pride?
5. What makes females fight males at times?
6. "There is safety in numbers." How do the facts in this handout support that statement?

Lesson 3:
The Kalahari: A Thirsty Land

Desperate to quench their thirst, bull elephants rush to the water hole. During their stay, they turn the pool into a mud bath.

Overview:

In the giant-screen film Roar: Lions of the Kalahari*, a water hole in Botswana that is featured in the film is described as "a precious pearl of water in a world of thirst." In this activity, students will study the geography and climate of the film's location, the Kalahari. They will use maps to acquire and report information about the location and characteristics of places in the region. With the understanding that the surface of the Earth changes, they will learn how physical processes have shaped patterns in the physical environment of the Kalahari and produced changes in its ecosystems, transforming parts of it into a "thirstland."*

This activity is a good accompaniment to the giant-screen film Roar: Lions of the Kalahari*. It is suggested that this activity be conducted after students see the film. However, it is not necessary that students see the film to conduct this activity.*

Information about the film: ***http://www.destinationcinema.com/our_films/roar/roar.asp***

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Connections to the Curriculum: Geography, life science, earth science, reading/language arts

Connections to the National Geography Standards: ***http://www.nationalgeographic.com/xpeditions/standards***

Standard 1: "How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective"

Standard 4: "The physical and human characteristics of places"

*Standard 5: "That people create regions to interpret Earth's complexity"

Standard 7: "The physical processes that shape the patterns of Earth's surface"

Standard 8: "The characteristics and spatial distribution of ecosystems on Earth's surface"

*Standard 14: "How human actions modify the physical environment"

Standard 15: "How physical systems affect human systems"

*Standard 18: "How to apply geography to interpret the present and plan for the future"

***Note:** Standard is connected to an optional activity.*

Connections to the National Science Education Standards: ***http://www.nap.edu/readingroom/books/nses/html***

Grades K–4 Content Standard A. Science as Inquiry: Abilities necessary to do scientific inquiry

Grades K–4 Content Standard B. Physical Science: Properties of objects and materials

Grades K–4 Content Standard C. Life Science: Characteristics of organisms, Organisms and environments

Grades K–4 Content Standard D. Earth and Space Science: Changes in earth and sky

Time: Will vary; minimum two class hours

Materials Required:

- Computer with Internet access
- Writing materials
- Wall map of Africa or the world, or a globe

Photocopies of the following:

- Handout 10: Food Chains in an Ecosystem (Handout10FoodChains.pdf)
- Handout 11: The Kalahari: The Great African Thirstland (Handout11Thirstland.pdf)
- Map Handout B: Political Map of Africa (MapBPolitical.pdf)
- Map Handout C: Physical Map of Africa (MapCPhysical.pdf)
- Map Handout E: Annual Precipitation in Africa (Average) (color) (MapEPrecipitation.pdf)

Note: *Handouts or a transparency of Map E* ***must*** *be in color.*

Objectives:

Students will

- observe maps to determine the location of the Kalahari, and acquire and report information about the characteristics of the Kalahari;
- use latitude and longitude coordinates to determine the absolute location of an unmarked water hole in the Kalahari;
- read, discuss, and analyze information in student handouts and National Geographic fact sheets to better understand the Kalahari;
- describe specific differences and similarities between the Kalahari and their hometown in a letter; and
- draw a food chain that could exist in the Kalahari near the water hole in the film.

Geographic Skills:

- Asking Geographic Questions
- Analyzing Geographic Information
- Answering Geographic Questions

Suggested Procedure

Opening:

Note: *This opening may vary, depending on whether or not students have seen the giant-screen film* Roar: Lions of the Kalahari.

When students hear the word "desert," what do they think of? What kinds of things might they see in a desert? Students may be surprised to know that even experts can't always agree how to define a desert. Deserts receive very little rainfall—usually as little as 10 inches (25 millimeters) a year. Briefly discuss different kinds of deserts. (Educators can find information at Nationmaster.com: Encyclopedia: Deserts: ***http://www.nationmaster.com/encyclopedia/Desert***.)

• If students have seen the film *Roar: Lions of the Kalahari*, ask them if they consider the area surrounding the water hole to be a desert.

• If students have not seen the film, you may wish to display photos of dry savanna areas in the Kalahari or elsewhere from reference books or from some of the Web sites at the end of this lesson. Ask students if they consider the pictured areas to be desert.

Draw a Know, Want to Know, and Learned (KWL) chart on the chalkboard or on a transparency. Ask students what they know about the Kalahari from the film, photographs, or other sources. Write their responses under Know. What questions do they have about the Kalahari? List their responses under Want to Know. Leave the Learned column blank. Save the list.

Development:

Note: *You may vary these activities, depending on the age and ability of students. If younger students are not familiar with food chains, you could review KidsPlanet: The Web of Life:* ***http://www.kidsplanet.org/wol/index.html***.

Introduce Food Chains, Populations, and Ecosystems. Distribute copies of Handout 10: Food Chains in an Ecosystem (Handout10FoodChains.pdf). (Students should read only the first page of the handout.) After students have read the handout, ask what would happen to an ecosystem if one of the elements in an important food chain were removed. For example, if no grass grew what would happen to grazing animals? If the number of grazing animals increases what happens to the grass? How might these changes affect predators? Tell students to save Handout 10.

If students have online access, have them review the Species Guide of the online feature "Kalahari: The Great Thirstland." The Guide lists diet and predators for different species, and will be useful for one of the Assessments.

PBS NATURE: Kalahari: The Great Thirstland: ***http://www.pbs.org/wnet/nature*** (under Search Nature type "Kalahari"; then click on "Kalahari: The Great Thirstland")

Locate the Kalahari Region. If students have done Lesson 1 (RoarLesson1.pdf) ask volunteers to point to the Kalahari on a map. If not, give students Map Handout B: Political Map of Africa (MapBPolitical.pdf). Ask them to speculate on the location of the Kalahari and point to it on the map. Then ask students to read the first three paragraphs of Handout 11: The Kalahari: The Great African Thirstland (Handout11Thirstland.pdf). Give students handouts of Map Handout C: Physical Map of Africa (MapCPhysical.pdf), which indicates the Kalahari. (Map C is in color, but can be printed in black and white for students.) How accurate were students' speculations?

Compare Regional Precipitation Patterns. If students don't have Internet access, give them a **color** handout or make a **color** transparency of Map Handout E: Annual Precipitation in Africa (Average) (MapEPrecipitation.pdf). Ask students to observe the map and its key. They will see that the Kalahari receives less rainfall than most of the areas northeast of it.

Examine the Physical Characteristics of the Kalahari. Have students read all of Handout 11: The Kalahari: The Great African Thirstland (Handout11Thirstland.pdf). As they read, they should refer to Map Handout B: Political Map of Africa (MapBPolitical.pdf) and Map Handout E: Annual Precipitation in Africa (Average) (MapEPrecipitation.pdf). These questions, which appear on the handout, can guide student reading. (They will apply information about the first two questions to an upcoming activity.) Discuss these questions when they finish reading.

1. How is the Kalahari alike or different from the area where you live?
2. What might your family or friends want to know about the Kalahari?
3. Which countries have parts of the Kalahari within their borders?
4. What season is it in the United States when summer comes to the Kalahari?
5. How does the location of the Kalahari affect its climate?
6. What is a pan?
7. As the seasons pass, how do the pans change when water changes from one state to another?
8. Where is the water hole featured in the film *Roar: Lions of the Kalahari*?
9. How would you describe the area surrounding the water hole?
10. How does the dry season help lions at the water hole?
11. How does the physical environment influence the way animals live in the Kalahari?

Note*:** *If younger students need background on latitude and longitude, you may wish to prepare them with parts of the National Geographic Xpeditions lesson "Introduction to Latitude and Longitude":* ***http://www.nationalgeographic.com/xpeditions/lessons/01/gk2/longlat.html.

Determine Absolute Location. Filmmaker Tim Liversedge identifies the coordinates of the water hole in the film as approximately 20° south latitude and 25° east longitude (latitude 19° 48' S, longitude 24° 45' E). Have students use these coordinates to mark the location of the water hole, which is located in Botswana, on Map Handout B: Political Map of Africa. Students' locations will be approximate; you may wish to substitute a map with smaller intervals of latitude and longitude. (***Option:*** *You or a student can customize a map of southern Africa at Online Map Creation:* ***http://www.aquarius.geomar.de/omc/make_map.html***.)

Write a Letter From the Perspective of a Tourist. Students should use the information in Handout 11 (Handout11Thirstland.pdf) and the map handouts to write a letter to a family member, neighbor, or classmate. The letter should describe how the Kalahari is like or different from where students live. Encourage students to include as many details as possible (i.e., physical features, wildlife, climate). If students have seen the giant-screen film *Roar: Lions of the Kalahari*, they could describe a day at the water hole.

Option: Investigate Regional Wildlife and Endangerment in the Region. *Older or more capable students could examine the Kalahari and its environmental issues in more depth online at "National Geographic Wild World: Terrestrial Ecoregions of the World": **http://www.nationalgeographic.com/wildworld/terrestrial.html**. Under "Find an Ecoregion" type "**AT0709**" and click "Go." In the pop-up click on the result. A map will appear. Place the cursor directly over "AT0709" and click. The ecoregion profile for the Kalahari Acacia-Baikiaea woodlands will appear. (If students don't have online access, educators can print the profile for them.) Students may access more information by scrolling to the bottom of the screen and clicking "World Wildlife Fund Scientific Report." (The report is formatted exactly like the fact sheet.) Students should note the following elements:*

- *The shape of the land and landforms*
- *The plant life described*
- *The plant eaters described*
- *The predators described*
- *How human activity influences changes in this ecosystem*
- *How human activities have changed the ecosystem and put lions or other wildlife at risk*

After students have finished reading, ask different students to write a brief statement about each element. Have them present what they've learned to the class. Explain why "woodlands" is used to describe the region. Have students read aloud and elaborate on their statements about their assigned elements. Focus class discussion on the changes human activity has made in this ecosystem and its organisms. How might changes to the balance of local plant life affect populations of wild grazing animals? Encourage students to compare or contrast the likely effects of these changes on animals that browse, or feed on leaves and branches of trees and bushes, rather than grazing on grasses. Finally, ask how changes made by cattle might affect lion populations through changes in the food web. Encourage the class to ask questions.

Closing:

Ask students again if they consider the area surrounding the water hole, or the area in the photographs, to be desert. Encourage them to explain their answers.

In small groups, have students read their letters to each other. Encourage students to ask questions, e.g., "What are the main differences between the Kalahari and our town?" and "Would you like to live in the Kalahari?" The reader of the letter should answer as a tourist.

Refer to the KWL chart. Have students evaluate the details they listed under Know, modifying as appropriate. Then have them suggest details for the Learned column. Finally, ask them which of their questions were or were not answered. Note the unanswered questions as topics for possible further research.

Suggested Student Assessment:

Refer students to Handout 10: Food Chains in an Ecosystem (Handout10FoodChains.pdf). Review the directions on the second page of the handout with them. Have them draw a food chain with organisms that are part of a real-life food chain in the Kalahari ecosystem. Label each organism. Then ask them to pretend that one element of their food chain disappears. What might the impact be? They could also describe, in writing, how animals live in the Kalahari. They should include the items in their food chain.

Ask students to create travel posters or brochures encouraging tourists to visit the Kalahari. They can use information from the handouts, the "National Geographic Wild World" fact sheets, and the Internet, including Web sites under Related Links. A search for "Kalahari" will yield samples of advertisements at travel or safari sites, as well as photos. Students can find compelling photographs of lions at Nature-Wildlife Lion Photography Gallery: ***http://www.nature-wildlife.com/lion0.html***.

Have students list the physical features and climate that characterize the region known as the Thirstland.

Extending the Lesson:

Encourage students to research and write a report about another ecosystem of interest to them. The report should include information about the ecosystem's wildlife and any threats to the ecosystem. Encourage them to print out photographs and maps to include with their reports, or make their own maps. Make the reports available in the classroom library, school library, or in a common area of the school.

Invite pairs of students to compare two African lion habitats using "National Geographic Wild World: Terrestrial Ecoregions of the World." Each partner should focus on one ecosystem, then share and compare their findings. Tell them to write their comparisons or illustrate them on a graphic organizer such as a Venn diagram. (See The Graphic Organizer: ***http://www.graphic.org***)

National Geographic Wild World: Terrestrial Ecoregions of the World:
http://www.nationalgeographic.com/wildworld/terrestrial.html

To find the fact sheets at the "Wild World" site:

• Under "Find an Ecoregion" type "**AT1309**" and click "Go." In the pop-up, click on the result. A map will appear. Place the cursor directly over AT1309 and click. The ecoregion profile of the Kalahari xeric savanna will appear in a pop-up.

• Under "Find an Ecoregion" type "**AT0711**" and click "Go." In the pop-up, click on the result. A map will appear. On the map, AT0711 is directly over Nairobi in a dark green and pink area. Place the cursor over the numerals "11" in AT0711 and click. The ecoregion profile of the Acacia-Commiphora bushlands and thickets will appear in a pop-up.

Encourage students to research and report to the class about the San or other peoples of the Kalahari. Suggest that students describe the San's traditional way of life and compare and contrast it with modern-day life in the Kalahari. Students can learn about the San online at "Arts & Life in Africa:"
http://www.uiowa.edu/~africart/toc/people/San.html. (The University of Iowa)

Related Links:

Department of Tourism of Botswana: Botswana Tourism
http://www.botswana-tourism.gov.bw

Destination Cinema: *Roar: Lions of the Kalahari*
http://www.destinationcinema.com/our_films/roar/roar.asp

Game-Reserve.com
http://www.game-reserve.com

Kalahari Conservation Society News Letter
http://www.delin.org/kalahari

Kalahari Peoples Fund
http://www.kalaharipeoples.org

National Geographic: *Geography Action!* Habitats: Home Sweet Home: Deserts and Tundra
http://www.nationalgeographic.com/geographyaction/habitats/deserts_tundra.html

National Geographic: *Geography Action!* Habitats: Home Sweet Home: Prairies
http://www.nationalgeographic.com/geographyaction/habitats/prairies.html

National Geographic: Maps and Geography
http://www.nationalgeographic.com/maps

National Geographic: Okavango: Africa's Savage Oasis
http://www.nationalgeographic.com/okavango/index.html

National Geographic Wild World: Terrestrial Ecoregions of the World
http://www.nationalgeographic.com/wildworld/terrestrial.html

Nationmaster.com: Encyclopedia: Kalahari Desert
http://www.nationmaster.com/encyclopedia/Kalahari-Desert

United Nations Cyberschoolbus: Country @ a Glance
http://cyberschoolbus.un.org/infonation/index.asp

US Geological Survey: Water Science for Schools—The water cycle
http://wwwga.usgs.gov/edu/watercycle.html

Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Activity—A Reason For the Season
http://www.nationalgeographic.com/xpeditions/activities/07/season.html

National Geographic: Xpeditions Lesson—Eco-Cycle: Finding the Parts of an Ecosystem
http://www.nationalgeographic.com/xpeditions/lessons/08/g35/ecocycle.html

National Geographic: Xpeditions Lesson—What Is Geography?
http://www.nationalgeographic.com/xpeditions/lessons/18/g35/geofeatures.html

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Lesson 4:
African Lions in Trouble

A black-maned Kalahari lion stands proud and confident.

Overview:

In this activity, students will investigate an alarming drop in African lion populations. After gaining a better understanding of how changing populations affect an ecosystem, they will consider how changes in physical environments can threaten or endanger a species. Specifically, they will examine the effect of growing human population and activity on lion populations in Africa. They will focus primarily on two geographic areas: one in Kenya and the other in and near a national park in the Kalahari. Students will gather information about the conflicting survival needs of human and lion populations and how a balance might be attained.

This activity, which can be adapted for older students, is a good accompaniment to the giant-screen film Roar: Lions of the Kalahari*. It is suggested that this activity be conducted after students see the film. However, it's not necessary that students view the film to conduct the activity.*

Information about the film: ***http://www.destinationcinema.com/our_films/roar/roar.asp***

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Connections to the Curriculum: Geography, life science, earth science, technology, reading/language arts, economics, government/civics

Connections to the National Geography Standards: ***http://www.nationalgeographic.com/xpeditions/standards***

Standard 1: "How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective"

Standard 3: "How to analyze the spatial organization of people, places, and environments on Earth's surface"

Standard 4: "The physical and human characteristics of places"

Standard 6: "How culture and experience influence people's perceptions of places and regions"

Standard 8: "The characteristics and spatial distribution of ecosystems on Earth's surface"

Standard 13: "How the forces of cooperation and conflict among people influence the division and control of Earth's surface"

Standard 14: "How human actions modify the physical environment"

Standard 18: "How to apply geography to interpret the present and plan for the future"

Connections to the National Science Education Standards: ***http://www.nap.edu/readingroom/books/nses/html***

Grades K–4 Content Standard A. Science as Inquiry: Abilities necessary to do scientific inquiry, Understanding about scientific inquiry

Grades K–4 Content Standard C. Life Science: Characteristics of organisms, Life cycles of organisms, Organisms and environments

Grades K–4 Content Standard E. Science and Technology: Abilities of technological design, Understanding about science and technology

Grades K–4 Content Standard F. Science in Personal and Social Perspectives: Personal health, Characteristics and changes in populations, Changes in environments, Science and technology in local challenges

Grades K–4 Content Standard G. History and Nature of Science: Science as a human endeavor

Time: Will vary; two class hours minimum

Materials Required:

- Computer with Internet access
- Writing materials
- Paper or computer program for constructing graphic organizers

Photocopies of the following:

- Handout 12: Lions and Livestock: Can Scientists Save Both? (Handout12Livestock.pdf)
- Map Handout A: Political Outline Map of Africa (MapAOutline.pdf)
- Map Handout C: Physical Map of Africa (MapCPhysical.pdf)
- Map Handout D: Land Use in Africa (color) (MapDLandUse.pdf)

Note: *Handouts or transparency of Map D* ***must*** *be in color.*

If students don't have access to the Internet, photocopies of the following:

- African Lion Working Group: Map of past and present ranges of lions (select "About lions," then "Conservation issues"): ***http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html***

Optional: Photocopies of the following:

- Handout 11: The Kalahari: The Great African Thirstland (Handout11Thirstland.pdf)

Note: *You may wish to have students skim this handout if you haven't conducted Lesson 3 (RoarLesson3.pdf).*

Objectives:

Students will

- investigate threats to African lion populations;
- use maps to interpret reasons for conflict when livestock and lions are close neighbors;
- read and discuss a student fact sheet to examine conflicts between people and lions;
- investigate how scientists are working to solve the problem of lion endangerment;
- use graphic organizers to analyze the problems facing lion populations in different parts of Africa and the proposed solutions;
- engage in a role-playing activity to recognize conflict between lions and livestock owners, and propose solutions for the conflict; and
- understand how technology helps scientists in their research.

Geographic Skills:

- Asking Geographic Questions
- Analyzing Geographic Information
- Answering Geographic Questions

Suggested Procedure

Opening:

Determine students' understanding of the concepts of extinction and endangerment. Do students know what "extinct" means? Many animals that once lived on Earth have disappeared—they are extinct. Have students list examples of animals that have disappeared. What does "endangered" mean? What do students know about animals that are endangered or at risk of disappearing? Discuss what they know about the part human activity plays in endangerment of species today, including changes made to the environment. What is the difference between "extinct" and "endangered"?

Explain that although tourists in Africa often see many lions and may believe that African lion populations are doing well, scientists believe they are in trouble. Lions are not listed as endangered, but over the past 20 years the number of lions in Africa seems to have dropped enough to alarm lion experts. Lions are in danger and dying outside the protected national parks and reserves, where tourists usually see them.

To engage thinking about land use and lion endangerment, print out or have students go online for the African Lion Working Group map showing past and present lion distributions in Africa. Then give them **color** copies of Map Handout D: Land Use in Africa (MapDLandUse.pdf).

African Lion Working Group map (select "About lions," then "Conservation issues"):
http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html

Instruct students to observe and analyze the maps. Note the overlap and proximity of present lion habitats and land used for nomadic herding and for stock raising on ranges. What are the implications of this overlap? Ask students to formulate questions by observing the maps. What might they expect to learn about land use issues and human activities putting people and lions in conflict? For example, if students owned a herd of cattle in Africa, would they be happy about having lions as neighbors? Why or why not? Have them predict what can happen when livestock and lions are close neighbors.

Development:

Note: *If students have not completed Lesson 3 (RoarLesson3.pdf), you may wish to have them skim Handout 11: The Kalahari: The Great African Thirstland (Handout11Thirstland.pdf).*

Locate the Regions Highlighted in This Lesson. Give students copies of Map Handout A: Political Outline Map of Africa (MapAOutline.pdf). Have students speculate on where Kenya, Botswana, and the Kalahari might be located. Then give students a handout of Map Handout C: Physical Map of Africa (MapCPhysical.pdf). (Map C is in color, but can be printed in black and white for students.) Have students compare their predicted locations with the actual locations. How accurate were their predictions?

Investigate Lion Endangerment. Have students read Handout 12: Lions and Livestock: Can Scientists Save Both? (Handout12Livestock.pdf). These questions, which are on the handout, can guide student reading and note taking. Discuss their answers in class after they finish reading.

1. What problems and threats are facing lion populations?

2. What recent changes have put lions in more danger than in previous times?

3. How do some researchers explain the cause of the danger?
4. What are the researchers' goals?
5. How has technology helped scientists in gathering data? Why do you think it's important for scientists to gather data about lions?
6. How have human activities changed the physical environment and put lions at risk?
7. How do the researchers plan to help livestock owners and lions live as neighbors?
8. What are some of the differences in how livestock is controlled in Kenya and Botswana?

Identify Problems and Solutions. Have students work in pairs and write a few paragraphs or use a Problem/Solution graphic organizer to summarize the problems described and the solutions researchers propose.

San Diego County Office of Education: Problem/Solution chart:
http://www.sdcoe.k12.ca.us/score/actbank/tprobsol.htm

Explain Problems and Solutions. Have students do a role-playing activity in groups of four, based on some of the people profiled in Handout 12 (Handout12Livestock.pdf). Explain to students that they will explore a problem from different points of view. State the issues (you may want to write them on the blackboard); e.g., Why is it difficult for people and lions to coexist? How can they successfully coexist? What can be done to allow them to coexist? Students can focus on these questions as they try to figure out what they should say in the role-play.

One student will play the role of Laurence Frank, one of Graham Hemson, one of a government representative, and the other of a livestock owner in the Kalahari. The livestock owner should explain the problems lions present, and the reasons he or she sometimes kills lions. Frank and Hemson should explain how they can solve these problems without killing lions. The government agent should focus on understanding both sides of the situation, and make sure all issues are covered.

Have several of the groups present their role-play discussions to the class. If additional issues were brought to light, list them on the board. Were additional solutions proposed? List them.

Closing:

Ask students what human activities might put people and lions in conflict. At the beginning of the lesson they predicted what can happen when livestock and lions are close neighbors. Have them review these predictions and verify or modify them as appropriate.

Debrief the role-playing discussions. Now that students have heard all different points of view, determine if students can reach consensus on a course of action to take to deal with the conflict.

Encourage students to share their problem/solution paragraphs or graphics.

Suggested Student Assessment:

Ask students to write a summary of findings and recommendations that Graham Hemson might send to a group of livestock owners or the government of Botswana. Students should explain that livestock owners are killing lions, why, and what the owners can do to protect their livestock without killing lions.

Tell students to imagine they have been hired as a consultant to help solve the problem between lions and livestock owners. Students should develop a chart and list the major arguments of the following: Laurence Frank, Graham Hemson, a livestock owner, and a government official. Below the chart, write: "What would **I** do?" Keeping in mind the different points of view and perspectives of the people on the chart, students should make a list of actions that they personally would recommend be done to protect the lions in Kenya and the Kalahari. Students should explain their rationale for each recommendation.

Extending the Lesson:

Have a group of students go to the Laikipia Wildlife Forum Ltd Web site to learn the purpose of a *boma*. The group could write directions for creating a strong boma or, based on the information given, students could make a model boma. Allow time for the group to display the model and explain how a boma should be designed and why.

Laikipia Wildlife Forum Ltd: ***http://www.laikipia.org/news_lions.htm***

Encourage students to undertake a project to help lions or other wildlife. They can find ideas at:

- Defenders of Wildlife—Kids' Planet: Defend It!: ***http://www.kidsplanet.org/defendit/***
- Tiger Information Center: Kids: ***http://www.5tigers.org/Directory/kids.htm***
- Tiger Missing Link Foundation: ***http://www.tigerlink.org***
- Wildlife Conservation Society: Kids Go Wild: Conservation Kids: ***http://kidsgowild.com/kidsgowild/conservationkids***

Kids can go online to learn more about wildlife conservation:

- American Zoo and Aquarium Association: AZA's Campaign News: For Kids: ***http://www.azasweb.com/default.aspx?tabindex=2&tabid=13***
- ASPCA: Animaland: ***http://www.animaland.org***
- Born Free Foundation: Kids—Go Wild! ***http://www.bornfree.org.uk/educ.htm*** (United Kingdom)
- Earth Dog: ***http://www.earthdog.com/entrance.html***
- National Wildlife Federation—kidzone: ***http://www.nwf.org/kids***
- U.S. Environmental Protection Agency: Environmental Kids Club: ***http://www.epa.gov/kids***
- U.S. Fish & Wildlife Service Students' Page: ***http://educators.fws.gov/students.html***
- World Wildlife Fund: Action Kit: ***http://www.worldwildlife.org/act***

Have a group of students go online to learn about Crittercam, an instrument worn by wild animals used to gather information. Ask them to report to the class how Crittercam might be helpful in continuing the research into lion movements and hunting behavior.

National Geographic: Crittercam Chronicles: ***http://www.nationalgeographic.com/crittercam***

Divide students into several teams to debate the following:

Resolved: Governments should pass laws against the killing of lions by livestock owners.

Before students begin to prepare for the debate, have them discuss the pros and cons of such a law. During the debate, you may wish to have students drop their assigned positions after presenting them, switch places, and present arguments for the opposing position. After debating in small groups, have each team select a member, then ask selected members to form a new team and conduct another debate before the class. Ask class members which side presented a better case.

Students can learn more about Graham Hemson's research at the Wildlife Conservation Research Unit (WildCRU) Web site: ***http://www.wildcru.org***.

Share the World is a free educational program for grade 3–5 students, designed to help them better understand and appreciate animals.

Share the World: ***http://www.sharetheworld.com***

Related Links:

2003 IUCN (The World Conservation Union) Red List of Threatened Species
http://www.redlist.org

African Lion Working Group
http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html

CITES: Listed Species Database
http://www.cites.org/eng/resources/species.html

Destination Cinema: *Roar: Lions of the Kalahari*
http://www.destinationcinema.com/our_films/roar/roar.asp

EE-Link: Endangered Species
http://eelink.net/EndSpp/specieshighlights-mainpage.html

Lion Research Center
http://www.lionresearch.org/main.html

Lion Research Center: Lions and People in the Ngorongoro Conservation Area
http://www.lionresearch.org/current_docs/dennis.html

National Geographic: Maps and Geography
http://www.nationalgeographic.com/maps

National Geographic News: Co-Existence Good for People and Wildlife, Conservationist Says
http://news.nationalgeographic.com/news/2003/08/0801_030801_masai.html#main

National Geographic News: Lions With Black Noses Are Fair Game, Hunting Study Says
http://news.nationalgeographic.com/news/2004/02/0223_040223_lionhunting.html

Oxford University Gazette: University biologist leads rescue effort for Kalahari lions
http://www.ox.ac.uk/gazette/1999-00/weekly/250500/news/story_3.htm

Species Survival Commission: Cat Specialist Group
http://lynx.uio.no/catfolk

United Nations Environment Programme World Conservation Monitoring Centre: Species
http://www.unep-wcmc.org/species/index.htm

Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Activity—Preserving Biodiversity
http://www.nationalgeographic.com/xpeditions/activities/08/biodiversity.html

National Geographic: Xpeditions Lesson—Lions and People—Uneasy Neighbors
http://www.nationalgeographic.com/xpeditions/lessons/18/g35/cclions.html

National Geographic: Xpeditions Lesson—People and Endangered Species
http://www.nationalgeographic.com/xpeditions/lessons/08/g35/endangered.html

National Geographic: Xpeditions Lesson—Wildebeest Migration
http://www.nationalgeographic.com/xpeditions/lessons/09/gk2/migrationwildebeest.html

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Handout 1:
Beliefs About Lions

Directions: Read these statements about lions. Place an X next to each statement that you believe to be true.

—If you have not seen the giant-screen film *Roar: Lions of the Kalahari*, place the X to the LEFT of the statement.

—If you have seen the film, place the X to the RIGHT of the statement.

Before	Belief	After
	Most lions live in jungles.	
	All lions live in groups called prides.	
	A male lion mates with one lioness for life.	
	Lionesses usually live in groups with related lionesses.	
	Once a male cub is born in a family, he usually lives his whole life with that family.	
	Once a female cub is born in a family, she usually lives her whole life with that family.	
	A male cub takes over his father's territory when his father dies or grows too old to defend it.	
	When males and females live together, male lions do most of the hunting.	
	Male lions protect their lionesses and cubs.	
	Male lions may kill cubs.	
	The lioness that makes the kill gets to feed first.	
	Male lions may fight other lions.	
	Female lions may fight other lionesses.	
	Male lions fight strange males that come into their territories.	
	Female lions may fight strange lionesses that come into their territories.	
	Male lions fight females that come into their territories.	
	Female lions may fight males that come into their territories.	
	The roar of a lion can keep other lions away.	
	A lion or lioness successfully kills almost all of the animals it stalks.	
	Lions may hunt alone.	
	A lion or lioness chases a hunted animal, sometimes for a long distance, until it catches it.	
	Grazing animals will not remain in an area if they see lions nearby.	

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. What was the filmmaker's purpose in making *Roar: Lions of the Kalahari*?
2. What is the theme of the story in the film?
3. What tools and methods did the filmmaker use? How did these tools and methods help solve some of the problems the filmmaker described?
4. What were some of the difficulties in making this film?
5. How did the physical environment make it hard to create the film?
6. How did the filmmaker combine real events and elements of fiction to create this story?
7. What part did scientists play in the production of the film?

Handout 2:

Making a Wildlife Film

With a loud trumpet the huge bull elephant charged toward the two lionesses—and filmmaker Tim Liversedge. The lionesses bolted past Tim. They missed him by inches. Ten yards (9.14 meters) from Tim the elephant kicked up dust and sand. The dust fell over Tim and his whirring camera.

As the elephant walked toward him Tim stood his ground. His camera kept rolling. Was he afraid? Yes, but not of the elephant. He was afraid his camera would run out of film!

The elephant shook his huge ears. An angry warning rumbled through his trunk. Tim had been a wildlife researcher. He knew an elephant-style threat when he saw one. He also knew that bull elephants would rather not fight unless they need to. The filmmaker weighed the odds. This footage seemed worth the small risk. It had so much to offer his audience.

Tim did not budge. The elephant changed direction. He moved away just as the film ran out.

The elephant had come to drink at a nearby water hole. In the huge dry Kalahari plains of Botswana, Africa, the water hole held the only water for miles.

Tim almost missed the moment. He had been filming the lionesses as they hunted and killed their prey. Then he stood alone filming the lionesses as they ate about 10 yards (9.14 meters) away from him.

The elephant appeared just after Tim removed the magazine, which held the film, from his camera. The film was almost used up. When he spotted the elephant Tim was packing up to leave.

Tim quickly loaded the camera. "I had no idea how much film, if any, was left," he said.

The Water Hole

Tim and his crew were filming lions in the Kalahari. The Kalahari is a huge dry region in southern Africa. Months pass without rain.

"Chance led me to the water hole in the Kalahari," Tim explained. Over the years Tim had conducted research about Botswana. He knew the Kalahari well.

The Kalahari dried up and heated up. Tim saw that the water hole drew more and more grazing animals. A small pride of lionesses had staked out the water hole and the land around it. Then a giant male lion had claimed the pride.

A Filmmaker's Goals

It took a long time and much hard work to make this short film. "The end product combines the highlights of several years of observation," said Tim.

"Over the years, I have watched many individual lions come and go around this water hole," said Tim. Wandering males were eager to take over this pride. It controlled the best hunting grounds around. Most lions did not hold this pride for long. Another male lion or group of males soon took over.

Tim decided to film the story of a real "lion king" and the rival that took over his "kingdom." He called the film *Roar: Lions of the Kalahari*.

The giant old lion in the film had a pride of several lionesses. Tim decided to film two of the lionesses. He showed only these two in the film.

Tim wanted to present scientific facts. He wanted to film real events, but he wanted his film to do something more. He wanted to stir the feelings of the audience. He wanted people to share the animals' hunger, thirst, anger, fear, sorrow, and happiness. He wanted them to feel the fondness of lions for one another and the devotion of lionesses for their cubs. He wanted them to understand a lone lion's longing for lionesses of his own. For this reason he used the facts, and the filmed events, in a story. The lions were the main characters of the story.

The Filmmaker

Tim Liversedge was already a successful filmmaker before he made *Roar: Lions of the Kalahari*. Since the mid-1980s he had made nature films for television. One series was about the Kalahari and the river delta that spills into it, the Okavango Delta. It won a Golden Panda award. Tim called the award "the Oscar of wildlife filmmaking." His next films won more awards.

After years of making films for television Tim decided to make large-format films. These films are shown in theaters on wide screens.

Such films were usually shot with huge cameras that use 70-mm (millimeter) film. These cameras needed to have film changed every few minutes. They were hard to set up and move around.

Cameras using 70-mm film make clearer pictures on a wide screen. Even so, Tim was not sure a 70-mm camera could do the whole job. The equipment was bulky. It was not good for filming fast, quickly changing action. Tim could not always predict what would happen or where action would take place.

What if he missed a great moment? Nature would not give him a second chance. Tim believed that many great stories have gone untold because filmmakers were held back by huge, bulky cameras.

Technology Solves Some Problems

Tim put together his own technology solution. He used a 35-mm camera when he needed to move fast. This camera was also used for very slow motion. A larger camera that used 70-mm film was used for wider shots. It was the better choice when Tim could predict what would happen and where.

Cameraman Richard Jones ran the 35-mm cameras. Meanwhile, Tim ran the 70-mm camera. "Of course, it took quite a while getting the animals used to the terrible sound the gigantic cameras make—they sound like a tractor starting up," said Tim. "You don't want the lions looking at you every time you start rolling, especially when they are sitting right next to you."

After shooting, Tim took the film to the United States. He gave it to Chris Reyna of IMAGICA USA, a visual effects company. Reyna ran experiments on the film. He used special technology to check how clearly the pictures showed on a large screen. They were excellent. Tim's solution worked.

"The film is as much about sound as pictures," said Tim. "I spent months working with sound engineers to get the right sounds—the different roars, all the bird sounds, the elephant's trumpet loud enough."

Risks and Precautions

Tim knew he was taking some risks so he took precautions. At first he shot from a Land Rover. His assistant, Bata, kept watch.

As they spent more time with the lions, the lions became used to them. Soon Tim felt safe enough to set up his camera in the open. He filmed some distance away from the Land Rover.

As a precaution he still kept a small fire extinguisher in his pocket. He never needed to use it. In fact, a lioness once lay down in his shadow.

A Long, Hot, Dusty Job

Tim said filmmaking is tiring. "You have to watch every movement, every second of the day when the lions are around, even when they are sleeping." He needed to predict what the lions were going to do. Then he could set up the camera before they did it.

"You wait and you watch. The heat is unbearable. Dust storms cover everything. But it's a wonderful feeling when something really special happens. I got a lion leaping up in front of me, catching an antelope high in the air just yards from my camera. A chance in a million."

The crew and the equipment baked in the fiery Kalahari sun. Keeping the film cool was a big problem. Again technology came to the rescue. A portable freezer kept the film cool.

The Takeover

At night after the cameras shut down roars shook the Kalahari. Tim could tell that a rival male was challenging the old lion. The rival wanted to take over the pride and the water hole. After six months of filming the huge male lion disappeared. It seemed that another male must have driven him away.

Tim wanted the audience to see a complete story on film. He had missed the chance to film the old lion's defeat. So he added film of an earlier fight between two males that he had filmed. It showed the takeover of the pride as it probably happened.

After the filming was done some scientists watched it. They asked questions and discussed their ideas about the scientific facts in it. The production team thought about what the scientists said. Then they chose the facts to include in the narration.

"My aim is to give audiences the experience of what it's like to be gazing up at the star-filled night skies over the Kalahari," said Tim. He wanted people to have the thrill of hearing two lions in a roaring contest. He wanted them to know how it feels to sit at the edge of a water hole a few feet away from elephants bathing in the moonlight.

The film was a learning experience for Tim as well. "In the end, this film has taken me on a journey." He explained that he had developed a new technology for gathering information about wildlife. This technology, he hoped, would bring a love of wild places to a wider world through large-format films.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Watch for These!

- You will see a map and aerial views near the beginning of the film. What continent is shown? What kinds of things do you see in the views from the air? How do the views from the air help you understand the plot of the story?
- What different animals are in the film?
- What measurements are given in the film? What tools would be used to make these measurements?

Handout 3:
Worksheet for *Roar: Lions of the Kalahari*

1. What physical processes created the pans described in the film? (The pans in the film are flat-bottomed depressions in the desert.)

2. How would you describe the places you see in the film? How would you describe the region? Why is the water hole an excellent territory for the lions? Why does the rival lion want to take over the water hole?

3. How do the physical features and climate of the region make it possible to film so many different African animals in one place?

4. What does the film show about weather changes from day to day and over the seasons near the water hole?

5. What changes take place in the environment while the water hole is being filmed? Which animals move to new locations?

6. What changes do the elephants make in this environment? Which animals are harmed? Which are helped?

7. How close are the springbok to the water hole when the lions charge them? How do the lions try to position themselves for the charge?

8. In this film what cues cause behavior such as running or taking flight?

9. According to the narrator, how are the cubs likely to be like their parents? What happens to the cubs at the end? Why?

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Handout 4:
"All Cats" and "Lions Only" Chart

	All Cats	Lions Only
Sample answer:	Have claws	Have manes

Anything Else?

Did you learn something about lions or cats that doesn't fit in either list? Write that here.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. Which structure (body part) helps make cats good night hunters? How does its structure help a cat hunt at night?
2. What happens to light after it enters the eye of a lion or other cat?
3. What structures make lions good hunters and fighters?
4. Besides their size, what makes adult male lions look different from other adult male cats?
5. Which structures make lions able to roar? What causes lions to make sound?

Handout 5:

Physical Characteristics of Lions

Lions belong to the cat family. In most ways, they are like other cats, but they are different in a few ways.

Structure and Function in Cats

Cats are carnivores, or meat eaters. They have short muzzles and broad, rounded heads.

Like other cats, lions have special hairs called whiskers. A cat's whiskers are very sensitive to even a light touch. Cats use them for testing objects in their way. Whiskers also help them sense changes in the environment. If necessary, cats can feel their way with whiskers. Cats don't need to depend only on their whiskers, though. They have excellent hearing and night vision. Experts believe a cat probably has a good sense of smell.

Cats' eyes have special adaptations that help them gather more light than the eyes of humans. The extra gathered light gives cats excellent night vision.

Structure and Function in Lions

After tigers, lions are the biggest cats. A full-grown male lion can weigh some 450 pounds (more than 200 kilograms). He stands about 4 feet (123 centimeters) tall at the shoulder. If a male lion stood next to a woman of average height the lion's shoulder would be almost as high as the woman's. Not including the tail, a male lion may be about six-and-a-half feet (two meters) in length. A tail may add around 39 inches (100 centimeters) in length. Adult female lions are smaller than adult males.

Lions are the only cats with manes, and only male lions grow manes. A lion's mane grows around the neck and shoulder area. It can reach to the underside of the belly. At about age two a young male begins to grow a small ruff. In most lions the ruff quickly grows into a full mane.

The mane of one lion may be very different from that of another. Some male lions have long, thick manes and others have almost no mane at all. Manes can also be different colors ranging from tan to black.

Lion experts are not sure why lions have manes. But a mane helps humans tell male from female lions.

In adult lions, body fur ranges from light tan to reddish brown. The mane, as well as the tuft on the tail, may be darker. Cubs are born with spotted fur. As the cubs grow up the spots slowly fade.

Lions have powerful bodies with huge, thick shoulders and strong front legs. Long, sharp claws and short, powerful jaws make lions fearsome fighters and hunters. An adult lion has 30 teeth. The large stabbing teeth grab and kill hunted animals. After a kill the scissor-like teeth cut into the flesh. Smaller teeth help scrape the meat from bones.

Lions can roar because of the way their throats are put together. Part of the windpipe has bands that vibrate, or make sound, when passing air causes them to move rapidly back and forth. In lions these cords are thick and strong. A set of bones called the hyoid supports this part of the windpipe. A cat has a long elastic cord that connects the bones in the hyoid. The stretched cord in the hyoid and the thick bands help the lion make a loud sound.

A lion's mighty roar can be heard five miles away, according to some experts. Tim Liversedge, producer of the giant-screen film *Roar: Lions of the Kalahari*, says that a lion's roar from close by will shake a Land Rover on its springs.

Male lions don't usually live longer than 12 years in the wild. Females may live as long as 17 years. In fact, some females can still breed at age 15. Captive lions live longer because they are well fed, prevented from fighting, and given care by veterinarians. They sometimes live 25 years or more.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. What behavior sets lions apart from all other cats?
2. What is a pride? What is a coalition?
3. Over a lifetime how does the family life of most female lions differ from the family life of most male lions?
4. In most prides, how do males and females usually help the pride survive?
5. How does living in a pride help its members survive?

Handout 6:

Lion Family Life

Most cats live and hunt alone, but most lions live in groups. The core of a pride, or group, usually includes two or more adult lionesses and their cubs. Prides are something like a family because the females are related. They may be sisters, half sisters, mothers, daughters, aunts, or cousins.

In a pride, females work together. They team up to care for cubs and hunt. Sometimes lionesses gang up to defend their cubs from male lions that take over a pride (see Handout 9: Takeovers).

Once born into a pride, a female lion usually remains within it for life. Young males are driven from a pride at about age three. If they are lucky they are driven out with brothers and cousins their own age. If so, they may remain together for life.

Some young lions are driven out alone. If so, they try to join up and cooperate with other young males. Groups of two or more male lions are called coalitions.

Some young lions end up alone after being driven from their prides. Whether alone or in a coalition, young males are at first nomadic, having no permanent home. They roam and hunt alone or together.

Sooner or later a coalition may try to take over a pride together. To do so, they usually need to drive off or kill the males already living with that pride (see Handout 9: Takeovers). A single nomadic lion may also try to take over a pride, but he usually needs to find a pride controlled by a single male to be successful.

In lands where prey animals are scarce prides may be small and have large ranges. A pride may have few females and one or two males. Where prey animals are plentiful prides tend to be large. Prides can have as many as 15 lions, or even more.

Lions seem fond of their pride members and coalition members. They lick each other's faces and rub heads and cheeks.

Lions spend most of their time resting. When they are awake, they divide the job of caring for the pride. Adult lionesses do most of the hunting (see Handout 7: Hunting and Feeding Behavior) and the cub care (see Handout 8: The Lion Life Cycle).

Pride females also defend the territory against females from other prides. They work together to drive them off.

Pride males patrol the territory, defending it against outside males (see Handout 9: Takeovers). Their fierce roars warn other males off.

When not in the midst of a takeover or bickering over a kill, pride members usually get along well. They work together to take care of the pride.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. In a pride, which members do most of the hunting? How does social behavior make it easier for individual lions to have enough food?
2. Besides hunting, what behaviors do lions use to feed themselves?
3. According to filmmaker Tim Liversedge, how have the lions in *Roar: Lions of the Kalahari* adapted their hunting behavior to the environment near the water hole in the film?
4. How do lion experts explain the reason most lion hunts fail?
5. In what order do pride members usually feed? How does this order affect cub survival?

Handout 7:
Hunting and Feeding Behavior

If you were to see a lion coming toward you would you get out of its way? It would probably be a good idea!

Lions are carnivores. They live on the flesh of other animals. They are also predators—they hunt and kill other animals for food. The animals they hunt are prey. Given a choice, lions seem to prefer medium- to large-size plant-eating mammals. Such prey animals might include zebra, wildebeest, buffalo, and antelope. They also hunt animals as small as hares or as large as giraffes.

Hunting Alone and Together

Lions hunt alone or in groups. Hunting alone, a lion sneaks up on its prey slowly and silently. It tries to get in position close to its prey. When it is within about 98 feet (30 meters), it charges toward its prey with a burst of speed. If the lion is lucky it grabs the prey, throws it to the ground, and kills it.

Both male and female lions can hunt. Males are stronger but slower than females. Males usually stick to larger prey. When it comes to hunting large prey animals, male lions' size and strength are more important than speed. In prides living in open areas, males usually feed on the female lions' kills.

In fact, most lions choose a free meal when given a choice. If a single lioness seems able to kill an animal alone other pride members often watch and wait. If teamwork seems necessary other lions join in.

In group hunts lions may surround the prey, cutting off all escape. Some lions may drive prey animals into the reach of others. Sometimes two or more lions grab and slash together to bring one animal down. Lions most often hunt together to kill faster or larger animals such as zebra and buffalo.

Success and Failure

When hunting, lions fail more often than they succeed. Lions hunting in groups of two or more succeed about twice as often as a lion hunting alone.

Lion experts explain the many failures in several ways. One problem with lions' hunting behavior is that they don't seem to pay enough attention to the wind direction. They may head toward prey from a position where the wind blows their scent to the prey.

If it has to chase its prey for a long distance a lion usually gives up. For short distances lions can run at speeds between 30 and 35 miles (48 and 56 kilometers) an hour. Even so, they tire too quickly to chase an animal very far.

Day and Night

Lions hunt during all times of the day and night. Hunts are usually more successful at night. Hunting during the day can raise lions' body temperatures. If so, the body heat causes them to tire quickly. Another reason to hunt at night is that lions can see in the dark very well. The lion's eye has adapted so that it can gather a large amount of light. The gathered light helps it see well in the dark.

On the open plain, hunting by day is difficult. As lions are trying to sneak up on prey, other grassland animals know that the lions are hunting. They watch any lions in sight. If they cannot see the lions, they are alert and looking around. The prey animals do not usually flee immediately. Often they wait until lions start to charge before they try to escape.

Daytime hunts can be successful in special locations such as a water hole. A small water hole in a dry area is a good place to hunt. Any animals that want to drink must come to the water hole even if lions are nearby. The water hole in the giant-screen film *Roar: Lions of the Kalahari* gathered large numbers of prey animals in a small space. "Lions adapt their hunting behavior to the environment," said Tim Liversedge, the filmmaker of *Roar: Lions of the Kalahari*. "At the water hole, they hunt during the day when the prey animals are there."

To drink, the prey animals need to lower their heads. From this position they cannot keep their eyes fixed on the lions. They cannot start running as quickly as they could if they were standing and watching.

Feeding

Whichever lion makes the kill, the biggest and strongest lions often push their way to the head of the line. If adult males are present they usually eat first. Then the adult females fight over the remaining meat. Young growing lions and cubs feed last during hard times. Sometimes nothing is left over for them. During hard times many cubs starve.

On average a lion eats about 17 to 18 pounds (8 kilograms) of meat daily. Even so, lions do not necessarily eat or hunt every day. Lions have stomachs that stretch and can hold huge amounts of food. When feeding on a large animal, a lion can eat nearly 80 pounds (more than 36 kilograms) of meat in one feeding. It then may not need to eat for several days.

"Fast Food"

Lions like easy meals. They scavenge for food when they have a chance. Eating bodies that are already dead can take less work and less risk than hunting. Hungry lions look for clues such as circling vultures. These clues lead them to downed animals. Lions will eat animals that have died from natural causes. Often they steal kills from other predators such as wild dogs, cheetahs, leopards, and hyenas. Large groups of predators such as hyenas can sometimes defend their carcasses against lions.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. Which characteristics of their parents would you expect cubs to inherit? Which abilities would they need to learn?
2. What happens when a lioness comes into estrus?
3. How do females in large prides raise their cubs?
4. How would you describe the social behavior of young males after they leave their prides of birth?
5. At about what age can lions start breeding?

Handout 8:

The Lion Life Cycle

Reproducing seems to be a lion's main goal in life. According to experts, this explains much behavior of male and female lions. It also may explain how prides are organized (see Handout 9: Takeovers).

Giving Birth

The reproduction process begins when a female lion comes into estrus. When she is in estrus the female is interested in mating and can become pregnant. The egg becomes ready to receive the male's sperm. Sometimes pride males fight over a female in estrus.

If a lioness mates and becomes pregnant her cubs are born after around 110 days. She gives birth in a private, hidden place. One lioness may choose a rocky shelter. Another might give birth in a clump of thick plant growth. Usually a lioness gives birth to between two and four cubs, but a lioness can bear as few as one or as many as six.

Cub Care

Cubs can begin walking within 10 days of birth. Most are walking within 15 days. When the cubs are between 4 and 10 weeks old the mother brings them out to the rest of the pride. Often other mothers have young cubs themselves. If so they may all raise their cubs together. They form a nursery-like group called a crèche (rhymes with "fresh").

Mothers and cubs live in the crèche until the cubs are older. Cubs drink their mother's milk for six months to one year. Meanwhile they nurse from all the mothers in the crèche. Even so, female lions would rather give milk mostly to their own cubs. Hungry cubs that want to nurse from somebody else's mother often wait until the lioness is asleep.

Growing Up

Even though cubs are drinking mother's milk they begin eating meat after a few months. When cubs are three months old and older the mothers lead them to nearby kills. There they can sometimes feed on meat. Mother's milk remains an important food during the first year, though.

At kills adult males usually eat first followed by adult females. Growing lions and cubs eat last if anything is left over. Sadly, during hard times many cubs starve (see Handout 7: Hunting and Feeding Behavior).

During their first year cubs play all the time. They sneak up on one another. They rush their playmates, chase them, and pull them down. Play behaviors help them practice the skills they will later need for hunting. They practice putting their strong front legs, sharp claws, and powerful jaws to work.

At about 11 months of age or younger cubs start learning to hunt with the pride. Most do not kill their own prey until they are about two years old. It may take more years of practice to become expert hunters. Young lions depend on their mothers until they are around a year and a half old. Then the mother is ready to breed again.

Lions are old enough to breed, or reproduce, between ages three and four. They continue growing until about age five or six. Females usually stay with a pride for life. As adults they begin to breed and hunt.

Young males are driven from the pride at about age three. They often leave with a group of brothers and cousins. Sometime around age five or six these males may take over and control a pride of their own. Then a new cycle of life will begin in a new pride.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. Which members of a pride are temporary, and which are usually permanent?
2. What is a male lion's main goal? How does it compare to the main goal of a female lion?
3. What must nomadic males do in order to join a pride?
4. Why do males kill cubs after they take over a pride?
5. What makes females fight males at times?
6. "There is safety in numbers." How do the facts in this handout support this statement?

Handout 9:

Takeovers

A pride includes both permanent and temporary members. Pride females are related. They usually spend their whole lives in one pride. Adult males are usually not related to the females but they may be related to one another. Within their lifetimes, one group of lionesses will see males come and go. The males may come and go alone or in groups.

In lands where plants and prey animals are scarce, prides may be small. A pride may have a few females and one male. Where prey animals are plentiful, prides tend to be larger, with as many as 15 lions or more.

The Drive to Reproduce

Young males are driven from their prides of birth alone or in groups. They then seek prides of their own. A lion may try to take over a pride alone or with a group called a coalition (see Handout 8: The Lion Life Cycle). The males' goal is to find females, mate, and have cubs of their own.

Male lions are not alone in this goal. Animals and other living things all want to reproduce. Living things pass on their characteristics in cell parts called genes. Like other living things, lions are driven to survive after death through the genes they pass on to their young. The contest is about which lion's genes will be passed on.

The males already living in a pride like living there. Fed by female hunters, they mate and father litters of cubs as long as they remain. They do not give up their position without a fight. Neither do they want to share their position with males outside their coalition.

Taking Over a Pride

To join a pride a homeless male or coalition must chase off the males that control the pride. The fighting can be fierce and bloody. Some lions may be killed.

Numbers matter. A single male cannot easily take over a pride that has more than one adult male. If he does succeed, he may have difficulty holding the pride if a coalition tries to take over.

When coalitions compete, the larger one most often wins the pride. Perhaps it is for this reason that related males stay together, and single males usually seek to team up.

After a takeover the violence may not end immediately. A takeover puts pride females and their cubs at risk. When new males take over they try to kill the cubs fathered by males of the defeated coalition.

As cruel as it may seem, the new males have reason to murder the cubs. These lions are in a hurry to father their own cubs.

Setting the Female Clock

A female needs between 18 months and 2 years to rear her cubs to independence. While her cubs depend on her, she does not come into estrus, the period when she can become pregnant and is interested in mating (see Handout 8: The Lion Life Cycle). Should her cubs die, she may come into estrus within days or weeks.

Thus, if incoming males let the old male's cubs survive they may need to wait a year or two before they can mate with the mothers and father cubs. A lion or coalition usually controls a pride for only two to three years. Sometimes takeovers are more frequent. With an early start, the new pride males may father cubs that have a chance to grow up.

Mothers Defend Their Young

Mothers, on the other hand, want their living cubs to survive. These competing goals pit females against males after a takeover. Mothers defend their cubs against outside or incoming males. One female lion is no match for a much larger male lion. On the other hand, females can sometimes defend their cubs by ganging up against a smaller number of males. A female sometimes leaves the pride with her cubs before the new males have a chance to kill them.

One advantage to group living is that females can raise their cubs in groups called crèches ("crèche" rhymes with "fresh"). In these nursery-like groups, several mothers can defend all the cubs when necessary (see Handout 8: The Lion Life Cycle).

Back to Business as Usual

Sometimes the incoming males wipe out all cubs from the defeated coalition. Then the mothers usually come into estrus around the same time. If so a number of females may later give birth within a few days or weeks of each other. This timing gives them more chances to form crèches.

Once the immediate violence of a takeover is over, relations are mostly peaceful among males, females, and young. Bickering sometimes breaks out over feeding at kills. Males may clash over a female in estrus. Such fights are quickly over.

By contrast, prides are unfriendly to one another. Pride females defend their hunting grounds, water holes, and birthing sites against outside females. Conflicts can be violent and can lead to death. Even so, a pride usually holds its territory much longer than a coalition holds a pride.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Handout 10:

Food Chains in an Ecosystem

Have you heard the expression "low on the food chain"? Do you know what it means? All living things depend on other living things for food. The order in which living things feed on one another is called a food chain. For example, you may eat grapes, but grapes never eat you. Therefore, you are higher on the food chain than grapes are.

All organisms, or living things, have basic needs. For example, animals need air, water, food, and light. Organisms can stay alive only in environments in which their needs can be met.

Every living thing needs a source of energy. For ecosystems, the main source of energy is sunlight. Energy from sunlight is changed by plants into a form they can use and store as food. That stored energy then passes from living thing to living thing.

All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants.

Green plants are producers. They make their own food. They use sunlight to make food out of nonliving matter such as minerals and gases. Producers are the first link in the food chain. That is why people sometimes say plants are low on the food chain.

Animals cannot make their food. They need to eat other living things for food.

Animals called herbivores are next after plants in the food chain. These animals eat plants. Most of the animals humans raise for food are herbivores.

Next in the food chain are animals that eat other animals. They are called carnivores. They are a link further, or higher, on the food chain. These animals also depend on plants, because without plants, they would not have animals to eat. For example, the lions in the giant-screen film *Roar: Lions of the Kalahari* could not hunt grazing animals at the water hole if plants did not grow nearby.

Some animals eat other carnivores. For example, when a lion dies, its body may be eaten by scavengers such as vultures. A snake may eat a mouse, and an owl may eat the snake.

Also in the food chain are animals and people who eat both animals and plants. They are called omnivores.

Some living things feed on the bodies of dead plants and animals. You know that they are at work when you see food rotting in the garbage. They also make leaves turn soft and crumbly on the ground. Some examples are bacteria and mushrooms. These living things break bodies down into minerals and gases, which plants may use to make food.

One living thing may be part of more than one food chain. For example, many birds eat both animals and plants. The birds may in turn be eaten by carnivores or omnivores. When organisms make connections among food chains, the connected food chains form a food web.

Activity: Draw a Food Chain

Directions:

In the space below draw a food chain using living things you learned about in your research or saw in the film *Roar: Lions of the Kalahari*. Include at least three living things in your chain. One should be a lion and one should be a plant. Be sure that any plant-eater you draw will eat the plant you have drawn. Label each living thing.

What would happen if one thing were removed from this food chain?

If you wish, draw a second food chain that includes different animals and plants. Be sure they can all be found in one ecosystem.

What would happen if one thing were removed from this food chain?

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. How is the Kalahari alike or different from the area where you live?
2. What might your family or friends want to know about the Kalahari?
3. Which countries have parts of the Kalahari within their borders?
4. What season is it in the United States when summer comes to the Kalahari?
5. How does the location of the Kalahari affect its climate?
6. What is a pan?
7. As the seasons pass, how do the pans change when water changes from one state to another?
8. Where is the water hole featured in the film *Roar: Lions of the Kalahari*?
9. How would you describe the area surrounding the water hole?
10. How does the dry season help lions at the water hole?
11. How does the physical environment influence the way animals live in the Kalahari?

Handout 11:

The Kalahari: The Great African Thirstland

Do you know exactly where the Kalahari is? Do you know how big it is? Do you know exactly what it is?

If your answer is no, you're not alone. Even the experts don't agree on where the Kalahari begins and ends, or what to call it. The larger region some experts call the Kalahari is in the southern part of Africa. It is a large basin that stretches into parts of Angola and Zambia in the north. The basin runs through Botswana into part of Zimbabwe in the east. It reaches south to the Orange River in South Africa and west to the highlands of Namibia. It includes many different types of plants and animals. The total area of this basin is hundreds of thousands of square miles (millions of square kilometers).

A Thirstland

The word *Kalahari* comes from the Setswana word *Kgalagadi*, meaning "the great thirst." The "thirstland" is a dry region within the larger basin. This "thirstland" covers most of central and southwestern Botswana, parts of west central South Africa, and eastern Namibia. It covers at least 100,000 square miles (260,000 square kilometers).

This dry region is often called the Kalahari Desert. Most of it is not what most experts call a desert, though. It has very little water and goes months without rain. Even so, it is mostly a dry grassland, rather than a desert.

In fact, the northeastern Kalahari, which receives the most rain, has palm trees and forests. The great Okavango River empties into the Kalahari from the northwest. It makes a delta that is rich with plants and animals. Some of the animals you see in *Roar: Lions of the Kalahari* migrate to this area, or to the Boteti River, during the dry season.

The Seasons

In the Kalahari winters are very dry. Months can pass without rain. Most of the rain falls during summer thunderstorms.

The path of the sun appears to change slowly over the seasons. The Kalahari is south of the Equator. The United States is north of the Equator. The sun heats the Kalahari least when it is heating the U.S. the most. Seasons are opposite in the U.S. and the Kalahari. Summer comes to the Kalahari when it is winter in the U.S.

The Oceans and Kalahari Climate

The Indian Ocean is the main source of moisture for the air over the Kalahari. On a map of Africa and the Indian Ocean you would see that there are more than 400 miles (643 kilometers) of land between the Indian Ocean and the Kalahari. Winds carrying water from the Indian Ocean must blow over this land. Suppose you look at a climate map of Africa. You would see that climates become drier as you look southwest on the map.

The Pans

The Kalahari was not always as dry as it is now. Streams and rivers once emptied into a huge lake. Now streams and rivers flow for a short time after rains, if at all.

These streams may empty into low spots (flat-bottomed depressions) in the desert. These low spots are called pans. There the water from the streams dries up. As it evaporates the water leaves its salt and some minerals behind. Pans vary in size from a few yards (meters) to tens of miles (tens of kilometers) in diameter. They offer sources of water for part of the year.

During the winter season many pans are completely dry. They are crusted with cracked clay. After the rains begin shallow pools form. Sometimes the rains bring floods. The floods make wetlands for birds and water holes for animals that are passing through. Some pans may be covered with grasses after a rain.

The Makgadikgadi pans, which were left behind by the huge, ancient lake, are surrounded by grasslands. Farther from the pans, bushes begin to dot the grasslands. Even farther out, trees stand here and there.

The Water Hole

Roar: Lions of the Kalahari was filmed at a water hole near the Nxai (rhymes with "eye") Pan. This small salt pan is near the larger Makgadikgadi salt pans. The water hole is surrounded by dry savanna, or dry grass plains, with a few bushes and scattered trees.

In the southern and central parts of the Kalahari only small widely scattered water holes hold water. These water holes draw migrating and year-round animals during the dry season. In turn, the water holes become excellent hunting grounds for meat-eaters.

Animals in the Kalahari

Many different types of mammals, birds, and reptiles live in the Kalahari. Among them are lions and cheetahs. These big cats hunt animals such as zebra, wildebeest, and antelope. Smaller meat-eaters include jackals, hyenas, and foxes. One type of antelope, the springbok, can easily live in dry regions such as the Kalahari. Living in holes under the plains are meerkats. They look and act something like the prairie dogs of North America.

The water hole in *Roar: Lions of the Kalahari* is in a protected area. It is miles from ranches or centers of human population. For part of the year it is the only water for miles around. The water and the rich grass coverage draw many different types of animals. Because of its special location and the many types of animals drawn there, it is one of the few places where a wildlife drama such as *Roar: Lions of the Kalahari* could be filmed.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. What problems and threats are facing lion populations?
2. What recent changes have put lions in more danger than in previous times?
3. How do some researchers explain the cause of the danger?
4. What are the researchers' goals?
5. How has technology helped scientists in gathering data? Why do you think it's important for scientists to gather data about lions?
6. How have human activities changed the physical environment and put lions at risk?
7. How do the researchers plan to help livestock owners and lions live as neighbors?
8. What are some of the differences in how livestock is controlled in Kenya and Botswana?

Handout 12:

Lions and Livestock: Can Scientists Save Both?

Is the African lion about to disappear? Not yet. Lions are not now listed as endangered. Even so, over the past 20 years the number of lions in Africa seems to have dropped enough to alarm lion experts. Scientists can only guess how many lions lived in Africa 20 years ago. Some say as few as 30,000. Others say as many as 200,000. Most experts put the numbers of lions today between 23,000 and 30,000, with many saying 23,000. "What is clear is that they are in very serious trouble now," said Laurence Frank.

Scientists Step In

Frank is a wildlife specialist at the University of California at Berkeley. He is studying the problem in Kenya in order to propose solutions. He worked for more than seven years in Laikipia, in central Kenya. Later he began studying the lion population in Southwest Kenya near Mt. Kilimanjaro.

In 1998, another scientist began a similar study closer to the water hole featured in the giant-screen film *Roar: Lions of the Kalahari*. That scientist is Graham Hemson, a researcher at Oxford University's Wildlife Conservation Research Unit. Working in Makgadikgadi Pans National Park, in Botswana, he investigated the reasons lions had been disappearing over the last 50 years. The number of lions had dropped to about 50.

Hemson likes science and has chosen it as his career. He hired help from among the local Kalanga who worked on nearby cattle posts.

The Problem: Raids and Retaliation

Hemson says that he and Frank often discuss and compare their findings. In separate studies in different countries, they agreed on one major cause of the problem: conflict between lions and livestock owners.

It's easy to see why lions and livestock owners can come into conflict—their survival needs are sometimes at odds. A lion is hungry. It has wandered far from its usual range without catching any wild prey. Survival is at stake. A meal flashes into view—a sheep grazing nearby. The lion kills the sheep. Now a livestock owner has lost a sheep that would have fed the family or brought in cash to meet its needs. If the sheep belongs to a small farmer, the farmer's survival may be at risk. For a large rancher, the profit is slashed.

The challenge for scientists and conservationists is to find ways both lions and livestock owners can survive. Frank and Hemson hope their research will help.

Livestock owners have always killed predators to protect cows, sheep, and goats. In recent times, though, human populations have exploded. Settlements reach closer to or farther into lion hunting ranges, making attacks on livestock more likely. With improved technology, herders can kill lions at a much faster rate. Poisons and guns are used in addition to spears and other older weapons.

Cattle posts have popped up all over the grassy plains, which are increasingly used for grazing land. According to Hemson, a cattle post may have a few mud huts, a few corrals, and a well for water. Cattle, goats, sheep, donkeys, and horses may graze on surrounding lands.

Roaming Lions

To visitors in parks, lions may seem to be plentiful. Lions are protected inside parks. The problem is that they sometimes wander outside protected areas. Lions often need to move over large ranges to find enough food. In drier areas with fewer prey animals, lions need larger ranges than lions in areas with plenty of prey.

Outside a park, lions are at risk whether or not they attack livestock. Risks include traps and poisoned meat farmers may set out. They may also die at the hands of farmers who kill lions on sight.

Graham Hemson said that the Kalahari lions in his study area sometimes killed only wild prey as long as they found plenty. They switched to livestock when wild prey animals were scarce. Other lions in his study never ate livestock. They followed herds of migrating animals, like one of the lions in *Roar: Lions of the Kalahari*.

The water hole in *Roar: Lions of the Kalahari* is in a protected area near the Nxai (rhymes with "eye") Pan (see Handout 11: The Kalahari: The Great African Thirstland). Yet it is close enough to the borders of a park that lions from the water hole can wander onto grazing land and cattle posts.

During the dry season, the water hole is the only water for miles around. Plenty of prey animals are drawn to the water hole.

During the filming, the main "characters" of the film stayed near the protected water hole. On the other hand, in the film one lion follows the herds, a lioness is driven off, and a mother leaves with her cubs.

In the Kalahari, Hemson explained, prey animals spread out over wider areas during wet seasons. They can find more sources of water and do not need to stay near one water hole. He said that probably when prey spread out the Nxai Pan lions roam over larger areas. The lions may come near livestock more often. He adds that livestock animals also move over wider areas during wet seasons. They can find water without going to a cattle post to drink. As a result, lions can hunt livestock animals farther from the cattle posts and herders.

Lion Behaviors

Beyond roaming large ranges, other facts of lion life and behavior can put lions at risk. For example, because they eat dead animals, they may eat poisoned carcasses put out to kill predators (see Handout 7: Hunting and Feeding Behavior).

Takeovers can multiply the effects of a single lion kill (see Handout 9: Takeovers). If killing a male lion leaves a pride undefended, a new male or coalition will usually take over. Right away the new males set out to kill any cubs fathered by the old male.

Even without takeovers many cubs die in their first year. During hard times cubs may starve, while older and stronger members eat (see Handout 7: Hunting and Feeding Behavior).

Studies and Technology

Researchers want to help livestock owners find ways of protecting their livestock without killing lions. First they must find out how many lions live in an area and what puts them at risk. In Kenya and Botswana lions were fitted with radio collars and tracked. The scientists used such technology as aircraft, radio receivers, and global positioning systems (GPS).

Laurence Frank has even fitted some lions with instruments called Crittercam, which have tiny video cameras and other information-gathering equipment. The early field trials suggest Crittercam could become a valuable tool for studying predators.

The information collected tells researchers where lions live, where they move, and which lions kill the most livestock. The researchers can use information they collect to help livestock owners protect livestock without killing lions.

Scientists Propose Solutions

According to Graham Hemson and Laurence Frank, keeping livestock behind strong fences at night cuts down on lion kills. Dogs can alert herders that predators are approaching. Other methods suggested include the use of armed guards to frighten predators, rather than kill them.

While livestock raids are common in both Kenya and Botswana, the researchers have observed differences. In Kenya most livestock attacks happen at the *bomas*, or *kraals*. Bomas are enclosed structures where livestock are kept at night, according to Frank. Bomas are supposed to keep predators out and livestock in.

As a result, Frank and his research partner in Laikipia, Rosie Woodroffe, wrote, "Good boma design and construction is by far the most important factor in protecting livestock from predators." They also recommend having people, or noises such as radios, at the bomas.

By contrast, in the Kalahari most livestock are killed away from cattle posts in the bush, according to Hemson. "Livestock are frequently left out at night and untended during the day," he explained. He said that herders should be present and watchful during the day and keep livestock in fenced areas at night. Using experienced people and enough people for daytime herding can reduce losses during the day. Hemson recommended that small farmers with few animals pool their money and hire able herders to watch over their combined herds.

"Unfortunately, many livestock owners do not do enough to prevent kills by predators," said Hemson. "People kill lions because it is cheaper to do so than to take better care of livestock and prevent the problem."

Governments Step In

In Botswana, a law against lion hunting has been in place since 2001. Government leaders understand the economic needs of livestock owners as well as the need to protect lions. They offer money to livestock owners who have lost animals to lions. Frank and his colleagues are trying out a similar system in the new Kilimanjaro study area.

Both Hemson and Frank are convinced that to be effective such payments should be linked to good livestock management. For example, farmers should not be paid for livestock killed at night in unfenced areas. In Kenya the payments will have what Frank describes as "a lot of strings attached," according to a news feature on the National Geographic Web site.

Plenty of Wild Prey Animals Helps

Both Hemson and Frank also noted that livestock kills in their study areas were rare when wild prey animals were plentiful. They suggested that if plenty of wild prey animals are present, lions might make fewer livestock kills. Then livestock owners would be less likely to kill lions. Hemson predicts that if hunters were to avoid hunting prey animals that do not migrate, their numbers might increase. Lions would have enough wild prey year-round. He offers antelope such as kudu as examples. Besides, they eat mostly leaves on bushes and trees rather than grass. Therefore, they do not compete for food with grazing livestock, according to Hemson.

Some conservationists hope that in Botswana and other areas, people will learn to value lions and wildlife as an economic resource. They hope the money tourists bring to Africa will make lions and other wildlife valuable in the eyes of Africans.

Risks and Benefits

To study and protect lion populations, researchers have taken personal risks. "When I told my friends what I did they thought I was mad," said Graham Hemson. "I lived in a tent 30 miles from the nearest village and often had lions walking around it. There were snakes and scorpions all over the place, and I have been charged by lions a few times." To put the tracking equipment on the lions, the researchers needed to drug them. Sometimes the lions were awake and growling.

"I think the benefits outweighed the risks," Hemson said. Probably conservationists think so, too. The information Hemson collected and his recommendations might help keep African lion populations from dropping.

Hemson further hopes his recommendations may cause lion populations to grow in some areas. He offers some words of hope. "Lions breed very fast when allowed to," he said. "Lions can rebuild their populations if they are left alone." Still, he warned, "One has to give the population a little breathing space for this to occur."

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Lesson 5:

Teaching Standards With *Roar: Lions of the Kalahari*

According to Tim Liversedge, a lion's roar can shake a Land Rover on its springs at close range. Although it appears to be roaring, this lion is actually yawning.

Overview:

In this activity students will learn about lions, the Kalahari, Kalahari wildlife, filmmaking, and the technology that supports filmmakers and scientists. They will integrate what they have learned about lions as they interpret the powerful story in the giant-screen film Roar: Lions of the Kalahari*, of a lion "king" in Africa that must fight the battle of his life against a young nomadic challenger, with the fate of two lionesses and the king's litter of cubs hanging in the balance.*

This activity, which can be adapted for older students, is an accompaniment to the film Roar: Lions of the Kalahari*. Students will watch for specific standards-related information as they view the film. It is recommended that part of this activity be conducted before students see the film to build background and enhance their interest, and the rest conducted after they see the film.*

Information about the film: ***http://www.destinationcinema.com/our_films/roar/roar.asp***

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Connections to the Curriculum:

Geography, life science, earth science, technology, reading/language arts, arts, media

Connections to the National Geography Standards: ***http://www.nationalgeographic.com/xpeditions/standards***

Standard 4: "The physical and human characteristics of places"

Standard 8: "The characteristics and spatial distribution of ecosystems on Earth's surface"

Connections to the National Science Education Standards: ***http://www.nap.edu/readingroom/books/nses/html***

Grades 5–8 Content Standard A. Science as Inquiry: Abilities necessary to do scientific inquiry, Understandings about scientific inquiry

Grades 5–8 Content Standard B. Physical Science: Transfer of energy

Grades 5–8 Content Standard C. Life Science: Structure and function in living systems, Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptations of organisms

Grades 5–8 Content Standard E. Science and Technology: Understandings about science and technology

Grades 5–8 Content Standard F. Science in Personal and Social Perspectives: Personal health, Risks and benefits, Science and technology in society

Grades 5–8 Content Standard G. History and Nature of Science: Nature of science

Time: Will vary; minimum three class hours, plus time for travel to and from the film

Materials Required:

- Computer with Internet access
- Writing materials
- Wall map of Africa or world, or a globe

Photocopies of the following:

- Handout 13: Beliefs About Lions (Handout13Beliefs.pdf)
- Handout 14: A Wildlife Film in the Making (Handout14WildlifeFilm.pdf)
- Handout 15: Worksheet for *Roar: Lions of the Kalahari* (Handout15Worksheet.pdf)
- Handout 16: Physical Characteristics of Lions (Handout16Characteristics.pdf)
- Handout 17: Lion Family Life (Handout17FamilyLife.pdf)
- Handout 18: Hunting and Feeding Behavior (Handout18HuntFeed.pdf)
- Handout 19: The Lion Life Cycle (Handout19LifeCycle.pdf)
- Handout 20: Takeovers (Handout20Takeovers.pdf)
- Map Handout A: Political Outline Map of Africa (MapAOutline.pdf)
- Map Handout C: Physical Map of Africa (MapCPhysical.pdf)
- National Geographic News: Filmmakers Use High-Tech Gear to Stalk Lions: ***http://news.nationalgeographic.com/news/2003/01/0103_030103_lions.html***

Optional: Photocopies of the following:

- Map Handout B: Political Map of Africa (MapBPolitical.pdf)

Objectives:

Students will

- view and discuss a giant-screen film;
- discuss the biological adaptations of structures, physiology, and behaviors that enhance cats' survival and reproductive success;
- relate the unique social behavior of lions to reproduction, hunting, and feeding behavior;
- examine how technology can enable observations of objects and phenomena that are otherwise unobservable;
- analyze how lions' unique social behavior formed the basis for the plot in *Roar: Lions of the Kalahari*; and
- analyze how the physical characteristics of the Kalahari influenced the location and activities of lions and the setting for the film.

Geographic Skills:

- Acquiring Geographic Information
- Analyzing Geographic Information

Suggested Procedure

Opening:

Tell students they will view a giant-screen film, *Roar: Lions of the Kalahari*. Explain that it weaves actual events into a story.

The Big Frame gives an overview of the making of the film:
http://www.destinationcinema.com/our_films/roar/documents/bigframe.pdf (Destination Cinema, Inc.)

The film was shot in Botswana. Give students Map Handout A: Political Outline Map of Africa (MapAOutline.pdf). Ask them to speculate on the locations of Botswana and the Kalahari, and point to those locations on the map. Show students a transparency or give them handouts of Map Handout C: Physical Map of Africa (MapCPhysical.pdf), or other map that indicates Botswana and the Kalahari. (Map C is in color, but can be printed in black and white for students.) How accurate were students' speculations?

Print and distribute Handout 13: Beliefs about Lions (Handout13Beliefs.pdf). Ask students to predict whether each statement will be supported in the film and their study of lions. If they think the statement will be supported, they should mark an X to the left of the statement. When students have finished, read each statement aloud and ask students to raise their hand if they marked the statement. Invite volunteers to explain why they believe the statement to be true and where they acquired the information or belief. Encourage them to elaborate on their knowledge of and experience with lions. Tell them to save the handout.

Explain that in Africa, lions and other big cats occupy the same or similar habitats. Write the two questions below on the chalkboard. Tell students to use these questions to guide their research and viewing of the film (see Assessment section for answers):

- Why did the filmmaker film lions for this story instead of another type of big cat?
- Could the filmmaker have used another type of big cat to tell the story he wanted to tell?

Development:

Note: *Lesson 6 (RoarLesson6.pdf) also includes this activity.*

Build Background for the Film. Use students' responses to Handout 13 and the ensuing discussion to assess their knowledge of and misconceptions about lions. Based on your assessment, you may wish to have students read some or all of Handouts 16–20. The statements on Handout 13 can guide students' reading, as can these three questions, which you may want to write on the chalkboard:

- What structures and behavior set lions apart from other cats?
- How do male lions' lives and behavior change during their lifetimes?
- What must most male lions do in order to mate and reproduce?

Students can read the handouts in groups of five, with each member reading one handout. Each student should then report to the group in one of two ways: 1) Answer the questions that appear the handout; or 2) Write three statements about the handout. After students finish reading and reporting within their groups, discuss the three questions above as a class.

Option: Determine Absolute Location. *If you will not be conducting Lesson 7 (RoarLesson7.pdf), you may wish to have students find the location of the water hole in the film, the only water hole for miles around in "a world of thirst." Filmmaker Tim Liversedge identifies the coordinates of the water hole as approximately 20° south latitude and 25° east longitude (latitude 19° 48' S, longitude 24° 45' E). On a wall map or Map Handout B: Political Map of Africa (MapBPolitical.pdf), have students use these coordinates to mark the location of the water hole, which is in Botswana. Students' locations will be approximate; you may wish to substitute a map with smaller intervals of latitude and longitude. Have students explain why a filmmaker or scientist studying a place or feature that is not marked on a map might want to know its exact latitude and longitude.*

Introduce Handout 14: A Wildlife Film in the Making (Handout14WildlifeFilm.pdf). Much of the footage in *Roar: Lions of the Kalahari* was filmed up close, with the filmmaker standing just feet or sometimes inches away from lions and other large animals. Assign students to read Handout 14. These questions, which appear on the handout, can guide their reading. Discuss these questions when they finish reading.

1. What was the filmmaker's purpose in making *Roar: Lions of the Kalahari*? What does he hope to achieve besides entertainment?
2. What is the theme of the story in the film?
3. What technology did the filmmaker use in making the film? How did technology help solve some of the problems the filmmaker described?
4. What were some of the challenges and hardships of making this film?
5. How did the physical environment make it hard to create the film?
6. Which animals could have put the filmmaker at risk, according to this handout? How did he assess the risks and benefits?
7. What safety precautions did the filmmaker take when working closely with lions?
8. How did the filmmaker combine real events and elements of fiction to create this story?
9. What part did scientists play in the production of the film? What did the production team do when the scientists had different interpretations and conclusions about the footage they watched and the narration?

Introduce Handout 15: Worksheet for *Roar: Lions of the Kalahari* (Handout15Worksheet.pdf). Give each student Handout 15. They should bring the handout to the film. Review each item under "Watch for These!" Students should pay special attention to the map and the aerial views of Africa featured near the beginning of the film; make a record of the different animals that they see; and watch for measurements given in the film and make notes about the tools that would be used to make these measurements.

Then assign different groups, pairs, or individuals to watch for the answers to the standards-based questions below. If more than one question is listed after a number, assign the questions to the same student or group.

1. What physical process created the pans described in the film? (The pans in the film are flat-bottomed depressions in the desert.)
2. What are the physical characteristics and climate of the region in which the water hole is located? How do the physical characteristics make the water hole an excellent territory for the lions? How do the physical characteristics and the climate make it possible to film so many different African animals in one place?
3. What type of information does the narrator communicate using numbers? How else could the information have been shared?
4. What populations of organisms (living things) do you find in the ecosystem surrounding the water hole? How do the populations of this ecosystem change? How do physical processes such as wind and rain influence the changes in populations of organisms? How do physical processes affect the survival of different species?
5. What changes do the elephants make in this environment? Which species are harmed? Which benefit?
6. According to the narrator of the film, which traits will the cubs receive from the genes of their parents?
7. Which behavioral responses shown in the film are likely to be determined by heredity? By experience?
8. Why does the challenger want to take over the water hole?
9. What happens to the cubs at the end? Why?

See the Film.

Discuss the Film. After students have seen the film, allow time for students to report their answers to their assigned questions. Discuss the maps and aerial views in the film as well as the measurements given and the measuring tools that would have been used. What do the aerial views and maps reveal about the environment of the Kalahari? How does the Kalahari environment influence the location of lion habitats and their activities? What animals did they see in the film? How does the physical environment influence how animals live in the Kalahari? Encourage class discussion.

Focus On Technology. After students have seen the film, print and distribute or have students go online to read "Filmmakers Use High-Tech Gear to Stalk Lions." After they read the article, have them discuss the high-tech gear in pairs. What kinds of gear are covered? What does the gear do? Then have them discuss and write their answers to these questions:

- What does the technology allow filmmakers to film that they otherwise could not?
- How could this technology be useful to scientists?

National Geographic News: Filmmakers Use High-Tech Gear to Stalk Lions:
http://news.nationalgeographic.com/news/2003/01/0103_030103_lions.html

Closing:

Encourage students to discuss their reactions to the film, and to imagine what it is like to film such animals and action from so close. Have them analyze the risks Tim Liversedge, the filmmaker, took in filming up close, and weigh them against the benefits. Do they agree with the filmmaker's assessment of the risks and benefits? Encourage volunteers to discuss how they enjoyed viewing the real-life events and footage in the context of the story. Invite them to speculate on the future of the wildlife "characters" in the film.

Refer to Handout 13: Beliefs About Lions (Handout13Beliefs.pdf). Ask students to consider which, if any, of their original responses do not seem to apply to the film content or their research findings. Would they reconsider any of their original responses? Tell them to mark X's to the right of any statements supported by the film or the research. Invite volunteers to explain any changes between their initial and final markings. Ask students to identify statements that may apply some, but not all, of the time. Encourage them to modify all statements so that they are completely accurate. They may do so by adding qualifiers such as *usually*, *sometimes*, or *some*.

Read or paraphrase this language from the National Science Education Content Standard F for grades 5–8: Science in Personal and Social Perspectives: Science and technology in society:

- Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment.
- Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact.

Remind students of the filmmaker's goal to educate the world about the need to protect wildlife and wildlife ecosystems. Ask students to predict how the story and the scientific knowledge in the film might influence the way audiences think about lions, the other animals in the film, and their environments. Do students think the film will make people more determined to protect what remains of those populations and their ecosystems? What other kinds of technology could be used to spread the message about protecting lion populations and their ecosystems? How did the filmmaker's approach to making a giant-screen film advance scientific understanding? In the early 1900s only a few people made motion pictures, which by today's standards were very simple. Keeping the past 100 years in mind, ask students to discuss how technological advances in filmmaking influence their quality of life, how they spend their free time, and the way they socialize.

Suggested Student Assessment:

In one or two paragraphs, ask students to answer these questions:

- Why did the filmmaker film lions for this story instead of another type of big cat?
- Could the filmmaker have used another type of big cat to tell the story he wanted to tell?

Discussion may center on the social behavior and organization that provide the theme, lion succession, as well as on the conflicts in the story (in the main plot, resident male versus nomadic male; and in the subplot, victorious challenger's genetic survival versus survival of the defeated male's cubs). As the only social cats, lions are the only ones about whom such a story could be filmed.

Ask students to generate a list of questions for a quiz about the events and scientific facts presented in the film. Encourage them to write questions about the geographic setting of the film. Questions can examine cause and effect; e.g., "When the Kalahari dried up and heated up, what happened at the water hole?" Questions can compare or contrast; e.g., "Once born into a pride, what lions usually remain within it for life? What lions are driven from a pride?" Choose between 10 and 20 questions from different lists, read them aloud, and assign each a number. Have students write the answers on a sheet of paper and discuss their answers when all the questions have been asked and answered.

Extending the Lesson:

Ask students to make posters advertising *Roar: Lions of the Kalahari* or write a review of it. You may wish to provide sample film reviews from periodicals. Encourage students to share their posters or reviews with the class. Numerous photos are available at Game-Reserve.com: African Wildlife & Landscape Photography Gallery (scroll to the bottom of the screen): ***http://www.game-reserve.com/index.html***.

Invite a representative from a local zoo, natural history museum, or university zoology department to speak to the class and answer their questions about lions, elephants, giraffes, or other animals featured in the film. Encourage students to prepare a list of questions in advance.

The American Zoo and Aquarium Association: ***http://www.aza.org/FindZooAquarium***
American Association of Museums: ***http://www.aam-us.org/resources/reference_library/sitesstate.cfm***

Invite students to use reference books or the Internet to research one or more of the animals featured in the film. Tell them to write and illustrate a report, and put it in the classroom reference section.

Invite students to research opportunities for a career in filmmaking. For example, people working on *Roar: Lions of the Kalahari* included a team of producers, photographers, camera operators, editors, researchers, scientific consultants, sound and visual effects engineers, as well as assistants and clerical or technical support for many aspects of filming and production. Students might begin by investigating job listings for a number of film production companies and related businesses. Have them choose a career and write a brief job description.

Have a group of students go online to learn about Crittercam, an instrument worn by wild animals used to gather information. Ask them to report to the class how Crittercam might be helpful to filmmakers, and to scientists studying wildlife.

National Geographic: Crittercam Chronicles: ***http://www.nationalgeographic.com/crittercam***

Ask pairs of students to write a possible life story of a male cub from the elder lioness's litter. They should write two versions. One partner should write the life story beginning where the film ended. The other should write the story as it might have been had the cubs' father held the pride for four more years. Encourage students to include details such as the physical characteristics and climate of the region and how the changing seasons affect the populations in the ecosystem. Students might look for ideas in Handouts 17, 19, and 20. Call on volunteers to read their stories to the class.

Related Links:

African Lion Working Group
http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html

African Wildlife Foundation
http://www.awf.org

Destination Cinema: *Roar: Lions of the Kalahari*
http://www.destinationcinema.com/our_films/roar/roar.asp

Lion Research Center
http://www.lionresearch.org/main.html

National Geographic: Be the Creature: Lion
http://www.nationalgeographic.com/channel/btc/lions.html

National Geographic: Crittercam Chronicles
http://www.nationalgeographic.com/crittercam

National Geographic: Lion Ghosts of Africa
http://www.nationalgeographic.com/ngkids/0206/ws_main.html

National Geographic News: Female Lions Prefer Dark-Maned Males, Study Finds
http://news.nationalgeographic.com/news/2002/08/0822_020822_TVlion.html

National Geographic News: Filmmakers Use High-Tech Gear to Stalk Lions
http://news.nationalgeographic.com/news/2003/01/0103_030103_lions.html

Natural History Museum of Los Angeles County: Cats! Wild to Mild
http://www.nhm.org/cats/home.html

Oakland Zoo: Africa: African Lion
http://www.oaklandzoo.org/atoz/azlion.html

Species Survival Commission: Cat Specialist Group
http://lynx.uio.no/catfolk

US Geological Survey: Water Science for Schools—The water cycle
http://wwwga.usgs.gov/edu/watercycle.html

Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Activity—A Reason for the Season
http://www.nationalgeographic.com/xpeditions/activities/07/season.html

National Geographic: Xpeditions Lesson—Lions and People: Keeping the Balance
http://www.nationalgeographic.com/xpeditions/lessons/18/g68/cclions.html

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at http://www.destinationcinema.com/our_films/roar/educators.asp

Lesson 6:
Lion Life and Society

The life of lions is a harsh one.

Overview:

In this activity, students will examine biological adaptations of structures, physiology, and behaviors in cats. They will focus on the anatomy and physiology of lions, as well as on their social, reproductive, hunting, and feeding behaviors. Then they will compare these elements with those of cheetahs, and of cats in general. Finally, they will integrate what they have learned about lions into the powerful story of a lion "king" that must fight the battle of his life against a young nomadic challenger, with the fate of two lionesses and the king's litter of cubs hanging in the balance.

This activity, which can be adapted for different ages, abilities, and instructional goals, is a good accompaniment to the giant-screen film Roar: Lions of the Kalahari. *This activity can be conducted before or after students see the film; however, it is not necessary that students see the film to implement the activity.*

Information about the film: ***http://www.destinationcinema.com/our_films/roar/roar.asp***

Connections to the Curriculum: Geography, life science, reading/language arts

Connections to the National Geography Standards: ***http://www.nationalgeographic.com/xpeditions/standards***

Standard 1: "How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective"

Connections to the National Science Education Standards: ***http://www.nap.edu/readingroom/books/nses/html***

Grades 5–8 Content Standard A. Science as Inquiry: Abilities necessary to do scientific inquiry

Grades 5–8 Content Standard B. Physical Science: Transfer of energy

Grades 5–8 Content Standard C. Life Science: Structure and function in living systems, Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptations of organisms

Grades 5–8 Content Standard D. Earth and Space Science: Earth's history

Time: Will vary; minimum two class hours

Materials Required:

- Computer with Internet access
- Writing materials

Photocopies of the following:

- Handout 16: Physical Characteristics of Lions (Handout16Characteristics.pdf)
- Handout 17: Lion Family Life (Handout17FamilyLife.pdf)
- Handout 18: Hunting and Feeding Behavior (Handout18HuntFeed.pdf)
- Handout 19: The Lion Life Cycle (Handout19LifeCycle.pdf)

- Handout 20: Takeovers (Handout20Takeovers.pdf)
- Map Handout B: Political Map of Africa (MapBPolitical.pdf)
- Map Handout F: Lion Habitats and Range of Cheetahs (MapFLionsCheetahs.pdf)

If students don't have Internet access, photocopies of the following:

- African Wildlife Foundation fact sheet: Lions: ***http://www.awf.org/wildlives/148***
- African Wildlife Foundation fact sheet: Cheetahs: ***http://www.awf.org/wildlives/65***
- African Lion Working Group: About lions, ecology and behavior (click "About lions," then "Ecology and Behavior"): ***http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html***
- **Color** printouts or transparency of Natural Vegetation in Africa Map: ***http://library.berkeley.edu/EART/maps/africa-veg.gif*** (University of California, Berkeley)

Note: *Handouts or a transparency of this map* ***must*** *be in color.*

Optional: Photocopies of the following:

- Handout 13: Beliefs About Lions (Handout13Beliefs.pdf)

Objectives:

Students will

- read and discuss fact sheets, student handouts, and Web documents to better understand lions and other cats;
- examine the biological adaptations in structures, behaviors, and physiology that enhance cats' survival and reproductive success;
- study the anatomy and physiology of lions and cats;
- relate the unique social behavior of lions to reproduction, hunting, and feeding behavior;
- compare and contrast lions with cheetahs;
- compare and contrast the spatial distribution of lions and cheetahs by observing maps; and
- if students have seen the film *Roar: Lions of the Kalahari,* discuss how lions' unique social behavior formed the basis for the film's plot.

Geographic Skills:

- Asking Geographic Questions
- Analyzing Geographic Information
- Answering Geographic Questions

Suggested Procedure

Opening:

STEP 1

If you have conducted Lesson 5, proceed to the next step. If not, print and distribute Handout 13: Beliefs about Lions. Ask students to predict whether or not each statement will be supported in this lesson. If they think the statement will be supported, they should mark an X to the left of the statement. Read each statement aloud and ask students to raise their hand if they marked the statement. Invite volunteers to explain why they believe the statement to be true and where they acquired the information or belief. Tell them to save the handout.

STEP 2

If students have seen the giant-screen film *Roar: Lions of the Kalahari*, call on volunteers to summarize the plot, including the major conflict.

If students have **not** seen the film, read aloud this summary:

> As the film opens, a giant male lion and two lionesses make up a pride. Their territory centers on an unnamed water hole in the dry Kalahari. Another male prowls the outer the edges of the pride territory. He is nomadic, meaning he has no permanent home. The nomadic male would like to make this territory his home and this pride his own. From a distance, he is "roaring" his challenge to the pride male. The pride male is roaring back, keeping him away. A few months later the elder lioness gives birth to cubs. The nomadic male lurks at the edges of the territory, moving into the territory. If the nomadic male finds the cubs, he will kill them. When the cubs are a little older, the two males fight. The pride male holds his territory—for the time being.

Stop here if students will view the film. Otherwise, read to the end.

> Later in the film, the nomadic male challenges and defeats the pride male. The younger lioness mates with the new pride male. The older female and her cubs leave their territory to avoid the new male, who will kill the cubs if he finds them.

STEP 3

If you have **not** conducted Lesson 5 (RoarLesson5.pdf), tell students that they will decide why the filmmaker filmed lions for this story instead of another type of big cat, and if he could have used another type of big cat to tell the story he wanted to tell. These and other questions will guide their readings and investigations (see Closing for answers). (***Note:*** *If students examined similar questions in Lesson 5, they can revisit them in light of the comprehensive detail they will acquire in this lesson.*)

If students will not see the film, the online feature "Be the Creature: Lion" is a good introduction to lions. National Geographic: Be the Creature: Lion: ***http://www.nationalgeographic.com/channel/btc/lions.html***

Development:

Compare Habitats. Point out to students that lions share habitats with other big cats. Give students Map Handout B: Political Map of Africa (MapBPolitical.pdf). Ask them to speculate where lions and cheetahs might be located, then shade in those areas on the map. Then give them Map Handout F: Lion Habitats and Range of Cheetahs (MapFLionsCheetahs.pdf). (Map F is in color, but handouts or a transparency can be in black and white.) Have students compare their maps of predicted locations with the actual locations. How accurate were their predictions? Ask them to compare the two range maps with each other, and with their own maps. As a class, compare the maps, noting the similarities and differences in the spatial distribution. Tell students that later they will compare lions and cheetahs.

Option: *Have students compare the spatial distributions of lions and cheetahs with the Natural Vegetation in Africa Map. Ask students how the natural environment might influence the location and activities of lions and cheetahs. Handouts or a transparency of this map* ***must*** *be in color.*

University of California, Berkeley: Natural Vegetation in Africa Map:
http://library.berkeley.edu/EART/maps/africa-veg.gif

Investigate Diversity and Adaptations of Organisms. Have students read and take notes on "Cats: Plans for Perfection" in groups, pairs, or individually. (If students don't have Internet access, educators can choose some, or all, of this feature and print those pages for students.) Tell them to pay particular attention to adaptations and structures (body parts) that enhance cats' survival as predators. Ask them to study each feature of physiology (skeleton, muscles, coat) from the main menu, and note any features that apply specifically to cheetahs or sabertooths. Then review each element of behavior, noting elements that apply specifically to lions or sabertooths. Tell each group to write one or two descriptive statements about each structure (skull, claw, spine, teeth, etc.) and behavior, paying particular attention to the survival value of the adaptive features and comparisons with the ancestor, the sabertooth. Students should save their notes.

National Geographic: Cats: Plans for Perfection: ***http://www.nationalgeographic.com/cats/index.html***

As a class, discuss these standards-based questions:

- What adaptations and structures (body parts) help cats survive as predators?
- What lion behavior enhances their survival as predators?
- What features set lions apart from other cats?
- What cats are now extinct? How do fossils such as bones help scientists learn about them?

Ask students to consider how much knowledge about saber-toothed cats might have been derived from fossils, how much from observation of modern day cats, and how much from educated guesswork. Call on a few volunteers to role-play scientists explaining how they formed their theories about sabertooths, their characteristics, and their behavior. Encourage classmates to ask questions.

Research Using Handouts 16–20. Have students work in groups of five. Give each group one copy each of handouts 16, 17, 18, 19, and 20. Each group member should receive one handout. If a group has four members, the first student to finish reading should read the extra handout. If a group has six members, have two students read Handout 16. *(**Option:** If you extend the lesson over several days, each student can study each handout.)* You may wish to pair English language learners or challenged readers with proficient, English-dominant readers to work on one topic. The standards-based questions listed on the handouts (and on the final page of this lesson) can guide student reading and/or be used for later assessment.

Tell students to read the handouts and take notes. They may organize their notes in several ways:

— Use the questions on the handouts.

— For Handouts 16, 17, and 18, use graphic organizers such as main idea detail webs. The Graphic Organizer contains samples of webbing organizers: ***http://www.graphic.org/goindex.html***.

— For Handouts 19 and 20, use sequence flow charts; for samples of flow charts go to The Graphic Organizer: ***http://www.graphic.org/bstring.html***.

Have each student write three key sentences that capture the essence of their handout and then share their sentences with their group. They will note some overlap in content, because physical structures and family life influence hunting and feeding behavior, takeovers influence family life, and so forth. Ask students to consider and discuss elements of lion behavior they believe to be common to all big cats in Africa, and those that are unique because of lions' social behavior and organization.

Compare and Contrast Lions and Cheetahs. For research, print out facts sheets or have students review online:

- African Wildlife Foundation fact sheet: Lions: ***http://www.awf.org/wildlives/148***
- African Wildlife Foundation fact sheet: Cheetahs: ***http://www.awf.org/wildlives/65***
- African Lion Working Group: About lions, ecology and behavior (click "About lions," then "Ecology and Behavior"): ***http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html***
- **Color** Natural Vegetation in Africa Map: ***http://library.berkeley.edu/EART/maps/africa-veg.gif*** (University of California, Berkeley)

  Note: *Handouts or a transparency of this map* ***must*** *be in color.*

Students with online access can review:

- National Geographic: Be the Creature: Lion: ***http://www.nationalgeographic.com/channel/btc/lions.html***
- National Geographic Creature Feature: Cheetahs: ***http://www.nationalgeographic.com/kids/creature_feature/0003/cheetah.html***

Students should also refer to notes they took while reading "Cats: Plans for Perfection." Elements to compare or contrast include: manes, hunting and feeding behaviors, family life, top speeds, vocalization, and any structure associated with behaviors or capabilities. After their research, each group should make a table, Venn diagram (with illustrations or photographs, if desired), or illustrate in another way (a) the similarities between the two species; (b) the differences between the two species; and (c) the factors that make the two species different. Students can find good models for contrasting/comparing matrices at The Graphic Organizer: ***http://www.graphic.org/goindex.html***.

Closing:

If students marked Handout 13 (Handout13Beliefs.pdf) for this lesson, refer to it. Ask students to consider which, if any, of their original responses do not seem to apply to their research findings. Would they reconsider any of their original responses? Tell them to mark X's to the right of any statements they found supported by the research. Read each statement aloud, and ask students to raise their hand if they marked the statement. Invite volunteers to explain any changes between their initial and final markings. Ask students to identify statements that apply some, but not all, of the time. Encourage them to modify all statements so that they are completely accurate. They may do so by adding qualifiers such as *usually*, *sometimes*, or *some*.

Refer to the opening discussion about what would guide students' research. Then pose these questions again:

- Why did the filmmaker film lions for this story instead of another type of big cat?
- Could he have used another type of big cat to tell the story he wanted to tell?

Discussion may center on the social behavior and organization that provide the theme, lion succession, as well as on the conflicts in the story (in the main plot, resident male versus nomadic male; and in the subplot, victorious challenger's genetic survival versus survival of the defeated male's cubs). As the only social cats, lions are the only ones about whom such a story could be filmed.

Encourage groups to share and discuss their comparisons of lions and cheetahs. They may wish to modify their own comparisons after discussion with other groups.

Suggested Student Assessment:

Ask students to reflect on the handouts and online materials to generate a list of lions' structures, and of the capabilities and behaviors that lions share with all cats. Then have them list the capabilities and behaviors that set them apart from other cats.

Have students write brief answers to the questions on the handouts, then pair up and discuss their answers.

Extending the Lesson:

Ask volunteers to create a lion poster for the classroom, with a large illustration of a lion. Suggest that they label body parts and include interesting information about the parts. Ask them to list interesting facts about lions on the poster.

Invite students to research career opportunities studying, working with, or supporting survival of lions, big cats, or other wildlife. Suggest that they research sites of zoos, universities with zoology departments, natural history museums, and schools of veterinary medicine. Ask them to summarize their findings in a brief oral report. Examples of organizations that support wildlife include:

- Born Free Foundation: ***http://www.bornfree.org.uk/index.shtml*** (United Kingdom)
- Conservation International: ***http://www.conservation.org***
- Defenders of Wildlife: ***http://www.defenders.org***
- Wildlife Conservation Research Unit: ***http://www.wildcru.org***
- Wildlife Conservation Society: ***http://wcs.org***
- World Wildlife Fund: ***http://www.worldwildlife.org***

Encourage students to use reference books, encyclopedias, and the Internet to research further lion topics of interest. Examples might include maneless males, what scientists think about the function of a mane, how scientists explain the role of takeovers in maintaining genetic diversity, or how the lives of lions in zoos or wild animal parks differ from those of their counterparts in the wild. Suggest that they publish their reports on a computer, with illustrations if possible. Some Web sites listed at the end of this lesson include printable photos or visuals. Make the reports available in the classroom library.

Ask students to write a "biography" of a real female or male lion in the wild. Have them brainstorm in groups the various possible life courses and events for males and females. Then have them work individually to write the life stories.

Related Links:

African Lion Working Group
http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html

Destination Cinema: *Roar: Lions of the Kalahari*
http://www.destinationcinema.com/our_films/roar/roar.asp

Lion Research Center
http://www.lionresearch.org/main.html

National Geographic: Be the Creature: Lion
http://www.nationalgeographic.com/channel/btc/lions.html

National Geographic: Cats: Plans for Perfection
http://www.nationalgeographic.com/cats/index.html

National Geographic Creature Feature: Cheetahs
http://www.nationalgeographic.com/kids/creature_feature/0003/cheetah.html

National Geographic: Lion Ghosts of Africa
http://www.nationalgeographic.com/ngkids/0206/ws_main.html

National Geographic News: Are Maneless Tsavo Lions Prone to Male Pattern Baldness?
http://news.nationalgeographic.com/news/2002/04/0412_020412_TVtsavolions.html

National Geographic News: Female Lions Prefer Dark-Maned Males, Study Finds
http://news.nationalgeographic.com/news/2002/08/0822_020822_TVlion.html

Natural History Museum of Los Angeles County: Cats! Wild to Mild
http://www.nhm.org/cats/home.html

Oakland Zoo: Africa: African Lion
http://www.oaklandzoo.org/atoz/azlion.html

PBS NATURE: Intimate Enemies
http://www.pbs.org/wnet/nature/enemies

Species Survival Commission: Cat Specialist Group
http://lynx.uio.no/catfolk

Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Lesson—Dugongs, Elephants, and Evolution
http://www.nationalgeographic.com/xpeditions/lessons/08/g68/ccdugong.html

National Geographic: Xpeditions Lesson—Lions and People: Keeping the Balance
http://www.nationalgeographic.com/xpeditions/lessons/18/g68/cclions.html

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Questions to Guide and Assess Reading and Understanding of Handouts 16, 17, 18, 19, and 20

Handout 16: Physical Characteristics of Lions

1. Which organ helps make cats good night hunters? How does its structure help a cat hunt at night?
2. What happens to light after it enters the eye of a lion or other cat?
3. Through adaptation over time, a species develops many structures and behaviors that improve its survival. What structures and behaviors make lions good hunters and fighters?
4. Besides their size, what makes adult male lions look different from other adult male cats?
5. Which structures make lions able to roar?

Handout 17: Lion Family Life

1. What behavior sets lions apart from all other cats?
2. What is a pride? What is a coalition?
3. Over a lifetime, how does the family life of most female lions differ from the family life of most male lions?
4. In most prides, how do males and females usually contribute to the pride's survival?
5. How does living in a pride help the survival of its members?

Handout 18: Hunting and Feeding Behavior

1. In a pride, which members do most of the hunting? How does social behavior make it easier for individual lions to obtain food?
2. Besides hunting, what behaviors do lions use to obtain food?
3. According to Tim Liversedge, how have the lions in Roar: Lions of the Kalahari adapted their hunting behavior to the environment near the water hole?
4. How do lion experts explain the reason most lion hunts fail?
5. In what order do pride members usually feed? How does this order affect cub survival?

Handout 19: The Lion Life Cycle

1. List some male behavior, female behavior, and details of pride organization, and explain how each serves reproduction goals.
2. What happens when a lioness comes into estrus?
3. How do females in large prides raise their cubs?
4. How would you describe the social behavior of young males after they leave their prides of birth?
5. At about what age can lions start breeding?

Handout 20: Takeovers

1. Which members of a pride are temporary, and which are usually permanent?
2. What lion behavior is explained by the urge of each lion to survive through its genes?
3. What must nomadic males do in order to join a pride?
4. Why do victorious males kill cubs after a takeover?
5. How does the urge to survive through genes pit males against females at times?
6. "There is safety in numbers." How do the facts in this handout support that statement?

Lesson 7:
The Kalahari: A Vast Thirstland

The inexperienced young lioness tries her luck with a giraffe.

Overview:

The narrator of the giant-screen film Roar: Lions of the Kalahari *describes the water hole in Botswana featured in the film as "a precious pearl of water in a world of thirst." In this activity, students will study the geography and climate of this world of thirst—the Kalahari. They will use maps to acquire and report information about the location and characteristics of places in the region. With the understanding that landforms are the result of a combination of constructive and destructive forces, they will learn how physical processes have shaped patterns in the physical environment of the Kalahari and produced changes in its ecosystems, transforming parts of it into a "thirstland." They will focus on the smaller region in which lies the water hole featured in* Roar: Lions of the Kalahari*. In addition, they will compare the Kalahari with another African lion habitat.*

This activity, which can be adapted for older students, is a good accompaniment to the giant-screen film Roar: Lions of the Kalahari*. It is suggested that this activity be conducted after students see the film; however, it is not necessary that students see the film to conduct this activity.*

Information about the film: ***http://www.destinationcinema.com/our_films/roar/roar.asp***

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Connections to the Curriculum: Geography, economics, life science, earth science, reading/language arts

Connections to the National Geography Standards: ***http://www.nationalgeographic.com/xpeditions/standards***

Standard 1: "How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective"

Standard 4: "The physical and human characteristics of places"

Standard 5: "That people create regions to interpret Earth's complexity"

Standard 7: "The physical processes that shape the patterns of Earth's surface"

*Standard 11: "The patterns and networks of economic interdependence on Earth's surface"

Standard 14: "How human actions modify the physical environment"

Standard 15: "How physical systems affect human systems"

*Standard 16: "The changes that occur in the meaning, use, distribution, and importance of resources"

Standard 18: "How to apply geography to interpret the present and plan for the future"

**Note:* *Standard is connected to an activity under "Extending the Lesson."*

Connections to the National Science Education Standards: ***http://www.nap.edu/readingroom/books/nses/html***

Grades 5–8 Content Standard C. Life Science: Populations and ecosystems

Grades 5–8 Content Standard D. Earth and Space Science: Structure of the earth system, Earth's history, Earth in the solar system

Time: Will vary; minimum two class hours

Materials Required:

- Computer with Internet access
- Print or online dictionary
- Writing materials

Photocopies of the following:

- Handout 21: Food Chains in an Ecosystem (Handout21FoodChains.pdf)
- Handout 22: The Kalahari: The Great African Thirstland (Handout22Thirstland.pdf)
- Map Handout B: Political Map of Africa (MapBPolitical.pdf)
- Map Handout C: Physical Map of Africa (MapCPhysical.pdf)
- Map Handout E: Annual Precipitation in Africa (Average) (color) (MapEPrecipitation.pdf)

Note: *Handouts or a transparency of Map E* ***must*** *be in color.*

Objectives:

Students will

- observe maps to determine the location of the Kalahari, as well as acquire and report information about its characteristics;
- use latitude and longitude coordinates to determine the absolute location of an unmarked water hole in the Kalahari;
- read, discuss, and analyze information in student handouts and National Geographic fact sheets to better understand the Kalahari;
- compare and contrast two African lion habitats; and
- draw a food chain that could exist in the Kalahari or in another habitat.

Geographic Skills:

- Organizing Geographic Information
- Analyzing Geographic Information
- Answering Geographic Questions

Suggested Procedure

Opening:

Note: *This opening may vary, depending on whether students have seen the giant-screen film* Roar: Lions of the Kalahari.

Ask students how they define a desert. Students may be surprised to know that even experts can't always agree how to define a desert. Deserts receive very little rainfall—usually as little as 10 inches (25 millimeters) a year. Briefly discuss different kinds of deserts. (Educators can find background information at Nationmaster.com: Encyclopedia: Deserts: ***http://www.nationmaster.com/encyclopedia/Desert***.)

• If students have seen the film *Roar: Lions of the Kalahari*, ask them if they consider the area surrounding the water hole to be a desert. Tell them they will revisit this question after the lesson.

• If students have not seen the film, you may wish to display photos of dry savanna areas in the Kalahari or elsewhere from reference books or some of the Web sites at the end of this lesson. Ask students if they consider the pictured areas to be desert. They will revisit this question.

Draw a Know, Want to Know, and Learned (KWL) chart on the chalkboard or on a transparency. Ask students what they know about the Kalahari and lion habitats in general from the film, photographs, or other sources. Write their responses under Know. What questions do they have about the Kalahari? List their responses under Want to Know. Leave the Learned column blank. Save the list.

Development:

Introduce Food Chains, Populations, and Ecosystems. To prepare students for study of the African ecosystems, distribute copies of Handout 21: Food Chains in an Ecosystem (Handout21FoodChains.pdf). Have students read the first page of the handout for background. (They will do the activity later.) After they have read the handout, ask what would happen to an ecosystem if one of the elements in an important food chain were removed. For example, if no grass grew what would happen to grazing animals? If the number of grazing animals increases what happens to the grass? How might these changes affect predators? Tell them to keep the food chain in mind as they make notes about which animals eat which plants, and which animals different predators eat. Save the handout.

Locate the Kalahari. If you have conducted Lesson 5 (RoarLesson5.pdf) ask volunteers to point to the Kalahari on a map. If not, give students Map Handout B: Political Map of Africa (MapBPolitical.pdf). Ask them to speculate on the location of the Kalahari and point to it on the map. Then give students Handout 22: The Kalahari: The Great African Thirstland (Handout22Thirstland.pdf), and ask them to read the first three paragraphs. Give students handouts of Map Handout C: Physical Map of Africa (MapCPhysical.pdf), which indicates the Kalahari. (Map C is in color, but can be printed in black-and-white for students.) How accurate were students' speculations?

Compare Regional Precipitation Patterns. If students don't have Internet access, give them a **color** handout or show a **color** transparency of Map Handout E: Annual Precipitation in Africa (Average) (MapEPrecipitation.pdf). Ask students to observe the map and its key. They will see that most of the Kalahari receives less rainfall than most of the areas northeast of it.

Analyze the Physical and Human Characteristics of the Kalahari. Students will compare the ecosystems of two African lion habitats. Have students read all of Handout 22: The Kalahari: The Great African Thirstland (Handout22Thirstland.pdf). Encourage students to refer to Map Handout B: Political Map of Africa (MapBPolitical.pdf) and Map Handout C: Physical Map of Africa (MapCPhysical.pdf) as they read about the boundaries of the Kalahari and its location relative to the Indian Ocean. These standards-based questions, which are on the handout, can guide student reading. Discuss these questions when students finish reading.

1. What is the relationship between the Mega Kalahari and the region called the Kalahari Desert?
2. Which governments have control over and responsibility for the ecosystems of the Kalahari?
3. What season is it in the United States when summer comes to the Kalahari?
4. How does the Earth's revolution around the sun affect seasons in the Kalahari and the U.S.?
5. How did physical processes affect the ecosystems of the Kalahari?
6. How does the location of the Kalahari affect its climate?
7. What is a pan?
8. How do the pans change with the seasons?
9. Where is the water hole featured in the film *Roar: Lions of the Kalahari*?
10. How does the handout describe the area surrounding the water hole?
11. How do the lions at the water hole benefit from the dry season?
12. What human migrations have occurred in the Kalahari?
13. How have human migrations affected the characteristics of the Kalahari "thirstland"?

Note: *If students need more work on latitude and longitude, you may refer them to "From Stargazers to Starships: Latitude and Longitude":* ***http://pwg.gsfc.nasa.gov/stargaze/Slatlong.htm*** *or conduct the National Geographic Xpeditions lesson "Latitude, Longitude, and Mapmaking":* ***http://www.nationalgeographic.com/xpeditions/lessons/01/g68/mapmaking.html***.

Determine Absolute Location. Explain that the film *Roar: Lions of the Kalahari* was filmed at a water hole in the Kalahari "thirstland." Filmmaker Tim Liversedge identifies the coordinates of the water hole in the film as approximately 20° south latitude and 25° east longitude (latitude 19° 48' S, longitude 24° 45' E). Have students use these coordinates to mark the location of the water hole, which is located in Botswana, on Map Handout B: Political Map of Africa. Students' locations will be approximate; you may wish to substitute a map with smaller intervals of latitude and longitude. *(**Option**: You or a student can customize a map of southern Africa at Online Map Creation:* ***http://www.aquarius.geomar.de/omc/make_map.html***.) Have students explain why a filmmaker or scientist studying a place or feature that is not marked on a map might want to know its exact latitude and longitude.

Note: *If you will conduct Lesson 8 (RoarLesson8.pdf), ask students to save their comparisons of the two ecosystems, and to take and save notes on the discussion of the ecosystems, in the Closing.*

Compare Characteristics of Two Regions. Students will work in pairs to compare the two African lion habitats: the Kalahari xeric savanna, in Botswana, and the Northern Acacia-Commiphora bushlands and thickets, in Kenya. Each partner will research one habitat, using online ecoregion profiles at "National Geographic Wild World: Terrestrial Ecoregions of the World": ***http://www.nationalgeographic.com/wildworld/terrestrial.html***.

Follow these directions to find information about the habitats:

• Kalahari xeric savanna. In "Find an Ecoregion" type "**AT1309**" and click "Go." In the pop-up, click on the result; a map will appear. On the map, place the cursor directly over AT1309 and click. The ecoregion profile will appear in a pop-up.

• Northern Acacia-Commiphora bushlands and thickets. In "Find an Ecoregion" type "**AT0711**" and click "Go." In the pop-up, click on the result; a map will appear. On the map, AT0711 is directly over Nairobi in a dark green and pink area. Place the cursor over the numerals "11" in AT0711 and click. The profile for ecoregion AT0711 will appear in a pop-up.

Explain that a Commiphora is a type of tree or shrub. Have students look up *acacia*, *xeric*, and *savanna* in a dictionary. After their research, students should explain why the term *xeric* might be applied to the Kalahari savanna. Students should read the summaries; older or more capable students may access the full reports. Suggest that as students read, they make notes about the following:

• The shape of the land and landforms

• The plant life, plant eaters, and predators described

• How human activity influences changes in these ecosystems

• How human activities have introduced hazards to lions through land-use decisions

• How wild animals make changes in these ecosystems

• Examples of animals that browse, or feed on leaves and branches of trees and bushes

• Examples of wildlife at risk

• Facts about this understanding, from National Geography Standard 15: How the characteristics of different physical environments provide opportunities for or place restrictions on human activities.

Have partners share their findings, then compare the two habitats, either in writing or visually with a graphic organizer such as a Venn diagram. For the comparisons they can also draw on information from the film *Roar: Lions of the Kalahari*, and Handout 22. Older or more capable students who have read the full reports may wish to use a visual aid such as a comparison matrix (The Graphic Organizer depicts such a matrix: ***http://www.graphic.org/commat.html***).

Closing:

Ask students again if they consider the area surrounding the water hole, or the area in the photographs, to be desert. Encourage them to explain their answers.

Refer to the KWL chart you began in opening this lesson. Have students evaluate the details they listed under Know, modifying as appropriate. Then have them suggest details for the Learned column. Finally, ask them which of their questions were or were not answered. Note the unanswered questions as topics for possible further research.

Call on volunteers to share their comparisons of the two lion habitats: the Kalahari xeric savanna and the Northern Acacia-Commiphora bushlands and thickets. Lead a discussion about the changes grazing cattle or wild animals

have made in the two local ecosystems. Ask students how changes in the balance of local plant life might affect populations of wild grazing animals. Encourage students to compare or contrast the likely effects of these changes for animals that browse, or feed on leaves and branches of trees and bushes, rather than grazing on grasses. Ask for examples of browsing animals. Finally, ask how changes made by cattle might affect lion populations through changes in the food web.

Call on volunteers to report how the population of elephants affects an ecosystem. Ask students how populations of other browsing or grazing wild animals can change ecosystems in their local area.

If students have seen the giant-screen film *Roar: Lions of the Kalahari*, ask them how the physical characteristics, geography, and climate of the region made the water hole an excellent territory for the lions. Ask also how these characteristics made it possible to film so many different African animals in one place.

Suggested Student Assessments:

Refer students to Handout 21: Food Chains in an Ecosystem (Handout21FoodChains.pdf). Ask them to follow the directions on the second page of the handout. Tell them to choose organisms that could be part of a real-life food chain in one of the ecosystems they compared. The organisms chosen should all be present in one ecosystem, the plant eaters they use in the chain should be the ones that eat the plants they have chosen, and the predator should be one that will eat the plant eater. Label each organism. What would happen if one element of their food chain disappears? What might the impact be? In addition, you might have students describe factors that help determine the lion's place in the food chain, or ask how understanding the food chain explains something about lion behavior.

Have students list the geographic features and climate that characterize the region known as the Kalahari Desert or Thirstland. Then have them list ways activity by humans and wildlife can and does change these characteristics.

Extending the Lesson:

Encourage students to research and write a short report about another ecosystem of interest to them. The report should include the ecosystem's wildlife, and address any threats to the ecosystem. Encourage students to print out maps and photographs to include with their reports, or make their own maps. Make the reports available in the classroom library.

Encourage students to research and write a report about the San or one of the other peoples of the Kalahari. Suggest that they describe their traditional way of life and compare and contrast it with modern day life in the Kalahari. Students can learn about the San online at "Arts & Life in Africa": ***http://www.uiowa.edu/~africart/toc/people/San.html***. (The University of Iowa)

Ask students to create travel posters or brochures encouraging tourists to visit the Kalahari. They can use information from the handouts, the "National Geographic Wild World" fact sheets, and the Internet, including Web sites under Related Links. If students search for "Kalahari," they will find many examples of advertisements at travel or safari sites, as well as many photos. Students can find compelling photographs of lions at Nature-Wildlife Lion Photography Gallery: ***http://www.nature-wildlife.com/lion0.html***.

Invite a group to research and prepare a report about the mineral resources of Botswana and the Kalahari and how they influence the economy, national and world trade, and the lives of the people. One member might research diamonds, another nickel, another copper and other mineral resources. Each student should write one or two paragraphs in a word-processing document; one member should incorporate all the paragraphs into the report. The report could include maps showing the locations of resources and their distribution routes. Ask the group to report its findings to the class.

Related Links:

Department of Tourism of Botswana: Botswana Tourism
http://www.botswana-tourism.gov.bw

Destination Cinema: *Roar: Lions of the Kalahari*
http://www.destinationcinema.com/our_films/roar/roar.asp

Game-Reserve.com
http://www.game-reserve.com

Kalahari Conservation Society News Letter
http://www.delin.org/kalahari

Kalahari Peoples Fund
http://www.kalaharipeoples.org

National Geographic: *Geography Action!* Habitats: Home Sweet Home: Deserts and Tundra
http://www.nationalgeographic.com/geographyaction/habitats/deserts_tundra.html

National Geographic: *Geography Action!* Habitats: Home Sweet Home: Prairies
http://www.nationalgeographic.com/geographyaction/habitats/prairies.html

National Geographic: Maps and Geography
http://www.nationalgeographic.com/maps

National Geographic: Okavango: Africa's Savage Oasis
http://www.nationalgeographic.com/okavango/index.html

National Geographic Wild World: Terrestrial Ecoregions of the World
http://www.nationalgeographic.com/wildworld/terrestrial.html

University of California-Berkeley: Natural Vegetation in Africa Map
http://library.berkeley.edu/EART/maps/africa-veg.gif

US Geological Survey: Water Science for Schools—The water cycle
http://wwwga.usgs.gov/edu/watercycle.html

Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Activity—A Reason For the Season
http://www.nationalgeographic.com/xpeditions/activities/07/season.html

National Geographic: Xpeditions Lesson—Latitude, Longitude, and Mapmaking
http://www.nationalgeographic.com/xpeditions/lessons/01/g68/mapmaking.html

National Geographic: Xpeditions Lesson—Geography and Your Dream Job
http://www.nationalgeographic.com/xpeditions/lessons/18/g68/careers.html

National Geographic: Xpeditions Lesson—Spatial Organization: Identification of Functional Regions
http://www.nationalgeographic.com/xpeditions/lessons/05/g68/regions.html

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Lesson 8:

African Lion Populations and Ecosystems in Trouble

Tim Liversedge and his assistant, Bata, wait for the male lion to move. During filming, the lions came close to the filmmakers of their own free will.

Overview:

In this activity, students will investigate an alarming drop in African lion populations. After they gain a better understanding of how changing populations change an ecosystem, they will consider the possible endangerment and extinction of species when environments change. Specifically, they will examine the effect of growing human population and activity on lion populations in Africa. They will focus primarily on studies in two geographic areas. One is in Kenya outside of the national park system, and another is in and near a national park in the Kalahari, not far from the water hole featured in the giant-screen film Roar: Lions of the Kalahari. *Students will gather information about the conflicting survival needs of human and lion populations and how a balance might be attained. They will consider how human activity in the Kalahari might potentially affect lions like the characters in the film.*

This activity, which can be adapted for older students, is a good accompaniment to the giant-screen film Roar: Lions of the Kalahari. *It is suggested that this activity be conducted after students see the film; however, it is not necessary that students see the film to conduct this activity.*

Information about the film: ***http://www.destinationcinema.com/our_films/roar/roar.asp***

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Connections to the Curriculum: Geography, life science, earth science, technology, reading/language arts, economics, government/civics

Connections to the National Geography Standards: ***http://www.nationalgeographic.com/xpeditions/standards***

Standard 1: "How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective"

Standard 3: "How to analyze the spatial organization of people, places, and environments on Earth's surface"

Standard 4: "The physical and human characteristics of places"

Standard 6: "How culture and experience influence people's perceptions of places and regions"

Standard 8: "The characteristics and spatial distribution of ecosystems on Earth's surface"

Standard 13: "How the forces of cooperation and conflict among people influence the division and control of Earth's surface"

Standard 14: "How human actions modify the physical environment"

Standard 18: "How to apply geography to interpret the present and plan for the future"

Connections to the National Science Education Standards: ***http://www.nap.edu/readingroom/books/nses/html***

Grades 5–8 Content Standard A. Science as Inquiry: Understandings about scientific inquiry

Grades 5–8 Content Standard C. Life Science: Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptations of organisms

Grades 5–8 Content Standard E. Science and Technology: Understandings about science and technology

Grades 5–8 Content Standard F. Science in Personal and Social Perspectives: Risks and benefits, Science and technology in society

Grades 5–8 Content Standard G. History and Nature of Science: Science as a human endeavor, Nature of science

Time: Will vary; two to three class hours minimum

Materials Required:

- Computer with Internet access
- Writing materials
- Paper or computer program for constructing graphic organizers
- Wall map of Africa or the world, or a globe

Photocopies of the following:

- Handout 23: Lions and Livestock: Can Scientists Save Both? (Handout23Livestock.pdf)
- Map Handout A Political Outline Map of Africa (MapAOutline.pdf)
- Map Handout C: Physical Map of Africa (MapCPhysical.pdf)
- Map Handout D: Land Use in Africa (color) (MapDLandUse.pdf)

  Note: *Handouts or a transparency of Map D* ***must*** *be in color.*

If students don't have access to the Internet, photocopies of the following:

- African Lion Working Group: Map of past and present ranges of lions (select "About lions," then "Conservation issues"): ***http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html***
- National Geographic News: "Lions Vs. Farmers: Peace Possible?" ***http://news.nationalgeographic.com/news/2003/07/0716_030716_lions.html***
- National Geographic News: "Revenge Killings: African Farmers Massacre Lions" ***http://news.nationalgeographic.com/news/2004/02/0210_040210_TVlionmystery.html***

Optional: Photocopies of the following:

- Handout 22: The Kalahari: The Great African Thirstland (Handout22Thirstland.pdf)
  Note: *If students have not completed Lesson 7 (RoarLesson7.pdf) you may wish to have them skim Handout 22.*

Objectives:

Students will

- investigate threats to African lion populations;
- observe maps and discuss the tensions that might arise when lions live near human settlements;
- read and discuss National Geographic News articles, a student fact sheet, and Web documents to examine conflicts between lions and livestock owners;
- investigate how scientists are working with governments and livestock owners to minimize livestock losses to lions;
- use graphic organizers to analyze the problems facing lion populations in different parts of Africa and the proposed solutions;
- engage in a role-playing activity to recognize conflict between lions and livestock owners, and propose solutions for the conflict; and
- discuss how technology helps scientists in their research.

Geographic Skills:

- Asking Geographic Questions
- Analyzing Geographic Information
- Answering Geographic Questions

Suggested Procedure

Opening:

Determine students' understanding of the concepts of extinction and endangerment. Do students know what "extinct" means? Many animals that once lived on Earth have disappeared—they are extinct. Have students list examples of animals that have disappeared. What does "endangered" mean? Ask students to list examples of species that are extinct or endangered. Encourage students to discuss what they know about the part human activity plays in endangerment of species today, including changes made to the environment. If your area includes protected habitats for endangered species, incorporate them into the discussion.

Explain that although tourists in Africa often see many lions and may believe that African lion populations are doing well, scientists believe they are in trouble. Lions are threatened outside the protected national parks and reserves, where tourists usually see them.

To engage thinking about land use and lion endangerment, print out or have students go online for the African Lion Working Group map showing past and present lion distributions in Africa. Then give them **color** copies of Map Handout D: Land Use in Africa (MapDLandUse.pdf).

African Lion Working Group map (select "About lions," then "Conservation issues"):
http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html

Instruct students to observe and analyze the maps. Note the overlap and proximity of present lion habitats and land used for nomadic herding and for stock raising on ranges. What are the implications of this overlap? Ask students to formulate questions by observing the maps. What might they expect to learn about land use issues and human activities that might put people and lions in conflict? List their responses on the board. Then ask them to list reasons people might want to kill lions in these areas. Explain that they will verify their predictions as they study assigned readings.

Development:

Note: *If students have not completed Lesson 7 (RoarLesson7.pdf) you may wish to have them skim Handout 22: The Kalahari: The Great African Thirstland (Handout22Thirstland.pdf).*

Locate the Regions Highlighted in This Lesson. Give students copies of Map Handout A: Political Outline Map of Africa (MapAOutline.pdf). Have students speculate where Kenya, Botswana, and the Kalahari might be located. Then give students a handout of Map Handout C: Physical Map of Africa (MapCPhysical.pdf). (Map C is in color, but can be printed in black and white for students.) Have students compare their predicted locations with the actual locations. How accurate were their predictions?

Investigate Lion Endangerment. Have students read three handouts:

- Handout 23: Lions and Livestock: Can Scientists Save Both? (Handout23Livestock.pdf)
- National Geographic News: "Lions Vs. Farmers: Peace Possible?"
  http://news.nationalgeographic.com/news/2003/07/0716_030716_lions.html
- National Geographic News: "Revenge Killings: African Farmers Massacre Lions"
  http://news.nationalgeographic.com/news/2004/02/0210_040210_TVlionmystery.html

These questions, which are on Handout 23, can guide student reading and note taking. Discuss these questions in class after students finish reading.

1. What problems and threats are facing lion populations?
2. What recent changes have put lions in more danger than in previous times?
3. How do some researchers explain the cause of the danger?
4. What are the researchers' goals?
5. How has technology helped scientists in gathering data? Why do you think it's important for scientists to gather data about lions?
6. How have human activities introduced hazards to lions through land-use decisions?
7. How do the researchers propose to resolve the conflicting needs of lions and human neighbors?

Invite older or more capable students to search the handout and news articles for details that support these statements from the National Science Education Standards:

- Content Standard F. Science in Personal and Social Perspectives: Risks and benefits
  —Important personal and social decisions are made based on perceptions of benefits and risks.
- Content Standard G. History and Nature of Science: Science as a human endeavor
  —Women and men of various social and ethnic backgrounds—and with diverse interests, talents, qualities, and motivations—engage in the activities of science . . . .

Identify Problems and Solutions. Have students work in pairs and write a few paragraphs or use a Problem/Solution graphic organizer to summarize the problems described and the solutions researchers propose.

San Diego County Office of Education: Problem/Solution chart:
http://www.sdcoe.k12.ca.us/score/actbank/tprobsol.htm

Evaluate Different Viewpoints Regarding Resource Use. Have students do a role-playing activity in groups of five, based on some of the people profiled in Handout 23 (Handout23Livestock.pdf). In each group, different members will play the roles of Laurence Frank, Graham Hemson, a livestock owner in the Kalahari, and government representatives of Kenya and Botswana. Groups should discuss the problems and proposed solutions, with members representing the perspective of the people they represent.

Following the role-play discussion, tell groups to identify the decision facing a livestock owner who is losing livestock to hungry lions. Then have them choose the option that makes the most sense, using a decision-making process such as the one below:

- Determine what the livestock owner needs to decide.
- Examine the facts necessary for making the decision.
- Identify the issues involved in the decision.
- Discuss alternative courses of action and predict the likely consequences of each.
- Make a decision based on the facts.
- Explain what the livestock owner will do first to implement the decision.

Encourage students to make their own decisions, based on the facts. They need not be constrained by the recommendations of either Frank or Hemson. Invite volunteers to share their decisions and the bases for them with the class.

Have several of the groups present their role-play discussions to the class. If additional issues were brought to light, list them on the board. Were additional solutions proposed? List them. Encourage students to ask questions and offer comments about the points each group makes.

Closing:

Ask students what they have learned about what human activities might put people and lions in conflict. Have them review the predictions they made at the beginning of the lesson when they answered these questions: (1) What might they expect to learn about land use issues and human activities that might put people and lions in conflict? (2) What reasons might people have to want to kill lions in the areas where lion habitats and lands used for nomadic herding or stock raising on ranges overlap or are in close proximity?

Debrief the role-playing discussions. Now that students have heard all different points of view, determine if students can reach consensus on a course of action to take to deal with the conflict.

Invite students to report the details they found to support their assigned statements from the National Science Education Standards. Encourage classmates to offer any additional examples they found.

Suggested Student Assessment:

Ask students to write a summary of findings and recommendations that Laurence Frank might send to the government of Kenya or Graham Hemson might send to the government of Botswana. Tell students to explain how human activity pits the survival needs of lions against those of their human neighbors, and offer suggestions that will enable both to survive as neighbors.

Extending the Lesson:

Have a group of students go to the Laikipia Wildlife Forum Ltd Web site to learn how to construct a strong *boma*—an enclosed structure in which livestock are kept at night. Tell them to write some directions for creating a strong boma, and make a model. Allow time for the group to display the model and explain how a boma should be designed and why.

Laikipia Wildlife Forum Ltd: ***http://www.laikipia.org/news_lions.htm***

Encourage students to undertake a project to help save lions or other wildlife at risk, such as making a poster to raise awareness and encourage action, or holding a fundraiser for an organization that works to preserve biodiversity. Below are some organizations that work to save species and preserve biodiversity:

- African Wildlife Foundation: Other Ways You Can Help: ***http://www.awf.org/act/other.php***
- Born Free Foundation: Big Cat Campaign: ***http://www.bornfree.org.uk/big.cat/index.shtml*** (United Kingdom)
- Conservation International: ***http://www.conservation.org***
- Defenders of Wildlife: ***http://www.defenders.org***
- U.S. Environmental Protection Agency: Student Center: ***http://www.epa.gov/students***
- Wildlife Conservation Society: Saving Wildlife: ***http://wcs.org***
- World Wildlife Fund: ***http://www.worldwildlife.org***

Have pairs or groups of students read "Conserving Lions in Hwange National Park Zimbabwe" to learn about a scientific investigation into threats to lion populations in Africa. Students can compare the observations of Graham Hemson in the Kalahari (from Handout 23) and the other Wildlife Conservation Research Unit (WildCRU) researchers in Zimbabwe, using a table, Venn diagram, or other method to illustrate (a) the similarities between the observations of the two research projects; (b) the differences between the two; and (c) the factors that make the observations different. If time permits, have one or two groups present their discussion in front of the class, and hold a class discussion on the points they've made.

Wildlife Conservation Research Unit: Conserving Lions in Hwange National Park Zimbabwe: ***http://www.wildcru.org/research/es/lions.htm***

The Graphic Organizer: ***http://www.graphic.org***

Have a group of students go online to learn about Crittercam, an instrument worn by wild animals used to gather information. Ask them to report to the class about why technology such as Crittercam is essential to science, and how Crittercam might be helpful in continuing the research into lion movements and hunting behavior.

National Geographic: Crittercam Chronicles: ***http://www.nationalgeographic.com/crittercam***

Have a group of students go online and read several letters. In "Life without lions," scientists express differing opinions. Graham Hemson disagrees with one of the scientists in "People and lions."

- New Scientist: Life without lions: ***http://www.newscientist.com/opinion/opletters.jsp?id=ns24188***
- New Scientist: People and lions: ***http://www.newscientist.com/opinion/opletters.jsp?id=ns24217***

Tell students to role-play for the class a discussion among the scientists who contributed the opinion letters. The dialogue should make clear the opinions of each scientist represented.

Related Links:

2003 IUCN (The World Conservation Union) Red List of Threatened Species
http://www.redlist.org

African Lion Working Group
http://wildnetafrica.co.za/wildlife/inc/african/africanlionworkinggroup.html

CITES: Listed Species Database
http://www.cites.org/eng/resources/species.html

Destination Cinema: *Roar: Lions of the Kalahari*
http://www.destinationcinema.com/our_films/roar/roar.asp

EE-Link: Endangered Species
http://eelink.net/EndSpp/specieshighlights-mainpage.html

Lion Research Center
http://www.lionresearch.org/main.html

Lion Research Center: Lions and People in the Ngorongoro Conservation Area
http://www.lionresearch.org/current_docs/dennis.html

National Geographic News: Co-Existence Good for People and Wildlife, Conservationist Says
http://news.nationalgeographic.com/news/2003/08/0801_030801_masai.html#main

National Geographic News: Lions With Black Noses Are Fair Game, Hunting Study Says
http://news.nationalgeographic.com/news/2004/02/0223_040223_lionhunting.html

Oxford University Gazette: University biologist leads rescue effort for Kalahari lions
http://www.ox.ac.uk/gazette/1999-00/weekly/250500/news/story_3.htm

Species Survival Commission: Cat Specialist Group
http://lynx.uio.no/catfolk

United Nations Environment Programme World Conservation Monitoring Centre: Species
http://www.unep-wcmc.org/species/index.htm

Related National Geographic Activities and Lessons:

National Geographic: Xpeditions Lesson—Can Crittercam Help Protect Humpbacks?
http://www.nationalgeographic.com/xpeditions/lessons/18/g68/cchumpback.html

National Geographic: Xpeditions Lesson—Lions and People: Keeping the Balance
http://www.nationalgeographic.com/xpeditions/lessons/18/g68/cclions.html

National Geographic: Xpeditions Lesson—People and Endangered Species
http://www.nationalgeographic.com/xpeditions/lessons/08/g35/endangered.html

National Geographic: Xpeditions Lesson—Why Preserve Biodiversity?
http://www.nationalgeographic.com/xpeditions/lessons/08/g68/preserve.html

The Teacher's Guide for *Roar: Lions of the Kalahari* is available online at
http://www.destinationcinema.com/our_films/roar/educators.asp

Handout 13:
Beliefs About Lions

Directions: Read these statements about lions. Place an X next to each statement that you believe to be true.

— If you have not seen the giant-screen film *Roar: Lions of the Kalahari*, place the X to the LEFT of the statement.

— If you have seen the film, place the X to the RIGHT of the statement.

Before	Belief	After
	Most lions live in jungles.	
	All lions live in groups called prides.	
	A male lion mates with one lioness for life.	
	Lionesses usually live in groups with related lionesses.	
	Once a male cub is born in a family, he usually lives his whole life with that family.	
	Once a female cub is born in a family, she usually lives her whole life with that family.	
	A male cub takes over his father's territory when his father dies or grows too old to defend it.	
	When males and females live together, male lions do most of the hunting.	
	Male lions protect their lionesses and cubs.	
	Male lions may kill cubs.	
	The lioness that makes the kill gets to feed first.	
	Male lions may fight other lions.	
	Female lions may fight other lionesses.	
	Male lions fight strange males that come into their territories.	
	Female lions may fight strange lionesses that come into their territories.	
	Male lions fight females that come into their territories.	
	Female lions may fight males that come into their territories.	
	The roar of a lion can keep other lions away.	
	A lion or lioness successfully kills almost all of the animals it stalks.	
	Lions may hunt alone.	
	A lion or lioness chases a hunted animal, sometimes for a long distance, until it catches it.	
	Grazing animals will not remain in an area if they see lions nearby.	

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. What was the filmmaker's purpose in making *Roar: Lions of the Kalahari*? What does he hope to achieve besides entertainment?
2. What is the theme of the story in the film?
3. What technology did the filmmaker use in making the film? How did technology help solve some of the problems the filmmaker described?
4. What were some of the challenges and hardships of making this film?
5. How did the physical environment make it hard to create the film?
6. Which animals could have put the filmmaker at risk, according to this handout? How did he assess the risks and benefits?
7. What safety precautions did the filmmaker take when working closely with lions?
8. How did the filmmaker combine real events and elements of fiction to create this story?
9. What part did scientists play in the production of the film? What did the production team do when the scientists had different interpretations and conclusions about the footage they watched and the narration?

Handout 14:

A Wildlife Film in the Making

With a loud, fierce trumpet, the bull elephant charged toward two lionesses—and filmmaker Tim Liversedge. The lionesses bolted past Tim, missing him by inches. From 10 yards (9.14 meters) away, the elephant kicked up dust and sand over Tim's loudly whirring camera.

As the elephant lumbered toward him, Tim stood his ground, his camera rolling. Was he afraid? Yes, but not of the elephant. He was afraid his camera would run out of film before he recorded some of the most dramatic wildlife footage ever filmed!

The elephant shook his huge ears. An angry warning rumbled through his trunk. As a former wildlife researcher, Tim knew an elephant-style threat when he saw one. He also knew that bull elephants would rather not do battle unnecessarily. After weighing the odds, Tim decided that what this footage could offer to his audience was worth the small risk.

Tim called it right. When the filmmaker did not budge, the elephant changed direction and moved away—just as the film ran out.

The elephant had come to drink at a nearby water hole. In the vast, dry Kalahari plains of Botswana, Africa, the water hole held the only standing fresh water for miles.

Tim almost missed the moment. He had been filming the lionesses as they stalked and killed their prey. Then he stood alone, about 10 yards (9.14 meters) away, as the lionesses gnawed at their kill.

The elephant appeared just after Tim removed the magazine of film from his camera. The film was almost used up. When he spotted the elephant, Tim was packing up to leave.

"I jammed the magazine onto the camera, frantically threaded the film and started rolling, just as the elephant came into the frame," said Tim. "I had no idea how much film, if any, was left."

The Water Hole

Tim and his crew were filming lions in the Kalahari, a huge, dry region where months can pass without rain. "Chance led me to the water hole in the Kalahari," Tim explained. Over the years Tim had conducted research about Botswana, and knew the Kalahari well.

As the Kalahari dried up and heated up, Tim noted that the water hole drew more and more grazing animals. A small pride of lionesses had staked out the territory surrounding the water hole, and a giant male lion had claimed the pride.

A Filmmaker Sets His Sights

It took a long time and much hard work to make this short film. "The end product combines the highlights of several years of observation," said Tim.

"Over the years I have watched many individual lions come and go around this water hole," said Tim. Nomadic males were eager to take over this pride with its prime hunting territory. Most lions did not hold it long before another individual male lion or coalition of males took over. Tim decided to film the story of a real life "lion king" and the challenger that took over his "kingdom." He called the film *Roar: Lions of the Kalahari*.

The giant old lion in the film had a pride of several lionesses, but Tim filmed two in particular. He included only these two in the film.

Tim wanted to present scientifically accurate facts and film real events, but he wanted something more. He wanted to stir the feelings of the audience. He wanted them to share the animals' hunger, thirst, anger, fear, sorrow, and happiness. He wanted them to feel the lions' fondness for one another, the devotion to their cubs, and a lone lion's longing for lionesses of his own. To this end, he packaged the scientific facts, the filmed events, and the life-and-death drama into an engaging story, with the lions as the main characters.

The Filmmaker

As a filmmaker, Tim had plenty of experience before he made *Roar: Lions of the Kalahari*. He had been making nature films for television since the mid-1980s. A series on the Kalahari and the river delta that spills into it, the Okavango Delta, won a Golden Panda award. Tim called the award "the Oscar of wildlife filmmaking." His films continued to win awards.

After years of making films for television, Tim decided to make large-format films to show in theaters on wide screens.

Such films were usually shot with huge cameras that use 70-mm film. These cameras needed to have film changed every few minutes, and they were hard to set up and move around.

Technology Solves Some Problems

The camera that used 70-mm film produced sharper images on a wide screen, but Tim was not sure it could do the whole job. The equipment was too bulky for filming fast, rapidly changing action. Tim could not always predict events or where they would take place. If he missed a dramatic moment, nature would not give him a second chance. "I believe many great stories have gone untold because filmmakers have been shackled by the unwieldy cameras," explained Tim.

Tim put together his own technological solution. He used 35-mm footage for situations that required a rapid response or very slow motion. A larger camera that used 70-mm film would be used for wider shots and events when Tim could predict the action.

To shoot the film, cameraman Richard Jones operated the 35-mm cameras. Meanwhile, Tim ran the 70-mm camera. "Of course, it took quite a while getting the animals used to the terrible sound the gigantic cameras make. They sound like a tractor starting up," said Tim. "You don't want the lions looking at you every time you start rolling, especially when they are sitting right next to you."

After shooting footage with this combination, Tim took it to Chris Reyna, of IMAGICA USA, a visual effects company in the United States. Reyna ran experiments on the footage. He used special technology to check the quality of the combined images on a large screen. They were excellent. Tim's solution worked. "I spent months working with sound engineers to get the right sounds—the different roars, all the bird sounds, the elephant's trumpet loud enough," said Tim.

Risks and Precautions

Tim knew he was taking some risks, so he also took precautions. At first he shot from a Land Rover with his assistant, Bata, keeping watch. As they spent more time with the lions the big cats became used to the filmmakers. Soon, Tim felt safe enough to set up his camera in the open, some distance away from the Land Rover. In fact, a lioness once lay down in his shadow.

As a precaution, Tim still kept a small fire extinguisher in his pocket to discourage attacking animals. He never needed to use it. "Lions are, in fact, highly predictable and very focused on what they do, so I didn't feel I was in any danger standing out in the open with them," explained Tim.

A Long, Hot, Dusty Job

"Filming can be absolutely exhausting," said Tim. "You have to watch every movement, every second of the day when the lions are around, even when they are sleeping. You have to anticipate what they are going to do. You can't start a sequence halfway through."

"You wait and you watch," Tim continued. "The heat is unbearable. Dust storms cover everything. But it's a wonderful feeling when something really special happens. I got a lion leaping up in front of me, catching an antelope high in the air just yards from my camera. A chance in a million."

The crew and the equipment also baked in the fierce Kalahari sun. Keeping the film cool was a big problem. Again, technology came to the rescue. A portable freezer kept the film cool.

The Takeover

At night, after the cameras shut down, deafening roars shook the Kalahari. Tim could tell that a rival male was challenging the pride male. The rival wanted to take over the pride and the water hole. After six months of filming, the huge pride lion disappeared. It seemed he had been defeated and replaced.

Tim wanted the audience to see a complete story on film. Because he had missed the chance to film the old lion's defeat, he added footage of an earlier fight between males that he had filmed. It showed the takeover of the pride as it probably happened.

Scientists and the Film

According to Tim, *Roar: Lions of the Kalahari* offered some scientists a valuable opportunity to observe lion behavior. "When I showed this film to the African Lion Working Group, a dedicated group of researchers who work daily with lions, they were totally amazed by the footage and the incredible behavior we were able to capture on film," said Tim.

People from Africa, the U.S., and other countries—with diverse interests and talents—played different roles in producing the finished film. After the filming a team of scientists from different countries reviewed the film. They discussed their interpretations of the animal behavior and events. Some compared the facts to their own observations and research about lions. Some had different interpretations and conclusions. The production team reviewed papers in which scientists discussed their differing conclusions about lions. Then the team decided what facts to include in the narration.

Of his goals, Tim explained, "My aim is to give audiences the experience of what it's like to be gazing up at the star-filled night skies over the Kalahari, to have the thrill of hearing two lions engaged in a roaring duel, or to sit at the edge of a water hole a few feet from elephants bathing in the moonlight."

The film offered a growth experience for Tim as well. "In the end," he said, "this film has taken me on a journey—not merely into the wilderness of the Kalahari, but into a new technology, which I hope will bring a love of wild places to a wider world through large-format films."

"Our wildlife films not only document the rapidly changing African wilderness, but I believe they are also vitally important for long-term conservation," Tim adds. "I have been studying large-format filmmaking for the past eight years and am convinced that, through this medium, we will be able to not only entertain but educate the world as to the need for protection and preservation of our wildlife and the environment in which they live."

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Watch for These!

- You will see a map and aerial views near the beginning of the film. What continent is shown? What kinds of things do you see in the views from the air? How do the views from the air help you understand the plot of the story?
- What different animals are in the film?
- What measurements are given in the film? What tools would be used to make these measurements?

Handout 15:
Worksheet for *Roar: Lions of the Kalahari*

1. What physical process created the pans described in the film? (The pans in the film are flat-bottomed depressions in the desert.)

2. What are the physical characteristics and climate of the region in which the water hole is located? How do the physical characteristics make the water hole an excellent territory for the lions? How do the physical features and climate make it possible to film so many different African animals in one place?

3. What type of information does the narrator communicate using numbers? How else could the information have been shared?

4. What populations of organisms (living things) do you find in the ecosystem surrounding the water hole? How do the populations of this ecosystem change? How do physical processes such as wind and rain influence the changes in populations of organisms? How do physical processes affect the survival of different species?

5. What changes do the elephants make in this environment? Which species are harmed? Which benefit?

6. According to the narrator of the film, which traits will the cubs receive from the genes of their parents?

7. Which behavioral responses shown in the film are likely to be determined by heredity? By experience?

8. Why does the challenger want to take over the water hole?

9. What happens to the cubs at the end? Why?

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. Which organ helps make cats good night hunters? How does its structure help a cat hunt at night?
2. What happens to light after it enters the eye of a lion or other cat?
3. Through adaptation over time, a species develops many structures and behaviors that improve its survival. What structures and behaviors make lions good hunters and fighters?
4. Besides their size, what makes adult male lions look different from other adult male cats?
5. Which structures make lions able to roar?

Handout 16:
Physical Characteristics of Lions

Lions belong to the cat family. They share some characteristics with all cats, but some structures and behavior set them apart from other cats.

Structure and Function in Cats

Cats have short muzzles and broad, rounded heads. Like other cats, lions have specialized hairs called whiskers. A cat's whiskers have nerve endings and are extremely sensitive to even the slightest touch. Cats use them for testing objects in their way and to sense changes in the environment. If necessary, they can feel their way with whiskers.

Cats don't need to depend only on their whiskers, though. They are also thought to have excellent hearing, vision, and probably sense of smell. The eyes of a cat have special adaptations that help them gather more light than the eyes of human beings can collect. This extra gathered light gives cats outstanding night vision.

Structure and Function in Lions

After tigers, lions are the biggest cats. A full-grown male lion can weigh some 450 pounds (more than 200 kilograms). He stands about 4 feet (123 centimeters) tall at the shoulder. If a male lion stood next to a woman of average height, the lion's shoulder would be almost as high as the woman's. Not including the tail, a male lion may be about six-and-a-half feet (two meters) in length. A tail may add around 39 inches (100 centimeters) in length. Adult female lions are smaller than adult males.

Manes set male lions apart from other cats, and also from female lions, who do not grow manes. A heavy, thickened mass of hair, a lion's mane extends from the neck and shoulder area, sometimes to the underside of the abdomen. At about age two, a young male usually begins to sprout a small ruff, which rapidly grows into a full mane.

The mane of one lion may be very different from that of another. Some male lions have long, thick manes, and others have almost no mane at all. Manes can also vary in color from tan to black.

Lion experts are not sure about the purpose of a mane. But a mane helps humans tell male from female lions.

In adult lions, body fur ranges from light tan to reddish brown. The mane, as well as the tuft on the tail, may be darker. Cubs are born with spotted fur. As the cubs grow up the spots slowly fade.

Lions are well designed as predators. They have powerful bodies with bulky, muscular shoulders and strong forelimbs. Long, sharp claws and short, powerful jaws combine with their size and strength to make them formidable fighters and hunters. Their 30 teeth include large piercing canines to seize and kill prey. After the kill, their scissor-like molars cut into the flesh, and small incisors help scrape the meat from bones.

Lions have special structures that enable them to roar. A cat has a long elastic ligament that connects the bones in the hyoid. The hyoid is the set of bones that supports the tongue and the larynx, the upper part of the windpipe. The larynx contains the vocal cords, or folds that vibrate to make sound. In lions, the elasticity of the special ligament, combined with specially designed, thick vocal folds, allows lions to make a loud roaring sound.

The resulting roar can be heard five miles away, according to some experts. In fact, according to Tim Liversedge, producer of the giant-screen film *Roar: Lions of the Kalahari*, a lion's roar at close range will actually shake a Land Rover on its springs.

Despite their size, strength, and natural weapons, male lions rarely live longer than 12 years in the wild. Females may live as long as 16 or17 years, and some breed as late as age 15. In captivity, where they are well fed, prevented from fighting, and given veterinary care, lions sometimes live 25 years or more.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. What behavior sets lions apart from all other cats?
2. What is a pride? What is a coalition?
3. Over a lifetime, how does the family life of most female lions differ from the family life of most male lions?
4. In most prides, how do males and females usually contribute to the pride's survival?
5. How does living in a pride help the survival of its members?

Handout 17:

Lion Family Life

Most cats are solitary, meaning they live and hunt alone, but most lions live in groups called prides. The core of the pride usually includes two or more adult lionesses and their cubs. Prides are something like an extended family because the females are related. They may be sisters, half sisters, mothers, daughters, aunts, or cousins.

Pride females work together, teaming up to care for cubs, hunt, and defend their territories from other pride females. Sometimes they gang up to defend their cubs from invading male lions (see Handout 20: Takeovers).

Once born into a pride, a lioness usually remains within it for life. By contrast, young males are driven from the pride at about age three. If young males are lucky, they are driven out with brothers and cousins of comparable age. If so, they may remain together for life.

Young lions that are expelled alone often join up and cooperate with other young males, much like boys forming cliques. Groups of two or more male lions are called coalitions.

Some young lions end up alone after being driven from their prides. Whether alone or in a coalition, these young males are at first nomadic, having no permanent homes. They roam and hunt alone or together.

Sooner or later a coalition may try to take over a pride together. To do so, they usually need to drive off or kill the males already living with that pride (see Handout 20: Takeovers). A single nomadic lion may also try to take over a pride, but he usually needs to find a pride controlled by a single male to be successful.

In lands where prey is scarce prides may have large ranges and be small in size, perhaps consisting of a few females and one or two males. Where prey is plentiful, prides tend to be larger, with as many as 15 lions or more.

Lions seem fond of their pride members and coalition members. They show this fondness by licking each other's faces, and rubbing heads or cheeks.

Lions spend most of their time resting. When they are awake, they divide the responsibilities of caring for the pride. Adult lionesses do most of the hunting for the pride (see Handout 18: Hunting and Feeding Behavior) and the cub care (see Handout 19: The Lion Life Cycle).

Pride females also defend the territory against other pride females that trespass on their territory. In lands where vegetation is dense and prey is plentiful, pride territories may be smaller and close together because of the high concentration of prey. Where vegetation and prey are scarce, territories often need to be much larger.

Pride males patrol the territory, defending against outside males (see Handout 20: Takeovers). They leave urine and other scent to warn off outsiders. Their fierce and deafening roars can keep other males at bay.

When not in the midst of a takeover or squabbling over a kill, pride members generally get along well. They cooperate for survival and reproduction.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. In a pride, which members do most of the hunting? How does social behavior make it easier for individual lions to obtain food?
2. Besides hunting, what behaviors do lions use to obtain food?
3. According to Tim Liversedge, how have the lions in the giant-screen film *Roar: Lions of the Kalahari* adapted their hunting behavior to the environment near the water hole in the film?
4. How do lion experts explain the reason most lion hunts fail?
5. In what order do pride members usually feed? How does this order affect cub survival?

Handout 18:
Hunting and Feeding Behavior

People who see lions coming usually get out of their way, and with good reason!

Lions are carnivores, living on the flesh of other animals. They are also predators, meaning they hunt and kill other animals for food. Given a choice, lions seem to prefer medium- to large-size plant-eating mammals such as zebra, wildebeest, buffalo, or antelope, but they also prey on animals as small as hares or as large as giraffes.

Hunting Alone and Together

Lions hunt alone or in groups. Hunting alone, a lion stalks its prey slowly and silently, trying to position itself close to its prey. When it is within about 98 feet (about 30 meters) it charges toward its intended meal with a burst of speed. If the lion is lucky, it grabs the prey, throws it to the ground, and kills it with a bite on the animal's neck, or more often, by holding its throat or mouth and nose closed in its jaws.

Both male and female lions can hunt. Pride males usually stick to larger prey. When it comes to hunting large prey animals, male lions' size and strength are more important than speed. Compared with females, males are stronger but slower. In prides living in open areas, males typically feed on the female lions' kills.

When they have a chance, lions will readily eat a free meal. If a single lioness seems capable of making a kill alone, other pride members often watch and wait. If the prey animal is large enough to feed all or most of the pride, and cooperative hunting is more likely to succeed, the lionesses usually team up. Teamwork also seems to depend on the difficulty of the kill.

In group hunts lions may surround their prey, cutting off all escape. Some lions may also drive prey into the reach of others. Sometimes two or more lions seize and slash together to bring one animal down. Lions often hunt together to kill faster or larger animals, such as zebra and buffalo.

Success and Failure

Most lions' hunts end in failure. Lions hunting in groups of two or more succeed about twice as often as lions hunting alone.

Lion experts explain the failure rate in several ways. Some believe that one flaw in hunting behavior is that lions may approach prey from upwind, and the animals catch their scent. If it has to chase its prey for a long distance, a lion usually gives up. For a short distance, female lions can charge at speeds between 30 and 35 miles (48 and 56 kilometers) an hour, but they lack the endurance to chase escaping animals very far.

Day and Night

Although lions hunt during all times of the day, they are generally more successful hunting at night. Hunting during the day can raise their body temperatures and cause them to tire quickly. Besides cooler temperatures, night hunting offers another advantage. Adaptations of the lion's eye allow it to gather abundant light, giving it excellent night vision, and the darkness may conceal a stalking lion from its prey.

Stalking by day on the open plain presents a big challenge. As lions are stalking, other grassland animals know that the lions are hunting. Their eyes are focused on any lions in sight. If they cannot see the lions, their eyes cast alert glances from here to there. The prey animals do not usually flee immediately. Often they wait until the lions commit themselves to the attack before they try to escape.

Daytime hunts can be successful in special locations such as a water hole, especially a small water hole in a dry area. Any animals that want to drink are forced to visit the water hole, whether or not the lions have staked it out. The water hole effectively concentrates large numbers of prey in a small space. "Lions adapt their hunting behavior to the environment," explained Tim Liversedge, filmmaker of the giant-screen film *Roar: Lions of the Kalahari*. "At the water hole, they hunt during the day when the prey animals are there."

To drink, the prey animals need to lower their heads. From this position the animals that are drinking cannot keep track of the lions as well or start running as quickly as those that are standing and watching.

Feeding

Regardless of which lion makes the kill, the strongest often push their way to the head of the line. If adult males are present, they usually feast before the adult females. Then the mature females squabble over the remaining carcass. When times are hard, juveniles and cubs feed last, and they are frequently left out entirely. Many cubs starve.

Some experts estimate that on average a lion eats about 17 to 18 pounds (8 kilograms) of meat daily, but that does not mean it hunts or eats every day. Lions have expandable stomachs that allow them to gorge. When feeding on a large carcass, a lion can eat nearly 80 pounds (more than 36 kilograms) of meat in one feeding. It then may not need to eat for several days.

Convenience Foods

Because they prefer an easy meal, lions will scavenge when they have a chance. Scrounging for dead bodies can involve less work and less risk than hunting.

Lions look for clues such as circling vultures. These clues lead them to downed animals. They will eat carcasses dead of natural causes, and also steal carcasses from other predators such as wild dogs, cheetahs, leopards, and hyenas. Large groups of predators, such as hyenas, can sometimes defend their carcasses against lions.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. List some male behavior, female behavior, and details of pride organization, and explain how each serves reproduction goals.
2. What happens when a lioness comes into estrus?
3. How do females in large prides raise their cubs?
4. How would you describe the social behavior of young males after they leave their prides of birth?
5. At about what age can lions start breeding?

Handout 19:

The Lion Life Cycle

Lions seem to operate with one main long-term goal—to reproduce and rear their young. Experts usually explain male behavior, female behavior, and pride organization in terms of how they serve reproduction goals (see Handout 20: Takeovers).

Giving Birth

The reproduction process begins when a female lion comes into estrus. In this state, the female is interested in mating and can become pregnant. The egg becomes ready to receive the male's sperm.

The pride male, or one of them, stays with the female for around three days. If pride males fight, it is often over a female in estrus. If the lioness becomes pregnant, she gives birth after around 110 days.

Before the birth, the pregnant female steals off to a private, hidden place such as a rocky shelter or a clump of dense plant growth. There she delivers her cubs. The usual litter size is between two and four cubs, but it can range from one to six.

Cub Care

Cubs can begin walking within 10 days of birth, and most are walking within 15 days. When the cubs are between 4 and 10 weeks old, the mother brings them out to the rest of the pride. If other mothers have recently given birth, they may all raise their cubs together in a nursery-like group called a crèche (rhymes with "fresh"). Cubs remain in the crèche until they are older.

Until they are weaned, between ages six months and one year, cubs nurse from all the mothers in the crèche. Even so, female lions prefer to give milk mostly to their own cubs. Hungry cubs that want to nurse from somebody else's mother often wait until the lioness is asleep.

Growing Up

Even though cubs drink mothers' milk for much of their first year, they begin eating meat before they are weaned. When cubs are three months and older, the mothers lead them to nearby kills so they can feed on meat. Mother's milk remains an important part of the cubs' diet during the first year, though.

At kills adult males usually eat first, followed by adult females, then juveniles, and cubs eat last, if anything remains. Sadly, during hard times, many cubs starve (see Handout 18: Hunting and Feeding Behavior).

During their first year, cubs play constantly—stalking, rushing, chasing, and pulling one another down. Their play behaviors sharpen the skills they will need for hunting.

At about 11 months of age, cubs start learning to hunt with the pride. Most do not kill their own prey until they are about one-and-a-half to two years old, and it may take more years of practice to become expert hunters. Young lions depend on their mothers until they are around a year and a half old, at which time the mother is ready to breed again.

Lions are old enough to breed between ages three and four, but they continue growing until about age five or six. Females typically remain with the pride for life, and as adults begin to breed and hunt.

Young males are driven from the pride at about age three, often with a group of brothers and cousins. Those that succeed in taking over a pride will usually do so sometime around age five or six. Then a new cycle of life will begin in a new pride.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. Which members of a pride are temporary, and which are usually permanent?
2. What lion behavior is explained by the urge of each lion to survive through its genes?
3. What must nomadic males do in order to join a pride?
4. Why do victorious males kill cubs after a takeover?
5. How does the urge to survive through genes pit males against females at times?
6. "There is safety in numbers." How do the facts in this handout support that statement?

Handout 20:

Takeovers

A pride includes both permanent and temporary members. Pride females are related, and usually spend their whole lives in the pride of birth. Adult males are usually not related to the females, but they may be related to one another. Within their lifetimes one group of lionesses will see males come and go, alone or in groups.

In lands where vegetation and prey are scarce, territories may be large and prides medium-sized to small, perhaps consisting of a few females and one male. Where prey animals are plentiful prides tend to be larger, with as many as 15 lions or more. Territories may also be smaller.

The Drive to Reproduce

Driven from their prides of birth, young males seek prides of their own, alone or in groups called coalitions (see Handout 19: The Lion Life Cycle). Their goal is to find females, mate, and father young of their own.

They are not alone in this goal. The urge to reproduce is common to all organisms. Organisms pass on their characteristics in cell parts called genes. A powerful drive of organisms is to "survive after death" through the genes they pass on to their descendants. The competition is about which lion's genes will be passed on.

The males already living in prides like the arrangement. Often fed by female hunters, they mate and sire litters of cubs as long as they remain in residence. They are not about to give up their position without a fight, or share it with males outside their coalition.

Taking Over a Pride

To join a pride, a nomadic male or coalition must chase off the resident males. A takeover often involves violent, bloody combat—sometimes to the death.

Numbers matter. A single male cannot easily take over a pride that is controlled by more than one resident male. If he does succeed he may have difficulty holding it if challenged by a coalition.

When coalitions face off, the larger one most often wins the pride. This advantage may partly explain why related males stay together and solitary males usually seek to team up.

The violence of a takeover does not end with the victory of an invading lion or coalition. The changing of the guard puts pride females and their cubs at risk. When new males take over they try to kill the young fathered by males of the defeated coalition.

As brutal as it may seem, the victorious males have a reason for killing the living cubs. These lions are eager to sire their own offspring.

Setting the Female Clock

A female needs about 18 months to 2 years to rear her cubs to independence. During this time she does not come into estrus, the period when she can become pregnant and is interested in mating (see Handout 19: The Lion Life Cycle). Should her cubs or young juveniles die, she may come into estrus within days or weeks.

Thus, if incoming males allow the defeated males' cubs to survive, they may need to wait a year or two before they can mate with the mothers and reproduce. A lion or coalition typically controls a pride for an average of only two to three years. In prime hunting areas, takeovers are often more frequent. With an early start, the new pride males may sire cubs that survive to maturity.

Mothers Defend Their Young

Mothers, on the other hand, want their living cubs to survive. These competing goals pit females against incoming or outside males during a takeover. Mothers aggressively defend their cubs against incoming males. While a female lion is no match for a much larger male lion in one-on-one combat, females can sometimes defend their cubs by teaming up against a smaller number of males. Females sometimes leave the pride with their cubs before the incoming males have a chance to kill the cubs.

One advantage of having several females in a pride is that females can raise their cubs in groups called crèches ("crèche" rhymes with "fresh"). In these nursery-like groups, several mothers are available to defend all cubs against males intent on killing them (see Handout 19: The Lion Life Cycle).

Back to Business as Usual

If the incoming males wipe out all cubs from the defeated coalition, the mothers often come into estrus around the same time. If so, a number of females may later give birth within a few days or weeks of each other, giving them opportunities to form crèches.

Once the immediate cycle of violence is over, relations are generally peaceful among males, females, and young. Bickering breaks out over feeding at kills or a female in estrus, but is quickly over.

By contrast, relations between prides remain hostile. Pride females defend their hunting grounds, water holes, and birthing sites against outside females. Conflicts can be violent and fatal. Even so, a pride typically holds its territory much longer than a coalition holds a pride.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Handout 21:

Food Chains in an Ecosystem

When people say, "low on the food chain," what do they mean?

One way or another, all living things depend on other living things for food. The order in which living things feed on one another is called a food chain. For example, you may eat strawberries, but strawberries never eat you. Therefore, you are higher on the food chain than strawberries are.

All organisms, or living things, have basic needs. For example, animals need air, water, food, and light. Organisms can survive only in environments in which their needs can be met.

Every living thing needs a source of energy. For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is changed by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.

All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants.

Plants are producers because they make their own food. They use sunlight to make food out of nonliving matter such as minerals and gases. Producers are the first link in the food chain. That is why people sometimes say plants are low on the food chain. It is the chlorophyll in green plants that enables them to make their food.

Consumers cannot make their food. They need to consume, or eat, other living things for food. All animals, including humans, are consumers.

Next after producers in the food chain are consumers called herbivores. These animals eat plants. Most of the mammals humans eat are herbivores.

Next in the food chain are animals that eat other animals. They are called carnivores. Like herbivores, they are consumers, but they are a link further, or higher, on the food chain. These animals also depend on plants, because without plants, they would not have animals to eat. For example, in the giant-screen film *Roar: Lions of the Kalahari*, the lions could not hunt grazing animals at the water hole if plants did not grow nearby.

Some animals eat other carnivores. For example, when a lion dies, its body may be eaten by scavengers such as vultures. A snake may eat a mouse, and an owl may eat the snake.

Also in the food chain are animals and people who eat both animals and plants. They are called omnivores.

Decomposers are consumers that use waste materials and dead organisms for food. These organisms feed on the bodies of dead plants and animals. When food rots in the garbage, or twigs become soft and crumbly on the forest floor, you know that decomposers are at work. They break bodies down into minerals and gases, which plants may use to make food. Bacteria are decomposers. So are mushrooms and other fungi.

One organism may be part of more than one food chain. For example, many birds eat both animals and plants. The birds may, in turn, be eaten by carnivores or omnivores. When organisms make connections among food chains, the connected food chains form a food web.

If you saw the film *Roar: Lions of the Kalahari*, try to recall all of the plants, insects, birds, and mammals in the film. When you think about the food chains and webs they form, you can see how complex the ecosystem around a water hole can be.

Activity: Draw a Food Chain

Directions:

In the space below, draw a food chain using organisms you learned about in your research. Label each organism. Include at least three organisms in your chain. One should be a lion, and one should be a plant. Be sure that any plant-eater you draw will eat the plant you have drawn.

What would happen if one thing were removed from this food chain?

If you wish, draw a second food chain that includes different animals and plants. Be sure they can all be found in one ecosystem.

What might happen to the ecosystem if one thing were removed from this food chain?

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. What is the relationship between the Mega Kalahari and the region called the Kalahari Desert?
2. Which governments have control over and responsibility for the ecosystems of the Kalahari?
3. What season is it in the United States when summer comes to the Kalahari?
4. How does the Earth's revolution around the sun affect seasons in the Kalahari and the U.S.?
5. How did physical processes affect the ecosystems of the Kalahari?
6. How does the location of the Kalahari affect its climate?
7. What is a pan?
8. How do the pans change with the seasons?
9. Where is the water hole featured in the film *Roar: Lions of the Kalahari*?
10. How does this handout describe the area surrounding the water hole?
11. How do the lions at the water hole benefit from the dry season?
12. What human migrations have occurred in the Kalahari?
13. How have human migrations affected the characteristics of the Kalahari "thirstland"?

Handout 22:

The Kalahari: The Great African Thirstland

Do you know exactly where the Kalahari is? Do you know its exact borders? Do you know exactly what it is? If your answer is no, you are not alone. Even the experts do not agree on where the Kalahari begins and ends, or what to call it. Generally speaking, the region we call the Kalahari is in the southern part of Africa, but some people use the term "Kalahari" to refer to a larger region, sometimes called the "Mega Kalahari." It is a large basin that stretches into parts of Angola and Zambia in the north.

The basin runs through Botswana into part of Zimbabwe in the east. It reaches south to the Orange River in South Africa, and west to the highlands of Namibia. It includes a wide variety of plants and climates. By some measures, the total surface area of this basin is hundreds of thousands of square miles (millions of square kilometers).

A Thirstland

The word *Kalahari* comes from the Setswana word *Kgalagadi*, meaning "the great thirst." The actual "thirstland" is what most people refer to as the Kalahari. It is a dry region within the larger basin. This "thirstland" covers most of central and southwestern Botswana, parts of west central South Africa, and eastern Namibia. Estimates of its size vary, but it covers at least 100,000 square miles (260,000 square kilometers).

This dry region is often called the Kalahari Desert, but most of it is not what most experts call a desert. Although it has very little water, and goes months without rain, it is mostly a dry grassland called a savanna rather than a desert.

In fact, the northeastern Kalahari, which receives the most rain, has palm trees and forests. The great Okavango River empties into the Kalahari from the northwest, creating an inland delta that is rich with plants and animals. Some of the animals in the giant-screen film *Roar: Lions of the Kalahari* migrate to this area or to the Botei River during the dry season.

In the Kalahari, winters are very dry. Months can pass without rainfall. Most of the rain falls during summer thunderstorms.

The Seasons

Seasons result from the tilt of the Earth on its axis as it revolves around the sun. The Earth makes one complete revolution around the sun each year. As it makes its annual revolution, the amount of the sun's energy hitting the surface of the Earth varies, as does the length of the day. This helps to explain the opposite seasonal effects in the U.S. and the Kahalari, because the U.S. is north of the Equator and the Kalahari is south of the Equator.

The Oceans and Kalahari Climate

Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat. Thanks to winds blowing from the east to the west, the Indian Ocean is the main source of moisture for the atmosphere over the Kalahari. On a map of Africa and the Indian Ocean you would see that there are more than 400 miles (643 kilometers) of land that separate the Indian Ocean from the Kalahari. Winds bearing water must blow over this land and its landforms. Suppose you look at a climate map of Africa. You can see that the climates become drier as you look southwest on the map.

Footprints of an Ancient Lake

The Kalahari was not always as dry as it is now. Streams and large rivers once emptied into a huge lake. Sometimes, though, internal and external processes of the Earth's system cause events that change or destroy wildlife habitats. In the case of the Kalahari, scientists believe movements in the Earth caused breaks in the Earth's crust. The new landforms blocked the rivers and kept them from flowing into the great lake, which dried up over time. Now, streams and rivers in most of the Kalahari flow only briefly after heavy rains, if at all.

The Pans

Streams may empty into depressions in the desert, known as pans. There the water from the streams dries up. As it evaporates, the water leaves its salt and some minerals behind.

Pans vary in size from a few yards (meters) to tens of miles (tens of kilometers) in diameter. Some provide temporary or semipermanent sources of surface water.

During the winter season many pans are completely dry and cracked. They are crusted with cracked clay. After the rains begin, shallow pools form. Sometimes the rains bring floods, resulting in wetlands for birds and water holes for migrating animals. Some pans may be covered with grasses after a rain.

The Makgadikgadi pans, which were left behind by the huge, ancient lake, are surrounded by grasslands. Farther from the pans, bushes begin to dot the grasslands. Even farther out, trees appear here and there.

The Water Hole

The giant-screen film *Roar: Lions of the Kalahari* was filmed at a water hole in the Nxai (rhymes with "eye") Pan, a small salt pan near the larger Makgadikgadi pans. The water hole is surrounded by dry savanna, or dry grass plains, with a few bushes and scattered trees.

In the southern and central parts of the Kalahari only small, widely scattered water holes hold surface water. These water holes become magnets for migrating and year-round animals during the dry season. In turn, they become excellent hunting grounds for predators.

Animals in the Kalahari

The mammals, birds, and reptiles living in the Kalahari are many and varied. Among them are lions and cheetahs that prey on animals such as zebra and antelope. Smaller carnivores include jackals, hyenas, and foxes. One type of antelope, the springbok, is well adapted to dry regions such as the Kalahari. Living in holes under the plains are meerkats, which might remind you of the prairie dogs of North America.

The Kalahari People

The human population of the Kalahari is small but growing. Residents include the San; the Bantu-speaking Tswana, Kgalagadi, and Herero; and a few settlers of European descent.

The San have lived in the Kalahari for more than 30,000 years. For thousands of years they lived by gathering the food plants that grew in the Kalahari. They also hunted its animals for food, hides, and leather.

Very few of the San people practice only traditional hunting and gathering today. Many raise livestock or work as laborers for ranchers.

Bantu-speaking Tswana and Kgalagadi arrived by 1800. In the Kalahari, most of the Bantu-speaking people raise livestock.

The water hole featured in *Roar: Lions of the Kalahari* is in a protected area. It is miles from ranches and centers of human population. At times it is the only water source for miles around, and its rich grass cover draws droves of animals. Its choice location and rich variety of wildlife make it one of the few places that a wildlife drama such as *Roar: Lions of the Kalahari* could be filmed.

To learn more about the giant-screen film *Roar: Lions of the Kalahari* go online:
http://www.destinationcinema.com/our_films/roar/roar.asp

Use these questions to guide your reading of this handout:

1. What problems and threats are facing lion populations?
2. What recent changes have put lions in more danger than in previous times?
3. How do some researchers explain the cause of the danger?
4. What are the researchers' goals?
5. How has technology helped scientists in gathering data? Why do you think it's important for scientists to gather data about lions?
6. How have human activities introduced hazards to lions through land-use decisions?
7. How do the researchers propose to resolve the conflicting needs of lions and human neighbors?

Handout 23: Lions and Livestock: Can Scientists Save Both?

Is the African lion racing to extinction? Not yet. Lions are not now listed as endangered. Even so, the International Union for Conservation of Nature and Natural Resources (IUCN) lists lions among animals that are at high risk of extinction in the wild. Over the past 20 years the number of lions in Africa seems to have dropped enough to alarm lion experts. Scientists can only estimate how many lions lived on the continent 20 years ago, and estimates vary widely—from as few as 30,000 to as many as 200,000. Estimates of populations today vary, but most experts put the numbers between 23,000 and 30,000, with 23,000 often cited. "What is clear is that they are in very serious trouble now," said Laurence Frank.

Scientists Step In

Frank is a wildlife specialist at the University of California at Berkeley. He is studying the problem in Kenya in order to propose solutions. He worked for more than seven years in Laikipia, in central Kenya. Later he began studying the lion population in southwestern Kenya near Mt. Kilimanjaro.

Another scientist launched a similar study closer to the water hole featured in the giant-screen film *Roar: Lions of the Kalahari*. In 1998, Graham Hemson, a researcher at Oxford University's Wildlife Conservation Research Unit, undertook this study in Makgadikgadi Pans National Park, in Botswana. He investigated the reasons lions had been disappearing over the last 50 years. Their numbers had plunged to about 50. Hemson recruited full-time and temporary help from among the local Kalanga who worked on nearby cattle posts. His permanent assistant in the investigation was Ithuteng Moremi.

The Problem: Raids and Retaliation

According to Hemson, he and Frank often discuss and compare their findings. Conducting separate studies in different countries, the researchers have agreed on one major cause of the problem: conflict between lions and livestock owners.

It's easy to see why lions and livestock owners can come into conflict—their survival needs are sometimes at odds. A lion is hungry. It has wandered far from its usual territory without catching any wild prey. Survival is at stake. A meal flashes into view—a sheep grazing nearby. Now a livestock owner has lost a sheep that would have fed the family or brought in cash to meet its needs. If the sheep belongs to a small farmer, the farmer's survival may be at risk. For a large rancher, the profit is slashed.

The challenge for scientists and conservationists is to find ways both lions and livestock owners can survive. Laurence Frank and Graham Hemson hope their research will help.

Livestock owners have always killed predators to protect cows, sheep, and goats. In recent times, though, human populations have exploded. Settlements reach closer to or farther into lion hunting ranges, making attacks on livestock more likely. With improved technology, herders can kill lions at a much faster rate. Poisons and guns are used in addition to spears and other traditional weapons.

Cattle posts have popped up all over the grassy plains, which are increasingly used for grazing. According to Hemson, a typical cattle post may have a few mud huts, a few corrals, or *bomas*, and a well or borehole for water. Cattle, goats, sheep, donkeys, and horses may graze on surrounding lands. The people who live and work on a cattle post may be families who own the livestock. More and more, Hemson said, they are workers hired by a livestock owner who does not live there.

Roaming Lions

To visitors in parks, where many lions live in one area, lions may seem to be plentiful. Lions are protected inside parks. The problem arises when they wander outside protected areas. Lions often need to range over large territories to find enough food. In drier areas with fewer prey animals, they need larger territories than lions in areas with plenty of prey.

Therefore, lions sometimes wander from the parks to places outside the protected areas. Whether or not they prey on livestock, they are at risk from traps and poisoned meat that farmers may set out. They may also die at the hands of livestock owners who kill lions on sight. In addition, Graham Hemson points out, coming near cattle posts exposes lions to diseases such as distemper, a deadly disease that can be passed from dogs to lions.

Speaking of Kalahari lions, Hemson said, "In my study area many lions were seasonal stock raiders—killing zebra and wildebeest when they were abundant and switching to livestock and nonmigratory wild prey animals during the lean periods. Other lions in our study never ate livestock and tracked the movements of migratory wildebeest and zebra throughout the year." He lists antelope such as kudu and gemsbok among species that usually do not migrate.

The water hole in the giant-screen film *Roar: Lions of the Kalahari* is in a protected area near the Nxai (rhymes with "eye") Pan (see Handout 22: The Kalahari: The Great African Thirstland). Yet it is close enough to the borders of a park that lions from the water hole can wander onto grazing land and cattle posts if they range far.

During the dry season, when the water hole is the only water for miles around, plenty of prey animals are drawn to the water hole. During the filming, the main lion "characters" of the film stayed near the protected water hole. On the other hand, in the film one lion follows the herds, a lioness is driven off, and a mother leaves with her cubs.

In the Kalahari, Hemson explained, prey animals spread out over wider areas during wet seasons. They can find more sources of water and do not need to stay near one water hole. "It is likely that when prey is more widely dispersed, the Nxai Pan lions cover larger areas and come into contact with livestock more frequently," said Hemson. He adds that livestock animals also move over wider areas during wet seasons. They can find water without going to the cattle post to drink. As a result, lions can hunt livestock farther from cattle posts and herders.

Lion Behaviors

Beyond roaming large ranges, other facts of lion life and behavior contribute to the decline in lion populations. For example, because they scavenge, they may eat poisoned carcasses put out to kill predators (see Handout 18: Hunting and Feeding Behavior).

Takeovers can multiply the effects of a single lion kill (see Handout 20: Takeovers). If killing a male lion leaves a pride undefended, the chances are a new male or coalition will take over. Right away, the new males set out to kill any cubs fathered by the old male.

Even without takeovers, many cubs die in their first year. During hard times cubs may starve, while older and stronger members eat (see Handout 18: Hunting and Feeding Behavior).

Studies and Technology

Researchers want to help livestock owners find ways of protecting their livestock without killing lions. The first task is to find out how many lions live in an area and what factors put them at risk. In Kenya and Botswana, lions were fitted with radio collars and tracked using such technology as aircraft, radio receivers, and global positioning systems (GPS).

Laurence Frank has even fitted some lions with instruments called Crittercam, which have tiny video cameras and other information-gathering equipment. The early field trials suggest Crittercam could become a valuable tool for studying predators.

The information collected tells researchers where lions live, where they move, and which lions kill the most livestock. The researchers can use information they collect to help livestock owners protect livestock without killing lions.

Scientists Propose Solutions

According to Graham Hemson and Laurence Frank, keeping livestock inside areas with strong fences at night cuts down on lion kills. Dogs can alert herders that predators are approaching. Other methods suggested include the use of armed guards to frighten predators, rather than kill them.

While livestock raids are common in both Kenya and Botswana, the researchers have observed differences. In Kenya most livestock attacks happen at *bomas*, or *kraals*. Bomas are enclosed structures where livestock are kept at night, according to Frank. Bomas are supposed to keep predators out and livestock in.

As a result, Frank and his research partner in Laikipia, Rosie Woodroffe, wrote, "good boma design and construction is by far the most important factor in protecting livestock from predators." They also recommend having people and noises such as radios at the bomas.

By contrast, in the Kalahari most livestock are killed away from cattle posts in the bush, according to Hemson. "In Botswana, livestock are frequently left out at night and untended during the day," he explains. "As such, strengthening bomas and having dogs and people at the bomas is perhaps of secondary importance in Botswana." More important, he adds, is that herders must be present and watchful during the day and keep livestock in fenced areas at night. Using experienced people and enough people for daytime herding can reduce losses during the day, according to Hemson. He recommends that small farmers with few animals pool their money and hire able herders to watch over their combined herds.

"Unfortunately, many livestock owners do not do enough to prevent kills by predators," said Hemson. "People kill lions because it is cheaper to do so than to take better care of livestock and prevent the problem."

Governments Step In

In Botswana, a ban on lion hunting has been in place since 2001. Government leaders understand the economic needs of livestock owners as well as the need to protect lions. They offer money to livestock owners who have lost animals to certain predators, including lions. Frank and his colleagues are trying out a similar system in the new Kilimanjaro study area.

Both Hemson and Frank are convinced that to be effective such payments should be linked to good livestock management. For example, farmers should not be paid for livestock killed at night in unfenced areas. In Kenya the payments will have what Frank describes as having "a lot of strings attached," according to a National Geographic online news article.

Plenty of Wild Prey Animals Helps

Both Hemson and Frank also noted that livestock kills in their study areas were rare when wild prey animals were plentiful. They suggested that if plenty of wild prey animals are present, lions might make fewer livestock raids. Then livestock owners would be less likely to kill lions. Hemson predicts that if hunters were to avoid hunting prey animals that do not migrate, their numbers might increase and lions would have enough wild prey year-round. He offers antelope such as kudu as examples. Besides, they eat mostly leaves on bushes and trees rather than grass. Therefore, they do not compete for food with grazing livestock, according to Hemson.

Some conservationists hope that in Botswana and other areas, people will learn to value lions and wildlife as an economic resource. They hope the money tourists bring to local African economies will make lions and other wildlife valuable in the eyes of the community.

Risks and Benefits

To study and protect lion populations, researchers have taken personal risks. "When I told my friends what I did they thought I was mad," said Graham Hemson. "I lived in a tent 30 miles from the nearest village and often had lions walking around it. There were snakes and scorpions all over the place, and I have been charged by lions a few times." To put the tracking equipment on the lions, the researchers needed to drug them, but sometimes the lions were awake and growling. "They were too drugged to do anything more," Hemson explained.

Hemson also worked in very remote areas in a 15-year-old car. To find lions, he flew a microlight, a very small aircraft something like a hang glider with an engine. "I could make an informed assessment of the risks," said Hemson. He adds that he was good at spotting problems such as lions in the grass or bad noises in an engine.

Hemson usually traveled with just one assistant. As a precaution he kept a radio with him, and kept in touch with safari operators and the wildlife department "so we had a reasonable chance of being rescued if we had needed it," he said.

"I think the benefits outweighed the risks," Hemson said. Probably conservationists think so, too. The information Hemson collected and his recommendations might help keep African lion populations from dropping.

Hemson further hopes his recommendations may result in an increase of lion populations in some areas. He offers some words of hope. "Lions breed very fast when allowed to," he explained. A drop in population results in extra resources such as space and food, he added. Competition is reduced, and more cubs survive. He suggests that lions can rebuild their populations if they are left alone. Even so, he warns: "One has to give the population a little breathing space for this to occur."

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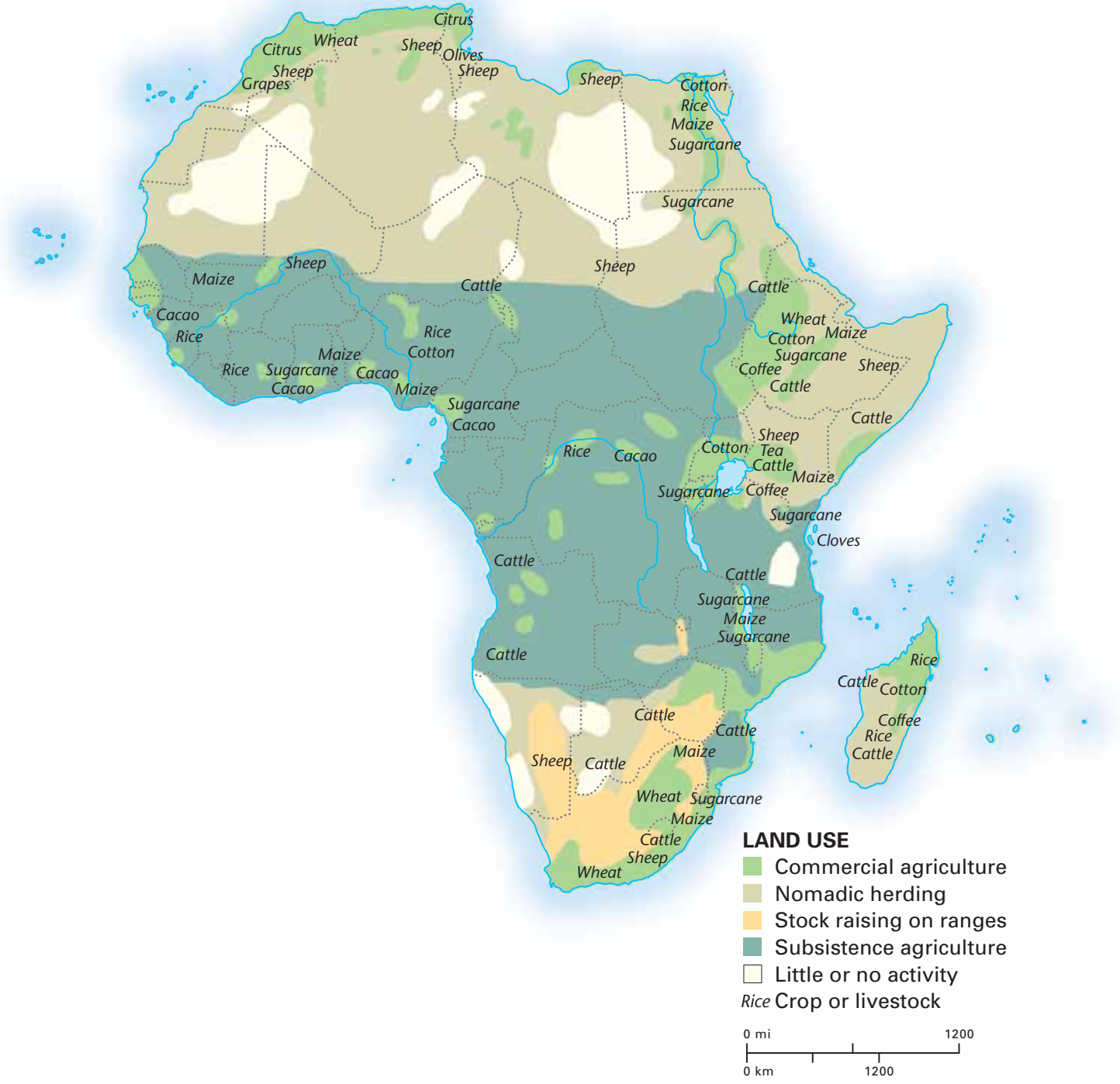
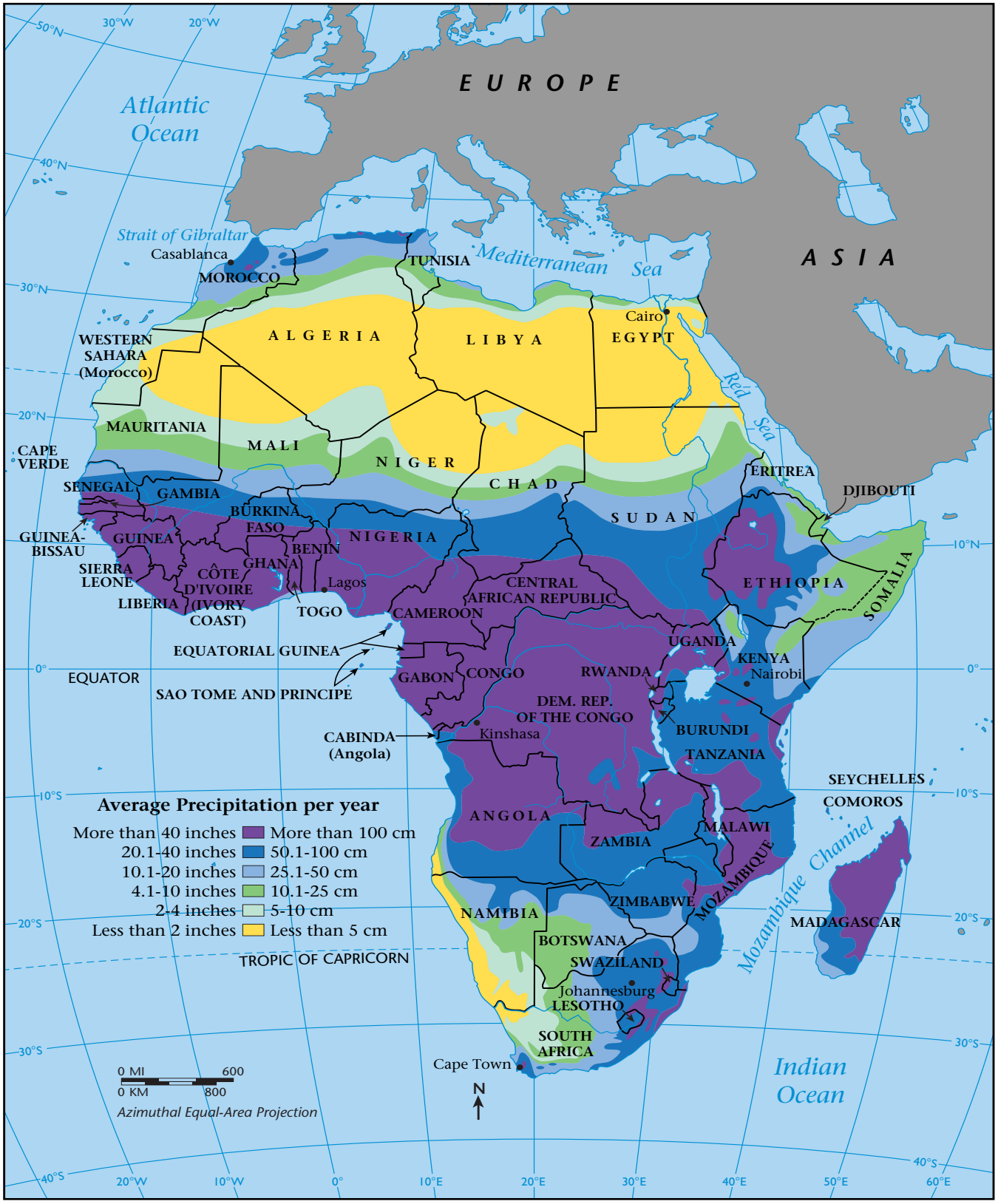
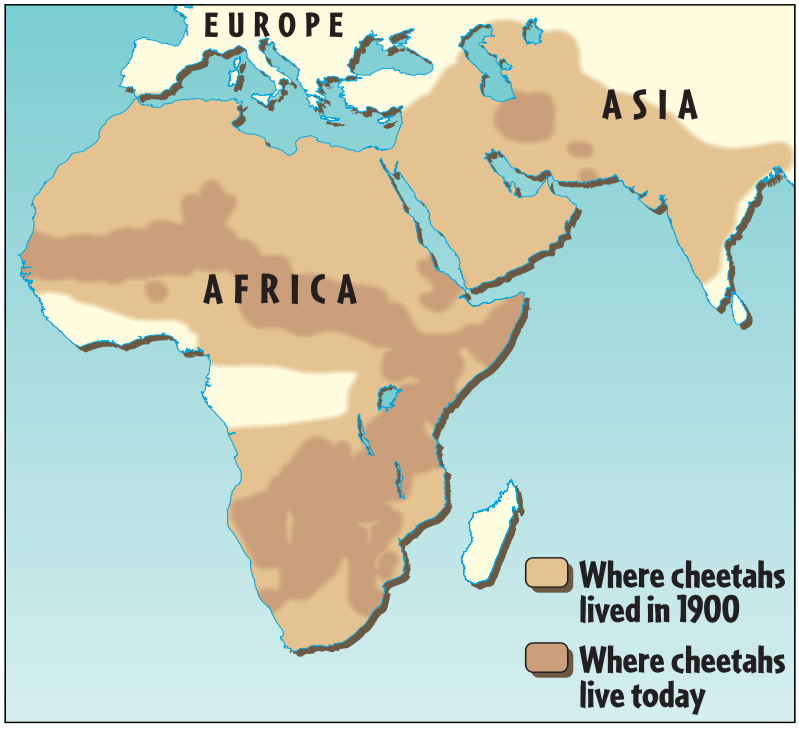




Lion Habitats

The shaded areas on the map show the primary habitats of lions today. A few still live in the Gir Forest of India. Lions once roamed Africa, southern Europe, and parts of Asia.

Range of Cheetahs



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BOTSWANA TOURISM