Date: _____

Your Name: _____

HUBBARD BROOK RESEARCH FOUNDATION ENVIRONMENTAL LITERACY PROGRAM

Suggested Answer Guide

Grade 11

Science Inquiry Task

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Ice Storm Damage

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GRADE 11
PRACTICE TEST SCIENCE INQUIRY TASK
TASK & ANSWER BOOKLET

Directions:

This Inquiry Task will measure your ability to think scientifically. This task will ask you to form hypotheses, plan and critique investigations, analyze data, and develop explanations.

First you will read a short story and then you will make predictions based on the information in the story. You will have 75 minutes to answer the questions about the story.

Write your answers in the spaces provided. Explain the reasons for all of your answers. You may include drawings or labeled diagrams to help explain your answers.

Part 1:	Part 2:	Part 3:
Planning an investigation.	Evaluating explanations and making predictions.	Developing explanations and Applying What you Learned

The words and concepts listed below are used in this investigation.

Species	Group of organisms that can interbreed.
Diameter at breast height	Diameter of tree trunk at 1.4 meters aboveground.
Tree crown	The aboveground parts of the tree extending from the main stem (branches, leaves, reproductive parts).
Newton (N)	Unit of force

GO ON

Read the story below.

Ice Storm Damage

At first the students, and especially the skiers, were excited. Just when it was about time to return to school from winter break, a large winter storm appeared in the weather forecast. The forecasters were saying it was a hard one to predict since the temperature was right around the freezing mark, but the students were optimistic, and eagerly watched the weather. When the power went out, they initially thought it was a good sign and assumed it would be back on in the morning in time for the phone call cancelling school. But by morning, there was no power, no heat, and no way they would get to school. Everything they could see outside was coated with ice. An ice storm had knocked over trees and power lines in all of the towns in their school district. They were out of school, but certainly wouldn't be building any snowmen, let alone skiing.

When the students finally return to school they find their school forest a mess. Huge branches are on the ground, some trees have snapped in half, while others have tipped over. Interestingly, some trees seem fine, and some have only minor damage. Since the amount of ice that coated every surface was the same in that small area, there must have been some characteristic of the tree that determined the amount of damage each tree experienced.

The students want to know what made a tree more or less susceptible to damage from the ice storm. In class, they discuss their ideas on what might cause one tree to withstand a heavy load of ice, while a nearby tree breaks. They come up with the following possibilities:

a. **The size of the tree**
b. **The shape of the tree**
c. **The strength of each species of tree (species strength)**

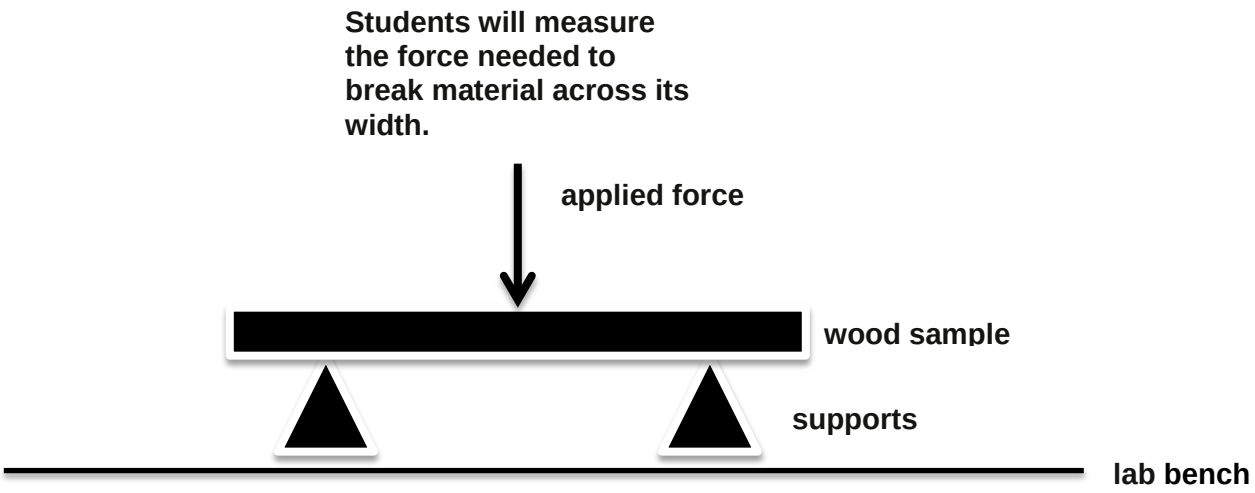
In order to determine which possibility is most important, they decide to collect data and perform experiments. They get information on tree species and tree size from data collected by the biology class the previous fall.

Table 1. Tree species found in forest.
American Beech
Paper Birch
Yellow Birch
Red Spruce
Balsam Fir
Sugar Maple

GO ON

PART 1. Planning Investigations

The school forest will not be safe for the students to work in until the ice has melted so they decide to start by testing the strength of each tree species in an indoor experiment. They will do this by measuring the force needed to break the wood of each tree species, as shown in the diagram below. The downward arrow indicates the force. For each wood sample students will increase the amount of force until the wood breaks.



1. The students collect pieces of wood from each tree species. The pieces are all different shapes and sizes. They want to compare the strength of all these species in a controlled experiment. Describe how they should prepare the pieces of wood and how many samples of each species are needed to conduct their experiment.

Broad Area of Inquiry 2*: Planning in Critiquing of Investigations*
Inquiry Construct 5 (DOK 3)*: Develop an organized and logical approach to investigating the question, including controlling variables*

Answers should show that students understand the concept of a controlled experiment. They need to indicate that size and shape need to be the same and they need more than one sample, preferably at least three. This is an opportunity to discuss with students the importance of carefully reading the question so that they understand what is being asked.

Example answer*: To compare species strength all boards should be the same size and shape and three replicate boards should be prepared for each species.*

1. The students collect pieces of wood from each tree species. The pieces are all different shapes and sizes. The Industrial Arts teacher offers to prepare the pieces of wood so that the students can do the strength analysis test, but she wants the students to provide the methods on how this should be done. Describe how the pieces of wood should be prepared and how many should be prepared so the students can compare the strength of each species in a controlled experiment.

I think they should have 3 of each type of wood, and they should all be the same shape/size. In order to conduct a controlled experiment they should test each type of wood at least 3 times just to be sure of their answers.

The results of the strength analysis are recorded in Table 2. Stronger wood requires more force to break.

Table 2. Species strength for tree species found in the school forest.

Species	Force needed to break wood, in Newtons /sq mm
American Beech	**100**
Paper Birch	**86**
Yellow Birch	**116**
Balsam Fir	**53**
Sugar Maple	**107**
Red Spruce	**70**

2. Organize the data from Table 2 into a graph to compare the strength for each species.

Broad Area of Inquiry 3*: Conducting Investigations*
Inquiry Construct 8 (DOK 2)*: Use accepted methods for organizing, representing, and manipulating data.*

Students need to represent the data accurately in an appropriate graph. For this information a bar graph is preferred. Graph must have a title, labeled axes, and an appropriate scale for the range of data This is an opportunity to remind students to use the whole graph area provided so that their graph is clear and to discuss independent and dependent variables and x and y axes. Labels should be complete and informative. Example graph below:

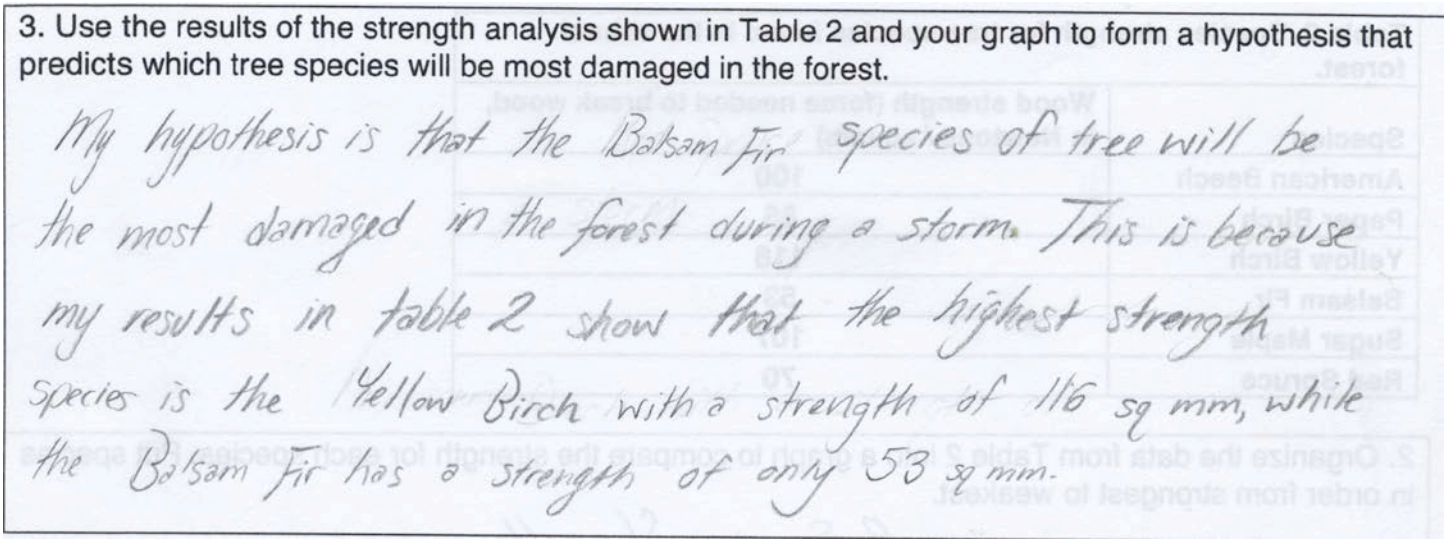
GO ON

3. Use the results of the strength analysis shown in Table 2 and your graph to form a hypothesis that predicts which tree species will be more heavily damaged in the forest.

Broad Area of Inquiry 1*: Formulating Questions and Hypothesizing*
Inquiry Constructs 3 (DOK 2)*: Make and describe observations in order to ask questions, hypothesize, make predictions related to the topic.*

Students need to show that they can interpret the results correctly and connect them to a prediction as to which species will be more damaged. This is an opportunity to discuss the use of scientific language for a hypothesis. Students should avoid starting statements with "I believe…." They can use "I predict" or just make the prediction (i.e. "A will affect B").

Example hypothesis*:*
I predict that Balsam Fir, Red Spruce, and Paper Birch will have more damage than American Beech, Sugar Maple, and Yellow Birch because less force is needed to break wood from Balsam Fir, Red Spruce, and Paper Birch.


3. Use the results of the strength analysis shown in Table 2 and your graph to form a hypothesis that predicts which tree species will be most damaged in the forest.

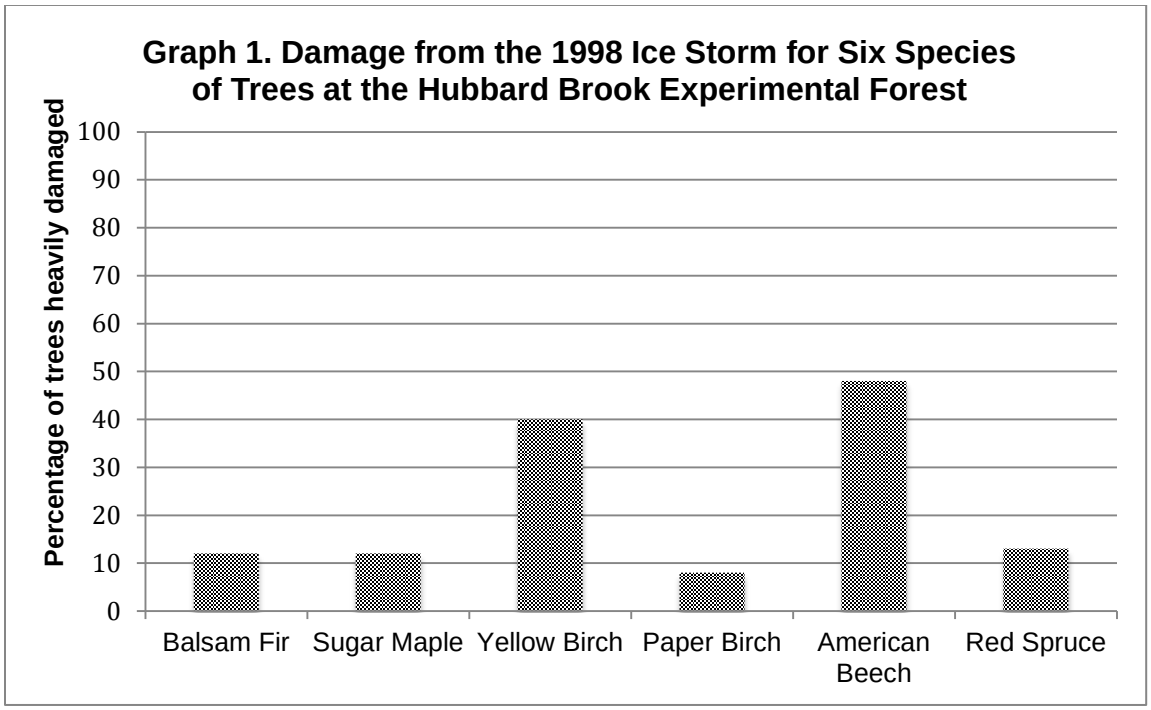
My hypothesis is that the Balsam Fir species of tree will be the most damaged in the forest during a storm. This is because my results in table 2 show that the highest strength species is the Yellow Birch with a strength of 116 sq mm, while the Balsam Fir has a strength of only 53 sq mm.

PART 2. Evaluating Explanations and Making Predictions

The students plan on measuring trees in their own forest to test their hypotheses, yet they need to wait for spring so the ice will be melted and the woods will be safer. While they wait, their teacher obtains a data set from the Hubbard Brook Experimental Forest, in Woodstock, NH. She asks them to use this data to test their species damage hypothesis. The forest at Hubbard Brook contains the same tree species and experienced a severe ice storm in 1998. After the storm, scientists measured over 1000 individual trees for ice storm damage. The data shown below summarize the percentage of heavily damaged trees for each species. This includes trees that lost 50 – 100% of their crown, had the top snapped off, or were completely uprooted.

Table 3. Percent of heavily damaged trees for six species at the Hubbard Brook Experiment Forest.	
Species	**Heavy to severe damage (%)**
Balsam Fir	**12**
Sugar Maple	**13**
Yellow Birch	**40**
Paper Birch	**7**
American Beech	**48**
Red Spruce	**11**

Graph 1. This graph shows the percentage of heavily damaged trees for six species at the Hubbard Brook Experiment Forest.



4. Use the data shown in Table 3 and Graph 1 to describe which species experienced the most damage. Do the results from the Hubbard Brook data set support your hypothesis? Explain why or why not.

Broad Area of Inquiry 4*: Developing and Evaluating Explanations*
Inquiry Construct 12 (DOK 3)*: Use evidence to support and justify interpretations and conclusions or explain how the evidence refutes the hypothesis.*

Students need to show that they can interpret the data correctly and use the data provided to support their answer.

***Example answer**: The results did not support my hypothesis. I predicted that Red Spruce, Balsam Fir and Paper Birch would have the most damage because they have the weakest wood, but most of these trees were not heavily damaged. These tree species had very low percentages of heavily damaged trees. Red Spruce had 11%, Balsam Fir had 12% and Paper Birch had 8%. American Beech and Yellow Birch had very strong wood and high percentages in the heavy to severe damage category. American Beech had 48% and Yellow Birch had 40%. Sugar Maple had strong wood, and a low percentage (13%) of heavily damaged trees, but this was not lower than Paper Birch, Red Spruce, and Balsam Fir.*

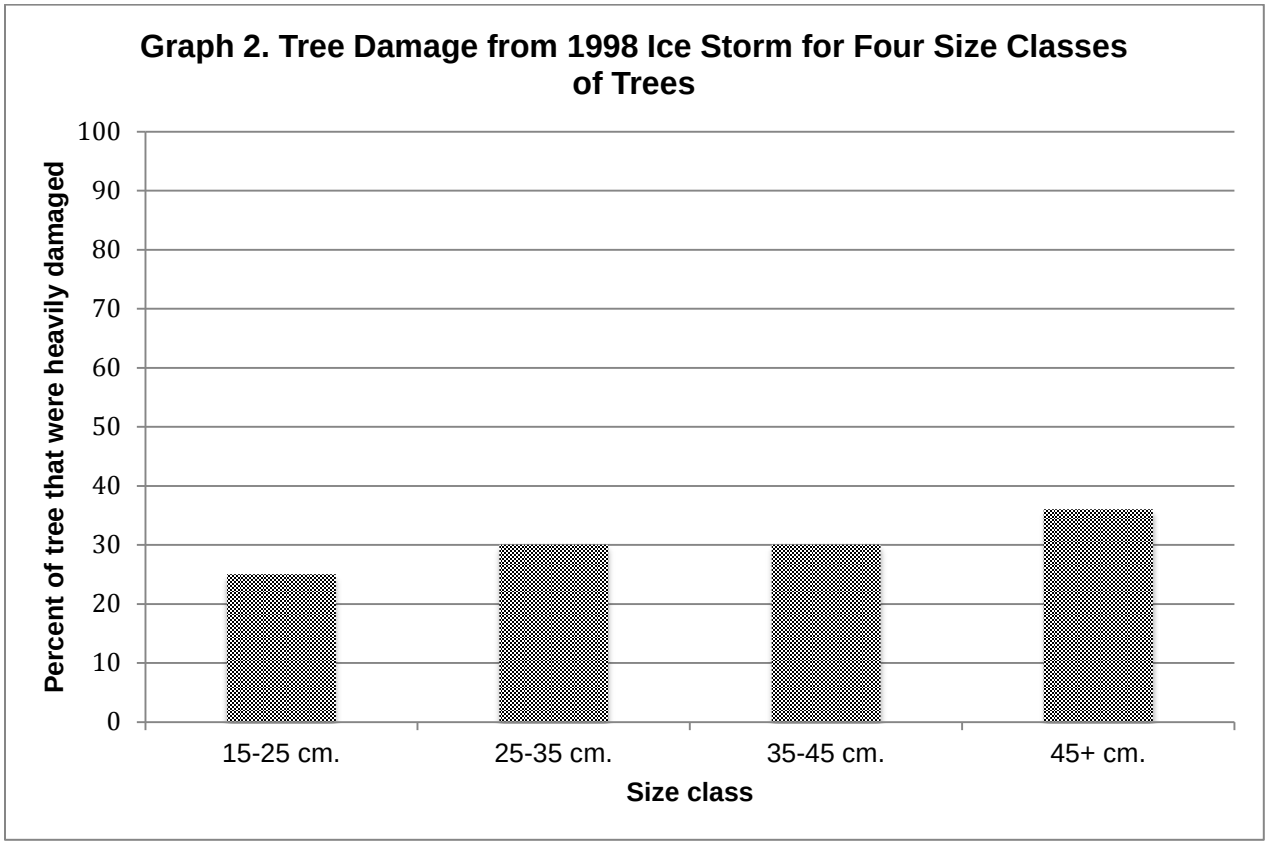
4. Use the data shown in Table 3 and Graph 1 to describe which species experienced the most (heavy to severe) damage. Do the results from the Hubbard Brook data set support your hypothesis? Explain why or why not.

The American Beech trees experienced the most heavy to severe damage. The results do not support my hypothesis because I thought that the Balsam firs would take the most damage because of how easy they are to break.

PART 3. Developing Explanations and Applying What You Learned

The students determine that the strength of each species does not predict how severely each tree was damaged for the Hubbard Brook data set. This surprises them and they decide to see if tree size and tree shape have anything to do with the amount of damage. They ask the Hubbard Brook scientists for more data so they can analyze damage by tree size. The scientists send them a data set that groups all species of trees together into different size classes (measured by diameter of trees). The students graph the data to learn if larger trees had heavier damage.

Graph 2. Results of Hubbard Brook Experimental Forest ice storm data for each tree size class. This graph shows the percentage of heavily damaged trees in different size classes at the Hubbard Brook Experiment Forest.



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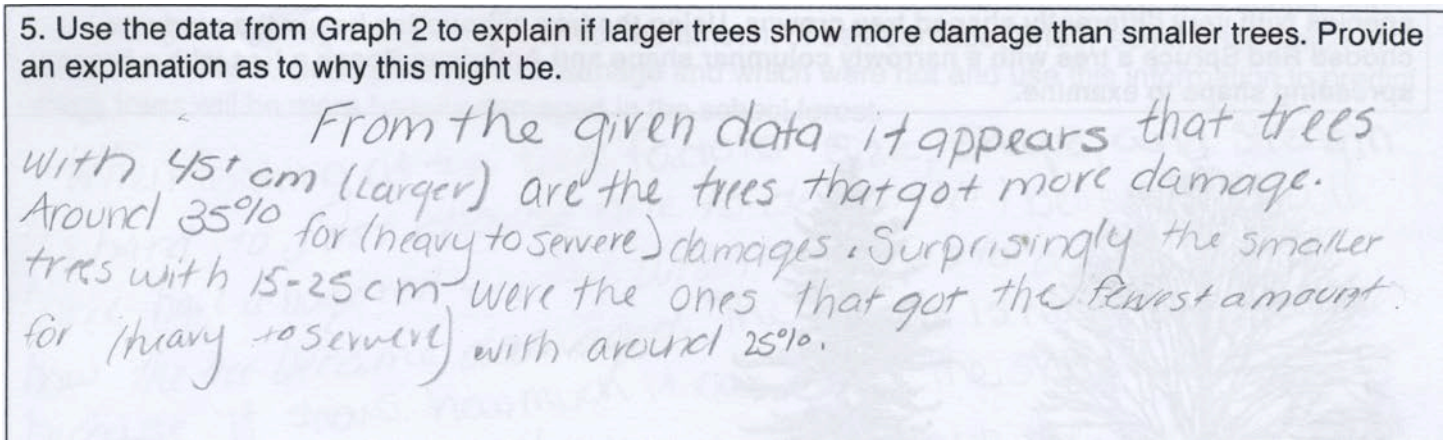
5. Use the data from Graph 2 to explain if larger trees show more damage than smaller trees. Provide an explanation as to why this might be.

Broad Area of Inquiry 4*: Developing and Evaluating Explanations*
Inquiry Construct 12 (DOK 3)*: Use evidence to support and justify interpretations and conclusions or explain how the evidence refutes the hypothesis*

Students should be able to interpret and explain the data to answer the questions. They then need to supply a brief, thoughtful explanation as to why the trend might occur. Remind students that in a two part question they need to clearly answer each part. In questions that have "use the data" want students are expected to refer to data in their answer.

Example answer*: Larger trees were more damaged than smaller trees. In graph 2, the largest size class had the greatest percentage of heavily damaged trees (about 35%), the middle size classes had slightly lower percentages (30% each) and the smallest trees had the lowest percentage of trees (about 15%). One reason for this is that larger trees might have stiffer branches and trunks and may be more liable to snap off then more flexible smaller trees.*

Note*: There are multiple reasons that can describe the second part of the question. The student's thought process and ability to explain thoughts clearly is more important here. The student answers below provide insight into varying abilities to completely answer the question.*

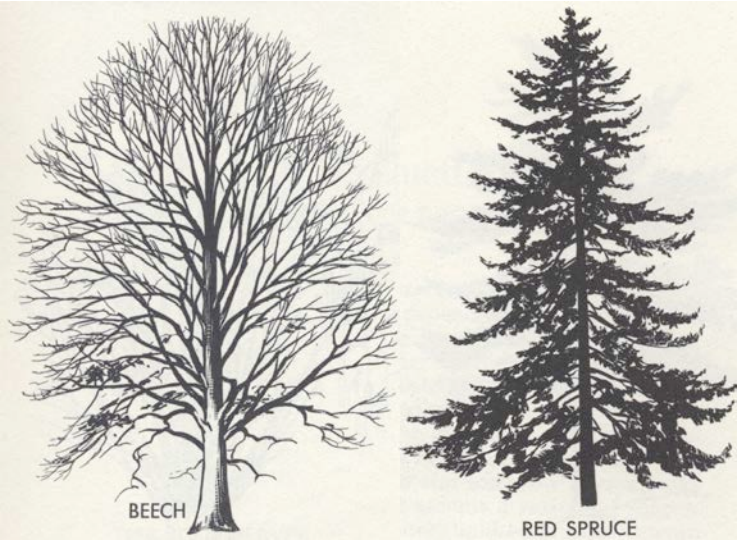

5. Use the data from Graph 2 to explain if larger trees show more damage than smaller trees. Provide an explanation as to why this might be.

From the given data it appears that trees with 45+ cm (larger) are the trees that got more damage. Around 35% for (heavy to severe) damages. Surprisingly the smaller trees with 15-25 cm were the ones that got the fewest amount for (heavy to severe) with around 25%.

5. Use the data from Graph 2 to explain if larger trees show more damage than smaller trees. Provide an explanation as to why this might be.

According to the last set of data the larger the tree the more severe the damage. I think this is the case because the larger/longer an object is without support in the middle the easier it is for it to break or be damaged, such as a bridge the greater distance between supports the weaker the bridge between those supports become. also, the larger the tree, the more tree there is available to become damaged, which might be another explanation as to why the larger trees had more damage. My last explanation would be that the larger trees are taller, and more exposed to wind, rain etc. and don't have as much protection from the trees around them as shorter trees would.

To investigate the effect of shape on severity of damage the students want to use data from two species with very differently shaped tree crowns. The students choose to compare data from American Beech, a tree with a broadly spreading shape, and Red Spruce, a tree with a narrowly columnar shape. A silhouette of each tree is shown below.



The Peterson Field Guide Series. A Field Guide To Trees and Shrubs, George A. Petrides. Houghton Mifflin Company Boston 1958

6. Reflect on the percent of trees that were heavily damaged for American Beech and Red Spruce in Graph 1. Describe the amount of damage for these species. How might the different shapes of these tree crowns cause the different levels of damage you observe?

Broad Area of Inquiry 4*: Developing and Evaluating Explanations*
Inquiry Construct 11 (DOK 2)*: Analyze data, including determining if data are relevant, artifact, irrelevant, or anomalous.*

Example answer*: In graph 1 American Beech had a much higher percentage (48%) of trees that were heavily damaged than Red Spruce (11%). The spread out shape of the tree crown may catch more ice making the branches very heavy. This might have caused more branches to break or trees to fall over for this species. The narrow cone shape of the Red Spruce may help freezing water to run off. The trees shape may protect it from damage.*

Note*: There are multiple reasons that can explain the association between shape and damage. The student's thought process and ability to explain thoughts clearly is more important here.*

6. Reflect on the percent of trees in the heavy to severe damage category for American Beech and Red Spruce in Graph 1. Describe the level of damage for these species. How might the different shapes of these tree crowns cause the different levels of damage you observe?

The American Beech has more damage than the Red Spruce. This may be because the branches of the Beech have a wider spread and slant towards the trunk, making it easier for ice to build up. The Red Spruce's branches slant away from the tree, which may cause the ice to slide off and not build up as much.

7. In the beginning of their investigation, the students identified 3 factors that they thought might affect the amount of tree damage from an ice storm: tree strength, tree shape, and tree size. Briefly summarize which of these factors were good predictors of damage at Hubbard Brook and which were not. Use this information to predict which trees will be more heavily damaged in the school forest.

Broad Area of Inquiry 1*: Formulating Questions and Hypothesizing*
Inquiry Construct 1 (DOK 3)*: Analyze information from observations, research, or experimental data for the purpose of formulating a question, hypothesis, or prediction.*

Students need to summarize their findings from their experiment and the Hubbard Brook data set and then use their summary to make a prediction. Their answers should be clear and be based on data and information provided in this task. They do not need to bring in outside information here.

Example answer*:*
The students learned that tree size and shape were better predictors of tree damage than wood strength. I predict that larger trees and trees with broadly branching crowns will be more heavily damaged than smaller trees and trees with narrow cone shaped crowns in the school forest.

7. In the beginning of their investigation, the students identified 3 factors: tree size, tree shape, and tree strength that they thought might affect the amount of tree damage. Briefly summarize which of these factors were good predictors of damage and which were not and use this information to predict which trees will be more heavily damaged in the school forest.

The tree strength test was not a good predictor of damage. The results of the test were opposite of the actual damage done to the trees. The tree size was a good predictor. The larger trees had more heavy to severe damage and the smaller trees had more low to moderate damage. The tree shape was also a good predictor. The trees will a wider, more spread out crown had more damage than the more compact trees.

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STOP

GO ON