FORCES
OF CHANGE

ARCTIC
A Friend Acting Strangely
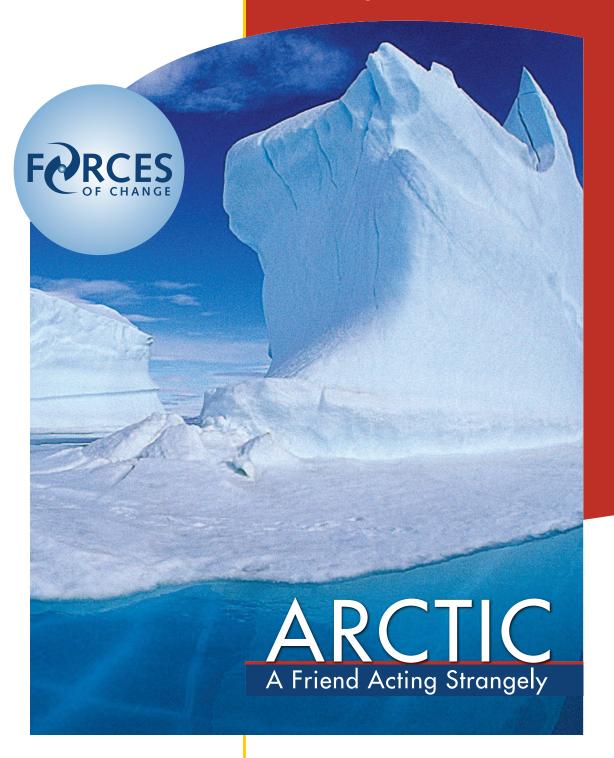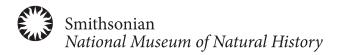
Smithsonian
National Museum of Natural History

ACTIVITY 5

CHANGES AHOOF?

COULD CLIMATE CHANGE AFFECT ARCTIC CARIBOU?

Caribou or Reindeer?

They are the same species, but called caribou in North America, and reindeer in Eurasia. Caribou are hunted in the wild. Reindeer are often domesticated and herded.

Photo Stephen Loring © Smithsonian Institution

OVERVIEW	Students run a simplified computer model and create board games to explore how climate conditions can affect caribou—the most abundant grazing animal in the Arctic.
SUGGESTED GRADE LEVEL	6 – 8
ALIGNMENT WITH NATIONAL STANDARDS	*National Science Education Standards* • Abilities necessary to do scientific inquiry • Regulation and behavior • Populations and ecosystems • Understandings about science and technology • Populations, resources and environments • Science as a human endeavor • Nature of science
ESTIMATED TIME	PART 1: Two 45-50 minute class periods PART 2: Two 45-50 minute class periods 　　　　　Five 45-50 minute work sessions during class or at home
MATERIALS	• Access to the Internet • Activity Sheet G • Activity Sheet H • Make transparency of *fig*. 5.1 • Make transparency of *fig*. 5.2 • Overhead projector

ACTIVITY 5

OBJECTIVES

Students will be able to:

1 > Define a climate model.

2 > Run a simple climate model and interpret its results.

3 > Use mathematics to interpret data.

4 > List five ways a warmer climate could affect caribou in the Arctic.

BACKGROUND

The Porcupine Caribou Herd lives in northern Alaska and Canada where researchers predict a warmer climate that could bring increased winter snowfall and increased summer insect activity.

Pregnant females traditionally return to the same calving grounds year after year.

Photo Stephen Loring © Smithsonian Institution

Research has shown that both insect levels and snow depth are linked to the how much time female caribous spend eating and the energy they use in various activities. In turn, those factors are linked to how many calves are born and how many calves survive.

In Part 1 of this activity, students run a simplified version of a computer model. The model looks at the effects of various levels of snow depth and insect activity on the size of the herd.

Students select a high, medium or low level of insect activity and a high, medium, or low level of snow depth. They then run the model to see what effect the two variables working together have on the size of the herd's population. There are nine possible combinations of variables with nine different outcomes. The model demonstrates how certain climate changes might alter the Porcupine Caribou Herd size after ten years.

Of course, many climate factors affect caribou and their access to food, use of energy, vulnerability to predators, ease of travel, etc. In Part 1 of the activity, students create board games to explore some of these additional climate factors. Student Activity Sheet H is a summary of some of these factors, grouped by seasons, which students use as a reference to create their board games.

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PROCEDURE

PART 1: COMPUTER MODEL
Students run the Caribou Computer Interactive and complete **Activity Sheet G.**

STEP 1 > Introduce the computer model.

1 > Explain that caribou, *Rangifer tarandus*, well adapted to survive the region's cold, harsh conditions, are the Arctic's most abundant large grazing animals. Show transparency of *fig*. 5.1, map of the range of *Rangifer tarandus*.

2 > Explain climate models. Climate scientists (climatologists) are predicting a warmer Arctic climate. This change could affect the caribou, but how? To help them find out, scientists build computer models to help them predict future outcomes. They keep certain factors constant while changing other ones. These factors are called variables.

3 > Tell students they will run a simple computer model that looks at how certain changes in climate might alter the size of a herd of caribou. The model examines the levels of two variables: (1) insect activity, which is affected by summer temperatures and (2) winter snow depth.

4 > The model was designed from years of observing the Porcupine Caribou Herd that lives in northern Alaska and Canada.

STEP 2 > Students run the computer model.

1 > Distribute **Activity Sheet G**.

See Teacher Reference #1

2 > Direct students to access the interactive computer model at http://forces.si.edu/arctic/02_04_05.html and to follow the directions on the screens. They will run the model nine times, once for each of the nine combinations of variables.

For each combination, or "outcome," the model will make a prediction of change to the herd size over a 10 year period. This prediction will be expressed as a line graph. Each graph begins in year "0" and ends in year "10." In year "0," the herd has 155,000 caribou. The size of the herd will increase or decrease from that number.

See Teacher Reference #2

3 > On their activity sheets, students:
   • Record the predicted herd size in year "10" for each of the nine outcomes.
   • For each of the nine outcomes, students calculate the number of caribou the herd has increased or decreased; and express that number as a percentage of change. Results should match the table below.
   • Answer the questions as preparation for a class discussion and creating a board game in Part 2 of this activity.

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STEP 3 > Class discussion (review of summary questions on Activity Sheet H)

1 > Which of the two variables—snow depth or insect activity—has the greater effect on herd size? What might be the reason for this?

2 > What combination of the two variables caused the greatest increase in the size of the herd? The greatest decrease?

3 > Explain that the model only dealt with two factors that could result from a warmer climate. In real life, many climate factors affect caribou. What might some of these be?

ASSESSMENT: BOARD GAMES

Give students a week to create board games as a homework assignment. When they have completed their games, have them share their games with each other on a "game day."

STEP 1 > Content and guidelines for creating the games

1 > Show the transparency of *fig*. 5.2 and discuss it. This drawing illustrates some of the impacts warming is having on caribou. It is based on observations made by the Kitikmeot Inuit of the Bathurst Caribou Herd as the herd migrates through the Kitikmeot's lands. (The observations were collected and analyzed by Natasha Thorpe as the principal researcher on the Tuktu and Nogak Project.)

2 > Explain: Caribou migrate seasonally between tundra in the north and open forests near the tree line in the south.

- In winter, evergreen forests provide refuge and high energy food. Compared to the tundra, forest snows are softer and easier for caribou to dig through for food, and the winds are less harsh.

- In spring, caribou move north to tundra. Females give birth to calves.

- In summer, tundra plants supply abundant calories for nursing females and for all the caribou to fatten up before winter. Winds on the open tundra help ward off summer's mosquitoes and flies. Patches of snow are places to keep cool.

- In autumn, caribou migrate back south to forested areas where they will remain during the winter.

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STEP 2 > Guidelines for creating the games

1 > Students work independently or in small groups of two to four.

2 > Distribute **Activity Sheet H**, which students use as a reference for creating their games. Review with guidelines on the **Activity Sheet H**.

2 > The sheet lists examples of conditions the caribou might encounter and the effect a condition might have on the caribou during its seasonal migration. Conditions can have positive or negative effects, and the game should include both for each season. It is okay to repeat conditions.

RESOURCES

http://www.taiga.net/coop/: information about the Porcupine Caribou Herd

http://arctic.fws.gov/carcon.htm: frequently asked questions about caribou

http://www.rem.sfu.ca/pdf/thorpe.pdf: full research report by Natasha Thorpe (impact of climate changes on Bathurst Caribou Herd)

http://www.beingcaribou.com/: scientists follow caribou migrations

ACTIVITY 5 › **CHANGES AHOOF?** › **ACTIVITY SHEET G**

Student Name

As your teacher directed, run the computer model. You will run the model nine times, once for each of the nine combinations of the two variables: snow depth and insect activity. After you run each combination, the model will produce an "outcome." It will be displayed as a line graph showing the predicted size of the herd in ten years. Each graph always begins at "0" year with 155,000 members in the herd. Different levels of snow depth combined with different levels of insect activity will yield different outcomes.

STEP 1 > What you do on this sheet:

For each of the nine combinations complete the table below. (The "outcome" for the first combination "low insect activity/low snow depth" has been filled in for you.)

1 > Enter the predicted herd size in year "10.
2 > Calculate and enter the increase *or* decrease in the size of the herd.
3 > Calculate and enter the percentage the herd increased *or* decreased in size

	Low snow level	**Medium snow level**	**High snow level**
Low insect activity	1> 214,500 total size	1>	1>
	2> 214,500 - 55,000 = 59,000 more members	2>	2>
	3> 59,000 / 155,000 = a 38.4% increase	3>	3>
Medium insect activity	1>	1>	1>
	2>	2>	2>
	3>	3>	3>
High insect activity	1>	1>	1>
	2>	2>	2>
	3>	3>	3>

STEP 2 > Answer these summary questions to prepare for a class discussion.

1 > Which of the two variables—snow depth or insect activity—has the greater effect on herd size? What might be the reason for this?

2 > What combination of the two variables caused the greatest increase in the size of the herd? The greatest decrease?

ACTIVITY 5 › **CHANGES AHOOF?** › **ACTIVITY SHEET H**

Student Name

Things to remember when you design your board game:

- Start" and "finish" should be at the same place on the board. The caribou will be migrating to their winter home and back again.

- Remember to include all four seasons.

- The winner is the player who gets the most members of its group to the finish first.

- Each player represents a group of individual caribou. You decide on the number.

- A group of caribou starts out together. But with each play, individual caribou will progress at different rates. It depends on what type of condition is encountered on each play. On some plays an individual may move ahead, move back, stay put, or is out of the game.

- The chart below includes examples of the types of conditions the caribou could encounter as they migrate. Some conditions have positive and some have negative effects. You decide how many moves ahead or back, each one is worth. You can repeat a condition.

- **Have fun!**

Winter Conditions	Spring Conditions	Summer Conditions	Fall Conditions
Deep snow in valley. Climb up to higher ground to find food.	Warm spring. Vegetation grows quickly. Lots of food.	Unusually hot. Some caribou overheat and have to rest.	Thin ice prevents herd from crossing river at the usual place. The herd walks five miles along the riverbank until it finds thicker ice to cross safely.
Deep, mushy snow. Hard to walk in.	Early thaw. Thin ice prevents you from crossing river at usual place. The herd walks five miles alongside the river until it finds thicker ice to cross safely.	Warm. Little wind. Run most of the day to avoid hordes of mosquitoes.	Snow melts and then refreezes. Hard to dig for food.
Deep snow. Spend more time pawing for food.	Early thaw. Water is very high in the river the caribou need to cross. Swimming is very difficult.	Warm. Little wind. Lots mosquitoes bite you. You lose a lot of blood and energy.	Summer heat has kept river levels low. It's easy to cross.
Deep snow. Move to windy open land. Encounter pack of wolves. Run to escape.	Early thaw: Fall through thin ice on river and drown.	Warm and dry. Plants die back early. Less food.	River is frozen solid. Caribou cross easily.
Nice soft snow. Easy to dig for food. You eat a lot.	A pack of wolves chases several caribou. The caribou outrun them.	Caribou find a snow patch to rest on. They avoid bugs but there are no plants to graze.	
Snow is not deep. Easy to get to food.	River is still frozen solid. The herd crosses it easily.	It is really hot and the bugs are really thick. Caribou stand in a lake to cool off, but there is nothing to eat there.	
	Herd crosses a fast-moving river. Some caribou need to rest after the difficult swim.	Cool, breezy day. Few bugs to bug the caribou. They spend lots of time grazing.	
	Herd crosses a fast-moving river. Some members are swept downstream.	Cool summer. Lots of food.	
		Good breezes. Bugs are not bad.	

ACTIVITY 5 › **TEACHER REFERENCES**

Teacher Reference #1: Sample "Outcome" Screen Produced by the Model

PORCUPINE CARIBOU HERD MODEL
Predictions of Change to Herd Size over a Ten-year Period

155,000   168,000

INSECT HARASSMENT: LOW

SNOW DEPTH: MEDIUM

NUMBER OF CARIBOU

YEARS UNDER THESE CONDITIONS

Teacher Reference #2: Table Showing Results of Running the Model Using All Combinations of the Two Variables

Teacher reference:

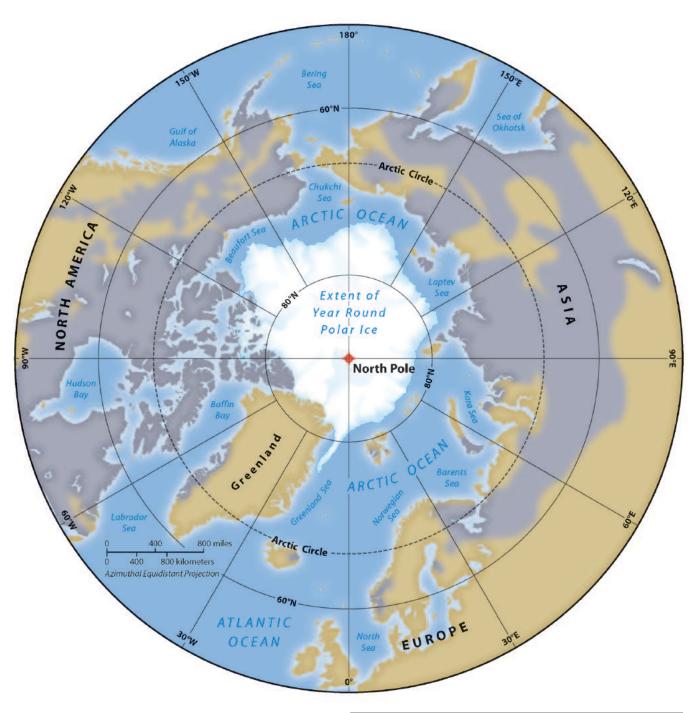*This table shows the results of running the model using all combinations of the two variables—insect harassment and snow depth. The top line in each cell of the table is the predicted size of the Porcupine Caribou Herd after 10 years. The next line is the amount and percentage of increase or decrease in size.*

insect harassment \ snow depth	Low	medium	high
low	214,500 +59,000 = 38.4% increase	168,000 +13,000 = 8.4% increase	132,000 -23,000 = 14.8% decrease
medium	206,100 +51,100 = 33% increase	157,000 +2,000 = 1.3% increase	123,200 -31,800 = 20.5% decrease
high	199,200 +44,200 = 28.5% increase	147,900 -7,100 = 4.6% decrease	115,800 -39,200 = 25.3% decrease

ACTIVITY 5 › **TEACHER REFERENCES**

Range of North American caribou and Eurasian reindeer

ACTIVITY 5 > **TEACHER REFERENCES**

Teacher Reference #4: Fig. 5.2 (Graphic Showing Changes in Climate Conditions and Its Effects)

HIGHER TEMPERATURES

UNPREDICTABLE WEATHER

LATE AUTUMN

EARLY SPRING

RAPID SPRING MELT

SPORADIC FREEZE-THAW CYCLES...
May starve if ice and crusty snow block access to forage.

MORE EXTREME HEAT DAYS...
Become exhausted and may die from overheating.

THINNER ICE...
Waste energy trying to avoid unsafe ice or fall through and drown if walking on thin ice.

LOWER WATER LEVEL...
Easier water crossings but less shoreline vegetation to use for shade and grazing.

LEADS IN SEA ICE OPEN EARLIER...
Traditional ice crossings not useable so change route to calving grounds.

MORE VEGETATION...
Shift migration routes to take advantage of richer forage.

Graphic by The M Factory © Smithsonian Institution