Hubbard Brook Environmental Literacy Program
Data Inquiry Activities

Moose Power	
Summary	Four part lesson in which students 1) investigate moose nutrition and energy requirements, 2) mimic moose browsing behavior in the forest, 3) examine data to investigate the impact of browsing on shrub structure, and 4) examine impact of shrub structure on bird nest siting.
Subject areas	Biology, Environmental Science
Skill level	Advanced
Objectives	Students will be able to: • Describe the nutritional needs and digestive adaptations of moose. • Identify how factors such as disturbance, forest succession, and climate change can affect moose. • Develop field research skills and techniques. • Interpret data gathered from field research as well as from Hubbard Brook Experimental Forest to draw conclusions about effect of moose browse upon ecosystem, specifically bird nesting habitat.
NH Science Framework Standards	• SPS1:11:2.2 Represent and understand results of investigations. • S:LS2:11:1.3 Identify the factors in an ecosystem that can affect its carrying capacity. • S:LS2:11:1.4 Analyze and describe how environmental disturbances, such as climate changes, natural events, human activity and the introduction of invasive species, can affect the flow of energy or matter in an ecosystem.
Time	Five 45-50 minute periods

Materials	**Activity One** • MoosePower.xls (note: there are 2 student tabs and 2 answer key tabs in file) • MooseSkullDiagram.pdf • Mysteries of Moose • Ghost in the Woods • Getting Calories from Fiber • Majestic Moose **Activity Two** • sample twigs • meter stick • balance or scale • twig size guide (prepared in previous class) • stomach bag (plastic bag) • watch • hand clippers • Optional: winter twig identification chart (from "Winter Keys to Woody Plants of Maine," see below). **Activity Three** • stake • meter stick • clothespins • clipboard • data sheet **Activity Four** • MoosePower.xls (note: there are 2 student tabs and 2 answer key tabs in file)
Assessment	Each activity has handouts to be completed by students, answer key included for each.

Acknowledgements: This lesson was developed, piloted and revised by Sarah Thorne, teacher at Prospect Mountain High School in Alton, NH. The Hubbard Brook Research Foundation appreciates the creativity, thought, effort and time Sarah gave to this project. Sarah wishes to gratefully acknowledges Michael McDonald, (2011 MS student, University of Vermont), for teaching her the field methods used for his research at Hubbard Brook Experimental Forest in Woodstock, NH and for contributing his moose browse data to this lesson.

Teacher's notes

You can adapt these activities for deer browsing in areas where moose are not present.

Activity One

This indoor activity will introduce students to moose ecology and nutritional needs. Students can work in groups of 2-4 to read the literature provided and answer the questions on the handout. They are asked to make a concept map. (Two student examples are provided in the answer key.) This will prepare them for the next activity.

You can use the NH-based articles listed below or find comparable literature from your area. Links to articles provided in Overview Table above.

- Bagley K. *Mysteries of Moose*. New Hampshire Wildlife Journal. NH Fish and Game Department. Sept./Oct. 2006 p. 5-7.
- Bergeron, Daniel. Ghost in the Woods. New Hampshire Wildlife Journal. NH Fish and Game Department. Sept./Oct. 2011 p.9. 9
- Silverberg, Judy. *Majestic Moose*. New Hampshire Wildlife Journal. NH Fish and Game Department. Sept/Oct 2004. P.13-14.
- Shen, Lilian. *Getting Calories from Fiber*. Northern Woodlands. Jan. 2012.
- Diagram of moose skull and teeth (abridged version of Skulls of Alaskan Mammals, Alaska Dept. Fish and Game).
- The *Theory Underlying Concept Maps* contains information on creating and using concepts maps as teaching and evaluation tools.
- Condensed version of *Theory Underlying Concept Maps*: https://www.msu.edu/~luckie/ctools/ .

Activity Two

This activity is designed to be conducted outdoors when the leaves are off the trees and shrubs. (Activity One should precede it.) Pick a location where students will not get lost over the course of a 20 minute browsing session. For example, it can be done along the shrubby edge of a playing field or along a trail or woods road. Students will work in groups of 3-4. Students should be shown examples of twigs from different species of trees and shrubs (hobblebush, red maple, sugar maple, etc.) before beginning activity.

A more challenging version of this lesson can ask students to identify the 5 top species collected when they return to the classroom. A winter twig identification handout is only needed if you choose to provide your students with this challenge. We recommend Winter Keys to Woody Plants of Maine, by Christopher S. Campbell and Fay Hyland, University of Maine at Orono Press, 1977.

Activity Three

In this outdoor data gathering activity, students measure shrub structure, tabulate and graph data, and analyze results. This will be conducted by groups of 3-4 students in the woods or brushy areas. It is designed for hobblebush (*Viburnum alnifolium*) patches, but it could be adapted for use on red maples

and other browse species favored in your area. If you have access to computers and Excel, have students enter their data into and generate graphs with Excel, Google Speadsheets, or Create-a-Graph.

Activity Four

Indoors, students will interpret data collected at Hubbard Brook Experimental Forest comparing shrubiness indices in plots with and without nests. Then they will relate these findings back to previous activities. Data is embedded on Student Handout, but also accessible as Excel file: MoosePower.xls (note: there are 2 student tabs and 2 answer key tabs in file).

Moose Power

Name_____

Activity One:
Investigating Moose Diet-- What does a moose need to eat to survive?

Indoors. Form a group of 2-4 students. Use the articles provided to your group to answer the questions below. Then, discuss and compile the answers as a group and hand in one complete set of answers.

1. What vegetation makes up a moose's diet? Consult **Table A** in MoosePower.xls, which provides data on the types of tree species browsed by moose. List the top 5 species in order of importance.

2. In what habitats does a moose feed and what forms of vegetation does it seek in different seasons:
   a. Spring-

   b. Summer, fall-

   c. Winter-

3. What is browse?

4. How are moose teeth adapted to enable it to eat vegetation? (see Moose Skull Diagram)

5. Moose and deer have similar digestive systems. Consult *Calories from Fiber* to describe how the digestive systems of these animals are adapted to extract calories from the vegetation they eat.

6. What do you think might affect the digestibility of browse? Are buds or twigs more digestible? Why does this matter?

7. What do you think might affect a moose's browsing rate?

8. How do you think a disturbance in the ecosystem might affect the availability of food for the moose? Would a moose prefer early or late successional habitat and why?

9. Why is calcium an important nutrient for both male and female moose? Explain how low concentrations of calcium in soil might affect moose.

10. What does the term “ghost moose” mean? Explain how the winter tick affects moose?

11. How might climate change affect moose and why?

12. With the information you have gathered, draw a causal concept map to show the natural and human-related factors that affect moose survival in its habitat. You can show direct and indirect factors. Use arrows to show which factors affect moose (direct effect) or other factors (indirect effect). Put a “+” sign next to the arrow to show a positive effect and a “-“ sign to show a negative effect of that factor on moose survival.

Activity Two: Browse like a moose

With the knowledge that you gained in Activity One, your group of 3-4 will take to the woods and browse like a moose. Each member of your group will have a specific role and contribute data to the group's data sheet. After you get organized, conduct your browse experiment for 20 minutes.

Moose Facts

Weight of adult bull moose	1000 lbs	Wet matter winter intake is:	20 kg/day
Weight of adult cow moose	800 lbs	Twig height for feeding:	1.2- 3 m
Ave moose feeds:	8 hrs/day	Max twig diameter	3 mm

Materials:

- winter twig identification chart (optional)
- meter stick
- sample twigs
- balance or scale

Inside, the day before you go outside

1. Before you go outside, what does a moose need to know? Using your knowledge from Activity One and the **Moose Facts** box above, answer these questions.

- ✓ Where will the moose go to browse? *(Discuss your strategy with your team mates and teacher.)*
- ✓ What species will it want to eat in winter? Hardwood or softwood? What are its 5 favorite species?
- ✓ How high off the ground will it browse? (*While you are indoors, use meter stick to measure against your leg. Use yourself as the measuring stick outdoors.)*
- ✓ What maximum stem diameter will it select? (*While you are indoors, cut and weigh a twig of the proper stem diameter that you can take outdoors with you as your twig size guide.)*

  twig diameter*:* _____ mm twig mass: _____ grams
- ✓ How many grams of food does the moose need to eat:

  kg/hour _____ g/ hour _____ g/ minute _____
- ✓ How many twigs does the moose need to eat per minute: _____

  (g/min. divided by g/twig)

You will use this information to set your pace for browsing when you go outside.

Outside Roles and procedure:

Materials:

- twig size guide (prepared in previous class)
- stomach bag (plastic bag)
- watch
- hand clippers

2. In your group of 3-4, assign moose roles below.

Eyes. One student will find and select the species the moose desires, at the right height.

Legs. This student will record the browse session starting and stopping time, and try to keep the moose moving at the right pace so that it will get the right amount of food as calculated inside (twigs per minute).

Mouth. One student will use a pair of hand clippers to cut twigs off the vegetation to simulate the moose browsing. Check the stem diameter using the twig guide to determine where the bite will be taken. Be careful with the clippers and keep them closed with the safety latch when you are not using them. Put your bites into your "stomach" bag.

Stomach. One student will represent the stomach and hold the "stomach bag."

3. Gather your materials and head out into the forest or field edge. Pick your browse locations for maximum efficiency. Browse for 20 minutes according to the procedure above. Only one student at a time can be the "mouth," but you can take turns.

Back Inside

Materials:

- scale or balance
- calculator

4. Once you have collected your browse in the stomach bag, weigh it. ____ g.

5. What are the major species of trees and shrubs that you browsed?

6. Your moose browsed at a rate of:

____ g/20 min ____g/hour _____ kg/hr

7. A moose needs 20 kg per day. Based on your browsing, how many hours of browsing would it take to satisfy your moose's winter energy needs? Show your calculations:
_____ hours

8. Will your moose survive the winter? Approximately how many hours per day does a moose browse (see **Moose Facts** box). If your answer was 9-10 hours, what do you think might happen? Over 10 hours? Consider how many hours of daylight there are in winter.

9. Reflect on the impact of vegetation species, browse density and quality, and other factors on survival. Look back at your concept map for ideas. What changes to your browsing strategy or habitat could improve your moose's chance of survival?

Activity Three: How does moose browsing affect the structure of a shrub?

Outdoors. To answer this question, University of Vermont researcher Michael McDonald developed a method to quantify browse effects at the Hubbard Brook Experimental Forest. We are going to test this out in our forest.

Materials:

- stake
- meter stick
- clothespins
- clipboard
- data sheet

1. Select a patch of shrubs or tree seedlings of one species that are less than 2m in height. Make sure there are at least 5 stems of this species. Measure the size of the patch in square meters. _____ sq m.
2. Plant your stake vertically in the center of the patch. Now use a meter stick to delineate a one meter radius around the stake. This is your shrub plot in which you will conduct your measurements.
3. Using clothespins, mark each stem within the shrub plot at the base where the stem emerges from the ground. Stop after you have marked 10 stems.
4. Select your first stem. Measure the height of that stem with the meter stick and record.
5. Count the number of branches on that stem. Record on your data sheet (**Table 1)**.
6. Now count the number of leaves (or buds if leaves are off) on that stem and record.
7. Count the number of browsed twigs (stubs) on that stem.
8. Repeat steps 4-7 for each stem (up to 10) in the shrub plot.

Activity 3 Group Data Sheet

Group Names _____

Table 1

Stem #	Stem height in cm	# branches	# leaves	# browsed twigs	Shrubiness Index
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Ave					

9. To calculate the ***shrubiness index*** for each stem, divide its number of branches by the stem height.

10. Calculate and enter your average values in the bottom line of the table.

11. Draw a line graph plotting the shrubiness index for your stems vs. the number of browsed twigs. Do you think that browsing affects the shrubiness of the stems? Why? Attach your graph.

Back Inside

Now create a class data sheet on the white board. Each group will report their average data and record the class data below. To calculate the shrubiness index, divide the number of branches by the stem height.

Table 2. Class Browse Plot Data

Group/ Species	Ave. Stem height	Ave. # branches	Ave. # leaves	Ave. # browsed twigs	Shrubiness Index
1					
2					
3					
4					
5					
6					
Class Ave.					

12. For the class data, draw a bar graph to compare the shrubiness indices by species. What do you observe? What can you conclude about the effect of browsing on the structure of your shrubs or tree sprouts?

13. Do you think there is a relationship between the shrubiness of a stem and the number of leaves? How would you answer this question?

14. How might changes in shrub structure affect other organisms in the forest? Develop a hypothesis and write it below.

Activity Four: Where would you build your nest?

Indoors

How does moose browse affect the forest vegetation, specifically nesting habitat for black-throated blue warblers (BTBW)? Scientists at the Hubbard Brook Experimental Forest wanted to find out. UVM Researcher Michael McDonald and his assistant Allen Tate measured *Viburnum alnifolium* (hobblebush) patch characteristics around 30 BTBW nests and randomly selected nearby patches without nests for comparison. Answer these questions in groups of 3-4.

1. In the table below, data from patches of hobblebush **with** black-throated blue warbler nests ("nest plots") and **without** BTBW nests ("random plots") are compared. Add up the total height of the stems and total number of branches for the random plots and then for the nest plots. Now calculate the average by dividing the total height by the number of plants (rows).
    - Is there a difference in the average height of stems between the random and nest plots? Explain using the data.

    - Is there a difference in the average number of branches between the random and nest plots? Explain using the data.

2. By dividing the number of branches by the plant height, calculate the "shrubiness index" (SI) and enter the number in the space provided. This is a measure of how dense the shrub is. How might shrubiness be an advantage for the warbler?

3. Did the warblers actually select nest sites that were shrubbier? Use the data to support your answer.

Table 3. Characteristics for *Viburnum alnifolium* in plots with and without black-throated blue warbler nests. Data courtesy of M. McDonald, 2011.

Random Plot				Nest Plot			
Plant #	**Height (cm)**	**# Branches**	**SI**	**Plant #**	**Height (cm)**	**# Branches**	**SI**
1	38	1		1	32	5	
2	32	4		2	49	2	
3	37	1		3	38	1	
4	64	6		4	47	1	
5	34	1		5	38	1	
6	66	10		6	33	1	
7	71	7		7	38	11	
8	32	3		8	60	5	
9	52	13		9	41	11	
10	58	9		10	38	14	
11	32	1		11	39	4	
12	40	4		12	30	1	
13	44	1		13	41	3	
14	63	2		14	37	1	
15	32	1		15	34	4	
16	92	8		16	33	3	
17	94	10		17	54	4	
18	43	6		18	32	2	
19	194	57		19	47	3	
20	92	7		20	31	1	
21	65	9		21	45	7	
22	109	24		22	83	16	
				23	38	4	
				24	40	19	
Total							
Average							
Plot SI							

4. Now refer back to your results from Activity 3. Compare Michael's SI data from the White Mountains in Table 3 to the data from your class in Table 2.

5. In light of this, develop a hypothesis explaining how you might expect moose browsing to affect bird nesting habitat and survival around your school.

6. What do you predict would happen to the BTBWs if the carrying capacity for moose in the White Mountains were to decrease? Use your concept map to help you answer. What might cause a reduction in carrying capacity for moose? What might happen to bird nesting habitat if the number of moose dramatically increased?

References:

Bagley K. *Mysteries of Moose*. New Hampshire Wildlife Journal. NH Fish and Game Department. Sept./Oct. 2006 p. 5-7.

Bergeron, Daniel. *Ghost in the Woods*. New Hampshire Wildlife Journal. NH Fish and Game Department. Sept./Oct. 2011 p.9.

Campbell, Christopher S. and Fay Hyland. Winter Keys to Woody Plants of Maine. University of Maine at Orono Press, 1977. (Optional- for use in Activity 2 if asking students to identify twigs without leaves.)

Shen, Lilian. *Getting calories from fiber*. Northern Woodlands, January 2013.

Silverberg, Judy. *Majestic Moose*. New Hampshire Wildlife Journal. NH Fish and Game Department. Sept/Oct 2004. P.13-14.

MooseSkullDiagram.pdf, taken from *Skulls of Alaskan Mammals*, Alaska Department of Fish and Game, 2005, p. 58.

Answer Key

Activity One:
Investigating Moose Diet-- What does a moose need to eat to survive?

1. What vegetation makes up a moose's diet? Consult **Table A** in MoosePower.xls, which provides data on the types of tree species browsed by moose. List the top 5 species in order of importance.
   Hobblebush (66% of moose winter diet)
   Balsam fir (9%)
   Striped maple (8%)
   American beech (6%)
   Sugar maple (4%)

2. In what habitats does a moose feed and what forms of vegetation does it seek in different seasons:
   a. Spring- *prefer denser, more concentrated areas of vegetation because moose don't want to travel around as much (females are pregnant or giving birth) Bagley 2006*
   b. Summer, fall- *aquatic plants (Silverberg 2004) food is abundant, broad feeding pattern, prefer shady areas, young hardwood stands, close to water Bagley 2006*
   c. Winter- *prefer denser, more concentrated areas of vegetation because moose don't want to travel around as much (tough to travel in winter) Bagley 2006*

3. What is browse?
   Browse refers to the vegetation that browsers such as moose eat: twigs, leaves and buds of hardwood and softwood trees and shrubs. (Silverberg 2004)

4. How are moose teeth adapted to enable it to eat vegetation? (see Moose Skull Diagram)
   Moose have no incisors or canine teeth in their upper jaw. Instead the upper jaw has a hard palate that the lower teeth press again to nip plants, which they gather and hold in the diastema (a gap between incisors and cheek teeth). This allows moose to quickly gather and eat large quantities of food while walking around to find more to browse upon.

5. Moose and deer have similar digestive systems. Consult *Calories from Fiber* to describe how the digestive systems of these animals are adapted to extract calories from the vegetation they eat.
   The vegetation that moose eat in winter contains a lot of fiber. Without help from microbes, animals are unable to digest this fiber. A moose's digestive system contains four chambers. In the rumen (first chamber) microbes such as

bacteria and protozoa are present and break down fiber through fermentation. The fermented fiber is then regurgitated, chewed some more and then re-swallowed where it passes into the moose's hindgut, where fatty acids (calories) and water are absorbed. The acidic conditions in the hindgut kill the fermenters that have passed through from the rumen, and these are also digested. "…(moose) grow their own food on fiber in the rumen and then harvest it." (Shen 2013)

6. What do you think might affect the digestibility of browse? Are buds or twigs more digestible? Why does this matter?
   The amount of fiber in a piece of browsed vegetation affects its digestibility. Buds have less fiber- they are more tender and calorie and nutrient-rich. Moose prefer buds over twigs. If moose find lots of buds to eat, they won't have to spend as much time browsing compared to the amount of time spent foraging if only twigs can be found. The preference for buds might actually affect a plant's productivity as well as the structure of the forest, if moose significantly nip buds that would have grown branches and leaves.

7. What do you think might affect a moose's browsing rate?
   Density of browse affects rate. Moose are able to browse quickly when shrubs and young trees are growing close together. If browse is sparse, moose must spend more time traveling from shrub to shrub/tree to tree. Also, moose have low tolerance for heat and seek shady habitats in which to browse. Hot days may require moose to slow down so as not to overheat.

8. How do you think a disturbance in the ecosystem might affect the availability of food for the moose? Would a moose prefer early or late successional habitat and why?
   Disturbances such as hurricanes or logging operations create opportunities for understory growth. Moose prefer this early successional habitat, as young forests contain more shrubs and young trees (more browse).

9. Why is calcium an important nutrient for both male and female moose? Explain how low concentrations of calcium in soil might affect moose.
   Calcium is an essential nutrient for all animals, as it is required for all moose in formation of bones and teeth. Additionally, male moose require calcium for antlers, and female moose require calcium for reproduction of offspring. If calcium is limited in the environment, then calcium levels in browse may not be sufficient to meet the needs of moose. The Silverberg article mentions osteoporosis and arthritis as health problems that affect older moose.

10. What does the term "ghost moose" mean? Explain how the winter tick affects moose?

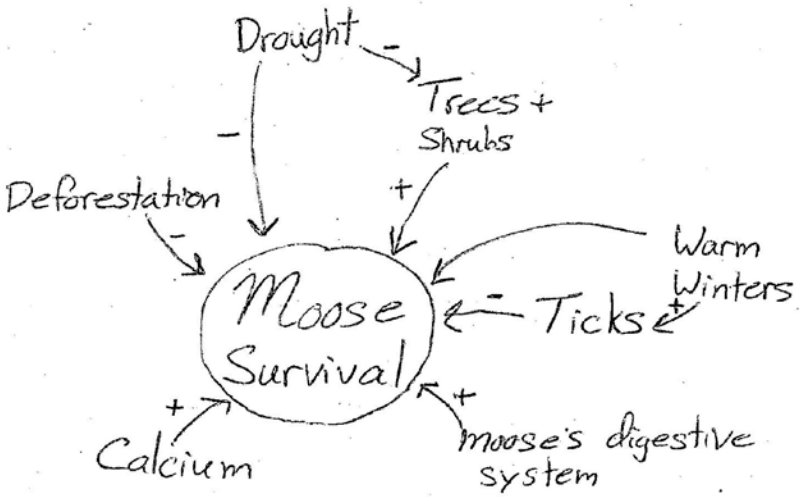
A ghost moose is a moose that has lost a lot of hair, which is a sign that it has been heavily infested by the winter tick. The grooming that moose do to try to remove the tick results in hair loss. "The hair loss follows a distinctive pattern, starting at the moose's neck and working its way back, sometimes until all the hair has been removed. The amount of hair loss is related to the number of biting adult ticks." Bergeron 2011).

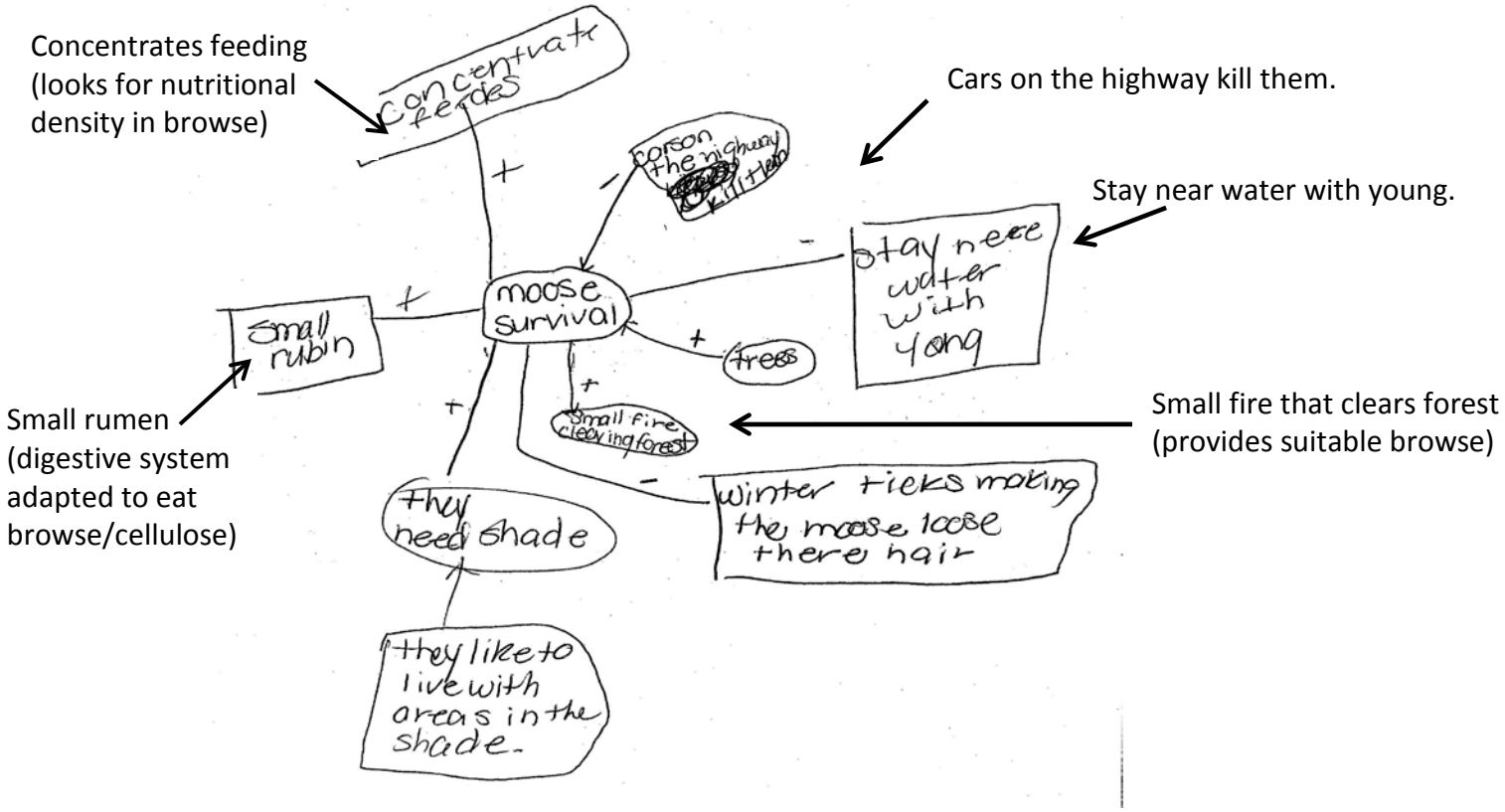
Large winter tick infestations "can cause problems for moose, including loss of winter coat, anemia (blood loss), reduced growth in young and even death." (Bergeron 2011).

11. How might climate change affect moose and why?
"If fall and spring weather is mild with little or no snow, winter ticks will survive to attach to moose, mate and lay eggs. If the weather becomes consistently warm, however, tick numbers are likely to remain high…. The high number of winter ticks in 2010 was most likely caused by the warm, snowless spring, which allowed more adult female ticks to drop from moose and survive to lay eggs…. Warm weather is the biggest driver of winter tick numbers, though, and moose are northern creatures – so the predicted effects of climate change for New Hampshire could create a paradise for ticks and perfect conditions for severe annual tick infestations." Bergeron 2011.

13. With the information you have gathered, draw a causal concept map to show the natural and human-related factors that affect moose survival in its habitat. You can show direct and indirect factors. Use arrows to show which factors affect moose (direct effect) or other factors (indirect effect). Put a "+" sign next to the arrow to show a positive effect and a "-" sign to show a negative effect of that factor on moose survival.

Answers will vary. There are many websites available to assist with creating concept maps. We recommend the Florida Institute for Human and Machine Cognition's http://cmap.ihmc.us/, particularly the article written by J.D. Novak and A.J. Cañas, "*The Theory Underlying Concept Maps and How to Construct and Use Them" (http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf)*





Activity Two: Browse like a moose

Inside, the day before you go outside

1. Before you go outside, what does a moose need to know? Using your knowledge from Activity One and the **Moose Facts** box above, answer these questions.

- ✓ Where will the moose go to browse? *(Discuss your strategy with your team mates and teacher.)*

- ✓ What species will it want to eat in winter? Hardwood or softwood? What are its 5 favorite species?

- ✓ How high off the ground will it browse? (*While you are indoors, use meter stick to measure against your leg. Use yourself as the measuring stick outdoors.)*

- ✓ What maximum stem diameter will it select? (*While you are indoors, cut and weigh a twig of the proper stem diameter that you can take outdoors with you as your twig size guide.)*
  twig diameter*:* _____ mm twig mass: _____ grams
  Example answer from student work: twig diameter: 3mm, twig mass= 0.6 grams

- ✓ How many grams of food does the moose need to eat:
  kg/hour __*2.5*__ g/ hour ___*2500*__ g/ minute _*42*___

- ✓ How many twigs does the moose need to eat per minute: _____
  (g/min. divided by g/twig)
  Example answer from student work: 70 twigs

4. Once you have collected your browse in the stomach bag, weigh it. ____ g.
Example answer from student work: 202.25 g

5. What are the major species of trees and shrubs that you browsed?
Answers will vary.

6. Your moose browsed at a rate of:

____ g/20 min ____g/hour _____ kg/hr
Example answer from student work:
202.25g/20 min, 606.75 g/hour, 0.6 kg/hr, 4.8 kg/day (8 hour day)

7. A moose needs 20 kg per day. Based on your browsing, how many hours of browsing would it take to satisfy your moose's winter energy needs? Show your calculations:
_____ hours
Example answer from student work: 33.3 hours (20/0.6)

8. Will your moose survive the winter? Approximately how many hours per day does a moose browse (see **Moose Facts** box). If your answer was 9-10 hours, what do you think might happen? Over 10 hours? Consider how many hours of daylight there are in winter.
Based on student examples, no, the moose would not survive the winter. There would not be enough daylight for the moose to browse.

9. Reflect on the impact of vegetation species, browse density and quality, and other factors on survival. Look back at your concept map for ideas. What changes to your browsing strategy or habitat could improve your moose's chance of survival?
Answers will vary.

Activity Three: How does moose browsing affect the structure of a shrub?

Answers will vary.

Activity Four: Where would you build your nest?

1. In the table below, data from patches of hobblebush **with** black-throated blue warbler nests ("nest plots") and **without** BTBW nests ("random plots") are compared. Add up the total height of the stems and total number of branches for the random plots and then for the nest plots. Now calculate the average by dividing the total height by the number of plants (rows).

- Is there a difference in the average height of stems between the random and nest plots? Explain using the data.
  Yes, there seems to be a difference in stem height between the plots where BTBW nest and those where they do not. The average height of stems in plots

with nests is 45.36 cm, while average height in non-nest plots is much greater (62.01 cm).

- Is there a difference in the average number of branches between the random and nest plots? Explain using the data.
  Yes, there seems to be a difference in the average number of branches between the plots where BTBW nest and those where they do not. The average number of branches in plots with nests is 125, while average number of branches in non-nest plots is 185.

2. By dividing the number of branches by the plant height, calculate the "shrubiness index" (SI) and enter the number in the space provided. This is a measure of how dense the shrub is. How might shrubiness be an advantage for the warbler?
   SI for random plots = 0.13367
   SI for nest plots = 0.12425
   Shrubs with greater foliage and branch density might hide warblers and their nests from predators more effectively than less dense shrubs. Perhaps shrubs with greater branch and foliage density also protect better from weather.

3. Did the warblers actually select nest sites that were shrubbier? Use the data to support your answer.
   No, it does not seem that warblers located their nests in sites that are shrubbier! The plots without BTBW warbler nests actually have a greater SI (0.13367), but the difference between these plots and those with nests (0.12425) is not that great. This makes it hard to determine whether warblers are influenced by the shrubiness of hobblebush (or other species) when choosing nest sites.

Table 3. Characteristics for *Viburnum alnifolium* in plots with and without black-throated blue warbler nests. Data courtesy of M. McDonald, 2011.

See Answer Key tab in Excel file: MoosePower.xls

4. Now refer back to your results from Activity 3. Compare Michael's SI data from the White Mountains in Table 3 to the data from your class in Table 2.
Answers will vary.

5. In light of this, develop a hypothesis explaining how you might expect moose browsing to affect bird nesting habitat and survival around your school.
Answers will vary, depending on whether student data agrees or conflicts with McDonald's data. Based on McDonald's data alone, it seems that although the browsing of moose does affect plant structure, it does not create a shrubbier plant or affect the locations warblers choose to build nests. Therefore a hypothesis might be: Moose browsing will not affect bird nesting habitat and survival around our school.

6. What do you predict would happen to the BTBWs if the carrying capacity for moose in the White Mountains were to decrease? Use your concept map to help you answer. What might cause a reduction in carrying capacity for moose? What might happen to bird nesting habitat if the number of moose dramatically increased?
It doesn't seem that warblers would be affected by a decline in moose population in the White Mountains. However, if moose are declining due to lack of available food, this might also indicate a lack of suitable nesting habitat for BTBW. Conversely, if the number of moose and thus moose browse increased dramatically, it might decrease the amount of suitable habitat available to BTBW.