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Mt. Ararat High School Forest Inventory Growth (FIG)

Purpose
The broader purpose of this project is to gather data about a small plot of land that will then be entered into a state website to help record overall tree health, as well as more species-specific data to track how each type of tree is growing across Maine. This plot was measured in 2016 and has not been measured since.

Question
Which size of tree has grown the most since the last time the data was recorded in 2016?

Hypothesis
The larger trees with DBH greater than 10 inches DBH will have grown the most since 2016.

Background

Forests are a key factor in human survival. Almost 90% of Maine is covered by forests. Trees absorb carbon dioxide, water, and sunlight and use it to produce energy to grow and survive, then trees release oxygen into the atmosphere, which allows humans to breathe and live. Trees are important to other creatures as well. They provide nutrients and hold soil in place, which is beneficial to an innumerable amount of species. They also protect water by filtering out harmful chemicals and excesses of nutrients. The existence of trees also creates jobs for loggers, and forestry workers.

The Maine Forest Inventory Growth program, or FIG, compiles together data about tree growth from different plots in Maine. These trees are studied to monitor their status and whether they are healthy and to determine their growth patterns. Most of the plots are run by schools, land trusts, and environmental organizations, as an opportunity for students and other members of the community to contribute by recording data of Maine's forests. A FIG plot is a circular plot with an area of one tenth of an acre, which means that the radius must be 37.4 feet. Each year possible, they are observed and studied using a constant procedure that is carried out in the same way for each plot across the state of Maine. All of the information is collected in a statewide database and can be viewed by the public.

The plot in this study lies outside of Mt. Ararat High School, includes Red Maple, Eastern White Pine, Red Oak, and Red Spruce. It was established in 2016 by Cam Cox for his senior capstone project. Since then, part of the plot was harvested for construction. Because of this, not every single tree from the original plot was still present.

The factors that are measured as part of the FIG project relating to the trees are: tree species, tree status, total height, DBH, type of damage to the crown, percentage of crown damaged, type of damage to the bole, and percentage of bole damaged. The species of a tree can be identified through its leaves and bark. A tree's status is either live, dead standing, dead down, or dead harvested. DBH is the diameter of the base of the tree and is measured at 4.5 feet from the bottom of the tree. Crown damage can be damage to either the branches or to foliage. A good example is if lightning struck the top of a tree and caused many of the upper branches to be damaged. The bole is the lower section of a tree, which is mostly the trunk. Bole damage is caused by either insects, disease, mechanical causes, weather, or other, which is everything else than can cause the bole of the tree to be damaged. The factors that are measured relating to soil are soil type, texture, moisture, and pH level. These pieces of data are measured at multiple layers, because different layers of soil have different characteristics. The four major soil layers are the O layer, which is the closest layer to the surface, and the A, B, and C layers, which are increasingly further beneath the surface. The layers measured in this experiment were the A, B, and C layers, which were measured at 3, 6, and 12 inches beneath the surface respectively. All of the soil layers, and the characteristics that they show are important in relation to the growth of the trees, and the health of Maine forests. Soil type and texture are measured by looking and feeling. Different soil types could be mud, sand, dirt, or many others. Texture can be described as a clumpy texture, or perhaps a fine texture like small grains of sand. Moisture is a measure of the amount of water in the soil in a percentage. It is important because the amount of moisture in the soil can affect tree growth. Trees also need to be able to take in moisture from the soil to perform photosynthesis. Trees absorb water from the soil underground. pH level is a measure of the acidity of the soil. This is important because very acidic soil would be harmful to the trees. Soil pH is measured on a logarithmic scale from zero to fourteen, with zero being the most acidic, seven being neutral, and fourteen being the most basic possible. The "perfect" pH for most tree species is about five to eight on the logarithmic scale. A soil acidity reading outside of a tree's ideal range will cause the tree to have difficulty surviving, bordering on impossible.

There are two major types of trees, which are deciduous and coniferous. Maine forests are made up of both types of trees, but coniferous trees are slightly more dominant, making up about 58% of forest in Maine, which leaves 42% to deciduous trees. A large majority of coniferous trees are also known as evergreens. They keep their green needles year round, which is where they get their name. Deciduous trees, on the other hand, have leaves instead of needles, and they lose their leaves in the fall and get them back in the spring. As mentioned, the types of trees present in the studied plot are, Red Maple, Eastern White Pine, Red Oak, and Red Spruce:

- **Red Maple** - The scientific name for the red maple is <u>Acer rubrum</u>. They are deciduous trees with leaves that have 3 or 5 lobes. They prefer wetlands and poorly drained sites. They are fast growing trees that can grow to 50-60 feet tall and 1-2 feet in diameter and are typically found in swamps and poorly drained sites.
- **Eastern White Pine** - The scientific name for the white pine is <u>Pinus strobus</u>. They are coniferous trees with long needles that come off in groups of five. This can be remembered by the number of letters in the name, W-H-I-T-E. Young trees have thin green bark with red or brown spots, and old trees have thicker bark that is very dark. These trees prefer well-drained soil and a cool humid climate. They are fast growing trees that have an average height of 80-100 feet, and an average diameter of 103 feet. White pines grow in partial shade to full-sun, moist situations, on uplands, and on sandy soil. White pine is the only five-needled pine in easter U.S. and Canada, which makes it easy to distinguish.The Eastern white pine lives/grows in the east to north east of North America spreading as south as South Carolina and as North as Newfonlend.
- **Red Oak** - The scientific name for northern red oak is <u>Quercus rubra</u>. They are deciduous trees with leaves that are 5-9 inches long, 4-6 inches wide, and have 7-9 bristle-tipped lobes. Their bark is dark gray or practically black. The red oak is the most common species of oak in Maine, and are typically found in the southern part of the state. Red oaks grow relatively quickly. They can grow up to 70-150 feet tall, and the trunk can grow to 2-3 feet in diameter. Red oak (like Eastern White Pines) live in eastern North America streating as far south as Alabama and as north as Quebec.
- **Red Spruce** - The scientific name for red spruce is <u>Picea rubens</u>. Red spruces are coniferous trees, and they have round needles that are about ½ inch long. Red spruces are medium sized trees that can grow to over 400 years old. They grow at an average speed and can grow to 60-80 feet in height, and 1-2 feet in diameter. Red spruces grow well on rocky upland soils and on the north side of mountain slopes. Red spruces have longer

needles than black spruce, and they have cones. Red spruces live in the North East in America and into Canada. Red spruces can grow as far south as North Carolina but in low population numbers. Red spruces can also grow as far north as Novia Scotia and Quebec.

MTA FIG

Procedure

1. Find the center post of the plot at 43º57’29”N, 69º57’48”W by following the road from Mt Ararat High School towards Mt Ararat Middle School until you can see the deep basin on the left. Walk along the left side of the basin until you can see the marker and the marked trees on your left.
2. Check that the four corners of the plot (N,E,S,W) are 37.4 feet away from the center post using a 100-foot tape measure with one person at each end. The tape should stay horizontal.
3. Find the northernmost tree that is closest to due north from the center on the east half, and is a minimum of 5 inches in diameter at breast height (4.5 feet).
4. Identify the tree’s species.
5. Identify the tree’s status; 1=alive, 2=dead standing, 3=dead down, or 4=dead harvested.
6. Measure the tree’s diameter at DBH (4.5 feet up from where the root turns into trunk).
7. Identify any damage (type (for crown:1=branches, and 2=foliage. For bole:1=insects, 2=disease, 3=mechanical, 4=weather, and 5=other) and the percentage of damage) to crown and/or bole using the key on the data sheet.
8. Repeat with each tree, going around the plot clockwise.
9. Return to the center of the plot. Dig up soil samples from 3 inches deep, 6 inches deep, and 12 inches deep using an AMS Soil Probe
10. Collect the soil samples in plastic bags and take them inside.
11. Record the soil texture, type, and color.
12. Find a plastic tray and mass it. Put the soil samples from 3 inches into the tray and mass it together. Subtract the mass of the tray from the mass of the soil and tray to find the mass of the soil only.
13. Repeat with the other two soil samples.
14. Place the samples under an incubator to evaporate the water out. Measure the mass again, and subtract it from the original mass to calculate how much of the soil’s mass was water.
15. Record the water mass and calculate the moisture percentage.
16. Add a small amount of distilled water to moisten the 3 inch sample and use a piece of pH paper to find out the pH level of the soil.
17. Repeat with the other two samples.

Materials

1. DBH measurement stick
2. Tags
3. Nails
4. Hammer
5. DBH tape measure
6. Data table
7. Flags
8. 50ft. Tape measure
9. Maine Tree Identification Field Guide

Map explanation: This image is a google earth image. The softball field and the old MTA high school can be seen in the image. The coordinates are 40º56’34N 69º57’41”W. The circle between the pond and the road indicates the approximate location of the FIG plot.

Safety Considerations

The first safety hazard is unstable ground such as wet logs, leaves, and rocks that can cause you to slip. That is why it is important to wear good shoes that are meant for the woods. This helps you to get better grip on slippery surfaces. Open toed shoes are not recommended for doing this project because you will not have good grip, and sticks can poke your feet. Another safety hazard is temperature. Colder temperatures make it hard to pay attention as you are not comfortable, and they can cause worse bodily harm if you are in the cold temperatures for too long. This can be stopped by wearing the right clothes for the conditions you are working in for example you could wear gloves, a jacket, or a hat so you can be comfortable and also be able to give your full attention to the project. The last hazard is tree branches, as it is easy to trip and take a fall or maybe run straight into a branch you couldn't see. This is why it is important to give you full attention to your surroundings when you are in nature so you don’t get hurt.

Observations

The plot is different then the plot measured in 2016. The construction of water storage for storms has taken up around one third of the plot. This decreased the amount of trees in the original plot. This also makes the project more confusing as the trees in 2016 are numbered differently then the trees measured now. The dead and dying trees were difficult to measure since the decaying bark would make the DBH decrease which is unexpected data. Fallen leaves made the measuring of four feet from the ground harder because the leaves had to be moved so that the measurements are more consistent with the measurements made in 2016..

Red maple observations: There are 7 red maple in the plot, all being relatively small. This may be partly due to the high canopy in the plot which blocks out a lot of the sunlight that can't get to the smaller trees. This is shown when the average DBH for the Red Maple is 8.4 inches this is well below the average diameters showing they are all newer trees.

Eastern white pine observations: The Eastern White pine are some of the largest trees in the forest and form the canopy. There are 8 eastern White Pines in the plot that average 14.8 inches in diameter. This shows that the plot is a prime spot to grow these large trees.

Red Oak observations: There are six Red Oak trees in the plot. The average diameter of these trees is 7.2 inches. These trees are relatively low due to the high canopy of the plot. They don't get much sunlight so it is hard for them to get very large.

Red Spruce observations: The plot only had one red spruce tree; its DBH (Diameter of the tree at breast height) was 12.3 inches.

Data

Topography

- Slope: 2%
- Direction: East
- No Glaciation
- 130ft. Elevation
- Proximity to water
    - Direction: W
    - Distance: ~60 Meters
    - Name: Mt. Ararat Pond
    - Type: Marsh/Pond
- Bioregion: Midcoast Maine
- Watershed: Cathance River

Biotic and Abiotic Factors

- Canopy Cover: 51-75%
- Wind
    - Direction: North to South
    - Strength: 13mph
    - Physical Features: Man-made Drainage Basin
- Temperature:
    - Above Ground 6in.: 1ºC
    - Above Ground 1ft.: 0.8ºC
    - Above Ground 3ft.: 0.8ºC
    - Below Ground 3in.: 3ºC
    - Below Ground 6in.: 2ºC
    - Below Ground 1ft.: 1.5ºC

Soils

- Drainage:
- Parent Material:
- Overall Characteristics: Organic to Sand
- Depth to Mottling: ≈6in.
- Soil Mass:
    - 3in. 1.95 grams
    - 6in. 3.8 grams
    - 12in. 10.25 grams
- Soil dried:
    - 3in. 1.4 grams
    - 6in. 3.05
    - 12in. 8.75

Soil Data

Depth	3in. Depth	6in. Depth	12in. Depth
Soil Type	Organic	Sand	Sand
Texture	Clumpy	Fine	Fine
Moisture	28.2%	19.7%	14.6%
Microbes	-	-	-
pH	5.0	5.0	4.5
Color	Dark Brown	Gray	Gray

Tree Species and Condition Data

2020 Data

tree #	species	Tree status	Total height (feet)	DBH (Inches)	damage type crown	damage % crown	damage type bole	damage % bole	notes
1	Eastern White Pine	4 Dead Harvested (DH)							
1a	Red Maple	1		5.2	none		5	10%	
2	Red Maple	4 (DH)							
2a	Eastern White Pine	1		19.5	none		none		
3	Eastern White Pine	4 (DH)							
4	Eastern White Pine	4 (DH)							
5	Eastern White Pine	1		14	none		3	>5%	
6	Eastern White Pine	4 (DH)							
8	Eastern White Pine	1		9	none		none		
7	Eastern White Pine	1		13.1	none		3	≈1%	
9	Eastern White	1		13.6	none		none		

	Pine								
4a	Eastern White Pine	4 (DH)							
10	Red Maple	4 (DH)							
11	Red Spruce	1		12.3	none		none		
12	Red Spruce	4 (DH)							
13	Eastern White Pine	1		21	none		none		
3a	Red Maple	1		9	none		none		
4b	Eastern White Pine	2		8.3	Dead Standin g		Dead Standin g		
14	Red Maple	1		9.1	none		1	≈1%	
15	Red Maple	1		11.1	none		1	≈1%	
16	Red Maple	2		7.3	Dead Standin g		Dead Standin g		
17	Red Oak	2		6	Dead Standin g		Dead Standin g		
18	Red Maple	1		11.7	none		none		
19	Eastern White Pine	1		19	none		none		
20	Red Oak	2		6.1	Dead Standin		Dead Standin		

					g		g		
21	Red Maple	1		5.6	none		none		
22	Red Oak	1		11.4	none		none		
23	Red Oak	2		5.4	Dead Standin g		Dead Standin g		
24	Red Oak	1		9	none		none		
25	Red Oak	2		5.3	Dead Standin g		Dead Standin g		
26	Red Maple	4 (DH)							
27	Red Maple	4 (DH)							
28	Red Maple	4 (DH)							
29	Red Maple	4 (DH)							

Tree Status Code: 1 - Live, 2 - Dead Standing, 3 - Dead Down, 4 - Dead Harvested
Crown Damage Code: 1 - Branches, 2 - Foliage
Bole Damage Code: 1 - insects, 2 - disease, 3 - mechanical, 4 - weather, 5 - other

Average Canopy Height ≈ 70ft.

2016 Data Originally Recorded by Cam Cox

Tree #	Species	Status	Predicted height	Actual height	DBH (Inches)	Damage type Crown	Damage % Crown	Damage type bole	Damage % Bole
Nov 11 2016									
1	Eastern White Pine	Live	75.56		16.9	None		None	
2	Red Maple	Live	50.77		6.8	None		None	
3	Eastern White Pine	Live	84.58		22.1	None		None	
4	Eastern White Pine	Live	53.74		9.3	None		None	
5	Eastern White Pine	Live	67.92		13.7	None		None	
6	Eastern White Pine	Live	78.92		18.6	None		None	
7	Eastern White Pine	Live	64.82		12.6	None		None	
8	Eastern White Pine	Live	51.8		8.8	None		None	
9	Eastern White Pine	Live	65.98		13	None		None	
4a	Eastern White Pine	Dead Standing	39.36		6				
10	Red Maple	Dead Standin	44.55		5.4				

		g							
11	Red Spruce	Live	60.75		12.1	None		None	
12	Red Spruce	Dead Standin g	48.25		7.9				
13	Eastern White Pine	Live	81.53		20.1	None		None	
14	Red Maple	Live	56.73		9	None		None	
15	Red Maple	Live	60.16		10.4	None		None	
16	Red Maple	Dead Standin g	51.69		7.3				
17	Norther n Red Oak	Dead Standin g	41.4		5.8				
18	Red Maple	Live	61.67		11.1	None		None	
19	Eastern White Pine	Live	78.54		18.4	None		None	
20	White Oak	Live	42.62		6.1	None		Weathe r	25-50
21	Red Maple	Live	44.98		5.5	None		None	
22	Norther n Red Oak	Dead Standin g	62.96		10.7	None		None	
23	Norther n Red Oak	Dead Standin g	46.26		5.7				
24	Norther	Live	57.02		8.6	None		None	

	n Red Oak								
25	Northern Red Oak	Live	43.99		5.2	None		None	
26	Red Maple	Live	55.07		8.4	None		None	
27	Red Maple	Live	58.52		9.7	None		None	
28	Red Maple	Live	42.79		5	None		None	
29	Red Maple	Live	54.49		8.2	None		None	

Tree Status Code: 1 - Live, 2 - Dead Standing, 3 - Dead Down, 4 - Dead Harvested
Crown Damage Code: 1 - Branches, 2 - Foliage
Bole Damage Code: 1 - insects, 2 - disease, 3 - mechanical, 4 - weather, 5 - other

Summary Data Table 1

Tree #	Species	2016 DBH	2020 DBH	DBH Increase	% DBH Increase
5	Eastern White Pine	13.7	14	.3	2.2%
7	Eastern White Pine	12.6	13.1	.5	4%
8	Eastern White Pine	8.8	9	.2	2.3%
11	Red Spruce	12.1	12.3	.2	1.7%
13	Eastern White Pine	20.1	21	.9	4.5%
14	Red Maple	9	9.1	.1	1.1%
15	Red Maple	10.4	11.1	.7	6.7%
18	Red Maple	11.1	11.7	.6	5.4%
19	Eastern White Pine	18.4	19	.6	3.3%

20	White Oak	6.1	6.1	0	0%
21	Red Maple	5.5	5.6	.1	1.8%
22	Northern Red Oak	10.7	11.4	.7	6.5%
24	Northern Red Oak	8.6	9	.4	4.7%

Summary Data Table 2

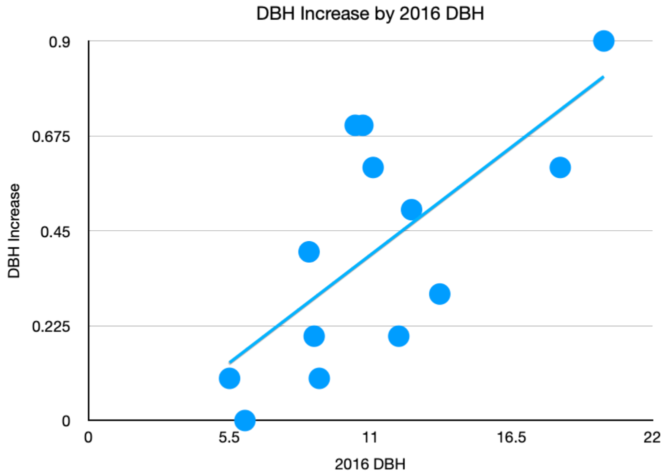
Tree DBH 2016	Number of Trees	Total DBH Growth 2016-2020	Average DBH Growth 2016-2020	Total % DBH Increase	Average % DBH Increase
<10” DBH	5	.8	.16	9.9%	1.98%
>10” DBH	8	4.5	.5625	34.3%	4.29%

Calculations

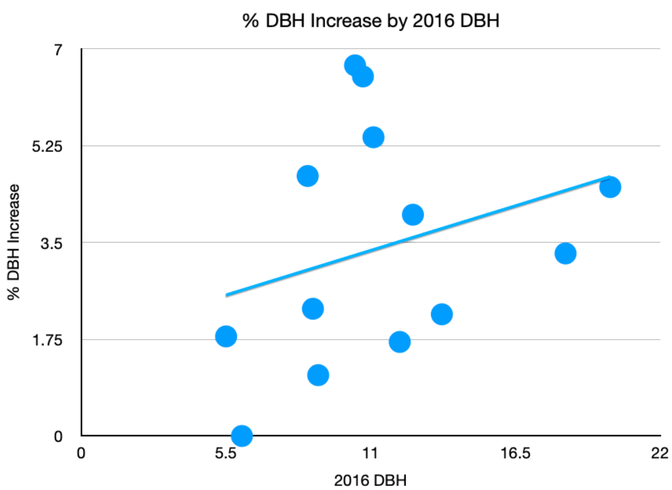
The Summary Data Table 1 includes the tree number, the species, the 2016 DBH, the 2020 DBH, the DBH Increase, and the percentage of DBH increase. To find the increase in DBH, subtract the 2016 DBH from the 2020 DBH. To find the percentage of DBH increase, divide the 2016-2020 DBH increase by the 2016 DBH.

The Summary Data Table 2 includes tree DBH from 2016, the number of trees within each DBH interval, the total DBH growth from 2016-2020 in all of the trees in each interval, the average DBH growth from 2016-2020 on each interval, the total percent DBH increase from 2016-2020 in all of the trees in each interval, and the average percent DBH increase on each interval. The intervals used are greater than 10 inches DBH and less than 10 inches DBH. To find the total DBH growth from 2016-2020, add each of the individual tree increases from Summary Data Table 1 together for each interval. To find the average DBH growth 2016-2020, divide the total DBH growth by the number of trees in the interval. To find the total percent DBH increase, add all of the percent increases from Summary Data Table 1. Finally, to find the average percent DBH increase, divide the total percent DBH increase by the number of trees in the interval.

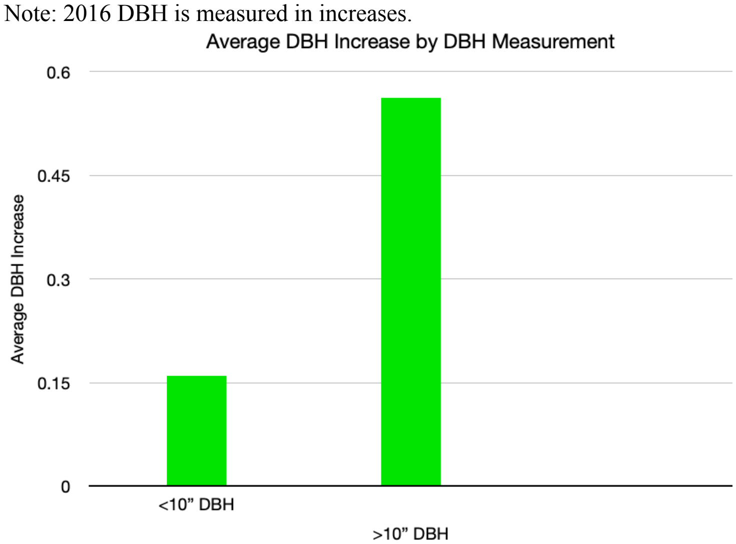
Graphs



Note: DBH Increase and 2016 DBH are both measured in inches.

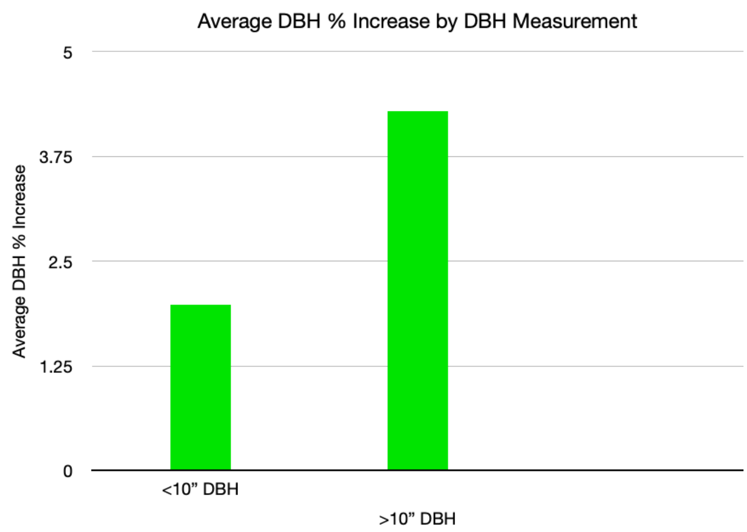


Note: 2016 DBH is measured in increases.



Note: Average DBH Increase is measured in inches.

DBH (Inches)



DBH (Inches)

Analysis

The bar graphs indicate that the trees with the higher DBH (above 10 inches) grew the most both in average DBH increase and average DBH % increase over the four years. The scatterplots also show an upward trend, which means that as DBH% increase, the total DBH growth also increased on average. The trees that were the largest grew the most, and the smallest trees grew the least. The scatterplots clearly show a linear relationship. The total increase vs 2016 DBH is clearer because the trend line has a greater slope. The bar graphs show a very similar outcome. Trees with a higher DBH above 10 inches grew much more on average and grew more percentage-wise on average. The trees that were above 10 inches DBH grew an average of .5625 inches, while the trees that were below 10 inches DBH only grew an average of .16 inches DBH. That is more than a .4 inch difference.

Conclusion

The hypothesis was that the tree with the largest diameter breast height would have grown the most since 2016 because they will have already been healthy enough to reach the DBH they are currently at. Based on the data this is true.

The largest remaining tree from 2016 was an Eastern White Pine that measured 20.1 inches at its DBH, and was perfectly healthy with no crown nor bole damage. This year, in 2020, that tree was measured again and had a DBH of 22 inches. This is an increase of 1.9 inches. This tree remains the largest tree, and had the largest increase, supporting the hypothesis to be true. However, the second biggest tree, an Eastern White Pine measuring 18.4 inches DBH in 2016, was not the tree with the second-largest increase, only increasing 0.6 inches which makes it a DBH of 19 inches. This shows that the hypothesis does not hold true for every tree, meaning that the order of largest to smallest DBH trees will not always be the same as the amount of increase.

With the smaller trees however, the hypothesis makes more sense, as trees with smaller DBHs had the least amount of growth. For example, a Red Maple with a DBH of 5.5 inches only grew 0.1 inches which is the second smallest increase.

The two scatter plot and bar graphs which use data from the summary data tables confirm this. The first scatter plot shows the trend line of tree DBH increase from 2016 to 2020 while the second scatter plot shows the trend line of percentage DBH increase from 2016 to 2020. Both indicate that the larger trees showed greater DBH increase. The bar graphs show the average increase in DBH from 2016 to 2020, with the first one showing larger trees having a higher average DBH increase, and the second bar graph showing larger trees having a higher average % DBH increase.

The opportunity for error in the measurements is fairly high for several reasons. The trees were measured by another person in 2016, so if they measured them in any way different, then that would allow for a small margin of error on every measurement. There also could have been slightly different tools used in 2016, which would also allow for some inaccuracy. In 2020 there were three researchers measuring the current trees, so a slightly different measuring technique could have thrown the measurements off. And lastly, some of the trees that were measured in 2016 were harvested, and so they were not able to be measured. The largest DBH tree in 2016 was 22.1in., whereas the largest tree from 2016 that hadn't been harvested was 20.1 DBH in. That means that there very well could have been a different result to the hypothesis had the researchers been able to measure that tree again.

Probably the biggest improvement would have been to be able to measure the trees that were harvested, as it would give more data on which tree actually had the most DBH growth, as well as maybe even different experimental results. It would have been interesting to do the predicted height for each and every tree if there was more time, as that would be another measurement that could be compared to the 2016 data to find changes in height. If this data collection could be repeated every year, every other year, or even not for another four years, it would help to provide an even more accurate account of which trees have a consistently larger increase in DBH than the others.

Acknowledgements

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Thanks to Cathance River Education Alliance (CREA) for loaning equipment and resources to help with this project.

Works Cited

Maine TREE foundation-Forest Ecology Research Network Plots (formally Forest Inventory Growth-Mt Ararat HS-1 Plot SIte 2016 data collected by Cam Cox assisted by Kevin Doran

Picea Rubens Sarg, www.srs.fs.usda.gov/pubs/misc/ag_654/volume_1/picea/rubens.htm#:~:text=Native Range,northern New Jersey, and Massachusetts.

Quercus Alba L, www.srs.fs.usda.gov/pubs/misc/ag_654/volume_2/quercus/alba.htm#:~:text=Native Range,to northern Florida and Georgia.

Region 5 - Outdoor Safety & Ethics, www.fs.usda.gov/detail/r5/recreation/safety-ethics/?cid=STELPRDB5365834.

"White Pine - Pinus Strobus: Wildlife Journal Junior - Wildlife Journal Junior." *New Hampshire PBS*, nhpbs.org/wild/karnerwhitepine.asp#:~:text=The white pine is found,as high as 5,000 feet.