Projected Effects of 80 Years of Climate Change on the Economic Benefits of Tree Species Located in Goshen Indiana

By Aidan Friesen

Assumptions and Limitations

Some details were limited or assumed in the process of this experiment and research. The first assumption is that the public trees in Goshen were inventoried correctly, whether determining the correct species or giving a reasonable estimate of height or diameter of individual trees. A limitation of this data is currently there are only 13,499 trees inventoried in Goshen;this is not the entire number of trees in Goshen - there are many more waiting to be inventoried.. The Climate Change Atlas database, provided by the United States Department of Agriculture: Forest Service Page, is another limiting factor, given that not all of the tree species in Goshen's data are represented in the Atlas. The final limitation is that these climate change projections are static, and don't factor in whether trees die off, grow, or new ones get planted;it essentially takes the current data set and places it in the year 2100.

Research Questions

1. What species of trees are located in the City of Goshen and what percentage of them are Maple genus?
2. What are the current economic benefits of the tree species located in Goshen and which are also listed in the Climate Change Database?
3. What are the projected economic benefits of those tree species (Goshen inventory and Climate Atlas) after 80 years of climate change?

Methods and Materials

Study Site

The area of interest is the City of Goshen located in Northern Indiana. The population is currently 33,000.

Field Research

The research conducted in Goshen included inventorying trees in the City. The majority of this inventory work was done by other individuals, and does not include all of the trees located in Goshen. The trees were plotted on a Google Earth map through the website, https://goshenin.treekeepersoftware.com. Data was imputed using smart devices in the field, and consisted of tree species, diameter breast height (DBH) and number of stems (NS).

Species

- The species were identified by talking to the City Forester, Aaron Sawatsky-Kingsley, and asking him for his professional identification. The researcher could determine some of the species.

Height

- The height of the tree was roughly estimated in feet. The purpose was not to be exact but to get a rough idea of the size of trees in the neighborhood.

DBH

- The DBH of a tree is the diameter of the tree measured in inches at 4.5 feet above ground.

NS

- The NS is counting the number of stems or trunks on each individual tree.

Climate Change Projections

The Climate Change Atlas from the United States Department of Agriculture projects an importance value for tree species in the year 2100 based on climate change models and habitat preference data. Importance value indicates the prevalence of a tree species relative to other tree species in a given geography. The tree species researched for this project were all those located in Goshen which also feature in the Climate Change Atlas database - 36 different species of trees. Those trees are:

> American Basswood, American Beech, American Hornbeam, Bald Cypress, Balsam Fir, Black Locust, Black Maple, Black Spruce, Bur Oak, Dogwood, Eastern Hemlock, Eastern Red Cedar, Eastern Redbud, Eastern White Pine, Green Ash, Hackberry, Honeylocust, Kentucky Coffeetree, Northern Red Oak, Paper Birch, Pawpaw, Pin Oak, Red Maple, Red Pine, River Birch, Sassafras, Serviceberry, Shagbark Hickory, Silver Maple, Sugar Maple, Shingle Oak, Swamp White Oak, Sweetgum, Sycamore, White Ash, and White Oak.

These tree species were then reviewed in the Climate Change Atlas and data collected for all 36 species in two climate models: the Hadley CM3 - A1fi (High, "Harsh") analysis, and the PCM - B1 (Low, "Mild") analysis. These two were selected because the Climate Change Atlas determined them to be the harshest and mildest scenarios of climate change.

Maps for all species, and for each climate change scenario (Figures 1&2), were downloaded and overlaid onto Google Earth (Figure 3). By enlarging the study site (Figure 4), the exact projected importance value of each species was determined. For importance values with ranges, the number in between those two numbers were chosen.

Current Importance Values

To determine the projected economic benefits of trees in the city, the current importance value for each species must be calculated based on the equation used in the Climate Change Atlas database. This equation is:

$$IVx = \frac{50\ BAx}{BA\ all\ species} + \frac{50\ NSx}{NS\ all\ species}$$

$$IV_x = \frac{50 \times BA_x}{BA_{all\ species}} + \frac{50 \times NS_x}{NS_{all\ species}}$$

Where:

- IV_x = The calculated importance value of a species x
- BA_x = The basal area of species x
- $BA_{all\ species}$ = The total basal area of all species in the set being calculated
- NS_x = The number of stems of species x
- $NS_{all\ species}$ = The total number of stems of all species in the set being calculated

The basal area of the species was calculated using the foresters constant (FC) that converts the DBH of a tree in inches to the basal area in ft^2. The foresters constant is:

$$FC = 0.005454$$

The formula to convert from diameter breast height to basal area is:

$$BA = DBHsquared * FC$$

Goshen Public Tree Inventory Database

This database calculates estimations for the economic benefits (in dollars) from the trees in Goshen. These calculations were developed by the US Forest Service for the i-Trees Tool, a peer-reviewed analysis and assessment software suite, which is freely available.

Projected Economic Benefits

To determine the projected economic benefits of individual tree species a ratio was created between the economic benefits and the importance values. The equation is:

$$\frac{IV_{present}}{IV_{projected}} = \frac{EB_{present}}{EB_{projected}}$$

Where:

- $IV_{present}$ = This is the IV, of one species, that was calculated using the current importance value equation
- $IV_{projected}$ = This is the projected IV, of one species, from the climate change atlas database
- $EB_{present}$ = This is the current economic benefits of a tree species, calculated through the Trees for Goshen database
- $EB_{projected}$ = This is what is being solved for, and determines the projected economic benefits for an individual species by using a ratio to calculate it

.

Results

As of December, 2019, there were 85 different tree species in Goshen, populated by a total of 13,499 trees. Of these 13.5 thousand trees 5,910 of them are maple genus. In fact, the top 4 most dominant trees in Goshen are maples (Table 1). Of these 85 tree species located in Goshen, only 36 had information in the Climate Change Database, equaling a total of 8,650 individual trees, of which 4,581 are maple .

(Table 2 & Figure 5). The top seven most dominant trees in this study were: Silver Maple with 2,304 individuals, Sugar Maple with 1,527 individuals, Red Maple with 698 individuals, Eastern White Pine with 474 individuals, Honeylocust with 398 individuals, Northern Red Oak with 363 individuals, and Hackberry with 308 individuals.

Currently, the 13.5 thousand trees in the City of Goshen provide $1,463,469.04 of economic benefits annually. The 8,650 trees in this study provide $1,092,950.03 in annual benefits, which is about 75% of the total economic benefits for the City of Goshen. Maple trees in the study provide $812,381.65 which is about 74% of the total economic benefits of trees in the study. Currently the top seven most economically beneficial tree species are; Silver Maple with $520,481.96 benefits, Sugar Maple with $223,962.96 benefits, Red Maple with $58,175.77 benefits, Honeylocust with $47,182.65 benefits, Eastern White Pine with $23,174.67 benefits, Hackberry with $22,444.67 benefits and Northern Red Oak with $20,951.40 benefits (Table 3).

The basal area of each tree species was found in order to calculate a current importance value of the species, using the DBH to BA equation above. The total BA of all the trees in Goshen's database was calculated to be 17,440.81 ft^2, while the total BA of the trees in the study data set is 13,335.43 ft^2,about 76% of the total database BA. The maple trees in the study data set have a total BA of 9,878.07 ft^2 which is about 74% of the total BA of the trees in the data set. The number of stems were then recorded for each tree species to give a total NS of the trees in

Goshen and the data set. In Goshen the total NS is 15,433, while in just the study set it is 9,632 which is about 62% of the total NS. The maple trees in the study data set have a total NS of 5,105 or 53% of the NS of the data set. This gives a range of importance values from 0.004 - 26.9 (Table 4).

Using the ratio of importance values and economic benefits, the projected economic benefits for the trees in the city were calculated. On the mild climate change trend the economic benefits of the trees in the data set drop from $1,092,950.03 to $818,751.77, about a 25% decrease over 80 years. The maple trees in the data decrease from $812,381.64 to $160,222.38, or almost an 81% drop on a low climate change trend. On the high climate change trend the total benefits of the data set goes from $1,092,950.03 to $492,193.47, about a 55% decrease in economic benefits after 80 years. The change of economic benefits for just maple trees in the data set, on a high climate change trend, drops from $812,381.64 to $85,757.47 or almost a 90% decrease after 80 years (Table 5). Importantly, in both scenarios, the value and benefits of some non-maple species increase over the same 80 year period, offsetting some of the large losses projected in maples.

Discussion

Climate change is a phenomenon that will affect many aspects of our lives directly or indirectly. There will be change in how trees can grow, thrive, and survive. In order to understand how the urban forest around us will be affected, we first have to understand what types of trees are living with us. Aaron Sawatsky-Kingsley, the City Forester of Goshen Indiana, said “The 2011 public tree inventory showed that 50% of our public trees are maples in the City of Goshen. My guess is that if we look at all of the trees, including on private property, in the community of Goshen its closer to 60% maple.” Public trees inventoried before December, 2019,

showed that maples make up 43.8% of the population. While it is good to note that the maple population in the public inventory is trending down, it is still true that there are many more trees (including on private property) in Goshen that haven't been inventoried, so there could easily be more maples than this project outlines. In order to be certain more inventorying of trees is needed.

Currently maple trees have a total basal area of 9,878.07 ft^2 compared to the total basal area of public trees in the city at 17,440.81ft^2:even though maple trees are less than half of the total number of trees in Goshen they represent about 57% of the basal area of public trees. This data (Table 4) indicates something of the size (and associated productivity – measured as economic benefits) of maple trees in Goshen – not only their numbers – and the reason that they represent so much value currently. Shifting their value across other species would protect the over-all value of the urban forest against climate change impacts.

It is interesting to see how the most dominant tree species compare to the most economically beneficial. We would expect that the more dominant tree species are going to be more economically beneficial and this is true for part of the data. The top three species, which also happen to be maple trees, provide the most economic benefits currently. This is expected, especially since there is such a large gap between the number of individuals of these species and the rest of the data. After these top three species though the data does not correlate as clearly . The Eastern White Pine consist of about 80 more trees than Honeylocust, but Honeylocust provides more than twice the amount of economic benefits. Northern Red Oak and Hackberry are similar in current economic benefits but about 60 individuals different, in favor of Red Oaks. In both comparisons – Eastern White Pine to Honeylocust and Northern Red Oak to Hackberry – these differences may be explained by further analysis of DBH and/or basal area per species,

theorizing that overall size is a more important indication of economic value than sheer numbers. (Figure 6).

The trees located in Goshen provide a large amount of money for the city annually. Currently all the public trees in Goshen provide around $1.46 million in benefits. In the study subset of data the total amount is around $1.09 million. That means that the trees in this data provide about 75% of the total annual benefits, even though they are only about 64% of the total public trees in Goshen. Stated more clearly, roughly 2/3 of the City's public trees provide ¾ of the annual economic benefits. Further, maples from the study data subset (not including Norway maple which is not analyzed by the Climate Change Atlas) provide 55% of the total annual benefits ($812,381 out of $1.46 million); considering that these projections show maples being most negatively impacted by climate change, there is urgency in increasing the diversity of Goshen's urban forest (Table 3). Climate change is going to affect all the trees located in Goshen, just some more than others. In the mild climate change model, the total economic benefits of the trees in the data setdrop about 25% to $818,751; maples alone decrease almost 81% to $160,222. This is a large projected decrease in economic benefits despite significant reductions to greenhouse gas emissions. In the harsh climate change model projected benefits in the data set drop 55% to $492,193,while maple trees drop almost 90% to $85,757 (Figure 7). A loss in benefits of this magnitude will effect private and public budgets.

The City of Goshen is trying to increase the urban forest canopy cover to 45% by the year 2045. In order to do so the city has to plant on average 2,000 trees a year for the next 25 years. This research can be expanded and used to plan strategically which trees should be planted, which trees will continue to be economically beneficial for the city over the next 80 years. This data shows that many trees will gain economic benefits with climate change. The top trees in this

research are Black Locust which becomes 18 times more valuable, American Beech which becomes 14 times more valuable, and Shagbark Hickory which becomes 9 times more valuable. Not only do these trees become more valuable over time, but they are equally valuable in the harsh and mild climate change models(Table 5 & Figure 8). This suggests that these trees are suitable for more planting in Goshen. (It appears that Pawpaw becomes 50 times more valuable and Sassafras becomes 500 times more valuable in Figure 8. However, the data is skewed since there are only 3 Pawpaw and 1 Sassafras in the inventory, making it seem like their economic benefits increase significantly.) Trees that drop off in economic benefit after climate change trends are Eastern White Pine ($\frac{1}{5}$ as valuable), Red Maple ($\frac{1}{2}$ as valuable), River Birch ($\frac{3}{4}$ as valuable), Silver Maple (almost $\frac{1}{10}$ as valuable), and Sugar Maple (about a $\frac{1}{3}$ as valuable). These are trees that currently provide a lot of economic benefits for the city and represent some of the highest importance value, but over the next 80 years their economic benefits are projected to drop off significantly. This doesn't mean that these species should be removed, it just means that they should be planted less frequently, and favorable species planted more. Another note is that while it appears that Bald Cypress, Black Spruce, Eastern Hemlock, Paper Birch, and Red Pine lose all their economic benefits over the next 80 years (Figure 8), in actuality, the Climate Change Atlas simply does not currently project habitat trends for these species in our geographic region.

Conclusion

There are currently 13,499 trees inventoried in the City of Goshen. Of these trees 5,910 of them are maple genus. Though maples represent less than half of the public trees, they make up about 57% of the total basal area of the City's public trees. The most dominant and

economically beneficial trees are all maple species: Silver Maple, Sugar Maple, Norway Maple and Red Maple. Currently the public trees in the city provide $1.46 million economic benefits for the city.

This study focused on 8,650 public trees, 53% of which are maple genus. The trees in this data set provide $1.09 million of the total public tree benefits. In a mild climate change model the economic benefits of the trees in this data set decrease 25%, and in a harsh climate change model decrease 55%. The economic benefits of just the maple trees in this study drop 81% in the mild climate change model and drop 90% in the harsh climate change model. Some non-maple species are projected to show increases in economic benefits, making up for some of the losses projected to maples. Nevertheless, economic benefit losses will be felt in private and public budgets. This research suggests that in order to achieve increased and sustained urban forest canopy coverage in the long term, some species which have historically been over-planted in Goshen should be planted less frequently due to projected negative impacts from climate change: Eastern White Pine, Red Maple, River Birch, Silver Maple and Sugar. According to this study tree species which should be planted more frequently due to projected climate-related increase in value, include: American Beech, Black Locust, and Shagbark Hickory. Future studies could focus on research related to tree species which are only minimally present in Goshen currently, and which may thrive in our geography as the climate changes over the next 80 years.

Tables

Tree Species	# of Trees	% of Total		Tree Species	# of Trees	% of Total
Silver Maple	2304	17.1		Black Maple	52	
Sugar Maple	1527	11.3		Catalpa	50	
Norway Maple	854	6.3		Bald Cypress	43	
Red Maple	698	5.2		Eastern Hemlock	43	
Crabapple	622	4.6		Shingle Oak	40	
White Pine	475	3.5		Tree of Heaven	37	
Honey Locust	398	3.0		Unclassified Elm	36	
Colorado Blue Spruce	525	3.9		Eastern Red Cedar	34	
Pear	375	2.8		Black Tupelo	32	
Red Oak	363	2.7		American Elm	29	
Maple Crimson King	342	2.5		Little Leaf Linden	28	
Green Ash	311	2.3		Shagbark Hickory	26	
Hackberry	308	2.3		Magnolia	26	
Tulip	195	1.4		Japanese Maple	22	
Pin Oak	192	1.4		Unclassified Hickory	22	
Dogwood	191	1.4		Unclassified Pine	22	
Eastern Redbud	179	1.3		Balsam Fir	20	
Black Spruce	173	1.3		Apple	19	
Ash Bittmore	168	1.2		American Beech	19	
Norway Spruce	167	1.2		Peach	14	
Mulberry	162	1.2		Black Locust	13	
Hawthorn	157	1.2		Unclassified Oak	12	
Chinese Elm	155	1.1		Invasive Species	11	
Arborvitae	152	1.1		Lilac	11	
White Oak	142	1.1		Euoropean Copper Beech	10	
Cottonwood	136	1.0		English Pyramida Oak	7	
Red Pine	125			Black Ash	4	
Swamp White Oak	121			European Linden	3	
American Basswood	120			Pawpaw	3	
Unclassified Maple	111			Apricot	2	
Sycamore	108			Camperdown Elm	2	
Serviceberry	103			Chinquapin Oak	2	
Bur Oak	95			Fringetree	2	
Plum	88			Dawn Redwood	2	
Sweetgum	83			Alder	1	
London Planetree	79			Black Poplar	1	
River Birch	75			Buckeye	1	
White Ash	72			Holly	1	
Paper Birch	71			Japanese Zelkova	1	
Wild Black Cherry	71			Persimmon	1	
American Hornbeam	69			Sassafras	1	
Ginkgo	66			Sawtooth Oak	1	
Kentucky Coffeetree	54					
				All Maple Species	5910	43.8
				Total	13488	

Table 1: *All the species of trees inventoried in the City of Goshen, as well as how many of each species were found, and their percent total of the whole group.*

Tree Species	Number of Trees
American Basswood	120
American Beach	19
American Hornbeam	69
Bald Cypress	43
Balsam Fir	20
Black Locust	13
Black Maple	52
Black Spruce	173
Bur Oak	95
Dogwood [Flowering]	191
Eastern Hemlock	43
Eastern Redcedar	34
Eastern Redbud	179
Eastern White Pine	474
Green Ash	311
Hackberry	308
Honeylocust [Thornless]	398
Kentucky Coffeetree	54
Northern Red Oak	363
Paper Birch	71
Pawpaw	3
Pin Oak	192
Red Maple	698
Red Pine	125
River Birch	75
Sassafras	1
Serviceberry	103
Shagbark Hickory	26
Shingle Oak	40
Silver Maple	2304
Sugar Maple	1527
Swamp White Oak	121
Sweetgum	83
Sycamore	108
White Ash	72
White Oak	142
Total (Maples)	4581
Total (in set)	8650
Total (in Goshen)	13499

Table 2: *The species of trees and the number of individuals of that species that are located in Goshen Indiana and have information in the Climate Change Atlas Database.*

Tree Species	Economic Benefits Now
American Basswood	13,565.53
American Beach	2,613.09
American Hornbeam	660.83
Bald Cypress	1,443.55
Balsam Fir	645.98
Black Locust	1,424.09
Black Maple	9,761.52
Black Spruce	12,473.63
Bur Oak	2,846.26
[Flowering] Dogwood	1,542.42
Eastern Hemlock	1,313.33
Eastern Redcedar	1,313.33
Eastern Redbud	840.87
Eastern White Pine	23,173.67
Green Ash	18,780.32
Hackberry	22,444.67
Honeylocust	47,182.65
Kentucky Coffeetree	645.42
Northern Red Oak	20,951.40
Paper Birch	4,770.13
Pawpaw	7.56
Pin Oak	31,451.40
Red Maple	58,175.77
Red Pine	6,332.90
River Birch	3,908.12
Sassafras	51.29
Serviceberry	308.08
Shagbark Hickory	4,312.50
Shingle Oak	2,264.63
Silver Maple	520,481.96
Sugar Maple	223,962.39
Swamp White Oak	1,909.56
Sweetgum	6,495.40
Sycamore	16,145.94
White Ash	12,944.88
White Oak	15,804.96
Total (Maples)	812,381.64
Total (in set)	1,092,950.03
Total (in Goshen)	1,463,469.04

Table 3: *The current economic benefits (in U.S. dollars) of the trees in Goshen that are also in the Climate Change Atlas Database. All of this information comes from the website https://goshenin.treekeepersoftware.com/ where you can calculate the economic benefits of tree species.*

Tree Species	Total Basal Area	Relative Basal Area	Total Number of Stems	Relative Number of Stems	Calculated Importance Value
American Basswood	213.9072435	0.012264757	126	0.008164323	1.021454021
American Beach	24.932961	0.001429576	22	0.001425517	0.14275465
American Hornbeam	13.558644	0.000777409	76	0.004924512	0.285096085
Bald Cypress	12.860532	0.000737382	43	0.002786237	0.176180953
Balsam Fir	5.50854	0.000315842	31	0.002008683	0.116226238
Black Locust	17.387352	0.000996935	19	0.001231128	0.111403163
Black Maple	115.319376	0.006612044	78	0.005054105	0.583307452
Black Spruce	167.225094	0.009588152	189	0.012246485	1.091731843
Bur Oak	48.5228745	0.002782146	96	0.006220437	0.450129158
Dogwood [Flowering]	18.45982656	0.001058427	266	0.017235793	0.914711042
Eastern Hemlock	10.55349	0.000605103	61	0.003952569	0.227883627
Eastern Redcedar	9.87174	0.000566014	35	0.002267868	0.141694078
Eastern Redbud	22.60001468	0.001295813	35	0.002267868	0.178184006
Eastern White Pine	255.95622	0.014675711	506	0.032786885	2.373129814
Green Ash	154.037322	0.008832007	331	0.021447547	1.513977743
Hackberry	239.6790979	0.013742433	338	0.021901121	1.782177695
Honeylocust [Thornless]	301.4930295	0.017286646	420	0.027214411	2.225052837
Kentucky Coffeetree	2.9710665	0.000170351	56	0.003628588	0.189946977
Northern Red Oak	541.3152949	0.031037288	369	0.023909804	2.74735457
Paper Birch	33.591186	0.001926011	169	0.01095056	0.643828583
Pawpaw	0.0122715	7.03609E-07	3	0.000194389	0.009754613
Pin Oak	416.0215755	0.023853347	192	0.012440873	1.814711002
Red Maple	489.981906	0.028093995	746	0.048337977	3.821598623
Red Pine	64.569906	0.003702232	127	0.008229119	0.596567566
River Birch	29.162538	0.001672087	182	0.011792911	0.673249898
Sassafras	0.267246	1.5323E-05	1	6.47962E-05	0.004005962
Serviceberry	2.761428375	0.000158331	214	0.01386639	0.701236084
Shagbark Hickory	49.735026	0.002851647	26	0.001684702	0.226817447
Shingle Oak	24.455736	0.001402214	40	0.002591849	0.199703116
Silver Maple	6346.379389	0.363881097	2693	0.174496209	26.91886531
Sugar Maple	2926.387332	0.16778969	1588	0.102896391	13.53430406
Swamp White Oak	24.7461615	0.001418866	121	0.007840342	0.462960394
Sweetgum	61.095708	0.003503032	84	0.005442882	0.447295732
Sycamore	319.664394	0.018328534	116	0.007516361	1.292244751
White Ash	121.313322	0.006955718	87	0.005637271	0.629649434
White Oak	249.127812	0.014284192	146	0.009460248	1.187221974
Total (Maples)	9878.068003		5105		
Total (in set)	13335.43266		9632		
Total (in Goshen)	17440.80538		15433		

Table 4: *The calculated Basal Area (ft^2) of each species and their relative basal area. The total Number of Stems of each species with their relative number of stems. Then the calculated Importance Values of all the species.*

Tree Species	Economic Benefits Now	Projected Economic Benefits (Low)	Projectecd Economic Benefits (Harsh)
American Basswood	13,565.53	26561.21514	6640.303785
American Beach	2,613.09	36609.52561	36609.52561
American Hornbeam	660.83	4635.840587	11589.60147
Bald Cypress	1,443.55	0	0
Balsam Fir	645.98	2778.976638	2778.976638
Black Locust	1,424.09	25566.41955	25566.41955
Black Maple	9,761.52	8367.388388	8367.388388
Black Spruce	12,473.63	0	0
Bur Oak	2,846.26	12646.4147	12646.4147
[Flowering] Dogwood	1,542.42	3372.474866	3372.474866
Eastern Hemlock	1,313.33	0	0
Eastern Redcedar	1,313.33	18537.54258	18537.54258
Eastern Redbud	840.87	9438.220853	2359.555213
Eastern White Pine	23,173.67	4882.512086	4882.512086
Green Ash	18,780.32	24809.24187	24809.24187
Hackberry	22,444.67	62969.7871	25187.91484
Honeylocust	47,182.65	42410.36367	42410.36367
Kentucky Coffeetree	645.42	1698.947806	1698.947806
Northern Red Oak	20,951.40	15252.0539	3813.013476
Paper Birch	4,770.13	0	0
Pawpaw	7.56	387.5089737	387.5089737
Pin Oak	31,451.40	34662.70933	8665.677333
Red Maple	58,175.77	30445.77714	30445.77714
Red Pine	6,332.90	0	0
River Birch	3,908.12	2902.428959	2902.428959
Sassafras	51.29	25606.83084	25606.83084
Serviceberry	308.08	219.6692435	219.6692435
Shagbark Hickory	4,312.50	38026.17531	38026.17531
Shingle Oak	2,264.63	22679.96658	5669.991645
Silver Maple	520,481.96	38670.42343	38670.42343
Sugar Maple	223,962.39	82738.79066	8273.879066
Swamp White Oak	1,909.56	8249.344975	2062.336244
Sweetgum	6,495.40	7260.744448	7260.744448
Sycamore	16,145.94	24988.98136	24988.98136
White Ash	12,944.88	174750.3835	41117.73729
White Oak	15,804.96	26625.11365	26625.11365
Total (Maples)	812,381.64	160222.3796	85757.46803
Total (in set)	1,092,950.03	818751.7737	492193.4715
Total (in Goshen)	1,463,469.04		

Table 5: *The current economic benefits (U.S Dollars) and the projected economic benefits (U.S. Dollars) on the harsh and low climate change trends. The "0's" in the projected column, are due to their not being accurate data for those species in the climate change atlas.*

Figure Captions

Figure 1: *HadleyCM3 - A1Fi (High, "Harsh") Climate Change scenario of Dogwood in the year 2100, from the United States Department of Agriculture Forest Service page.*

Figure 2: *PCM - B1 (Low, Mild) Climate Change scenario of Dogwood in the year 2100, from the United States Department of Agriculture Forest Service page.*

Figure 3: *HadleyCM3 – A1Fi (High, "Harsh") Climate Change scenario of Dogwood projected onto Google Earth map, and zoomed in on the U.S.*

Figure 4: *HadleyCM3 – A1Fi (High, "Harsh") Climate Change scenario of Dogwood projected onto Google Earth map, and zoomed in on Elkhart County.*

Figure 5: *Compares the number of individuals of each species located in Goshen Indiana. The scale is in* $log_{10}(x)$.

Figure 6: *Compares the top seven most dominant tree species in Goshen with the top seven most economically beneficial tree species in Goshen, as of 2019.*

Figure 7: *Compares the current economic benefits of all trees and maples in the data set to the projected economic benefits after a mild and harsh climate trend.*

Figure 8: *Compare the current economic benefits of the trees in the data set to their projected economic benefits after a mild and harsh climate trend.*

disclaimer: the graph is in* $log_{10}(x)$*, so the data appears a lot closer than it actually is

Figures

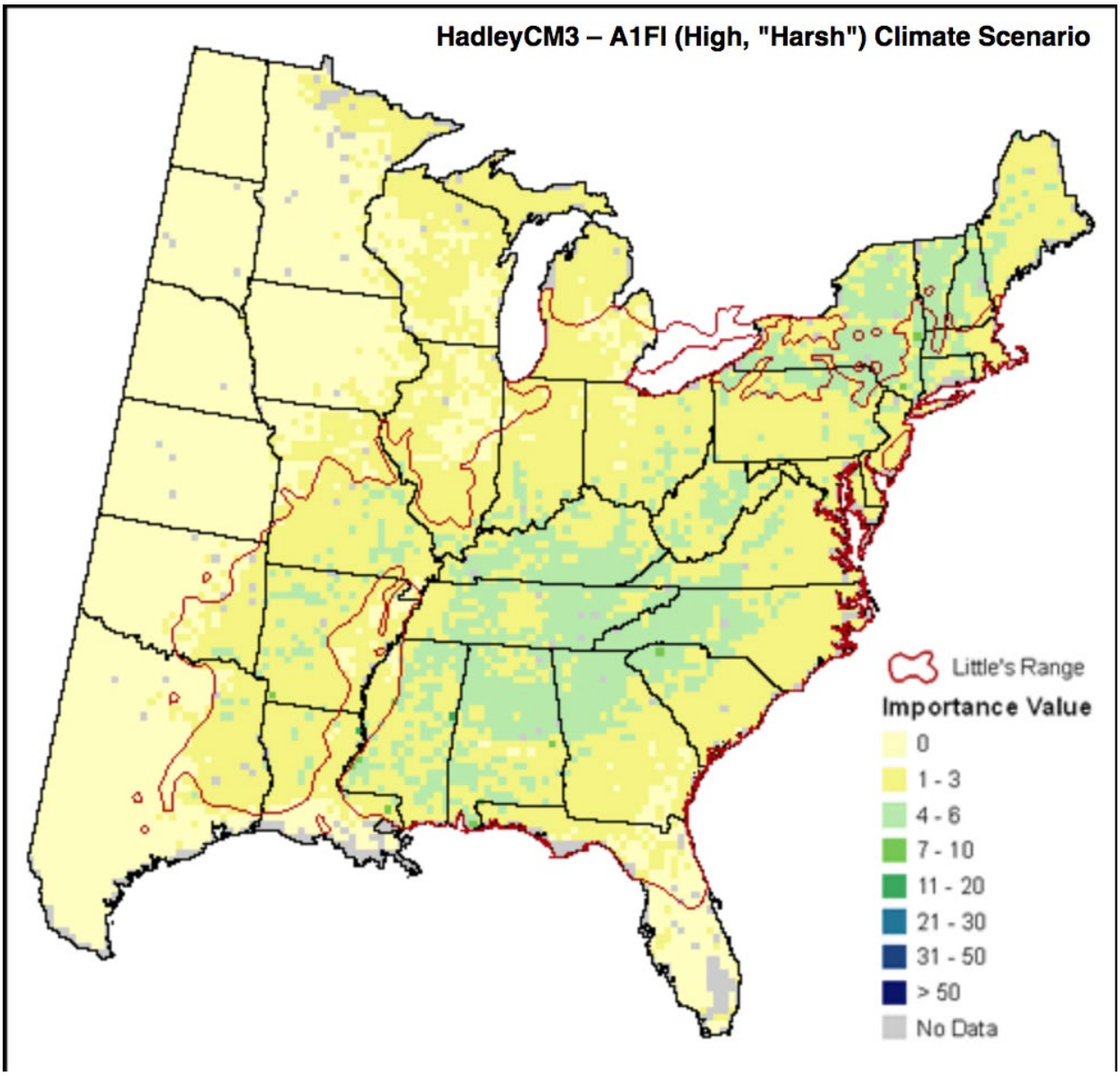
HadleyCM3 – A1FI (High, "Harsh") Climate Scenario
Little's Range
Importance Value
0
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
> 50
No Data

Figure 1

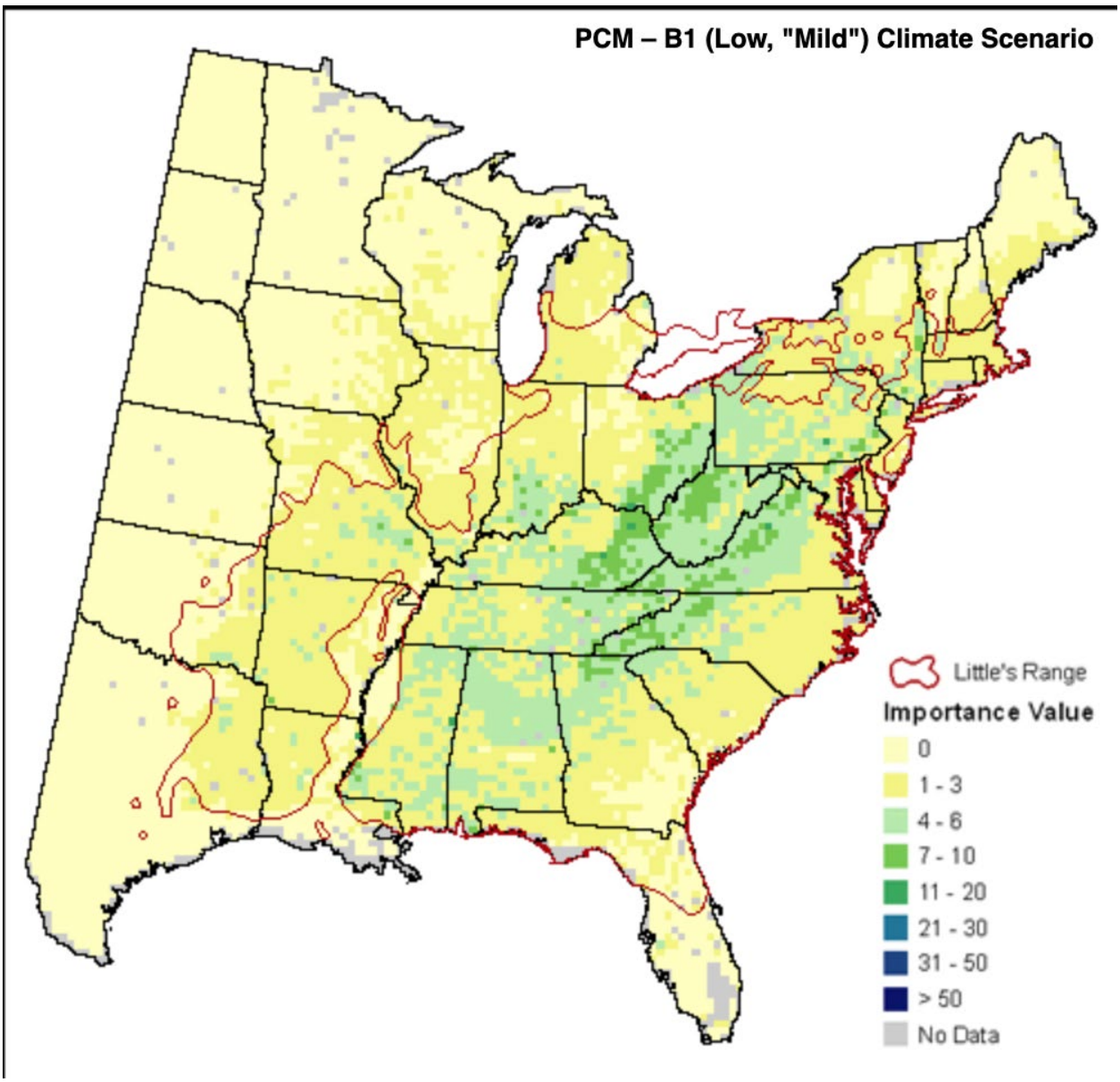
PCM – B1 (Low, "Mild") Climate Scenario
Little's Range
Importance Value
0
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
> 50
No Data

Figure 2

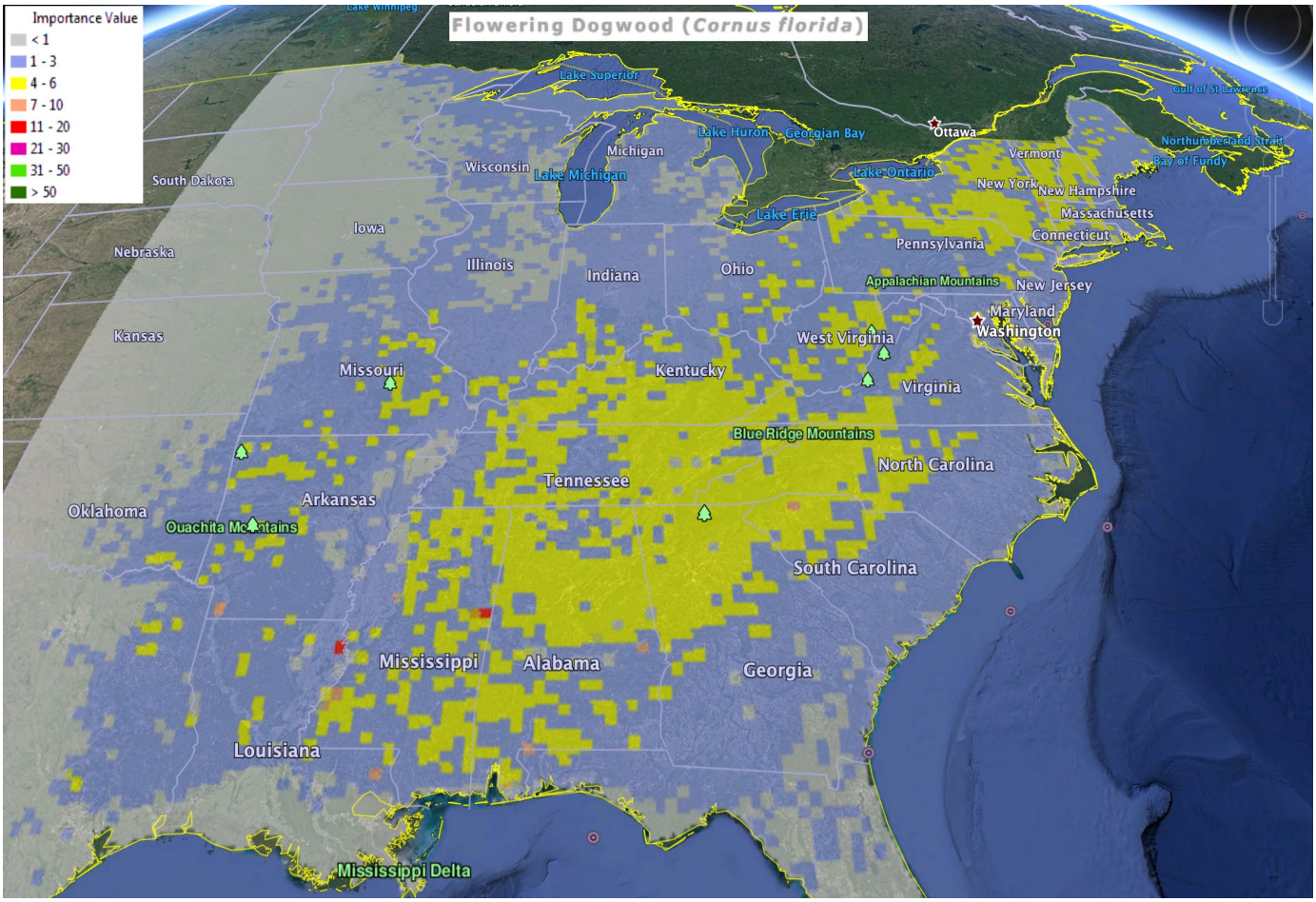
Flowering Dogwood (Cornus florida)
Importance Value
< 1
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
> 50
Lake Superior
Lake Huron
Georgian Bay
Ottawa
Gulf of St Lawrence
Northumberland Strait
Bay of Fundy
Michigan
Wisconsin
Lake Michigan
Lake Ontario
Vermont
New York
New Hampshire
Massachusetts
Connecticut
Lake Erie
Pennsylvania
South Dakota
Iowa
Nebraska
Illinois
Indiana
Ohio
Appalachian Mountains
New Jersey
Maryland
Washington
Kansas
West Virginia
Missouri
Kentucky
Virginia
Blue Ridge Mountains
North Carolina
Tennessee
Arkansas
Oklahoma
Ouachita Mountains
South Carolina
Mississippi
Alabama
Georgia
Louisiana
Mississippi Delta

Figure 3

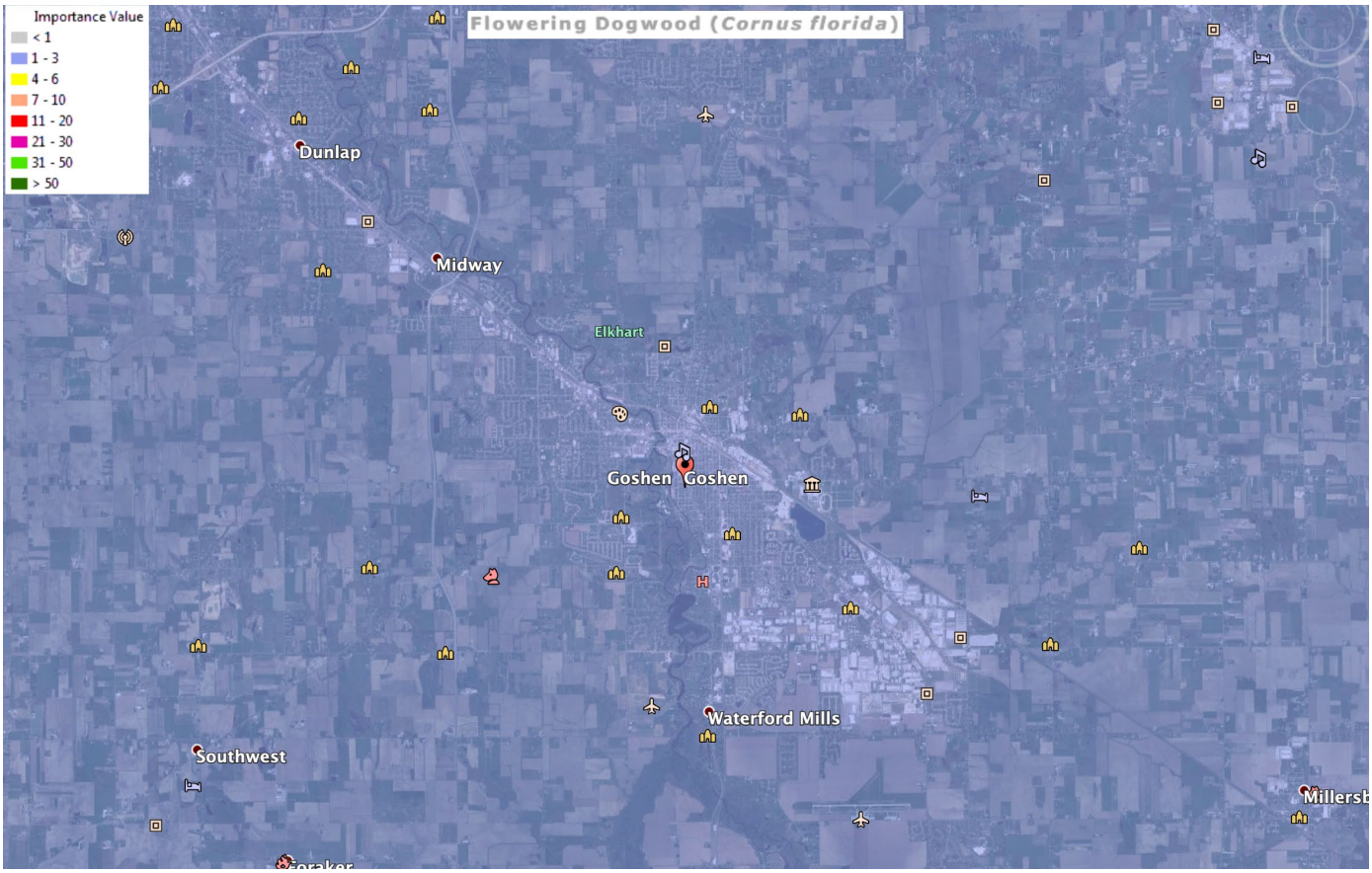
Flowering Dogwood (Cornus florida)
Importance Value
< 1
1 - 3
4 - 6
7 - 10
11 - 20
21 - 30
31 - 50
> 50
Dunlap
Midway
Elkhart
Goshen
Goshen
Waterford Mills
Southwest

Figure 4

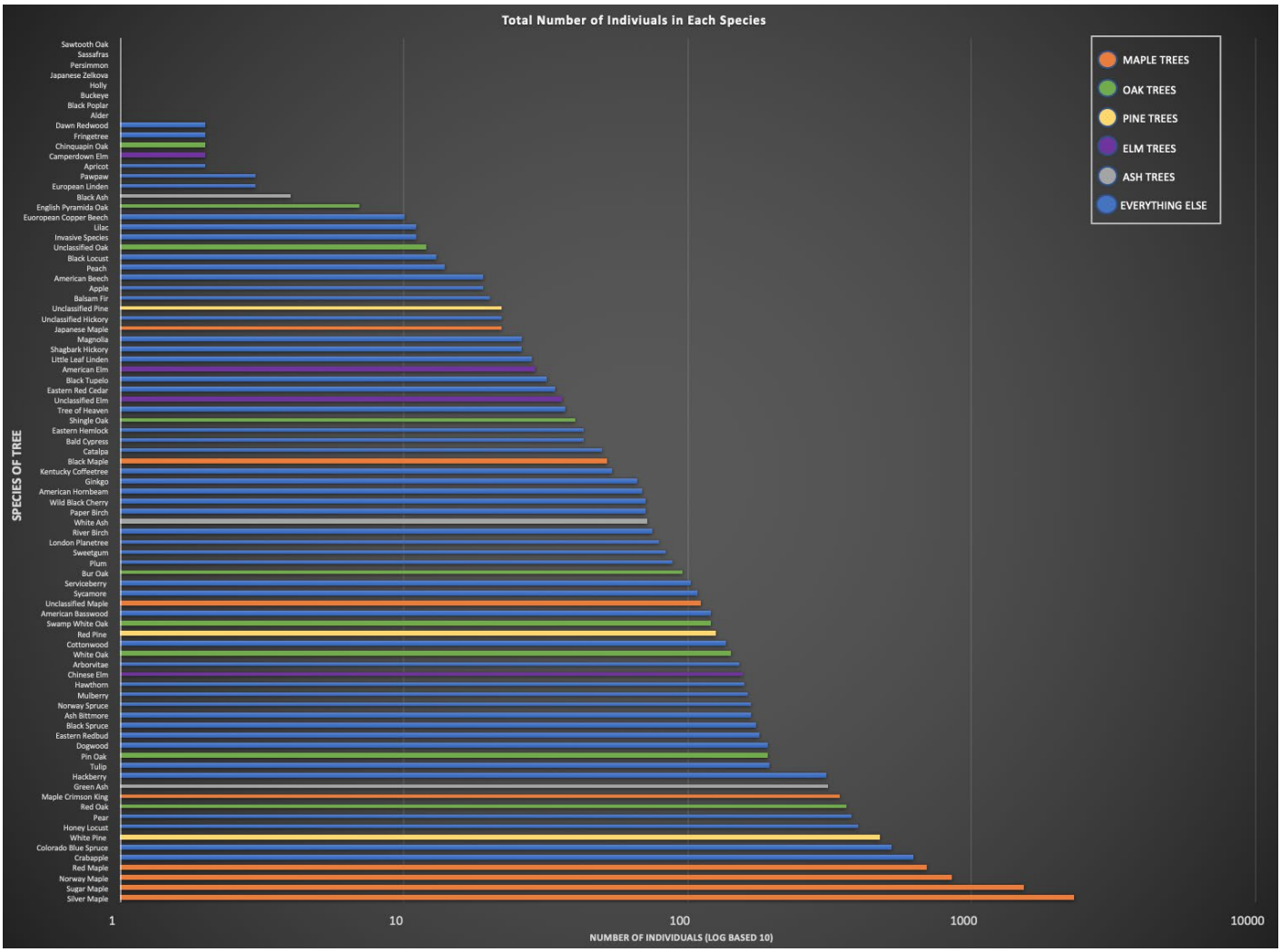
Total Number of Indiviuals in Each Species
MAPLE TREES
OAK TREES
PINE TREES
ELM TREES
ASH TREES
EVERYTHING ELSE
SPECIES OF TREE
Sawtooth Oak
Sassafras
Persimmon
Japanese Zelkova
Holly
Buckeye
Black Poplar
Alder
Dawn Redwood
Fringetree
Chinquapin Oak
Camperdown Elm
Apricot
Pawpaw
European Linden
Black Ash
English Pyramida Oak
Euoropean Copper Beech
Lilac
Invasive Species
Unclassified Oak
Black Locust
Peach
American Beech
Apple
Balsam Fir
Unclassified Pine
Unclassified Hickory
Japanese Maple
Magnolia
Shagbark Hickory
Little Leaf Linden
American Elm
Black Tupelo
Eastern Red Cedar
Unclassified Elm
Tree of Heaven
Shingle Oak
Eastern Hemlock
Bald Cypress
Catalpa
Black Maple
Kentucky Coffeetree
Ginkgo
American Hornbeam
Wild Black Cherry
Paper Birch
White Ash
River Birch
London Planetree
Sweetgum
Plum
Bur Oak
Serviceberry
Sycamore
Unclassified Maple
American Basswood
Swamp White Oak
Red Pine
Cottonwood
White Oak
Arborvitae
Chinese Elm
Hawthorn
Mulberry
Norway Spruce
Ash Bittmore
Black Spruce
Eastern Redbud
Dogwood
Pin Oak
Tulip
Hackberry
Green Ash
Maple Crimson King
Red Oak
Pear
Honey Locust
White Pine
Colorado Blue Spruce
Crabapple
Red Maple
Norway Maple
Sugar Maple
Silver Maple
1
10
100
1000
10000
NUMBER OF INDIVIDUALS (LOG BASED 10)

Figure 5

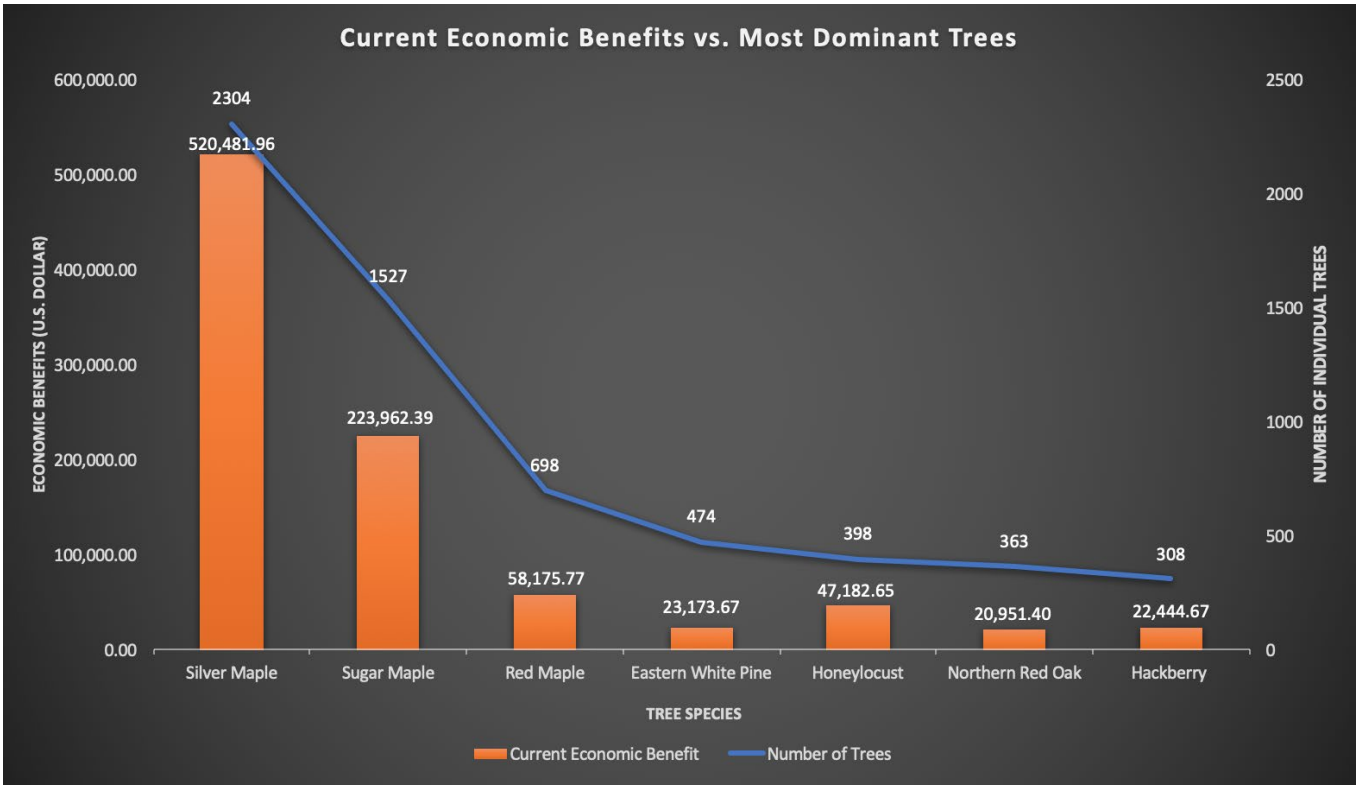
Current Economic Benefits vs. Most Dominant Trees
600,000.00
500,000.00
400,000.00
300,000.00
200,000.00
100,000.00
0.00
ECONOMIC BENEFITS (U.S. DOLLAR)
2500
2000
1500
1000
500
0
NUMBER OF INDIVIDUAL TREES
2304
1527
698
474
398
363
308
520,481.96
223,962.39
58,175.77
23,173.67
47,182.65
20,951.40
22,444.67
Silver Maple
Sugar Maple
Red Maple
Eastern White Pine
Honeylocust
Northern Red Oak
Hackberry
TREE SPECIES
Current Economic Benefit
Number of Trees

Figure 6

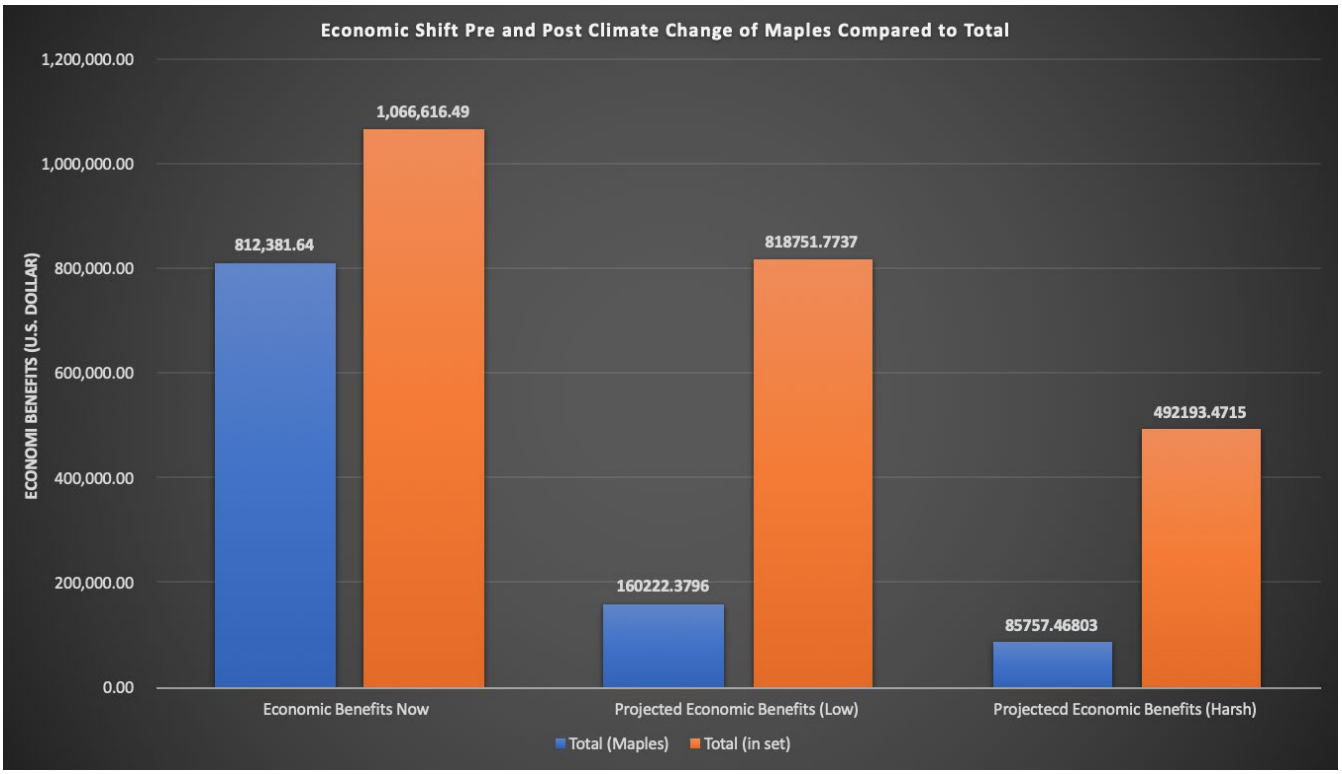

Figure 7

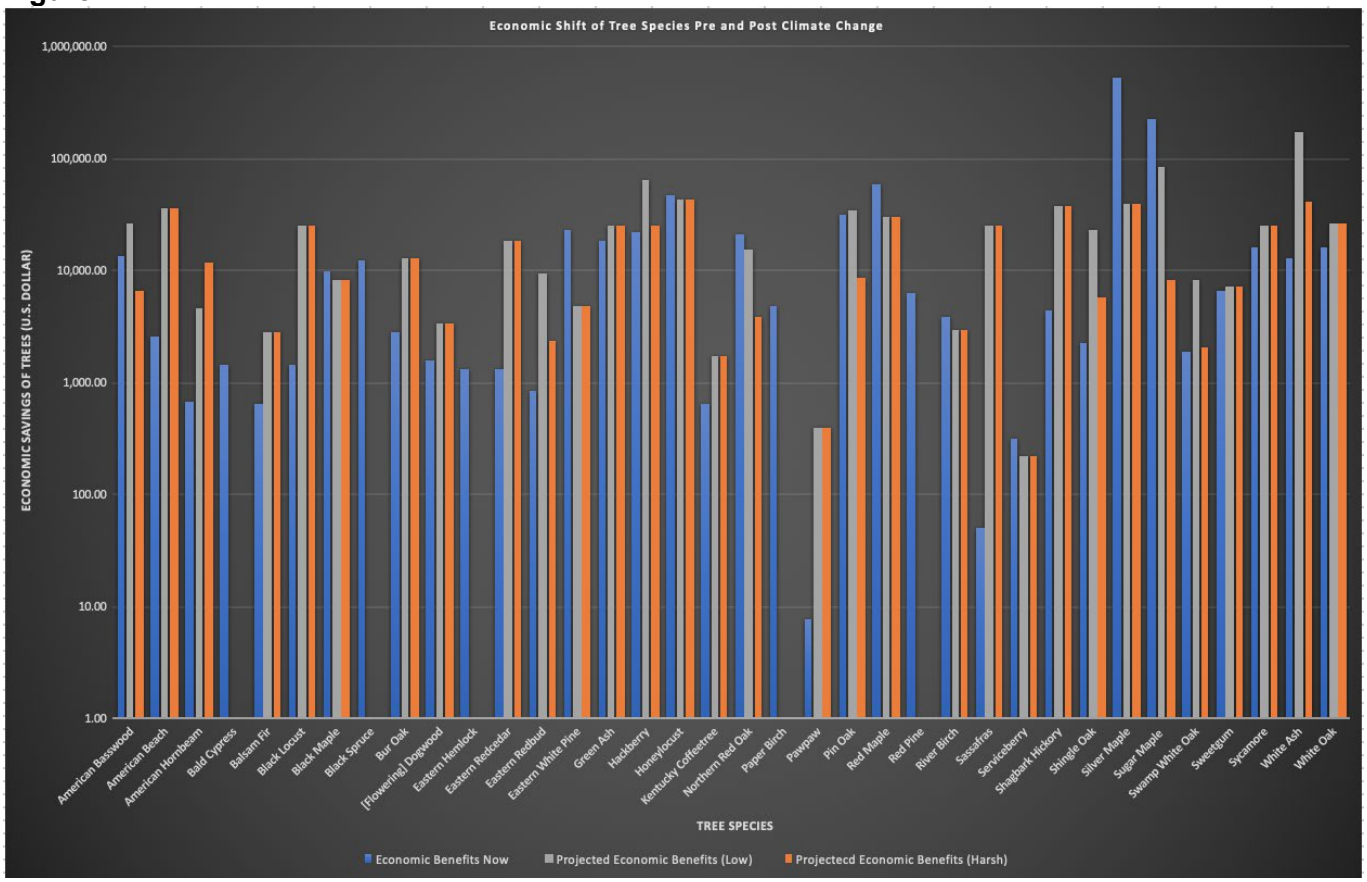

Figure 8