TEACHER GUIDE

CONCEPTS + ACTIVITIES

Grizzly Bear Biology

Grizzly Bear Conservation Strategy

British Columbia

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TEACHER GUIDE

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Table of Contents

Note: Tables 1–3 are found in the Student Guide Book.

What is a Grizzly?

"Those who have packed up into grizzly country know that the presence of even one grizzly on the land elevates the mountains, deepens the canyons, chills the winds, brightens the stars, darkens the forests, and quickens the pulse of all who enter it."
(John Murray, *The Great Bear*)

This is a Biology program with a difference! Here students meet a remarkable animal—the grizzly bear. Through a series of activities exploring the bear's anatomy, behaviour and habitat, they develop an understanding of several important biological principles. Students follow the footsteps of grizzly bear researchers, using original data and current information to examine bear evolution and population dynamics. The grizzly bear presents an ideal case study for teaching biological principles while engaging students in critical thinking about a wildlife conservation topic. The great bears' majesty, mystery and vulnerability combine to make them a remarkable example for studying human interaction with the natural world.

A Future for the Grizzly Bear High School Biology Learning Resource directly addresses the curriculum of British Columbia as well as curricula of other provinces and states. Concepts of evolution and ecology are the focus. The resource consists of a Teacher's Guide, Student Guide Books and a background information pamphlet. All of the information needed to implement the activities is included.

Learning Outcomes

Adaptation and Evolution

It is expected that students will:

- describe the process of natural selection
- suggest conditions under which the allelic frequencies of a population could change, including genetic drift, differential migration, mutation, and natural selection
- differentiate among and give examples of convergence, divergence, and speciation

Anatomy of a Grizzly as an Example of Subphylum Vertebrata

It is expected that students will:

- understand the basic skeletal plan of the vertebrates
- describe relationships between the structure and function of important characteristics of a typical vertebrate

Ecology

It is expected that students will:

- describe factors that limit and control population growth, and suggest reasons for cyclic population fluctuations
- solve simple population problems based on changes in natality, mortality, immigration, and emigration
- collect, display, and interpret data
- define and describe a pyramid of energy in terms of energy flow through an ecosystem[1]

[1]British Columbia Ministry of Education, Skills and Training, 1996. Biology 11&12 Integrated Resource Package, pp. 16-41.

Important Science Skills and Processes

The skills and processes students use and develop in science courses are the same as those used by scientists at work. These are the tools needed to understand the workings of the world. The development of these skills and processes allows students to solve problems, think critically, make decisions, find answers, and satisfy their curiosities.[2]

The activities in this learning resource model the work of biologists and resource managers in wildlife biology. Working with real data and real issues adapted for these activities, students:

- examine and interpret data
- look for patterns and hypothesize reasons for them
- and communicate their findings[3]

As the decision-makers of the next generation, our high school students need to understand the complexities of ecological relationships. Their decisions, as voters, as workers and as consumers will determine the fate of wildlife species such as the grizzly bear. Teachers can help students become informed and responsible decision-makers. **Join us in ensuring a future for the grizzly.**

Bear Adaptations Discussion: What is a Grizzly S.G. pg. 3

1) The ability to stand upright enhances smelling and viewing of potential prey or threats, especially in brush-covered meadows frequented by grizzlies.
2) Long claws are primarily adaptations for digging.
3) The long muzzle (relative to the black bear, for example) is probably adaptive for digging (they root with their muzzles) and for improved smell (important in finding food).
4) The massive shoulder muscle is in large part an adaptation for digging.
5) Bears, in general, are omnivores, with diets that usually include considerable vegetation. The eyes-forward adaptation is more pronounced in grizzlies than most other bear species, suggesting a greater role for predation.
6) Massive forearms function in running and digging. Grizzlies are fast runners, capable of bursts of speed to 55 km/hr.

[2] British Columbia Ministry of Education, Skills and Training, 1996. Biology 11 & 12 Integrated Resource Package, p. 6.

[3] See p. D-15 in the BC Biology 11 & 12 IRP for a sample of an assessment and evaluation strategy using the learning sequences outlined in this Future for the Grizzly Bear learning resource.

ACTIVITY 1

Bears over Time

In this activity, students progress from a genealogy to the larger evolutionary picture portrayed by an evolutionary tree (phylogeny) of bears.

Objectives

It is expected that students will:

- differentiate among and give examples of convergence, divergence, and speciation
- identify the role of extinction in evolution
- compare a genealogy to a phylogeny
- given information on the fossil record, comparative anatomy, chromosome and gene structure, and studies of molecular evolution, determine a phylogeny for bears

This activity in context

One effective way to teach how evolutionary relationships are related to speciation and extinction is to examine a phylogeny in detail. Bears offer an ideal group, since there is a good fossil record, there are eight extant species, and several molecular studies on the group have been carried out. Many of the early ideas about relationships among living bears (such as the notion that the panda is not a bear, or the notion that the polar bear belongs to a distinct genus), have been turned upside down by the combination of evidence that is now available to science, and is summarized here. In this activity, an established genealogy provides a springboard to building the phylogeny.

Background knowledge and preparation required

Studying evolutionary biology is often a highly theoretical exercise for students, since most of the concepts and principles must be inferred from complex sets of evidence. The element of time involved in the evolutionary process adds a further level of difficulty to this study.

Students should understand that phylogeny is both the *process* and the *product* of defining evolutionary relationships or building evolutionary trees. Background discussions of evolutionary trees and the methodologies used to determine them will help set the context for this activity. Many of the concepts of evolution will be brought to a more concrete level of understanding through the constructing of a phylogeny for bears, and thinking about its implications for the processes of evolution.

Key terms and concepts

- classification
- diversification
- phylogeny
- adaptive radiation
- genealogy
- gradual phyletic change
- common ancestor
- extinction
- allied species
- comparative anatomy

Related terms/concepts

- chromosome
- homology
- paleontology
- analogy

Notes/Discussion

The simplified genealogy provided in the student handbook is concerned with common ancestry and does not show marriage relationships as revealed in elaborate genealogies. Individuals are shown by circles, whereas ovals represent couples. The bear phylogeny activity may be tackled by students in groups of 2-4. All of the evidence should be considered and synthesized to develop the phylogeny. This activity models, on a small scale, the thinking, research and work carried out by evolutionary biologists.

Answer to Questions *Genealogical Tree s.g. pg. 5*

Ans. Q 1

The parents of the reader. This question can open up an interesting discussion regarding the genetic relationships of pairs of individuals in the chart. Sibling pairs share 50-100% of their genes. Parent-offspring pairs share at about 50% of their genes. (This percentage may increase slightly depending on the degree of genetic similarity of the parents, which is a function of generations since their common ancestry).

Ans. Q 2

The reader's great grandparents

Ans. Q 3

The common ancestor (at the base fork of the diagram).

Ans. Q 4

This question may spark a lively discussion. To answer it students must necessarily think about the process of speciation - what is the nature of the founder population that would be called the ancestors to all humans? Is it possible that this founder population was very small (a mated couple) or is it possible that the species went through a 'bottleneck' of just one couple?

Phylogenetic Tree for Bear Species *S.G. pg. 10*

Ans. Q 5

Cephalogale

Ans. Q 6

Ursus minimus, the Auvergne bear. (Both *Cephalogale* and *Ursavus elemensis* are also ancestral to Ursus, but they are ancestors of other genera as well).

Ans. Q 7

The panda bear, *Ailuropoda melanoleuca*. It is a true bear but it can be considered more closely related to other carnivore groups than other bears, since its lineage branched off earliest in bear evolution. It shares more genetic code with other groups, especially the raccoon group, the Procyonids, than do the other bears.

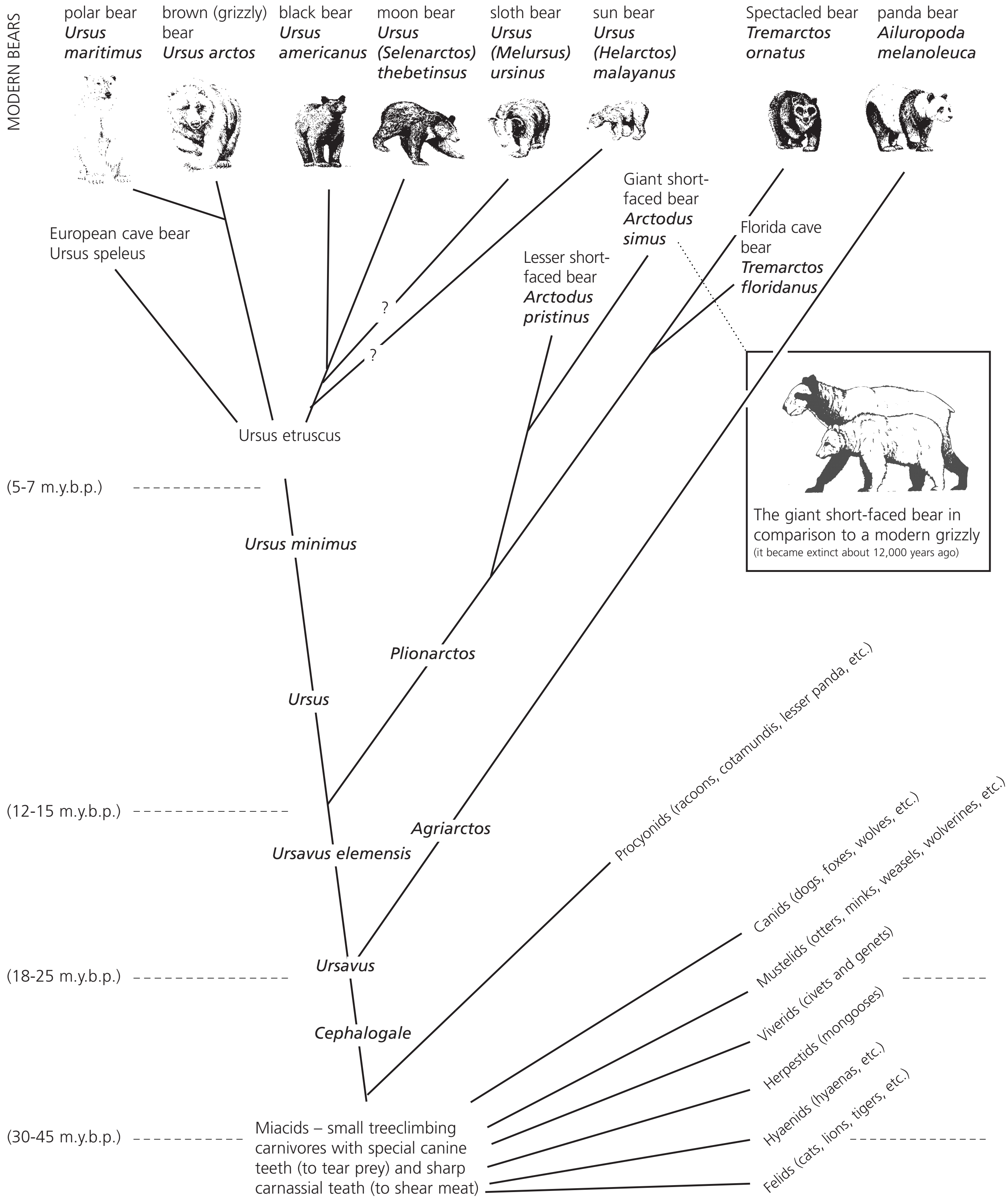
Ans. Q 8

Gradual phyletic change. It is difficult to know from the information provided here (or from the total information available to science, for that matter), but the evidence tends to indicate that gradual phyletic change may have occurred in all lines with the exception of the radiation that seems to have occurred from *Ursus etruscus* around 3-5 million years ago.

Ans. Q 9

Rapid adaptive radiation or diversification may have occurred in Europe and Asia about 3-5 million years ago with the evolution of 5 bear species of the genus, *Ursus*. It can not be determined from the information whether this evolutionary trend would represent punctuated equilibrium, but the evidence does tend to support a more rapid process of evolution with a relatively short radiation of the *Ursus* line.

Bear Evolution - A Phylogenetic Tree



ACTIVITY 2

The Making of a Species: The Polar Bear

In this activity, the polar bear and grizzly become the focus for a look at how a new species gets started.

Objectives

It is expected that students will:

- describe the process of natural selection
- suggest conditions under which the allelic frequencies of a population could change, including genetic drift, differential migration, mutation, and natural selection

This activity in context

The element of time in evolution is difficult to comprehend, particularly with regard to the process of speciation. Species evolve over intervals involving several to hundreds of generations; yet this is a mere drop in the bucket of geological time. Polar bears are an excellent example of a relatively short speciation time. Geographic isolation is easy to imagine for anyone with knowledge about glaciers and their massive extent during recent ice ages.

Background knowledge and preparation required

Biology texts generally devote considerable space to the key concept of speciation—usually referring to the Galapagos finches as the classic example.

Key terms

species
hybridization
reproductive isolation
premating mechanisms
sympatric speciation
founder population
speciation
hybrid
postmating mechanisms
allopatric speciation
sibling species

Related terms/concepts

exponential growth
competition
predation
reproductive success
adaptations
populations
selective breeding
morphological
behavioural
evolutionary distance

Answer to Questions

Comparing Polar Bears and Grizzlies / Speciation s.g. pg. 14–15

Ans. Q 1

Polar bear canines are relatively longer and more massive; adapted more for puncture and holding prey species (such as seals). Polar bear molars are narrower and less flattened; reflecting their use in tearing meat rather than primarily grinding vegetation as in grizzlies. The higher, more massive structure of the muzzle reflects extra strength needed for frequently crushing frozen meat and bones. The larger muzzle may also contain more blood vessels for heat-exchange warming of the frigid Arctic air.

Ans. Q 2

a) Polar bear legs are longer relative to those of grizzlies.

b) Polar bears have narrower and longer skulls.

c) Polar bear teeth are modified more for tearing meat and less for chewing plants relative to grizzlies.

d) Their claws are relatively shorter than grizzlies.

e) They do not have the highly developed shoulder muscle mass of grizzlies, an adaptation for digging.

f) They have much denser white fur, with hollow hairs better at trapping insulating air. The hairs also trap ultraviolet light.

g) They have many different behaviours such as the fact that they swim extensively, male polar bears do not den, and male home ranges may be thousands of square kilometers.

Ans. Q 3

- Evidence for polar bear evolution in the north: their current distribution in Arctic regions; fossils found in northern regions; suspected time of evolution corresponds to glaciated times.
- Possible scenarios: A population of grizzly bears began to thrive in areas where seals were abundant through much of the year. Over time, as the climate became colder they may have become cut off from emigration by advancing glaciers.
- Possible food: Perhaps their vegetation food began to dwindle, but those bears that survived were the ones that concentrated more effort on seal hunting. Eventually, adaptations for hunting, and more efficiently eating seals were selected for, especially as plant foods became scarcer.

Ans. Q 4

Food preference, adaptations for surviving in the cold environment, and behavioural adaptations for capturing animal prey are some of the adaptations that would tend to be selected for in the Arctic environment of these polar bear precursors. The ability to survive the winter without denning and capture food during the winter may have been critical as an early step in the evolution of the polar bear.

Ans. Q 5

It is easier, perhaps, to speculate on behavioural differences that might lead to premating isolation. Denning and the timing of mating would be particularly important. Bears that don't den (except for pregnant females) and that mate early, would tend to remain reproductively isolated from grizzlies (that do den and mate later). Aggressive behaviour differences in the two populations may also have reinforced reproductive isolation. Large size and longer legs may have been important anatomical differences that led to limited reproductive success. Postmating mechanisms might have involved the abandonment of cross-bred cubs, or the sterility of the 'hybrid' offspring.

Ans. Q 6

20,000 years represents about 2000 generations of polar bears. The actual isolation of polar bears and the period of speciation may have been only a few tens of generations (hundreds of years). In the context of the duration of a mammal species (perhaps 3-5 million years on average) this is a very small interval.

ACTIVITY 3 Grizzly Bears and Black Bears

Behaviour, Form and Function

This activity looks at the adaptive value of anatomy and behaviour in grizzly bears and black bears, focusing on the concept of the ecological niche.

Objectives

It is expected that students will:

- examine the ecological niche of two bear species
- speculate on the degree that black bears and grizzlies compete ecologically
- describe relationships between structure and function in bears
- differentiate among and give examples of convergence and divergence

This activity in context

Students rarely have the opportunity to study a species in sufficient depth to develop an understanding of its evolution in the context of the ecological theatre. Adaptations evolve because they provide a competitive advantage. The principle of competitive exclusion is a key concept linking form and function to natural selection. By studying the biology of two bear species that may compete, students gain insights into how natural selection shapes the anatomy and behaviour of an organism over time.

Background knowledge and preparation required

Most biology textbooks at this level can provide some background on the principle of competitive exclusion and the ecological niche. This activity can reinforce or elaborate the text approach, or it can be used as a particularly good example to initiate a study of the general principles.

Key terms and concepts

extinction

principle of competitive exclusion

ecological niche

anatomical

behavioural

adaptations

Related terms/concepts

divergence

convergence

Answer to Questions
Grizzlies and Black Bears s.g. pg. 21–22

Chart comparing grizzly bears and black bears:

	Grizzlies	**Black Bears**
a) preferred habitat	open slopes, margins of forests	deep forest
b) tree climbing adaptations	claws straightened; cubs climb but adult climbing abilities limited	curved claws; climbing throughout lifetime
c) digging abilities	shoulder muscle mass; massive front paws and claws strongly adapted for digging	lacks shoulder muscle mass; front paws and claws allow relatively limited digging
d) length of parental care	2.5 years +	1.5 years
e) aggressive behaviour	extremely aggressive in many situations	can be dangerous but tends to be less aggressive

Ans. Q 1

a) Grizzlies tend to use more open habitats, often at higher elevations. Black bears use openings, but are less likely to range very far from protective cover.

b) Black bears, especially adult females with cubs, tend to stay close to trees that they can climb when the cubs are threatened. Forests with dense understories provide visual or security cover that hides bears when threatened.

c) Biomass in dense forests tends to be more concentrated in trees and tree roots than in food plants. Openings such as wetlands, meadows, avalanche paths, beaches and estuaries and recent clearcuts tend to provide more foods - berries, herbaceous plants and plants with edible roots. Therefore, black bears tend to thrive in areas where there is a variety of habitats, both open and forested.

d) More aggressive behaviour, larger size, ability to protect food resources would all be selected for in open-habitat favouring animals.

Ans. Q2

a) Short, sharp, curved claws and strong arms. The heavier the bear, the more weight it must lift and hold to the tree. Other things being equal, lighter bears should be better tree climbers.

b) Again, younger bears or adult females with cubs feeding in large openings would be less likely to be near trees in the event of a threat.

c) Bears less capable of climbing trees would likely tend to be more aggressive to defend their young and themselves. Tree climbing bears might tend more to flight and safe retreat to trees.

d) Coastal bear habitats are more concentrated in super-productive valley bottoms and lower slopes—particularly in the spring and salmon-feeding periods. In dry interior areas, habitats are more disperse across space and through time. Interactions between the species are therefore more likely on the coast where more bears are packed into less available habitat. Black bears on Vancouver Island (where there are no grizzlies) tend to be more daytime active than black bears on the mainland coast in areas where there are grizzlies present. Black bears on the mainland appear to avoid interactions with grizzlies partly by using important habitats at night.

Ans. Q3

a) Grizzly bears have longer front claws and heavier shoulder muscles that are not particularly good adaptations for climbing, but have evolved for digging food (e.g., ground squirrels, marmots and roots) and for excavating dens.

b) With these adaptations, the grizzly is a more capable aggressor, and better able to dig, but less capable as a tree-climber.

Ans. Q 4

Staying with cubs and aggressively protecting them would cost a female grizzly energy, but would increase her fitness overall if more offspring survived. Living and feeding in the open, the aggressive nature of male grizzlies and their drive to mate with females (killing cubs of the female fathered by a different bear), and the size of grizzly bear competitors would all tend to select for longer parental care. The denser forest habitat of the black bear, their smaller size, and their tree-climbing abilities would tend to allow offspring to survive on their own earlier.

Ans. Q 5

a) Naive grizzlies would tend to be more aggressive than naive black bears. Black bears would tend to be wary of potential predators such as grizzlies, whereas grizzlies would be less shy.

b) The dominance of grizzlies, their larger size, their tendencies for open slope habitats and their lack of tree-climbing would tend to favour more aggressiveness.

c) Polar bears are the 'ultimate extension' of these tendencies, lacking any protection in their environment, and being the top-level predators. In the polar bear habitat, anything that moves or stands out as different from the icy environment would be considered food.

Ans. Q 6

Removal of grizzlies from a region of grizzly/black bear range overlap would favour population increase of black bears. In a scenario where humans do not influence the course of natural selection, black bears with characteristics that favour survival and reproduction in the more open areas would tend to be selected for in those habitats. In time, forces of natural selection might favour a speciation process that would split the black bear species (geographical isolation would be necessary), leading to a new bear species occupying the ecological niche previously occupied by the grizzly.

Ans. Q 7

a) The principle of competitive exclusion can be applied to bears and humans.

b) Human hunting of grizzly bears, killing 'nuisance bears', or poaching and other forms of illegal killing are a form of direct competition with grizzly populations. Competition for food resources includes fish harvesting (often far from the streams where bears would be feeding on the fish), poor logging practices (which may destroy food resources such as fish or skunk cabbage swamps), development which destroys natural bear foods, and so forth. Many human activities can frighten bears away from their food resources thus directly affecting the bears' abilities to compete in their ecological niche.

ACTIVITY 4

Population Studies

This activity introduces the fields of wildlife inventory and estimating populations, as well as the basic equations of population change.

Objectives

It is expected that students will:

- describe factors that limit and control population growth
- solve simple population problems based on changes in natality, mortality, immigration, and emigration

This activity in context

Grizzly bear populations have been decimated over much of the North American range they occupied 150 years ago. Will this trend continue? Will the grizzly survive? Many biologists consider the grizzly to be a key indicator species for wildlife conservation, primarily because its habitat requirements are so extensive. Conserving grizzly populations will help to ensure the survival of most mammal species that share their habitat. Conserving grizzly populations will require the ability to estimate or inventory populations and follow population fluctuations through time.

Background knowledge and preparation required

Activities 2 and 3 provided background information on grizzly biology useful in discussing population dynamics. In particular, Table 3: Biological Characteristics of North American Bears (page 16 of the Student Guide) is useful.

Key terms and concepts

density-dependent limiting factors
DNA fingerprinting
emigration
human-caused mortality
immigration
implanting

Related terms/concepts

closed populations
open populations
mortality
natural mortality
natality
poaching
population
radio collaring

Notes/Discussion

A closed population is one without immigration or emigration. In a closed population, as long as mortality exceeds natality the population will eventually go extinct.

Detailed data such as the data provided in this activity are only available for a few populations where absolute abundance has been measured. Almost every bear in a population must be known and monitored—a highly unlikely scenario. The grizzlies of Yellowstone National Park represent one such population. Most of the small grizzly (brown) bear populations of Europe are also known on an individual, bear-by-bear basis. Most grizzly populations in the mountainous, forested regions of British Columbia and elsewhere are too difficult to monitor precisely. The bears are secretive and highly varied in their movements and habitat selection. Population estimates are used, involving capture/mark/recapture data. In Activity 5, students model population changes using data determined through capture/mark/recapture studies.

Quantitatively, how does the factor below affect change in grizzly bear populations?

1) Age distribution in a population. (Grizzly bears may live as long as 20-25 years. Females begin to have young at 5-7 years of age.)

Quantitatively, how does the factor below affect change in grizzly bear populations?

2) Interval between litters. (Grizzly bears cubs stay with their mother for 2-4 years. During this time, the female does not breed.)

Quantitatively, how does the factor below affect change in grizzly bear populations?

3) Intraspecific predation on cubs. (Male grizzly bears may kill and eat cubs. Some biologists believe this increases their chances to mate with the female, thus fathering more of their own offspring.)

Qualitatively, how might the factor below affect change in grizzly bear populations?

4) Abundance and distribution of grizzly bear foods in a region.

Qualitatively, how might the factor below affect change in grizzly bear populations?

5) Road access to grizzly bear habitat.

Qualitatively, how might the factor below affect change in grizzly bear populations?

6) Human behaviour when hiking in grizzly bear habitat.

Qualitatively, how might the factor below affect change in grizzly bear populations?

7) Municipal and personal garbage management in occupied grizzly bear habitat.

Qualitatively, how might the factor below affect change in grizzly bear populations?

8) Competition for food resources between females (including those with cubs) and dominant males.

Qualitatively, how might the factor below affect change in grizzly bear populations?

9) Media coverage of grizzly bear attacks on humans.

Qualitatively, how might the factor below affect change in grizzly bear populations?

10a) Hunting of males allowed in a grizzly bear population.
10b) Hunting of females allowed in a grizzly bear population.

Qualitatively, how might the factor below affect change in grizzly bear populations?

11) Over the years, agricultural development completely surrounds a small wilderness area containing grizzly bears.

Qualitatively, how might the factor below affect change in grizzly bear populations?

12) Exceptionally poor crop of berries, especially huckleberries and other late-ripening berries.

Qualitatively, how might the factor below affect change in grizzly bear populations?

13) Increased industrial or recreational development taking place in occupied grizzly bear habitat.

Qualitatively, how might the factor below affect change in grizzly bear populations?

14) Beliefs about medicinal value and enhanced sexual performance attributed to the consumption of bear parts.

Qualitatively, how might the factor below affect change in grizzly bear populations?

15) Price of bear parts on the black market.

Answer to Questions *Population Studies: s.g. pg. 27–28*

Ans. Q 1

The approximate size of grizzly bear populations must be known if we are to monitor the status of this species. The species is vulnerable or threatened in much of its range, and it has been extirpated from a considerable portion of its historic range. Wildlife biologists are particularly interested in grizzly bear survival, since grizzlies can be considered an indicator species for the general health of wildlife populations in an area. This question should prompt discussion of extinction and ethical issues of wildlife conservation.

Ans. Q 2

Bear management usually refers to the process of monitoring bear populations and the movements, behaviour, and habitat choice of bears in order to make informed decisions about issues that affect bears. Traditionally, these decisions have related mostly to bear hunting and bear removal from human settlement areas, but increasingly, decisions about other potential impacts are considered by wildlife managers.

Ans. Q 3

Humans and human activities now represent one of the greatest threats to grizzly bear survival. A variety of human activities in bear-occupied habitat can affect populations, from hunting and illegal poaching, to inadequate disposal of garbage, to frequency of hiking in bear country and behaviour of hikers while there. Bears can be: killed; driven away from an area of food source; conditioned to humans to the point where they become nuisance bears; and so forth. Humans must be 'managed' through such means as education about hiking in bear country or garbage handling etiquette, enforcement of hunting regulations, garbage disposal regulations, trail closures, etc.

Ans. Q 4

$$\Delta P = B + I - D - E$$

$$= (L_{ave} \times N_{rf}/I \times f_m) + I - (D_n + D_c + D_h + D_{nu} + D_{po}) - E$$

Area	N_{start}	L_{ave}	N_{rf}	L_i	f_m	**I**	D_n	D_c	D_h	D_{nu}	D_{po}	**E**
A	806	2.3	185	3.3	.93	7	64	21	32	6	22(est)	2
B	421	2.2	104	3.8	.93	2	33	11	11	0	0 (est)	5

a) 120 + 7 - (64 + 21 + 32 + 6 + 22) - 2 = - 20 (population declined by 20 bears)

b) 56 + 2 - (33 + 11 + 11 + 0 + 0) - 5 = -2 (population declined by 2 bears)

Ans. Q 5 Discussion/Answers to the Population Impact Cards

1. Natality is directly proportional to number of breeding age females.
2. Natality is inversely proportional to the interval between litters.
3. The intraspecific predation of male grizzlies on cubs may be a density-dependent factor. As population density becomes higher, cub predation may increase.
4. Time and energy spent hunting for foods may affect natality and the natural death rate. In low food years, the survival of cubs may go down.
5. Increased road access to grizzly habitat may lead to disturbance at feeding areas (see 4), increased hunting, increased poaching or other illegal killing, increases in habituation to humans, and a subsequent increase in deaths of grizzlies considered 'nuisance bears.'
6. In the long term, humans may frighten bears off essential food sources, leading to increased mortality or decreased natality. Bears may become habituated to food at camping areas—leading to deaths of 'nuisance bears'.
7. Poor garbage management may 'benefit' some bears in the short term by providing more food but it has been shown to be very detrimental in the long run. Nuisance bear deaths go up. 'Natural deaths' from ingestion of poisons goes up. Cub predation may go up. Hunting near dumps may increase, as may poaching.
8. Natality may decrease if dominant males limit access of females to foods.
9. Media coverage has much influence on people's perception of dangerous or nuisance bears. The long-term effect might possibly lead to unnecessary killing of bears perceived as threats. On the other hand, media coverage may influence people to respect bear habits and habitats more, leading to fewer bears killed as nuisance bears. Bear/human conflict is as much a people management as a bear management issue.
10. a) Hunting of male grizzlies contributes to human-caused death rate. A combined level of 4% hunting deaths and mortality from other human causes is thought to be the acceptable level for negligible impact on population dynamics. Naturally, human-caused mortality can have a significant impact on population change if above certain levels, as has been shown by the history of bear extirpation in North America and elsewhere.

    b) Hunting females adds to the population mortality rate and also directly lowers the natality rate. Adult female mortality in a concentrated area can have an even greater effect.
11. Emigration and immigration are eliminated from such a population if the surrounding agricultural areas are large. Competition for limited resources and

habitat may lead to increased natural mortality. Increased human-caused mortality is likely as bears along the margins of the occupied area are likely to have more contact with humans.

12. Berries are an essential 'fattening up food' of many populations. A poor berry crop may lead to decreased female productivity (lower natality) and possibility to increased natural mortality. Decreased cub production results because females unable to obtain adequate food resources in the fall will not 'implant'. Even though mating occurs in the late spring or early summer, development of the fertilized eggs is arrested. These tiny embryos, known as blastocysts, float freely in the female reproductive tract for up to five months. If the female has plenty of fat reserves, the embryo will implant in the uterine wall in October, and the short gestation will begin (known as delayed implantation).
13. Commercial development may affect bear feeding habitat leading to decreases in reproduction or increases in mortality. Increased human-caused mortality is a factor related to increased access and increased bear/human contact, as increased hunting, poaching and other illegal killing may occur.
14. Poaching for the trade in bear body parts is a significant problem. Beliefs that lead to this trade influence how likely a bear population will be subjected to poaching mortalities.
15. The price of bear parts on the black market will have some influence on the possibility that someone might engage in this illegal activity. Higher prices may lead to more poaching mortalities.

ACTIVITY 5

The Life Table

This activity extends the qualitative and simple quantitative population problems of Activity 4, providing students with the opportunity to manipulate dynamic variables and see the results in populations over time.

Objectives

It is expected that students will:

- describe factors that limit and control population growth
- solve simple population problems based on changes in natality, mortality, immigration, and emigration
- collect, display, and interpret data
- model population changes using a life table on computer spreadsheet

This activity in context

What better way to study the relatively complex concepts of population dynamics than to model population changes in a life history table using a familiar species? Grizzly bear population dynamics is particularly important because the conservation and wildlife management strategies for this species depend on estimates of population levels and changes. The life history table is a simple population dynamics simulator.

Background knowledge and preparation required

This activity extends and refines concepts associated with population dynamics. All of the questions can be referenced in the context of the classic population growth curve shown in biology texts. Questions 1-6 deal with a population probably at or near carrying capacity. The population in Question 7 is in the exponential growth portion of the curve. The concept of age class structure of a population is well-illustrated by the life tables used in this activity.

Key terms and concepts

life table
age-class structure (age structure)
doubling time
survivorship
natality
reproductive rate
population
carrying capacity

Related terms/concepts

density-dependent
density-independent

Notes/Discussion

Biologists have concluded that the most sensitive variable for grizzly population dynamics is survivorship of adult females.

Discussions of carrying capacity, and population dynamics modeling can be applied to human populations.

Setting Up a Grizzly Bear Population Life Table

Setting up a life table to show how grizzly bear populations might change under different scenarios is relatively easy using computer spreadsheet applications such as Excel, Lotus, Clarisworks, Works, etc.

Table 4 (p. 24) is a printed example of the Life History Table for a generalized steady-state grizzly bear population, showing the formulas and data entered in a spreadsheet application to create that table. A list of variables in the table, along with important notes is provided on page 25.

Some teachers may prefer to have students set up the Life History Table on a spreadsheet application, while others may want to distribute copies of the formulated spreadsheet on disk. Pairs of students or groups of 3–4 working at a computer may facilitate discussion of the questions and concepts.

Table 4: Formulas and Variables for the Life History Table Spreadsheet

	A	B	C	D	E	F	G	H	I	K
1		Year 1				Year1	Year 2	Year3	Year4	etc.
2	Age	Pop	S_x	m_x	$S_x m_x$	Pop	Pop	Pop	Pop	etc.
3	0-1	123	0.808			=B3	=B9*E9+ B10*E10+ B11*E11+ B12*E12+ B13*E13+ B14*E14+ B15*E15+ B16*E16+ B17*E17+ B18*E18+ B19*E19+ B20*E20+ B21*E21	=E9*G9+ E10*G10+ E11*G11+ E12*G12+ E13*G13+ E14*G14+ E15*G15+ E16*G16+ E17*G17+ E18*G18+ E19*G19+ E20*G20+ E21*G21	=E9*H9+ E10*H10 E11*H11+ E12*H12+ E13*H13+ E14*H14+ E15*H15+ E16*H16+ E17*H17+ E18*H18+ E19*H19+ E20*H20+ E21*H21	etc. etc.
4	1-2	99	0.849			=B4	=C3*F3	=C3*G3	=C3*H3	etc.
5	2-3	84	0.903			=B5	=C4*F4	=C4*G4	=C4*H4	etc.
6	3-4	76	=C5			=B6	=C5*F5	=C5*G5	=C5*H5	etc.
7	4-5	68	=C5			=B7	=C6*F6	=C6*G6	=C6*H6	etc.
8	5-6	62	=C5			=B8	=C7*F7	=C7*G7	=C7*H7	etc.
9	6-7	56	0.923	0.29	=C9*D9	=B9	=C8*F8	=C8*G8	=C8*H8	etc.
10	7-8	52	=C9	=D9	=C10*D10	=B10	=C9*F9	=C9*G9	=C9*H9	etc.
11	8-9	48	=C9	=D9	=C11*D11	=B11	=C10*F10	=C10*G10	=C10*H10	etc.
12	9-10	44	=C9	=D9	=C12*D12	=B12	=C11*F11	=C11*G11	=C11*H11	etc.
13	10-11	41	=C9	=D9	=C13*D13	=B13	=C12*F12	=C12*G12	=C12*H12	etc.
14	11-12	37	=C9	=D9	=C14*D14	=B14	=C13*F13	=C13*G13	=C13*H13	etc.
15	12-13	35	=C9	=D9	=C15*D15	=B15	=C14*F14	=C14*G14	=C14*H14	etc.
16	13-14	32	=C9	=D9	=C16*D16	=B16	=C15*F15	=C15*G15	=C15*H15	etc.
17	14-15	30	=C9	=D9	=C17*D17	=B17	=C16*F16	=C16*G16	=C16*H16	etc.
18	15-16	27	=C9	=D9	=C18*D18	=B18	=C17*F17	=C17*G17	=C17*H17	etc.
19	16-17	26	0.9	=D9	=C19*D19	=B19	=C18*F18	=C18*G18	=C18*H18	etc.
20	17-18	22	0.8	=D9	=C20*D20	=B20	=C19*F19	=C19*G19	=C19*H19	etc.
21	18-19	18	0.7	=D9	=C21*D21	=B21	=C20*F20	=C20*G20	=C20*H20	etc.
22	19-20	13	0.6	=D9	=C22*D22	=B22	=C21*F21	=C21*G21	=C21*H21	etc.
23	21-25	7	0			=B23	=C22*F22	=C22*G22	=C22*H22	etc.
24	Total	=SUM (B3:B23)				=SUM M(F3:F23)	=SUM (G3:G23)	=SUM (H3:H23)	=SUM (I3:I23)	etc. etc.

Formulas in the spreadsheet need not be manipulated in the activities (although there may be other equivalent formulas that can be used when the spreadsheet is set up).

Fixed values and variables are explained as follows:

Cell	Variable	Comment
(A:3 to A:23)	age class	The total life span of grizzly bears is usually less than 20 years, but a few individuals live to 25 or more. For simplicity, we have lumped bears older than 20 into a non-reproductive category.
(B:3 to B:23) or (F:3 to F:23)	Pop_x	The age class structure of a population of 1000 females has been calculated for these cells. Note that the F column is simply a repeat of the B column, to facilitate graphing. Students will manipulate individual population levels in different age classes to simulate a variety of conditions acting on the population. **Use column B rather than column F for these manipulations.**
(C:3)	S_c	= Survivorship of female cubs. A decimal variable manipulated to reflect increases or decreases in survival rate of female cubs during first year. In natural populations, cub survivorship values as low as 33% (0.33) have been measured. Survival of 90% (0.90) of cubs is high.
(C:4)	S_y	= Survivorship of female yearlings. A decimal variable manipulated to reflect increases or decreases in survival rate of female yearlings during second year of life.
(C:5)	S_s	= Survivorship of female subadults. A decimal variable manipulated to reflect increases or decreases in survival rate of subadult females.
(C:9)	S_a	= Survivorship of female adults. A decimal variable manipulated to reflect increases or decreases in survival rate of adult (breeding age) females. This is a key variable, with 0.92 (92% survival) considered to be the critical level for self-sustaining populations in many bear populations studied.
(C:19 to C:23)	S_x	Survivorship values reflecting an increase in mortality near the end of the grizzly bear life span. These values assume a gradual decline in survivorship.
(D:9 to D:22)	m_x	= Average reproductive rate as number of female cubs per adult female per year. This value takes into account the breeding interval (generally about 3-4 years) and the average litter size (generally about 2).

Answer to Questions *The Life Table s.g. pg. 31–33*

Ans. Q 1

Changes in the survivorship of any age class will lead to proportional changes in populations of the next age class. The effect will ripple through the populations—increased survivorship will lead to population growth, decreased survivorship to declines. Changes in reproductive rate yield changes in offspring (age class 0-1), leading to corresponding population changes over time.

Ans. Q 2

To model this effect, change cell B4 from 99 to 61 (half of those born survive in one year rather than .808 as before). The population does not recover to 1000 during the 20 year period of the life table, but it does stabilize at a new steady-state level of 968 female bears. (An extended table reveals that the population continues at the steady state of 968). For this population to recover to 1000 female bears, there must be an increase in survivorship or in reproduction.

Ans. Q 3

Values in column B become (from top) 123, 86, 64, 58, 52, 47. The population falls to 901 in year 15, and then begins to climb back. (It will eventually stabilize at about 907, by about year 25, if all conditions went back to the steady state). It is likely that such harsh conditions would also have an effect on reproduction, especially if the late-season food supplies were at all depressed. If females that have bred are poorly nourished at the start of hibernation, they will not implant the embryos—leading to a reduction in reproductive rate.

Ans. Q 4

In general, hunting 4% of adult males should have minimal effects on the population, as long as there are sufficient males in the population to maintain a full reproductive rate and the loss of males does not influence survivorship of females or reproduction. The direct loss of males cannot be modeled in the life table. On the other hand, hunting even 1% of adult females can have a strong effect on the population over time when all other factors remain unchanged. To model this effect, change cell C-9 (survivorship of adult females) from 0.923 to 0.913. This yields a declining population, approaching 900 after 20 years (and 800 after 40 years).

Ans. Q 5

To model this situation, decrease the survivorship values of cubs of the year (age 0-1) and second year cubs (age class 1-2) to lower values (Cells D3 and D4). If other aspects of the steady-state life table remain unchanged, the population begins to diminish at even slight decreases in cub survivorship. This model suggests that populations where dominant males are hunted should be watched closely for the possible effects of predation on cubs by subdominant males. To the date of this publication, conclusive evidence for this effect has not been recorded.

Ans. Q 6

As one would expect, the loss of 5 females by poaching and other illegal killing in a large population (such as 1000 females), has a relatively small effect compared to the same loss in a small population such as 100 females. However, the model shows that, depending on the age of females removed from the population, neither the larger nor the smaller population will recover completely in 20 years (or even 50 years), as long as the original steady-state conditions persist. Experimenting with the age of the killed bears shows that killing older bears has less effect on the population. If illegal killing continued, there would be continued population decreases. Illegal killing of any bears is wrong, but it is perhaps even most deplorable if perpetrated against small, vulnerable or endangered populations.

Ans. Q 7

Note the printout of the Flathead River Life Table (page 27).

a) This growing population would double in about 12 years.

b) Continued exponential growth is not likely. Food resources and habitat will tend to limit the population at some point - the population will reach carrying capacity. It is probable that bears are emigrating from the region.

c) The 1930s fires probably opened up many slopes to revegetation by huckleberries and other berries. These berries make excellent fall foods, leading to successful hibernations where embryos in fertilized females are more likely to be implanted. Over time, berries are likely to be replaced or suppressed by trees which will outcompete berry bushes. As this food resource diminishes, population growth is likely to decrease as survivorship and reproduction rates go down.

Ans. Q 8

a) The population is definitely decreasing.

b) Without immigration or significant changes in survivorship or reproduction, the population will decrease, perhaps to zero. If the population is not dwindling at the drastic rate suggested by the life table, it is likely that immigration into the area is replacing some of the population loss. Considering the high population growth rate to the north (as suggested by question Q 7 above) it is likely that bears are moving in from the growing population.

c) Management policies may most easily affect the human-caused mortality. Restricting road access or providing ongoing enforcement may help to stem the illegal hunting. Correct management of garbage facilities may reduce the need to remove 'problem bears' caused by garbage habituation.

Life history tables

Life history table for generalized steady-state grizzly bear population — numbers represent female grizzly bears

Age	Year 1 Pop	Sx	mx	Sxmx	Year 1 Pop	Year 2 Pop	Year3 Pop	Year4 Pop	Year5 Pop	Year6 Pop	Year7 Pop	Year8 Pop	Year9 Pop	Yr10 Pop	11 Pop	12 Pop	13 Pop	14 Pop	15 Pop	16 Pop	17 Pop	18 Pop	19 Pop	20 Pop
0-1	123	0.808			123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123
1-2	99	0.849			99	99	100	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
2-3	84	0.903			84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
3-4	76	0.903			76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76
4-5	68	0.903			68	69	68	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69
5-6	62	0.903			62	61	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62
6-7	56	0.923	0.29	0.268	56	56	55	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
7-8	52	0.923	0.29	0.268	52	52	52	51	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
8-9	48	0.923	0.29	0.268	48	48	48	48	47	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
9-10	44	0.923	0.29	0.268	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
10-11	41	0.923	0.29	0.268	41	41	41	41	41	41	40	41	41	41	41	41	41	41	41	41	41	41	41	41
11-12	37	0.923	0.29	0.268	37	38	37	38	38	38	38	37	37	37	37	38	38	38	38	38	38	37	38	38
12-13	35	0.923	0.29	0.268	35	34	35	35	35	35	35	35	34	35	35	35	35	35	35	35	35	35	35	35
13-14	32	0.923	0.29	0.268	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
14-15	30	0.923	0.29	0.268	30	30	30	29	30	29	30	30	29	29	29	29	29	29	30	30	30	30	30	30
15-16	27	0.923	0.29	0.268	27	28	27	28	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
16-17	26	0.9	0.29	0.261	26	25	26	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
17-18	22	0.8	0.29	0.232	22	23	22	23	23	23	22	23	23	23	23	23	23	22	23	23	23	23	23	23
18-19	18	0.7	0.29	0.203	18	18	19	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
19-20	13	0.6	0.29	0.174	13	13	12	13	13	13	13	13	12	13	13	13	13	13	13	13	13	13	13	13
21-25	7	0			7	8	8	7	8	8	8	8	8	7	8	8	8	8	8	8	8	8	8	8
Total	1000				1000	1001	1001	1001	1001	1001	1001	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1001	1001

Sx = age-specific survivorship
mx = reproductive rate (average female cubs/adult female/year)

Life history table for Flathead River data, question 6

Age	Year 1 Pop	Sx	mx	Sxmx	Year 1 Pop	Year 2 Pop	Year3 Pop	Year4 Pop	Year5 Pop	Year6 Pop	Year7 Pop	Year8 Pop	Year9 Pop	Yr10 Pop	11 Pop	12 Pop	13 Pop	14 Pop	15 Pop	16 Pop	17 Pop	18 Pop	19 Pop	20 Pop
0-1	92	0.867			92	208	208	208	208	208	208	208	236	263	288	312	335	356	377	403	434	470	509	549
1-2	80	0.944			80	80	180	180	180	180	180	180	180	205	228	250	271	290	309	327	349	376	408	442
2-3	75	0.931			75	76	75	170	170	170	170	170	170	170	193	215	236	256	274	292	308	330	355	385
3-4	70	0.931			70	70	70	70	158	158	158	158	158	158	158	180	200	220	238	255	272	287	307	331
4-5	65	0.931			65	65	65	65	65	147	147	147	147	147	147	147	167	186	204	222	238	253	267	286
5-6	61	0.931			61	61	61	61	61	61	137	137	137	137	137	137	137	156	174	190	206	221	235	249
6-7	57	0.946	0.42	0.399	57	57	56	56	56	57	57	128	128	128	128	128	128	128	145	162	177	192	206	219
7-8	54	0.946	0.42	0.399	54	54	54	53	53	53	54	54	121	121	121	121	121	121	121	137	153	168	182	195
8-9	51	0.946	0.42	0.399	51	51	51	51	50	51	50	51	51	114	114	114	114	114	114	114	130	145	159	172
9-10	48	0.946	0.42	0.399	48	48	48	48	48	48	48	48	48	48	108	108	108	108	108	108	108	123	137	150
10-11	45	0.946	0.42	0.399	45	45	46	46	46	45	45	45	45	45	45	102	102	102	102	102	102	102	116	129
11-12	43	0.946	0.42	0.399	43	43	43	43	43	43	43	43	43	43	43	43	97	97	97	97	97	97	97	110
12-13	41	0.946	0.42	0.399	41	41	40	41	41	41	41	41	40	40	40	41	41	91	92	92	92	92	92	92
13-14	39	0.946	0.42	0.399	39	39	38	38	38	39	39	39	39	38	38	38	38	38	87	87	87	87	87	87
14-15	36	0.946	0.42	0.399	36	37	37	36	36	36	37	37	37	36	36	36	36	36	36	82	82	82	82	82
15-16	34	0.946	0.42	0.399	34	34	35	35	34	34	34	35	35	35	34	34	34	34	34	34	77	78	78	78
16-17	32	0.9	0.42	0.38	32	32	32	33	33	33	32	33	33	33	33	33	32	32	32	33	32	73	73	73
17-18	29	0.8	0.42	0.338	29	29	29	29	30	30	29	29	29	29	29	29	29	29	29	29	29	29	66	66
18-19	23	0.7	0.42	0.295	23	23	23	23	23	24	24	23	23	23	24	24	24	23	23	23	23	23	23	53
19-20	16	0.6	0.42	0.253	16	16	16	16	16	16	17	17	16	16	16	16	17	16	16	16	16	16	16	16
21-25	9	0			9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Total	1000				1000	1117	1218	1313	1401	1483	1560	1631	1726	1841	1973	2119	2278	2446	2623	2814	3023	3253	3504	3772

Sx = age-specific survivorship
mx = reproductive rate (average female cubs/adult female/year)

ACTIVITY 6

Grizzly Feeding, Habitat and Populations

Graphical data on British Columbia grizzly bear diets are examined and evaluated to develop a picture of the bear's food and habitat needs.

Objectives

It is expected that students will

- describe factors that limit and control population growth, and suggest reasons for cyclic population fluctuations
- collect, display and interpret data
- analyze human activities in relation to habitat needs of grizzly bears

This activity in context

Grizzly populations and individuals within populations vary greatly in the amount of habitat and range they require. Every grizzly depends on a variety of different foods throughout the yearly cycle, and bears migrate between these food sources at times appropriate to best utilize them. Some food sources are particularly important to bear survival. Disturbance away from these sources at critical times may impact populations.

This activity allows students to understand the ecological role of a complex omnivore/carnivore such as the grizzly. Thinking about the dietary needs of bears allows students to better understand the difficult task of habitat assessment and biological conservation.

Key terms and concepts

carrying capacity
ungulates
hibernation
carrion
sedges
forbs
succulent
rumen
implantation
foraging

Related terms/concepts

conservation biology
biodiversity

Notes/Discussion

Emphasize that the graphs represent average diet over the years of the study. Considerable variation from year to year occurs, and individual bears have different preferences, habitats, and access to food resources. For example, dominant male grizzlies may limit access of other bears to a resource through threat or attack. In the extreme, grizzlies will guard and fight for an animal carcass they have found or killed.

Answer to Questions

Grizzly-Feeding, Habitat and Populations s.g. pg. 38–39

Ans. Q 1

	Coastal Population	**Interior Population**
a) foods at emergence in early spring	grasses, sedges, bullrushes and skunk cabbage.	elk (probably mostly as winter-kill carrion), roots, grasses and horsetails.
b) relative importance of berries	berries form only a moderate portion of the mid summer diet.	berries extremely important in late summer/early fall, forming as much as 90% of the food intake.
c) four main sources of energy	1) skunk cabbage, 2) grasses, sedges and bullrushes, 3) salmon, 4) cow parsnip.	1) huckleberries, 2) roots, 3) grasses and horsetails, 4) cow parsnip.
d) relative importance of meat	Meat may be slightly more important for the coastal population in terms of overall quantity. Its use is concentrated at the time of salmon runs.	Meat appears to be slightly less important for the interior population. Its use is spread over the spring and fall.
e) types and timing of meat consumption	Salmon is particularly important in the time when coastal grizzlies are building fat for winter hibernation.	The meat of ungulates, mainly elk, is most utilized at the time of emergence and just before hibernation.
f) foods before denning	Salmon and dead salmon, skunk cabbage, grasses and sedges.	Bearberry, other berries, roots, elk, deer, and moose.

Ans. Q 2

Answers here are somewhat open-ended. Discussion/answers may follow arguments similar to the following.

a) Possible impacts—disturbance on feeding grounds could lead to reduced survival and reproduction.

   i) Bear feeding option—no development in sensitive area. Protect this critical habitat to maintain berry production and bear feeding.

   ii) Multiple use option—development allowed with extreme sensitivity to avoiding disturbance of bear feeding. Development work carried out during time when bears absent. Minimal or zero impact on vegetation. No access to area during bear feeding season. Maintain bear security cover adjacent to feeding habitat.

b) Removal of winter kill carcasses may impact bear populations that could rely on them for food at time of emergence from winter dens.

   i) Refuse permit in order to maintain grizzly 'emergence' food supply.

   ii) Study energy considerations for winter kills carefully before slowly phasing in limited carcass removal. Monitor and further limit carcass removal in years when winter kill is small. Make certain that carcasses left are within suitable range of bear dens.

c) These developments could have major impacts on bear populations in the valley, possibly damaging critical 'emergence' foods and late-season 'fattening' foods. Damage to the river could lead to loss of salmon stocks, an important 'fattening' food for the bears.

   i) Exclude all developments from this valley which might impact bear feeding.

   ii) Limit development and production activity to times when bears are not feeding in the area. Exclude road building from meadows, wetlands and skunk cabbage swamps. Restrict development and ongoing logging in the valley to areas that are not sensitive bear habitat, bear denning sites, or grizzly travel corridors.

d) Harvesting added numbers of salmon could severely impact populations of grizzlies that rely on the salmon as fattening up foods. Bear mortality could increase and natality could decrease as a result of increasing the salmon harvest.

   i) Do not allow increased harvest of salmon from a river where the bear population is in dynamic equilibrium keyed to returning salmon stocks.

ii) Phase-in limited expansion of the salmon harvest based on thorough studies of the predictable return of salmon to river. Insure that the escapement of salmon meets the reproduction needs of the salmon and the energy–harvesting needs of the bear population. Be cautious with the expansion of this fishery, err on the precautionary side.

e) Grizzly bears need to travel between different food supplies without disruption. Their requirement for body fat means they must efficiently reach food sources at the time when there is a high return of energy for the amount of time invested in eating. Clearly, it is necessary for grizzlies to use both sides of the valley. If the highway interrupts travel back and forth, it could impact the survival and reproduction of the bears. Another issue is increased human access to the valley, which may mean settlement, increased recreational use, etc. All of these uses may impact directly or indirectly on bear populations.

i) Exclude any development from this valley which might impact bear feeding.

ii) Study the movement patterns of the bears in the area. Carefully assess the food resources and habitat available. If the road is constructed, plan for unobstructed wildlife travel corridors (e.g., over or underpasses). Restrict access of human travelers away from these corridors. Route the highway away from critical habitat and travel paths.

Ans. Q 3

The carrying capacity of a landscape or habitat is largely determined by the amount of food available to the bears. At the most precise level of habitat assessment, biologists study and map all vegetation in the area to determine a value for the amount of available bear forage (and other foods). They should consider each food species and should consider the amount of food available during each week of the feeding season. Since this approach is impractical for a huge areas such as much of the Province of British Columbia, biologists must estimate carrying capacity. They base their habitat assessment estimates on the most comprehensive available studies of habitat, vegetation, and bear populations. They extrapolate these studies to other areas by making detailed maps of likely habitat for grizzly bear foods, and field-checking these maps whenever possible.