The Mathematics of Forestry

A Mathematics unit for 6th-8th grade by Debra Pelkey Woodstock Union Middle School, Woodstock, Vermont

First and foremost this is a middle level mathematics unit appropriate for use in grades 6 through 8. The lessons are written to meet the demands of a 42-minute class period and multiple math classes. As a standards-based statistics unit, the key topics of study are: frequency tables and line plots, constructing and interpreting bar graphs, broken line graphs and scatter plots, surveys and sampling and in general the organization and visual presentation of data. This series of lessons was instructed as part of an interdisciplinary unit based upon the study of local forests. Written in partnership with the Marsh-Billings-Rockefeller National Historical Park, the focus of the instruction brings students to a better understanding of the historical use as well as future use of this now public land. With a substitution of data used, the unit could be adapted to other forest related sites.

The focus of the forest element is forest management and the science of forestry. Students come to understand the critical role mathematics plays when it comes to knowing the forest. The original worksheets are the result of much research. All of the data, tables, and charts supplied to the students came from the Vermont Department of Natural Resources and the National Park Service.

As a central element of the unit is learning how and why foresters count trees, local experts were called upon to share their knowledge with students. The county forester and the park resource manager conducted workshops and guided the students through their culminating activity, a circle sweep plot survey at Marsh-Billings-Rockefeller National Historical Park. Three field trips to the park, one of which was their field study, were critical pieces of the learning experience.

In the end students should have a deeper appreciation of how foresters use data, the importance of interpreting this data, and why it is necessary to present this information in meaningful ways. A suggestion for a related community service project is also included.

The essential and guiding questions which bring focus to this unit are:

Understanding Forest Management Who counts the trees? Why do they count the trees? How do they count the trees?

Caring for Our Forests - A Legacy of Stewardship Grade 6-8 Math Component

Essential Question: Understanding Forest Management: Who counts the trees? How do they count the trees? Why do they count the trees?

Standards	Criteria	Learning and Teaching Activities	Products and Performances	Assessment
7.9 Students use	Construct and	Field Trip:		
statistics	interpret frequency	"Adventure in the		
to:	tables; line plots	Forest," forest		
aa. Create and	histograms, bar	observation		
interpret	graphs, and broken	activities.		
statistical tables and	line graphs.			
charts.		Lesson #1:	Hand-out: 1	Quiz-answer key
bb. Appropriately	Use and find	Organizing data:	Worksheet: 1A	
use measures of	measures of central	frequency tables,		
central tendency—	tendency in	line plots, and	Journal Entry	
mean, median,	appropriate ways.	histograms -Parks		
mode; understand		for the people		
the significance of	Interpret data	Guest lecturer/slide		
frequency and	presented in tables	presentation -		
distribution.	and statistics.	"Vermont's Forests:		
cc. Make		Past, Present, and	Worksheets:	
conclusions and	Collect and analyze	Future"	2,3,8	Answer key
recommendations	data.			-
based on data		Lesson #2: Reading	Bar Graph	Checklist
analysis.	Organize data and	and constructing bar	_	
	present data using	graphs		
1.17aa Students	the best possible	-Vermont's forested		
represent data and	representation.	acres -Looking at		
results in multiple		forest composition -		
ways (e.g. numbers	Understand the basic	Frederick Billings	Worksheet: 4	Answer key
and statistics, charts,	concepts of forest	purchases trees for		
and tables.)	management and.	reforestation project		
1.20 Students use	the science of			
graphs, charts, and	forestry.	Lesson #3:		
other visual		Understanding		
presentations to	Justify a proposal	measures of central		
communicate data	supported by data.	tendency		
accurately and		-Why and how		Answer key
appropriately.	Create a useful and	much land is	Worksheets:	_
4.6bb Students	relevant product.	donated to the Green	5,6,7	
demonstrate		Mt. National Forest?		
understanding of the	Perform effectively	-How much land do		

relationship between	on a team.	we own?	Line Graph	Checklist
their local	Demonstrate tactful	-How would this	1	
environment	and responsive	area compare to	Group work	Specified criteria
and community	behavior.	ownership in other	1	1
heritage as it relates		areas in our		
to agriculture (forest	Make connections	country?		
management.)	between			
	mathematics and the	Lesson #4:		
1.11 c. Students	science of forestry	Constructing line		
support proposals as	through direct	graphs -Recreational	Hand-out: 9	Answer key
appropriate	experience.	uses of forests.	Worksheet: 9A	5
through definitions,		-Foresters collect		
description,	Complete circle	data to track park		
illustrations,	sweep inventory.	visitations.		
examples from		-Frederick Billings		
experience, and		acquires land and		
anecdotes.		builds his estate	Hand-out: 11	
		- Growth of NPS	Worksheet: 11A	Collection of data,
2.13 Students design				class discussion
a product, project, or		Lesson #5:		
service to meet an		Scatter plots		
identified need.		-Looking for a		
		correlation	Group work: 12	Application
3.10 Students		between the dbh and	-	
perform effectively		saw log height of		
on teams that set and		sugar maples on		
achieve goals,		stand 39		Sharing data
conduct		(MBRNHP).	Inventory	
investigations, solve			Sheets	
problems, and create		Lesson #6	Calculations	
solutions (e.g., by		Tree Sampling	13, 13A, 14	
using consensus		Simulation - how		
building and		and why foresters		Rubric
cooperation to work		count trees?	Project: Hand-out	
toward group		-Line transect	10 Worksheet:	Unit Test
decisions.)		-Plot/quadrant	10A	Answer Key
		survey -Circle	Group	
3.11 Students		sweep	presentations	
interact respect-		-Determining best	persuasive essay	
fully with others,		sampling method for		
including those		MBRNHP		
with whom they		inventory;		
have differences.				
		Workshop:		
3.15 Students collect		Introducing the		
information about		cruiser's stick		

careers, and	-Windsor County	
experience Careers	forester instructs the	
directly or indirectly	use of the Biltmore	
through classroom	stick.	
work and		
community	Field	
experiences.	Trip/Culminating	
-	Activity I Circle	
1.14 Students	Sweep Survey at	
critique what they	MBRNHP -Stand 39	
have heard (e.g. oral	field study -	
presentation).	Compiling data	
4.6aa. Students	Lesson #7:	
apply knowledge 6f	Surveys and	
local environment	Samples -Designing	
through active	a merchantable trail	
participation in local	mix	
environmental		
projects.		

Culminating Activities:

Activity 1: Circle Sweep Survey on site, Marsh-Billings-Rockefeller National Historical Park Activity 2: Reception for community resource people, National Park rangers and staff and county forester, classroom presentations

Activity 3: Production and distribution of "Carriage Roads" Trail Mix

LESSON #3: Understanding Measures of Central Tendency

Focusing Question: The Green Mountain National Forest - who donates land, why do they donate, and how much land is generally donated each year to this public forest?

Vermont Standards addressed:

7.8 bb Students appropriately use measures of central tendency - mean, median, mode.

Length of Lesson: 1-2 class periods

Resources/Materials: Worksheet #4

Procedure:

1. Focus: Using worksheet #4, read the initial paragraph introducing the Green Mountain National Forest. Locate the forest on a state map. Introduce a discussion about public land, what are public lands? What are the purposes and uses of public land? Continue to focus on the need for management plans and the role of data when writing such plans.

2. Opening the Lesson:

Review the measures of central tendency, how each measure is found and how each is used to affectively represent data.

- **3. Teach:** Using the data on worksheet #4 about donated acres to the northern half of the Green Mountain Forest, have students work in pairs to answer the worksheet questions. The lesson focusing question should be written on the white board so that students will answer this question as they sort the data.
- **4. Practice:** Students should complete the worksheet and make a frequency table and line plot or histogram for the data. In addition, students should complete the investigation on the second page of the handout, gathering information on the land area of our homes.
- **5. Follow-up:** Use the data collected through their investigation to focus a follow-up class discussion. Use this opportunity to reinforce our unique sense of place in Vermont, for example, how would this data look different if you went to school in Boston or Miami or Boise? Why do some of us own a great deal of land and others own much less? How is location a factor? How is land-use a factor? In addition, share with students why and how people donate their land for public use. (Currently there is a waiting list to donate/sell land to the Green Mountain National Forest. Many people donate or sell their land for tax purposes. In addition much of the land which is given or sold is not readily accessible for commercial use. Contact the U.S. Forest Service at the national forest for additional information.)

Assessment:

Students will: complete worksheet #4, construct a frequency table

survey 10 people about land ownership and organize data using the measures of central tendency

complete quiz on frequency and central tendency

Teacher will: facilitate all discussions

review worksheet (answer key)

assess quiz (answer key)

LESSON #7: Surveys and Samples

Focusing Question: Designing a "merchantable" Trail Mix: what are your favorite ingredients in a trail mix?

Vermont Standards addressed:

1.11 c	Students support proposals as appropriate through definitions, description, illustrations, and examples from experience and anecdotes.
2.13	Students design a product, project, or service to meet an identified need.
3.10	Students perform effectively on teams that set and achieve goals, conduct investigations, solve problems, and create solutions (e.g., by using consensus building and cooperation to work toward group decisions.)
3.11	Students interact respectfully with others, including those with whom they have differences.

Length of Lesson: Group Project, 3 class periods. (This project requires 3 class periods, but will span more than a week in time as students will need several days to collect the data from their surveys. It works nicely if students work on the graph of the history of the National Park Service at this time as each project requires out of class as well as in class group work.)

Resources/Materials: Group project sheets: 10 (2 sheets), 10A (recipe template)

Procedure:

1. Focus: Using worksheet #10, pose the question; what are your favorite ingredients in a trail mix? Have students share their likes and dislikes as a group.

2. Opening the Lesson:

Inform students that as part of a community service project, they will be collecting important data as it relates to developing a recipe for a "merchantable" trail mix. This trail mix blend will reflect the species diversity found in Stand 39. There are 10 species currently recorded in the northern hardwood stand.

Using worksheet "Lesson 10: Taking a Survey" provide instruction on representative samples and surveys.

The students will work together in groups of four to develop surveys. Before students begin to develop their surveys ask the following guiding questions:

- What types of people enjoy trail mix?
- What age groups enjoy trait mix?

- Where can surveys be taken or distributed in a fair and safe manner so that the data reflects a true sampling?
- How should the survey be written? Should it be able to stand on its own so that it can be distributed and collected without the surveyor being present?

Establish fair criteria for the surveying process, such as appropriate deadlines for collecting data, how many surveys each group should complete, and what minimum number of choices for trail mix. Ingredients must be included in the survey. It is important at this point to troubleshoot any special circumstances which the students may encounter.

3. Practice: Each student in the group should design and type a sample survey for homework. During the next class, the group members must choose one or a combination of the best surveys in their group. That evening the final survey must be typed and presented for Xeroxing the next day. Students should have several days to collect their data.

When the surveys have been collected, students should complete frequency tables for the ingredient choices. Have students share their group tables with the class and construct one class frequency table on large grid paper.

Student groups should then go on to: construct a graph representing their data, determine the percentage for each of their responses, and write a proposal for their group recipe. Set appropriate due date for typed and edited proposal, see criteria on worksheet #10.

4. Follow-up: Using the class frequency table and the worksheet #10A, develop a class recipe for the trail mix based on the most frequently named ingredients. (Complete unit cost only if the information is readily available.)**

**Making the trail mix itself was one of the culminating activities for this unit of study. The activity is described in the Outline of Lessons.

Assessment:

Students will: be effective and thoughtful members of a small team

meet all due dates in a timely manner

successfully complete all criteria of the project including a table, graph, and written proposal

will design a "merchantable" trail mix recipe

Teacher will: encourage teamwork within the groups

establish fair due dates and assist students with process issues throughout the project

create a class frequency table of data assess project using grading guide and rubrics administer Unit Test (answer key)