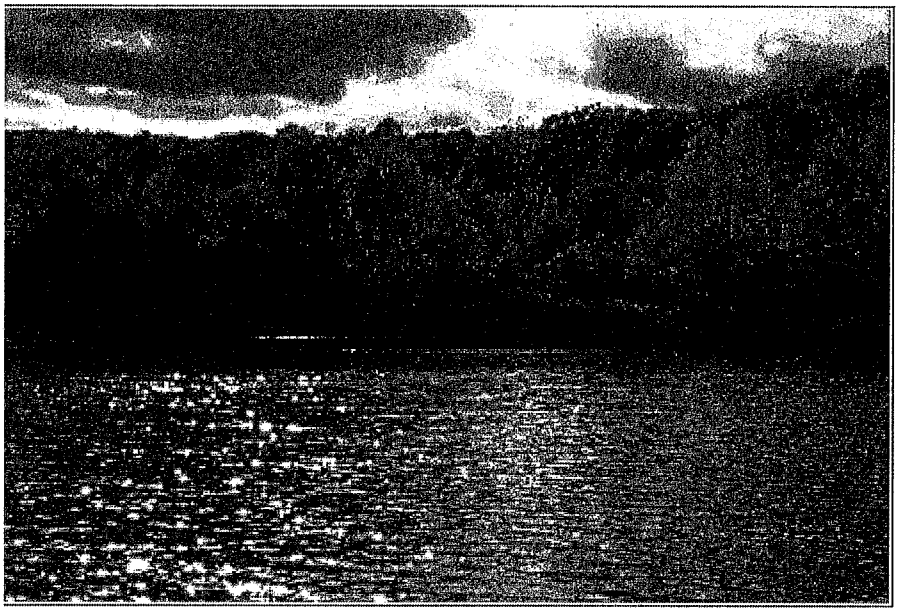
Forest Succession and Biomass Accumulation of 70 Year-Old Experimental Plots in

BLACK ROCK FOREST, NY



www.blackrockforest.com

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ENV MEASUREMENTS
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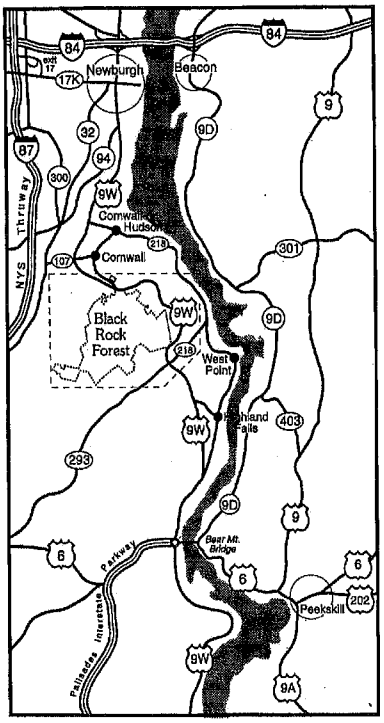
Abstract

Managers of Black Rock Forest, in southeast New York, have been collecting Diameter-at-Breast-Height (DBH) data since 1931, on two experimental plots. This data, along with records of species composition and environmental changes reveal rates of tree growth, survival, and succession of this deciduous forest. Initially, the purpose of the research was to observe ways to improve accumulation in stem growth of marketable trees within the forest. Using allometric biomass equations, the DBH data allowed the students of the Barnard College Environmental Science Department to analyze and compare the biomass accumulation and carbon sequestration of a pair of experimental plots. The results show the biomass equations accurately predict the stem biomass based on its DBH. The number of stems on the experimental plots has decreased though biomass continues to accumulate demonstrating a trend toward fewer, larger trees.

Introduction

What is BRF?

Black Rock Forest (BRF) is a 3700 acre (1530 ha) oak-dominated, aggrading, Eastern deciduous forest preserve located in the Hudson Highlands of Cornwall, New York as shown in MAP 1. This area is situated on the west bank of the Hudson River, 50 miles (80 km) north of New York City. The steep-sided valleys run northeast to southwest. Elevations range from 110 to 450 meters above sea level. (Schuster, 2002) View MAP 3 and MAP 4 for a more detailed layout of BRF.



MAP 2: BRF INDEX MAP

The last glacial age, occurring about 14,000 years ago, left the Highlands with a thin layer of rock strewn soil supporting this forest. (Maher, 1996) "The soils are predominately brown forest solid with bedrock or glacial till parent material at depths ranging from 25cm to 1m soil is acidic and low in nutrients."(Schuster, 2002) The average annual precipitation is 1.2 m. Seasonal temperature changes average -2.7 degrees Celsius in January to 23.4 degrees in July. (Schuster, 2002)

Ernest Stillman established BRF in 1928 as a facility of forest management research. The forest, managed by Harvard University from 1949 through 1989, is composed of diverse habitats ranging from young and mature forests, stream, ponds and wetlands. Since 1989, the Black Rock Forest Consortium, a group of educational and research institutions, use the preserve as a field station, promotes scientific research

within the forest and manages its ecosystem. Information on Black Rock Forest can be found at http://www.blackrockforest.org/

BRF before 1928 was subject to extremely variable and rapid land use changes as is illustrated in the timeline of IMAGE 1. During the 19th century, the mountain residents of the Highlands developed a "diversified economy based on agriculture, lumbering, dairying, fruit growing, then tourism." (Maher, 1996) Given its thin black soils and steep topography, Black Rock was poor farming land and never extensively cultivated. "The good black soils are generally limited to the valley bottoms and coves. ' Only 7.5% or 270 acres has been cleared for, [mostly subsistence] farming throughout its history. The most intense farming regions within BRF are between the mountains and its flat areas." (Maher, 1996)

Black Rock Forest residents would cut trees for home use and market, particularly as fuel. The wood was used to heat homes and power the Industrial Revolution until the impetus of coal followed by gas and electricity overpowered its practical use. Approximately 50% of the total land within Black Rock has been cleared for lumbering purposes. (Maher, 1996) All and all, BRF has been clear-cut at least two times in its history. By 1928, the poor agricultural and logging market, the repeated clear-cutting and frequent fires resulted in the regeneration of hardwoods in the forest. At the turn of the twentieth century, Gifford Pinchot, the first American trained as a professional forester, influenced Ernest Stillman with his "wise use" conservation ethic. The country's [timber] resources should be used efficiently to promote "the greatest good of the greatest number for the longest time." The inception of BRF began as an experimental forest to improve timber production. (Maher, 1996)

Purpose

As a member of Professor Bower's Environmental Measurements class at Barnard College, the research objective at BRF was to collect the 2002 DBH data for the two experimental plots, namely 5a4c (the control plot), and 5a4 (the treatment plot). The

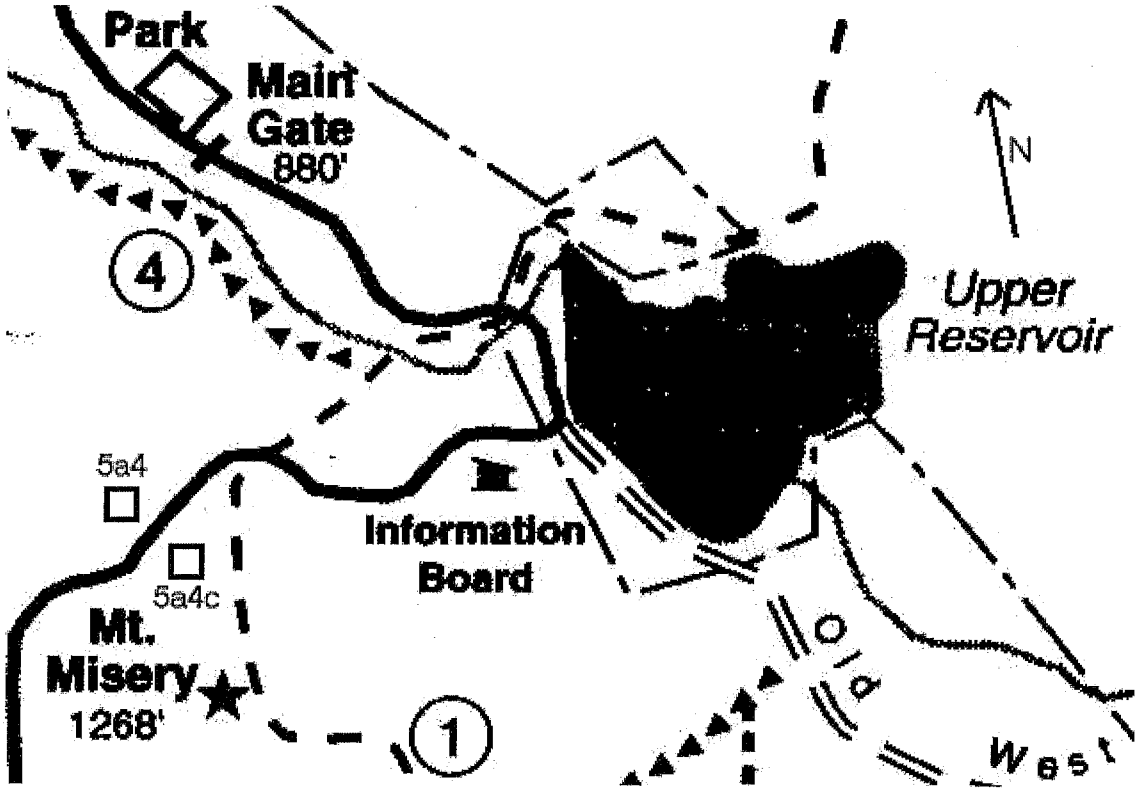


IMAGE 2: THE POSITION OF EXPERIMENTAL PLOTS IN BRF.

plots are located on either side of Aleck Meadow Road, just west of the Upper Reservoir in BRF.

Using biomass equations, DAGBIK and biomass accumulation over time in BRF was calculated and analyzed. Comparing the data between the plots projected the stability of a thinned or natural forest, and improved rates of biomass accumulation. Additionally, the accuracy of these equations was tested. On March 1, 2002, the Environmental Measurements class visited BRF with the purpose of cutting down a red oak, measuring its wet and eventually its wet weight, as well as calculating its other dimensions and

compare its manually measured biomass to the calculated biomass observed from applied the red oak equation. In October of 2000, a dead chestnut oak was cut down for the same purpose.

Experimental plots

The two plots, 5a4c and 5a4, are respectively a control and treatment plot whose growth has been monitored, and data collected since 1931 and every few years since. "In 1930, an inventory of trees of 'cordwood size,' roughly greater than 10cm [3.9 in] in diameter-at-breast-height (DBH), was made of BRF. [A second inventory was taken in 1985.] The forest was subdivided into 150 stands based on species composition and average tree density selected on the basis of its intermediate forest elevation and typical forest characteristics. The plots are part of a pair of four long-term experimental plots of roughly the same size. The surface area of 5a4c is .0406 hectares, and 5a4 is .041 hectares.

The treatment plots, treated once in 1931, were thinned of "dead, diseased, and dying trees including species considered less economically desirable."(Schuster, 2002) This thinning amounted to the removal of about 1/3 of the basal area of the treatment plots or about 50% of its biomass. Plot 5a4 was thinned of particularly more stems than the other treatment plots, almost 60% compared to 5a4c. (Schuster, 2002) The treatment was also applied to thirty acres surrounding the hillside of plot 5a4. The number of trees and the species composition of plots 5a4 and 5a4c were monitored and compared over time. The purpose of this experiment was to answer the question, " Will 'thinning' enhance the growth of 'marketable' trees?" Growth of the trees, which will be referred to as stems interchangeably, is determined by measurements of DBH or diameter-at-breast

height. Since this initial forest management experiment, the two plots have been used for a series of other research projects since it is rare to find plots "untouched" for such a along period of time and with available data.

Methods And Materials

Biomass Equations and DBH

The DBH or diameter-at-breast height is the diameter of a tree measured at a height of 1.37 meters, which is approximately the breast height of a person. The materials needed for this field project include: a field book, a clipboard, diameter measuring tape in inches, plastic ribbon, a listing of DBH measurements taken of plots 5a4c and 5a4 since 1931, a pencil, and the "Biomass Equations for Major Tree Species of the Northeast" compiled by Louise M.Tritton and James W. Hornbeck:

Species:	Equation
*red oak	11.0417-(0.5258*DBH*25.4)+(0.0076788* (DBH^2)*(25.4^2))
*sugar maple	5.248-(0.3661* DBH *25.4)+(0.007605*(DBH^2)*(25.4^2))
+white oak	(((10^((LOG(DBH *2.54)*2.1666)+2.3058)))+ ((10^((LOG(DBH *2.54)*1.738)+1.5849))))/1000
-chestnut oak	(1.5509*(DBH^2.7276))/2.205
-black birch	(1.6542*(DBH^2.6606))/2.205
*red maple	6.1147-(0.3598*DBH*25.4)+(0.006344*(DBH^2)*(25.4^2))
-black cherry	(1.8082*(DBH^2.6174))/2.205
*black oak	red oak equation
*gray birch	9.3701-(0.4489*DBH *25.4)+(0.007496*(DBH^2)*(25.4^2))
-hickories	(2.034*(DBH^2.6349))/2.205
*beech	5.3373-(0.3257*DBH*25.4)+(0.007173*(DBH^2)*(25.4^2))
+scarlet oak	((10^((LOG(DBH *2.54)*2.3948)+2.19))+ ((10^((LOG(DBH *2.54)*1.6436)+1.8565))))/1000
-hemlock	(1.3449*(DBH^2.45))/2.205
*general h: bg, mw	5.5247-(0.3352*DBH *25.4)+(0.006551*(DBH^2)*(25.4^2)) black gum, moosewood (striped maple)
*general s	4.5966-(0.2364*DBH *25.4)+(0.00411*(DBH^2)*(25.4^2)) dogwood

*Monteith, D,B, 1979. "Whole tree weight tables for NY". AFRI Research Report 40, Univ. of Syracuse, NY 40p.
+Whittaker and Woodwell. 1968 "Dimension and production relations of trees and shrubs in the Brookhaven Forest", NY. Journal of Ecology. 56:1-25
-Brennerman, B.B., Frederick, Gardner, Schoenhofen an Marsh. 1978. "Biomass of species and stands of West Virginia Hardwoods". pgs.159-178 in P.E. Pope ed., Proceedings Central Hardwoods Forest Conference II. Purdue Univ., West Lafayette, In.
**Pastor et al., 1984, "Biomass Production Using Generalized Allometric Regressions for Northeast Tree Species" Forest Ecology Management, 7:265-274. (except White Oak and Chestnut Oak: Whittaker et al., 1974)

TABLE 1: BIOMASS EQUATIONS

The tree species abbreviations presented in TABLE 2 are used frequently through out this text. Please observe carefully.

CO	CHESTNUT OAK	BB	BLACK BIRCH
WO	WHITE OAK	BE	BEECH
RO	RED OAK	MW	MOOSEWOOD (STRIPED MAPLE)
SO	SCARLET OAK	HM	EASTERN HEMLOCK
PH	PIGNUT HICKORY	BG	BLACK GUM
SH	SHAGBARK HICKORY	BC	BLACK CHERRY
RM	RED MAPLE	DW	DOGWOOD
SM	SUGAR MAPLE	SB	SHADBUSH
GB	GRAY BIRCH	CH	AMERICAN CHESTNUT
YB	YELLOW BIRCH		

TABLE 2: SPECIES ABBREVIATIONS

The biomass equations of TABLE 1 are allometric equations that have been revised for the purpose of measuring DBH in inches by Dr. William Schuster, the BRF Director. Excel is used to organize and calculate our data.

Allometric equations are equations created by measuring an easily measurable aspect of an "object" and correlating that aspect to parts of an object that are not as easy to measure. The equations correlate the easily measurable DBH of a tree and correlate it to the dry above ground biomass of a tree. This method of calculation is difficult because controls have to be set. Each species of tree requires a different equation considering species growth rates and regional variations in growth rates given climate, soil and other geographical conditions.

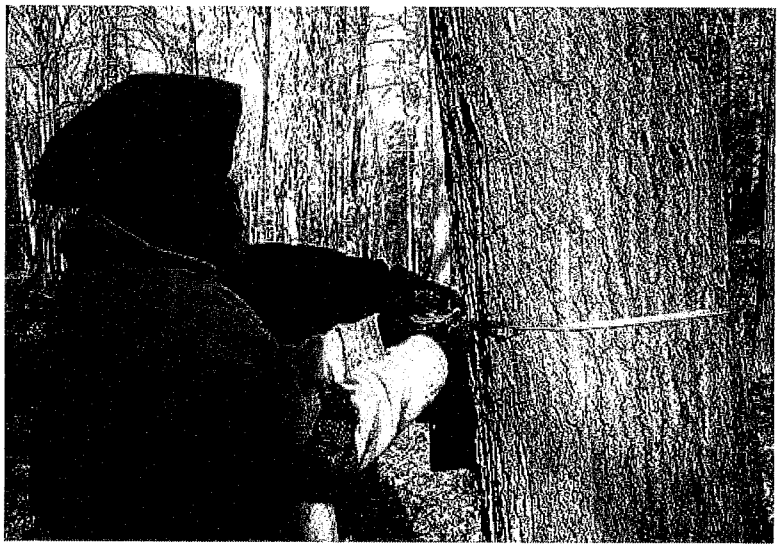


IMAGE 3: Rachel and Jennifer demonstrate how to measure DBH.

The equations are species and region specific and determine the dry above ground biomass in kilograms (DAGBIK) of each individual tree and, by sum, of each plot. This

DBH data, collected March 8, 2002 represent conditions of the 2001 growing season. Data taken after May represent the conditions at the end of the season for that year. (Schuster, 2002) This information was added to data collected every five years upon average since 1931, and each year after 1994. Approximately 50% of deciduous forest biomass is stored carbon.

Two groups of participants measured the DBH of the live trees present on either plot 5a4c and 5a4. By referring to the DBH listing, we were able to determine if a tree had previously died, though some had noticeably past on. Biomass for unplotted and dead trees is not included in our data set. Using our diameter measuring tape, the DBH of each tree was measured and remeasured by another participant for group accuracy. A plastic ribbon was then tied around each tree to mark it as having been measured. Our measurements were then recorded in field books and transferred to the DBH listing as data for the 2002, though it is correctly considered a 2001 addition.

The dimensions of the experimental plot are fairly square, as illustrated in IMAGE 4. The area was calculated using the following equation: $\sqrt{(s(s-a)(s-b)(s-c))}$, where $s= (1/2)(a+b+c)$.

Red Oak

The red oak tree, used to test the accuracy of the biomass equations, required additional field and lab materials that include: a transponder, clinometer, DBH measuring tape, chainsaw, spring scale, a tractor, heavy rope, permanent marker, Mettler lab scale and a large oven. The RED OAK SLIDESHOW relives this field experience.

Three methods were used to measure the height of the tree. The transponder, clinometer, and measuring tape were used separately to tell us the height of the red oak

tree. A transponder is a digital tool that bounces soundwaves to calculate distance. A clinometer is a projector-like mechanical tool projects height at an angle from a specific distance. The transponder and clinometer methods use trigonometry to determine height of the red oak. In a right triangle, knowing the length of the base of the triangle and the adjacent angle, the length of the side opposite that angle (the tangent) can be calculated. The distance and angle of the tree from where the measurements were taken are approximately 135.5 m and 30.3 degrees.

To observe wet weight of this red oak, the trunk was cut into, roughly, two-foot thick boles. The branches were trimmed and weighed in separate bundles. 13 two-inch thick boles were also trimmed to be dried and remeasured for future comparisons. The 2-inch thick bole #11 was cut into four similar sized pieces, reweighed using the Mettler scale in the lab, and baked in an oven at a fairly consistent temperature of 115 degrees Celsius over a period of 60 days. This temperature is preferred over a higher temperature to maximize the amount of water evaporated and limit the evaporation of other volatile materials that exist in the bole, as well as prevent the burning of the wood.

Chestnut Oak

The materials used to measure the chestnut oak were the same as for the red oak except for the use of chalk. The DBH of the chestnut oak tree was measured before it was cut into four-foot long boles. The rope was used to bundle the branches. Using chalk, the bundles and boles were numbered. The spring scale, attached to a bulldozer, was used to measure the field weight. The truck transported the chestnut oak pieces to a shed for drying. The chestnut oak wet weight was measured manually at the time it was felled.

The dry weight, measured a year later, was then compared to the DAGBIK calculated from the chestnut oak equation.

RESULTS

Stem Survival Rates on the Experimental Plots

The area of the experimental plots was last clear-cut in 1905; the oldest trees are about 95 years old. Pollen assemblages taken from a sediment core of Sphagnum Pond reveal oak trees have been abundant in this area for over 10,000 years. (Maenzer-Gmelch, 1996) Over the past seventy years, the number of stems (trees) on plots 5a4c and 5a4 has decreased about 75% each.

Using the long-term DBH data, organized in TABLE 13a for 5a4c, and TABLE 14a for 5a4, the following survival statistics were determined.

5a4c	1931	1937	1942	1947	1951	1961	1965	1973	1978	1983	1989	1994	1998	2002	Total
Stems	111	103	89	81	65	56	50	40	44	40	36	36	34	32	130.0
New	0	0	0	0	0	0	1	1	9	0	0	5	3	0	19.0
Dead	0	8	14	8	16	9	7	11	5	4	4	5	5	2	98.0
Cum. New	0	0	0	0	0	0	1	2	11	11	11	16	19	19	
Cum. Dead	0	8	22	30	46	55	62	73	78	82	86	91	96	98	
Net Change	0	-8	-14	-8	-16	-9	-6	-10	4	-4	-4	0	-2	-2	
Cum. Change	0	-8	-22	-30	-46	-55	-61	-71	-67	-71	-75	-75	-77	-79	

TABLE 3: Survival Statistics for plot 5a4c

5a4	1931	1937	1942	1947	1951	1961	1965	1973	1978	1983	1989	1994	1998	2002	Total
Stems	94	92	52	49	43	42	38	37	39	32	29	34	31	29	116
New	0	0	0	0	0	2	1	6	4	2	1	6	0	0	22
Dead	0	2	40	3	6	3	5	7	2	9	4	1	3	2	87
Cum. New	0	0	0	0	0	2	3	9	13	15	16	22	22	22	
Cum. Dead	0	2	42	45	51	54	59	66	68	77	81	82	85	87	
Net Change	0	-2	-40	-3	-6	-1	-4	-1	2	-7	-3	5	-3	-2	
Cum. Change	0	-2	-42	-45	-51	-52	-56	-57	-55	-62	-65	-60	-63	-65	

TABLE 4: Survival Statistics for plot 5a4

On plot 5a4c, 21 of the original 111 stems of 1931 are still living. 13 of the original stems that died were above cord-size (3.9 in or more). Of the surviving stems, bb, rm and ro accounted for 5 or more stems each. The new trees did not begin making an appearance until after 1965, the majority in 1978. 11 of the 19 "new stems," or stems

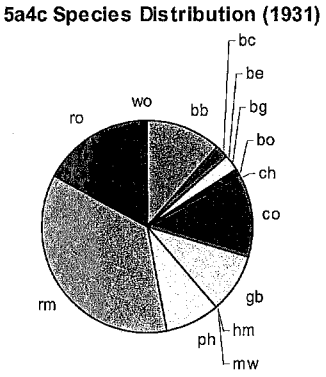
born after 1931, are still living. Of the seven that died (4 ch, 1 hm, 2 rm, 1 ro), only the two rm survived past one DBH survey. The red maples (rm) lived from about 1978 through 1994. There is a 58% survival rate of new stems on the control plot.

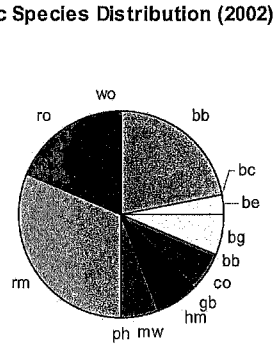
On plot 5a4, 17 of the original 94 stems are living. Of the 17, 3 were above cord size in 1931; all are red oaks. Red oak accounts for 6 of the surviving stems. Of the original stems that died, 6 or 8% of the stems were above cord-size. New trees appeared more evenly distributed after 1965. Of the 12 surviving stems from 1931, 9 are Black gum (bg). The "new stems" that died were 8 dogwoods (dw), 2 red maples (rm), and a brief appearance of a shadbush. There is a 50% survival rate of new stems on this plot.

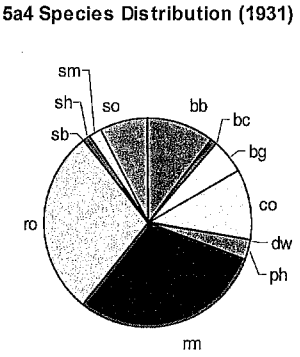
Species Composition

5a4c	%age	
Species	1931	2002
bb	11.7	21.9
bc	1.8	0.0
be	0.0	3.1
bg	2.7	6.3
bo	0.9	0.0
ch	0.0	0.0
co	12.6	6.3
gb	9.0	0.0
hm	0.0	6.3
mw	0.0	6.3
ph	8.1	0.0
rm	36.0	31.3
ro	16.2	15.6
wo	0.9	3.1
TOTAL	111	32

5a4	%age	
Species	1931	2002
bb	10.6	6.9
bc	1.1	0.0
bg	5.3	44.8
co	10.6	0.0
dw	0.0	0.0
ph	3.2	0.0
rm	29.8	17.2
ro	28.7	20.7
sb	0.0	0.0
sh	1.1	3.4
sm	2.1	6.9
so	7.4	0.0
TOTAL	94	29







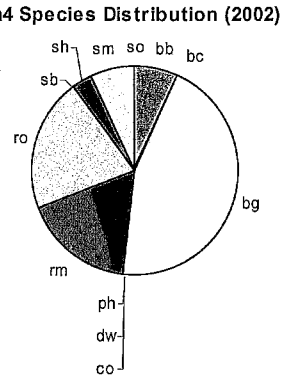


CHART 1: SPECIES COMPOSITION OF EXPERIMENTAL PLOTS

Red oak dominates the canopy and red maple, the understory of the Black Rock Forest. These two species combined account for 52.2% of the total species of stems in 1931 with a slight decrease, to 46.9% in 2002 on plot 5a4c. Black birch (bb) is the fourth dominating plant in 1931 and now overpowers ro. Though red oak and red maple have been able to maintain similar proportions over time, the larger magnitude of be, hm, mw, and wo, along with the co-domination of bb, may signify a successional overturn.

Red oak (ro) and rm take 58.5% of the 5a4 plot in 1931 to 37.9% in 2002. Black gum (bg) has increased to accumulation 44.8% of the species diversity. On plot 5a4, a "minor" species in 1931 has increased dramatically displacing three other species: co, dw, and ph. Around 1942, this treatment plot lost 40 of its 92 stems, which did not have a significant impact on DAGBIK rates of growth.

Biomass Accumulation

Comparing DAGBIK to the distribution of stem species reveal which species dominated carbon uptake. TABLE 13b and TABLE 14b are the DAGBIK data of plots 5a4c and 5a4 respectively calculated using the biomass equations. TABLE 5 provides the total DAGBIK of the datasets organized by year and species. On plot 5a4c, ro accounts for 49.6% of accumulation in 2002, compared to 13.3% in 1931.Black gum (bg) has increased to accumulation 44.8% of the species diversity but only 4.3% of the biomass. The older ro and rm constitute 66.1% and 6.8% respectively. The 13 bg stems total 406 kg of biomass in 2002.

The plots have lost about 75% of the stems over the past 70 years. CHART 2 and CHART 3 show biomass accumulation has increased at a similar rate to stem loss on both plots. Plot 5a4, the loss of 40 stems did not significantly affect the rate of accumulation.

DAGBIK for 5a4c has increased 464% since 1931, with a rate of 114kg per year. 5a4 accumulated more 700% at a rate of 95 kg per year. The stem loss of 1942 barely had any impact on DAGBIK growth. Accumulation on plot 5a4 actually increased at a higher rate than 5a4c until 1978. There is a significant depression in the DAGBIK rate during the mid-1980's and 1990's. Looking at CHART 4 and CHART 5, decreases in rates of biomass accumulation correlate to the loss of species of stems with a higher DBH.

Carbon accounts for 50% of the biomass in deciduous forests. As biomass accumulates so does the relative carbon uptake. Total accumulation over the last 70 years is 74.2% and 42.3% for 5a4 and 5a4c respectively. The rapid uptake of 5a4 can be attributed to regrowth of stems after the thinning treatment. Accumulation on 5a4c appears to be more stable.

Red Oak

The hemlocks, in an area near Hulse Road, have been invaded by an alien insect, the Woody Adelgid (Adelges tsugae). This aphid-like insect kills hemlocks by sucking the sap from its needles, eventually weakening the tree and making it vulnerable to other diseases. In an effort to control the spread of the insect, this area is being cleared of trees. This clearing gave us the opportunity to cut down this red oak within the "Hemlock Valley."

The height of the red oak tree was estimated using a transponder, clinometer, and right angle trigonometry. The actual height of the tree was measured manually, after the tree was felled, using a measuring tape. The results are as follows:

	Transponder (digital)	**Clinometer (mechanical)**	**Manual (tape)**
Height of Tree	30.1 m	29.4 m	29.7 m

TABLE 7: RED OAK HEIGHT MEASUREMENTS

The height between tree base and the initial cut measured 4 ft. (~1.1 m) and the height from the cut measured 28.6 m. In total, the red oak tree was manually measured at 29.7 m



IMAGE 4 & 5: LABELING AND WEIGHING THE RED OAK BOLES

tall, which is also the average of the transponder and clinometer measurements.

The felled tree was cut and weighed in the field using the spring scale. The Total Wet Above Ground Biomass is 5532 lbs (2509.3 kg) as shown in TABLE 8. A section of the red oak, bole #11, was taken back to the lab. The "wet" weight was measured again in the lab, dried and reweigh periodically. The weights and moisture loss of the bole is charted in TABLE 9.

There is a significant difference between the wet weight measured in the field and in the lab. 2-inch Bole #11, first weighed in at 24 lbs (10.89 kg) in the field on March 1. A week later, on March 8th, the first lab mass was measured at 19.37 lbs (8.79 kg) in the lab. The spring scale used in the field was not calibrated before use. The 3.63 lbs. (24-29.37) difference is most likely due to an inaccurate spring scale or moisture loss during the week. Since March 8th, the bole has lost an additional 31.9% of its moisture.

The bole was air-dried for one week then placed in the oven for 60 days. The field weight of the red oak is 10.89 kg. The bole dried to 5.98 kg. Using the initial wet weight measured in the field as a reference point, the bole lost 45% of its initial weight. The 45% moisture would amount to a DAGBIK, or dry weight of the entire red oak tree as 1377.93 kg.

Relative to the mass measured in the lab, 8.79 kg, the bole lost 2.81kg or 31.9% of its initial weight (as moisture) over 60 days. If the spring scale is in error and gives results that are 23% to high (i.e. 24/19.37), then the total initial wet weight of the red oak was not 2509 kg but 2025 kg. The corresponding DAGBIK (after a 31.9% moisture loss) is 1379 kg.

The DBH of the red oak was measured in the field as 18.46 in. The Red Oak biomass equation is 11.0417-(0.5258*DBH*25.4)+(0.0076788*(DBH^2)*(25.4^2)), the DAGBIK is 1452 kg. This equation calculates a moisture loss of 42.1% relative to the wet weight measured in the field. This calculated moisture loss falls between the range observed from "real" measurements (31.9% - 45%). Compared to the wet weight measured in the lab, the moisture loss was 28.3%. The percent difference between the measured DAGBIK and the DAGBIK calculated using the biomass equation suggests that the discrepancy between the field and lab wet weights is attributed to evaporation than measurement error. There is only about a 5% difference in DAGBIK using the observed wet weight(s) and the observed moisture loss in the lab compared to the calculated DAGBIK. To test this observation a suggestion is to air-dry a bole of a similar size for a week then measure and compare its moisture loss, should the opportunity arise. The Biomass Equations function extremely well.

Chestnut Oak

The Chestnut Oak, which probably died during the drought summer drought of 1999, was cut down and weighed October 6, 2000. The height of the chestnut oak was about 70 ft. The DBH was recorded as 35.45 cm (13.96 in) and the wet weight as 1117.2 kg (2463 lbs). The Bundles weights are represented in TABLE 10. The dry weight was manually measured as 916.8 kg. Using the biomass equation (1.5509*(DBH^2.7276))/2.205, DAGBIK is 933.67 kg. The difference between the calculate and real dry DAGBIK is 1.8%. Again, the biomass equations prove to function accurately.

DISCUSSION

Overall, this intermediate and old growth area of the forest maintain stable biomass accumulation even in times of climate change. CHART 6 of precipitation and temperature data taken from West Point, near BRF, illustrate climate variability over time...Flatter sites have improved soil water availability compared to the surrounding area. The location of the plots, in the basin of several hills, is beneficial for stem growth. Even when resources are low, the trees do not die, they slow their rate of growth. The annual increase of biomass per hectare as determined by the environmental measurements class is slightly higher compared to Schuster et al. The annual increase for 5a4c and 5a4 is 2363.2 kg and 2746.1 kg respectively. Schuster has determined a growth rate of 2512.5 kg and 2185.9 kg respectively. The average sequestration rate of carbon in North American forests is 598.6 kg per hectare per year. That measurement equates 1197.2 kg of biomass accumulation. (Schuster, 2002) Black Rock Forest is accumulating at twice the rate of other forests. The growth rate is prefaced with the understanding that BRF is not as old and stable as other North American Forests may be.

5a4c is a more stable plot than 5a4. 5a4 appears to be more susceptible to stem loss during droughts and has acquired less carbon per hectare than 5a4c, over the past seventy years. The extreme stem loss of 5a4 in 1942 is insignificant. The minimal impact on biomass accumulation suggests that there is a carbon carrying capacity to the forest plots. Looking at the carbon per hectare for 5a4 (TABLE 12), there is marked increase in biomass accumulation until 1965, when a drought impacted the area. The older trees were better competing for nutrients. Younger and smaller trees, when they die have less of an impact on the biomass accumulation of a plot than an older larger tree. In a young forest, the rate of growth may be high and uptake as much carbon as an older forest with slower rates of growth. As a forest ages, its ability to accumulate does not necessarily decrease, it may be less noticeable.

The thinning of plot 5a4 may have made it more vulnerable to the circumstances of Black Rock Forest. The period of the gypsy moths, which attack most hardwood trees, particularly oaks trees, did not affect either plot. This can be attributed to the diversity of tree species outside of the oaks. The lack of diversity may have, alternately, harmed the stems. During the thinning process, unprofitable shrubs such as the mountain laurel were removed. The Mountain Laurel was removed from the entire steep-side beyond 5a4. This shrub requires a particular fungus to survive. It is difficult, once it is removed from an area, to reestablish itself. It exists in great density on 5a4c. It is possible that the plant and other bushes on the plot provide nitrogen, which is limited in the thin glacial soils of the Highlands. The Mountain Laurel may also keep away deer that will eat seeds and seedlings otherwise. The plant is not a desirable food source to the animals in the forest.

The absence of red oak in the understory may represent a successional change. This succession of stems that would accumulate less biomass over time implies a change in the potential of BRF to grow as a carbon sink. This observation deserves future research. Environmental and anthropogenic factors have affected the diversity of stem survival. The increased density of the deer population that BRF is currently experiencing has selected against oak seeds for survival as they serve as a source of food. The oak trees contribute to the highest amount of carbon uptake. The gypsy moth infestation of the 1980's defoliated the trees. And the drought of 1960 and 1978 made survival a struggle for young stems. These factors alter the rate of sequestration for BRF.

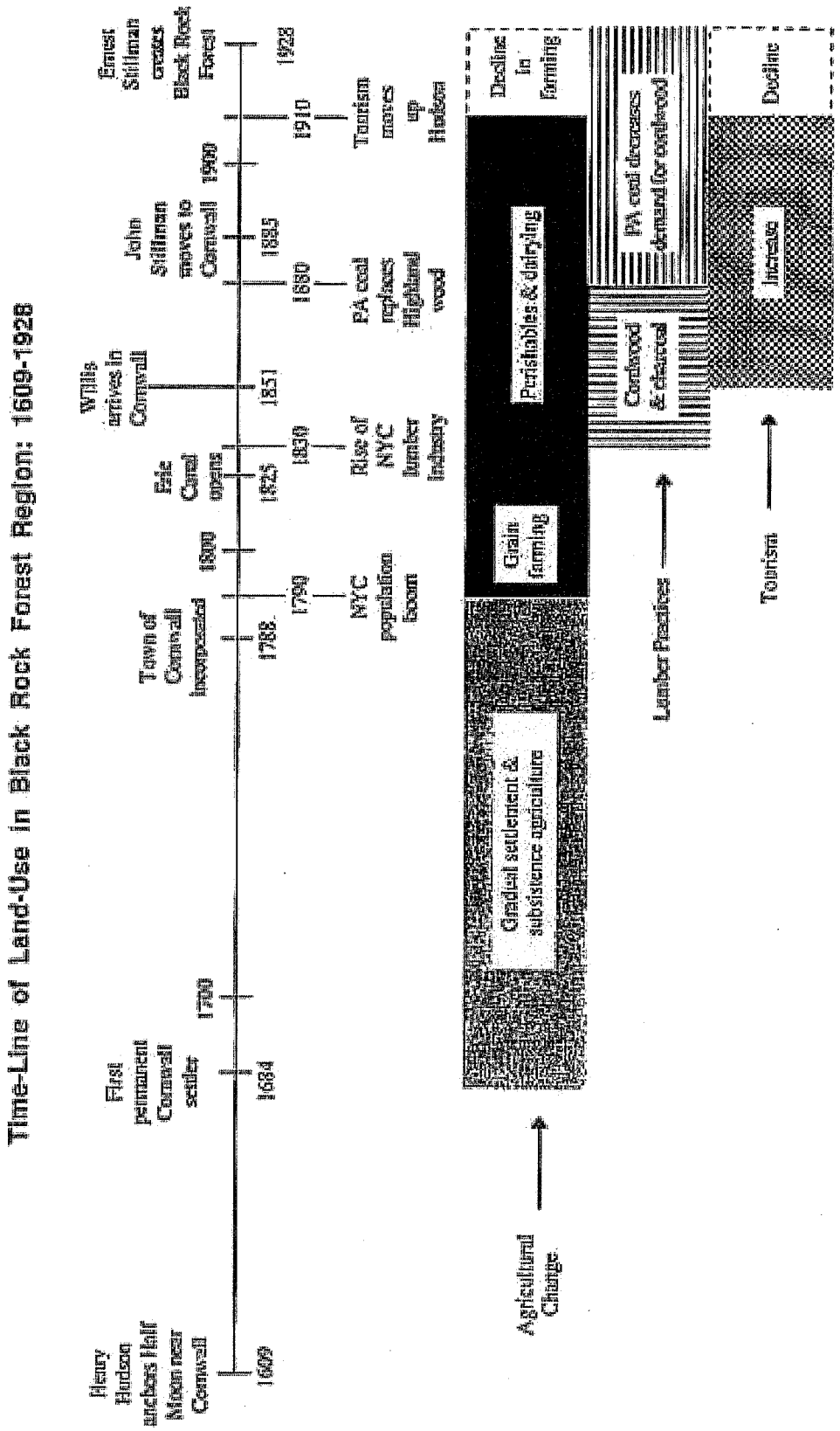
This study has shown that old growth forests continue to have the potential for biomass accumulation. That is not to say that the capacity is unlimited (remember 1942), but that trees as other living organisms do, adapt to their environment. We have observed only the above-ground biomass in living stems. These observations only account for 33% of carbon in a deciduous forest. Other reserves for carbon sinks are available within a forest system including the soil (50%) and woody debris (10%). (Schuster, 2002) There is an underestimation of the amount of Carbon within the forest. With further studies we can better understand the dangers of clear-cutting. At the moment, our most valuable asset towards balancing the Global Carbon Budget is the forest.

APPENDICES

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	4	5a4c AVG DBH /Species
	5	5a4 AVG DBH/Species
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LINK ADDRESSESS

Black Rock Forest: http://www.blackrockforest.org/
Map 1: http://www.blackrockforest.org/images/region.gif
Map 3: http://www.columbia.edu/itc/barnard/envsci/bc3016/brf_map/
Map 4:
Biomass Equations: http://www.columbia.edu/itc/barnard/envsci/bc3016/edit/biomass_eq.pdf
Red Oak Slide Show: http://www.columbia.edu/itc/barnard/envsci/bc3016/brf_redoak/
Table 13(a): http://www.columbia.edu/itc/barnard/envsci/bc3016/brf_online/resources/5a4cDBHtable.html
Table 13(b): http://www.columbia.edu/itc/barnard/envsci/bc3016/brf_online/resources/5a4cDAGBIKtable.html
Table 14(a): http://www.columbia.edu/itc/barnard/envsci/bc3016/brf_online/resources/5a4DBHtable.html
Table 14(b): www.columbia.edu/itc/barnard/envsci/bc3016/brf_online/resources/5a4DAGBIKtable.html
Black Rock's Hidden Past:
Sutherland Pond:


Time-Line of Land-Use in Black Rock Forest Region: 1609-1928
Henry Hudson anchors Half Moon near Cornwall
1609
First permanent Cornwall settler
1684
1700
Town of Cornwall incorporated
1788
1800
NYC population boom
1799
Erie Canal opens
1825
Rise of NYC lumber industry
1830
Wills arrives in Cornwall
1851
PA coal replaces Highland wood
1880
John Stillman moves to Cornwall
1885
1900
Tourism moves up Hudson
1910
Ernest Stillman creates Black Rock Forest
1928
Agricultural Change
Gradual settlement & subsistence agriculture
Grain farming
Perishables & dairying
Decline in farming
Lumber Prodcts
Cordwood & charcoal
PA coal decreases demand for cordwood
Tourism
Increase
Decline

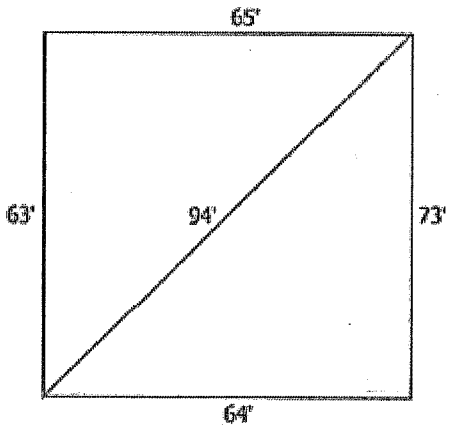
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Plot Dimensions: 5a4 and 5a4c

N ↑

area= $\sqrt{s(s-a)(s-b)(s-c)}$

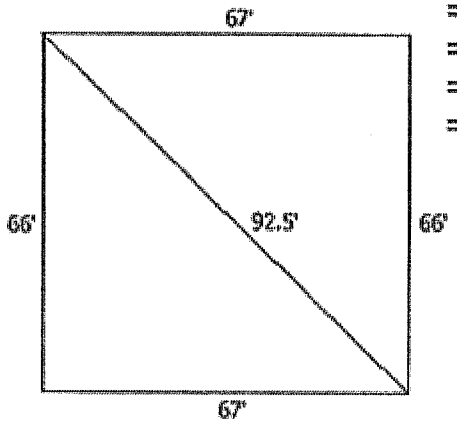
where s= (1/2)(a+b+c)



TOTAL AREA:
=2331.4+2041 sq ft
=4372.6 ft2
=406.23 m2
=.0406 ha

Alec Meadow Road

TOTAL AREA:
=2209.8+2209.8 sq ft
=4419.6 ft2
=410.6 m2
=.0410 ha



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ABLE 5 Total DAGBIK/ Species

5a4c	TOTAL DAGBIK/ Stem (kg)												
Species	**1931**	**1937**	**1942**	**1947**	**1951**	**1961**	**1965**	**1973**	**1978**	**1983**	**1989**	**1994**	**1998**	**2002**
bb	250.3	231.9	352.7	327.2	482.9	438.0	584.1	510.2	733.6	599.8	863.3	638.8	931.9	721.5
bc	3.6	3.6	4.1	4.7	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
be	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	10.8	12.1	12.1	35.5	43.4
bg	66.8	84.2	101.0	127.7	152.5	215.2	221.5	269.4	324.3	364.5	434.1	477.1	526.9	561.8
bo	4.1	4.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0	1.9	1.2	0.0
co	390.1	538.6	704.9	959.4	1091.6	1418.4	1539.0	1615.2	1882.3	2079.8	2252.5	1978.7	2114.9	2213.2
gb	194.0	236.6	250.9	279.1	194.5	225.5	119.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	2.6	7.0	16.4	26.3	34.7
mw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	7.7	10.0
ph	65.6	63.7	22.8	10.6	6.8	2.2	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rm	550.7	647.2	774.7	861.9	913.1	901.0	928.8	979.2	1069.5	1107.1	908.8	721.0	577.7	535.0
ro	290.9	460.0	679.9	1043.2	1449.9	2080.8	2272.3	2708.5	3218.1	3584.0	3938.1	4397.8	4842.6	5161.5
wo	365.4	425.3	475.3	528.2	551.8	669.4	687.2	732.7	751.4	779.9	799.2	818.7	838.5	847.4
TOTAL	2181.5	2695.8	3371.3	4142.0	4847.9	5950.4	6355.3	6815.2	7999.9	8528.5	9215.2	9067.3	9903.1	10128.4

5a4	TOTAL DAGBIK/ Stem (kg)												
Species	**1931**	**1937**	**1942**	**1947**	**1951**	**1961**	**1965**	**1973**	**1978**	**1983**	**1989**	**1994**	**1998**	**2002**
bb	46.9	86.8	97.9	146.1	199.8	249.4	255.5	226.6	263.2	279.7	309.1	325.9	318.9	344.2
bc	0.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
bg	0.0	14.9	26.7	39.3	78.3	98.5	98.5	111.1	154.1	198.4	233.6	300.1	347.0	406.0
co	227.1	405.9	475.0	677.4	805.1	1046.9	1137.6	1269.0	1471.8	0.0	0.0	0.0	0.0	0.0
dw	0.0	0.0	0.0	0.0	0.0	15.3	20.6	27.3	32.7	19.0	0.0	1.2	0.0	0.0
ph	4.0	7.4	6.0	3.7	3.7	4.3	5.0	5.7	7.4	7.4	7.4	0.0	0.0	0.0
rm	197.4	320.8	214.2	321.1	420.8	570.3	601.7	346.9	433.4	434.1	495.3	544.1	608.8	644.6
ro	347.2	663.8	963.3	1448.2	1993.5	2653.9	2883.6	3539.5	4095.5	4451.7	4816.1	5414.8	5879.6	6252.4
sb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
sh	13.9	31.1	45.7	64.0	74.7	82.3	86.3	90.4	94.7	94.7	94.7	94.7	94.7	94.1
sm	2.1	4.7	5.9	9.7	9.7	13.6	14.8	20.0	25.7	32.7	32.7	34.8	37.8	38.5
so	271.0	469.5	557.5	772.1	917.6	1257.8	1390.8	1657.8	1841.1	2014.3	1874.1	2060.1	2108.5	0.0
TOTAL	1110	2006	2392	3482	4503	5992	6494	7294	8419	7532	7863	8776	9395	7780

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TABLE 9 RED OAK BOLE AND BUNDLE WEIGHTS

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RED OAK BOLE AND BUNDLE WEIGHTS															
2-inch (lbs)			2-ft Boles												
#	WGT		#	WGT		#	WGT		#	WGT		#	WGT		
1	26		1	110		16	50		31	74		46	28		
2	22		2	146		17	142		32	102		47	36		
3	22		3	116		18	48		33	52		48	28		
4	14		4	138		19	82		34	38		49	38		
5	26		5	152		20	100		35	38		50	26		
6	20		6	142		21	90		36	102		51	16		
7	30		7	138		22	106		37	108		52	24		
8	28		8	128		23	94		38	70		53	24		
9	22		9	112		24	38		39	80		Bundles			
10	38		10	100		25	138		40	46		54	42		
11	24		11	140		26	132		41	28		55	120		
12	42		12	132		27	118		42	44		56	142		
13	42		13	112		28	110		43	44		57	132		
base	28		14	106		29	114		44	54		58	120		
notch	6		15	140		30	80		45	32		59	100		
												TOTAL		5532 lbs	2509.3 kg

TABLE 9 Red Oak Bole #11

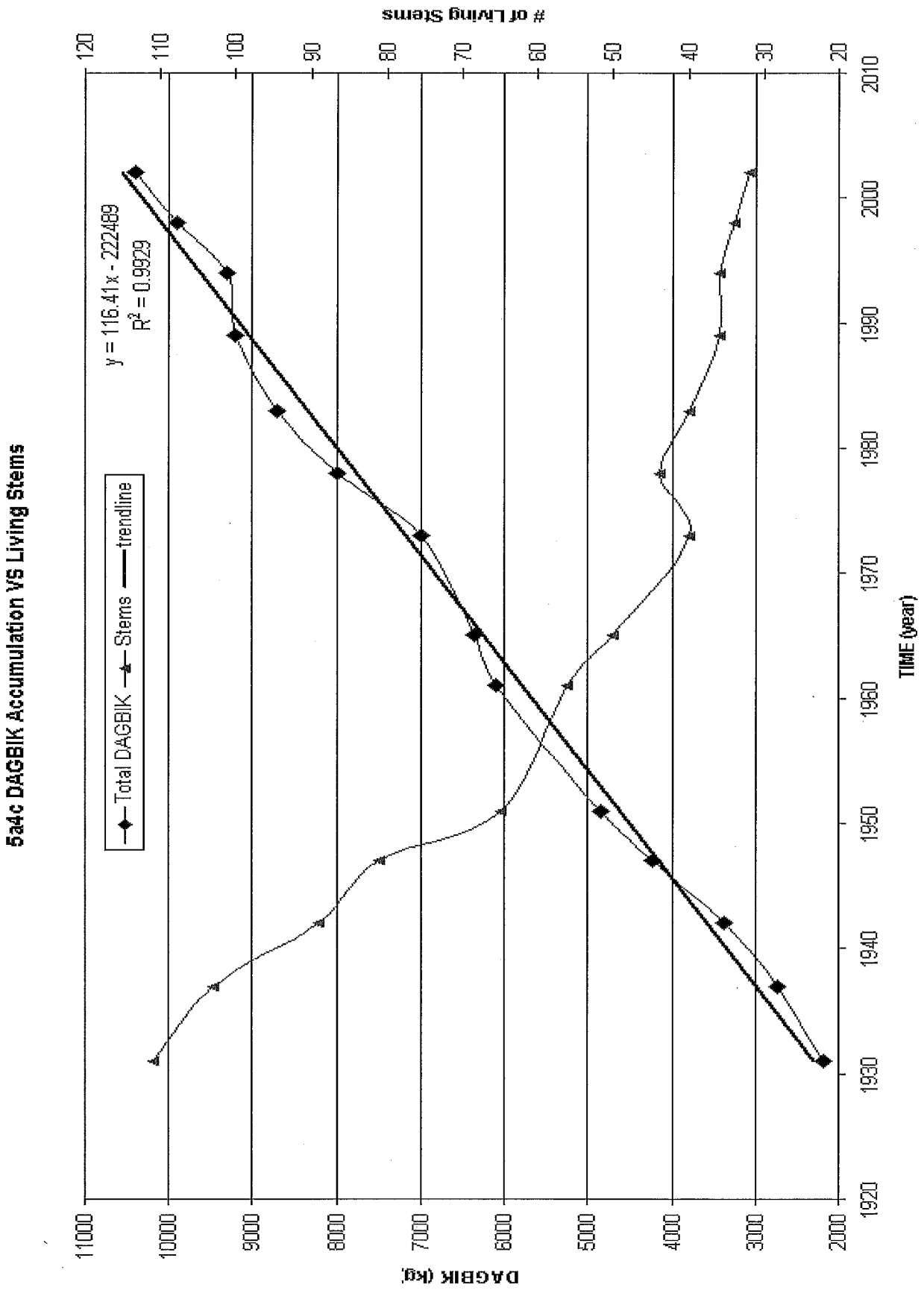
RED OAK BOLE #11									
Date	Time	Temp (C)							
1-May		None	Field Wgt (lbs)	24	(10.89 kg)	10890.0	g		
The Bole was cut into 4s in order to fit in the oven, mass in grams									
8-May	10:30a	None	11a	2871.1	2870.6				
			11b	1964	1962.1				
			11c	1551.5	1551.2	(%)	loss in evaporated biomass		
			11d	2402.2	2401.0				
			TOTAL	8788.8	8784.8	19.3	AVG	8786.8	(19.37 lbs)
13-May	9:15a	115	11a	1879.8					
			11b	1397.1					
			11c	1210.2					
			11d	1637.4			(%) BEGINNING MARCH 8TH		
			TOTAL	6114.5		43.9	30.4		
19-May	10:30a	121	11a	1868.8					
			11b	1377.6					
			11c	1205					
			11d	1627.4					
			TOTAL	6078.9		44.2	30.0		
21-May	9:20a	116	11a	1867.5					
			11b	1376.4					
			11c	1204.7					
			11d	1625.7					
			TOTAL	6074.3		44.2	30.9		
22-May	11:05a	115	11a	1865					
			11b	1375.5					
			11c	1202.7					
			11d	1625					
			TOTAL	6068.2		44.3	30.9		
25-May	3:00p	115	11a	1861.2					
			11b	1372.9					
			11c	1202.8					
			11d	1623.2					
			TOTAL	6060.1		44.4	31.0		
26-May	1:30p	116	11a	1858.4					
			11b	1372.1					
			11c	1202.2					
			11d	1622.3					
			TOTAL	6055		44.4	31.1		
2-Apr	4:15p	115	11a	1853.3					
			11b	1370					
			11c	1200.5					
			11d	1620					
			TOTAL	6043.8		44.5	31.2		
4-Apr	11:45a	115	11a	1851.8					
			11b	1368.2					
			11c	1199.1					
			11d	1616.9					
			TOTAL	6036		44.6	31.3		
10-Apr	5:50p	115	11a	1848.1					
			11b	1366.8					
			11c	1198.9					
			11d	1616					
			TOTAL	6029.8		44.6	31.4		
15-Apr	11:35a	115	11a	1846.6					
			11b	1364.6					
			11c	1198.1					
			11d	1612.1					
			TOTAL	6021.4		44.7	31.5		
19-Apr	9:50a	116	11a	1841.2					
			11b	1362.3					
			11c	1196.5					
			11d	1609.8					
			TOTAL	6009.8		44.8	31.6		
30-Apr	9:20a	114	11a	1833.7					
			11b	1359.2					
			11c	1193.4					
			11d	1601.3					
			TOTAL	5986.6		45.0	31.9		
			FINAL	5986.6					

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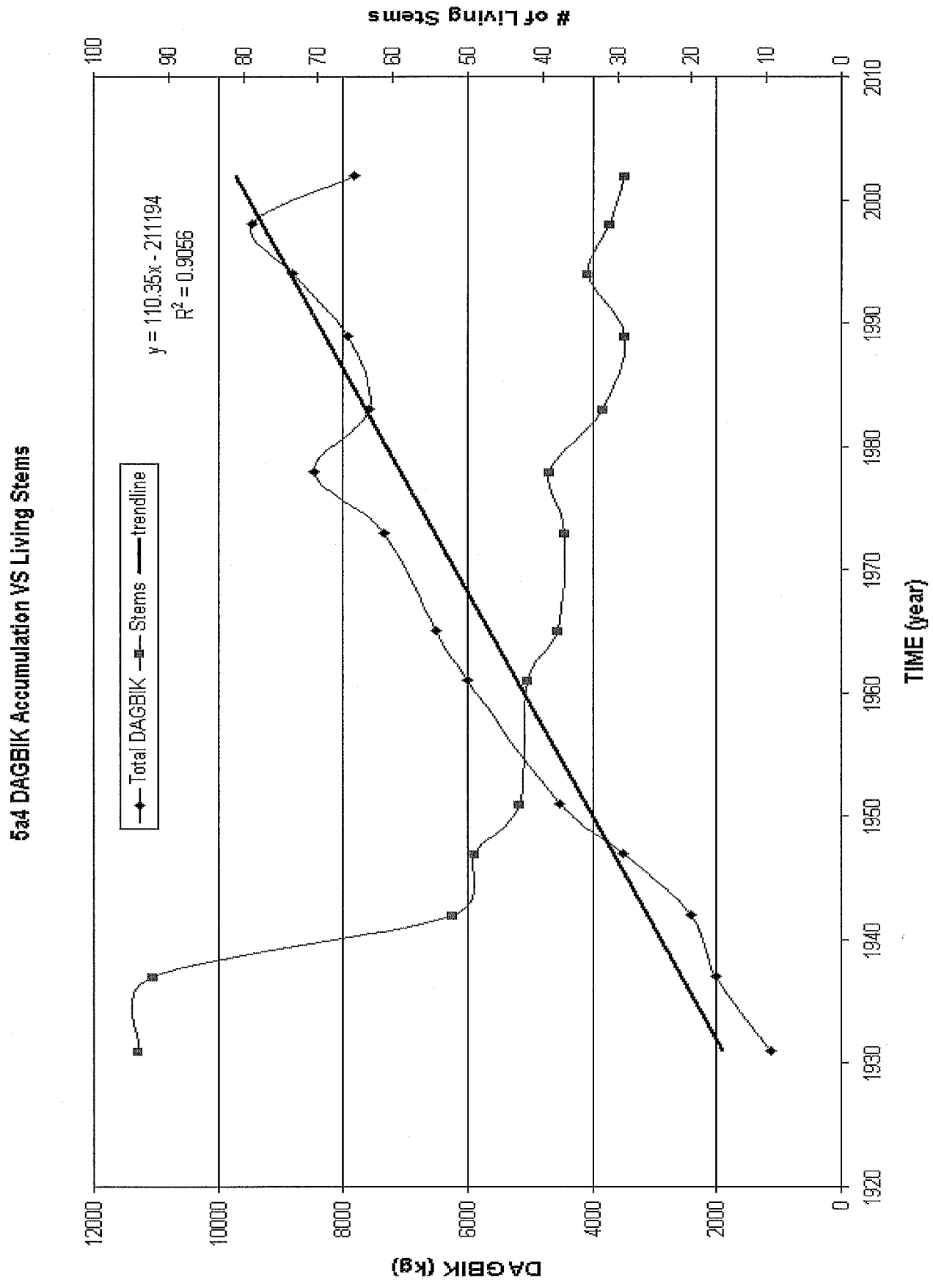
ABLE 12 Carbon/ Hectare

5a4c	Carbon/ Hectare (kg)													
Species	**1931**	**1937**	**1942**	**1947**	**1951**	**1961**	**1965**	**1973**	**1978**	**1983**	**1989**	**1994**	**1998**	**2002**
bb	305.20	337.34	430.16	507.96	588.87	727.71	712.33	850.93	894.62	951.99	1052.86	1060.10	1136.91	1210.16
bc	4.44	4.37	5.04	5.78	5.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
be	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.21	13.16	14.80	14.80	43.33	52.92
bg	81.46	102.66	123.23	155.78	186.01	262.44	270.07	328.50	395.44	444.47	529.42	581.85	642.52	685.09
bo	5.06	5.91	5.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.96	0.00	0.00	2.27	1.41	0.00
co	475.76	656.84	859.69	1169.97	1331.25	1729.73	1876.83	1969.79	2295.44	2536.39	2746.97	2412.99	2579.16	2699.01
gb	236.55	288.49	305.99	340.38	237.14	275.00	146.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
hm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.15	3.14	8.48	20.05	32.07	42.29
mw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.93	9.35	12.18
ph	79.97	77.64	27.82	12.90	8.35	2.73	3.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
rm	671.54	789.24	944.76	1051.05	1113.58	1098.75	1132.72	1194.17	1304.26	1350.11	1108.32	879.21	704.55	652.47
ro	354.82	560.98	829.16	1272.26	1768.18	2537.50	2771.11	3302.99	3924.55	4370.74	4802.62	5363.12	5905.61	6294.48
wo	445.63	518.66	579.59	644.16	672.95	816.31	838.00	893.57	916.34	951.06	974.60	998.44	1022.60	1033.44
TOTAL	2660.42	3342.13	4111.34	5160.23	5912.11	7450.17	7750.39	8539.96	9755.97	10621.05	11238.07	11338.77	12077.51	12682.04
Rate		0.20	0.19	0.20	0.13	0.21	0.04	0.09	0.12	0.08	0.05	0.01	0.06	0.05
5a4	Carbon/ Hectare (kg)													
Species	**1931**	**1937**	**1942**	**1947**	**1951**	**1961**	**1965**	**1973**	**1978**	**1983**	**1989**	**1994**	**1998**	**2002**
bb	57.82	106.69	120.57	179.95	246.01	307.12	314.60	279.03	324.10	344.49	380.68	401.38	392.79	423.88
bc	1.01	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bg	18.31	32.87	48.40	96.41	121.26	121.25	136.82	169.76	226.36	256.47	318.43	354.58	400.40	429.84
co	279.65	499.85	584.94	834.29	991.51	1289.26	1401.01	1562.80	1812.57	0.00	0.00	0.00	0.00	0.00
dw	0.00	0.00	0.00	0.00	0.00	18.79	25.31	33.65	40.27	23.42	0.00	1.53	0.00	0.00
ph	4.96	9.06	7.35	4.60	4.60	5.34	6.16	7.05	9.07	9.07	9.07	0.00	0.00	0.00
rm	243.11	395.08	263.82	395.39	518.22	702.30	741.04	427.21	533.68	534.61	609.96	670.09	749.80	793.90
ro	427.56	817.45	1186.37	1783.55	2455.09	3268.38	3551.17	4359.00	5043.66	5482.33	5931.11	6668.47	7240.83	7700.05
sb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sh	17.12	38.27	56.31	78.87	91.96	101.38	106.31	111.39	116.61	116.61	116.61	116.61	116.61	115.95
sm	2.60	5.76	7.22	11.94	11.94	16.79	18.24	24.66	31.68	40.27	40.27	42.81	46.56	47.36
so	333.68	578.16	686.54	950.84	1130.05	1549.01	1712.84	2041.67	2267.42	2480.61	2308.06	2537.01	2596.71	0.00
TOTAL	1385.82	2484.70	2961.52	4335.85	5570.64	7379.65	8013.51	9036.22	10405.42	9287.89	9714.19	10792.48	11543.69	9510.98
Rate		0.44	0.16	0.32	0.22	0.25	0.08	0.11	0.13	-0.12	0.04	0.10	0.07	-0.21

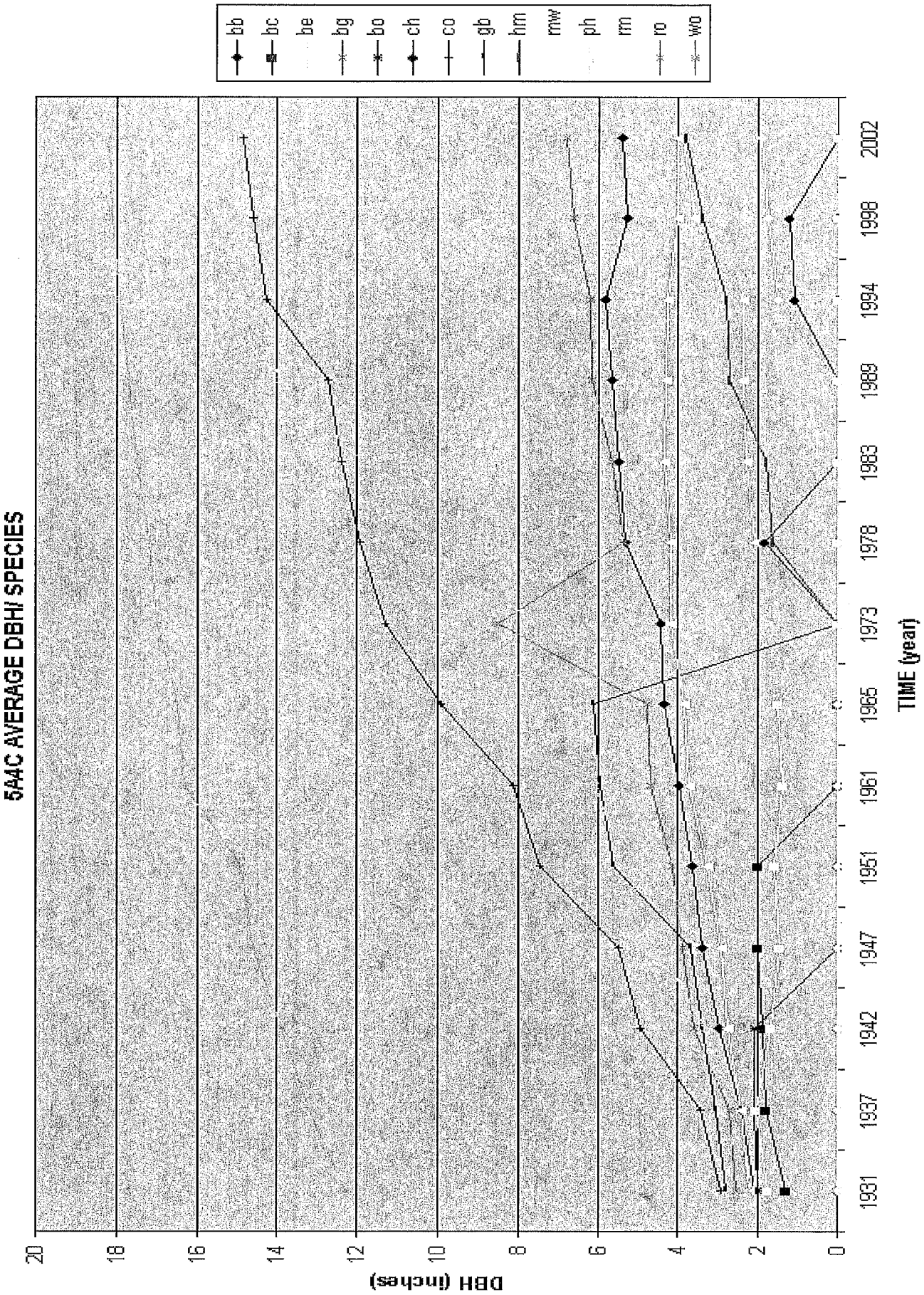
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5a4c DAGBIK Accumulation VS Living Stems
Total DAGBIK
Stems
trendline
y = 116.41x - 222489
R² = 0.9929
DAGBIK (kg)
# of Living Stems
TIME (year)
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
120
110
100
90
80
70
60
50
40
30
20
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

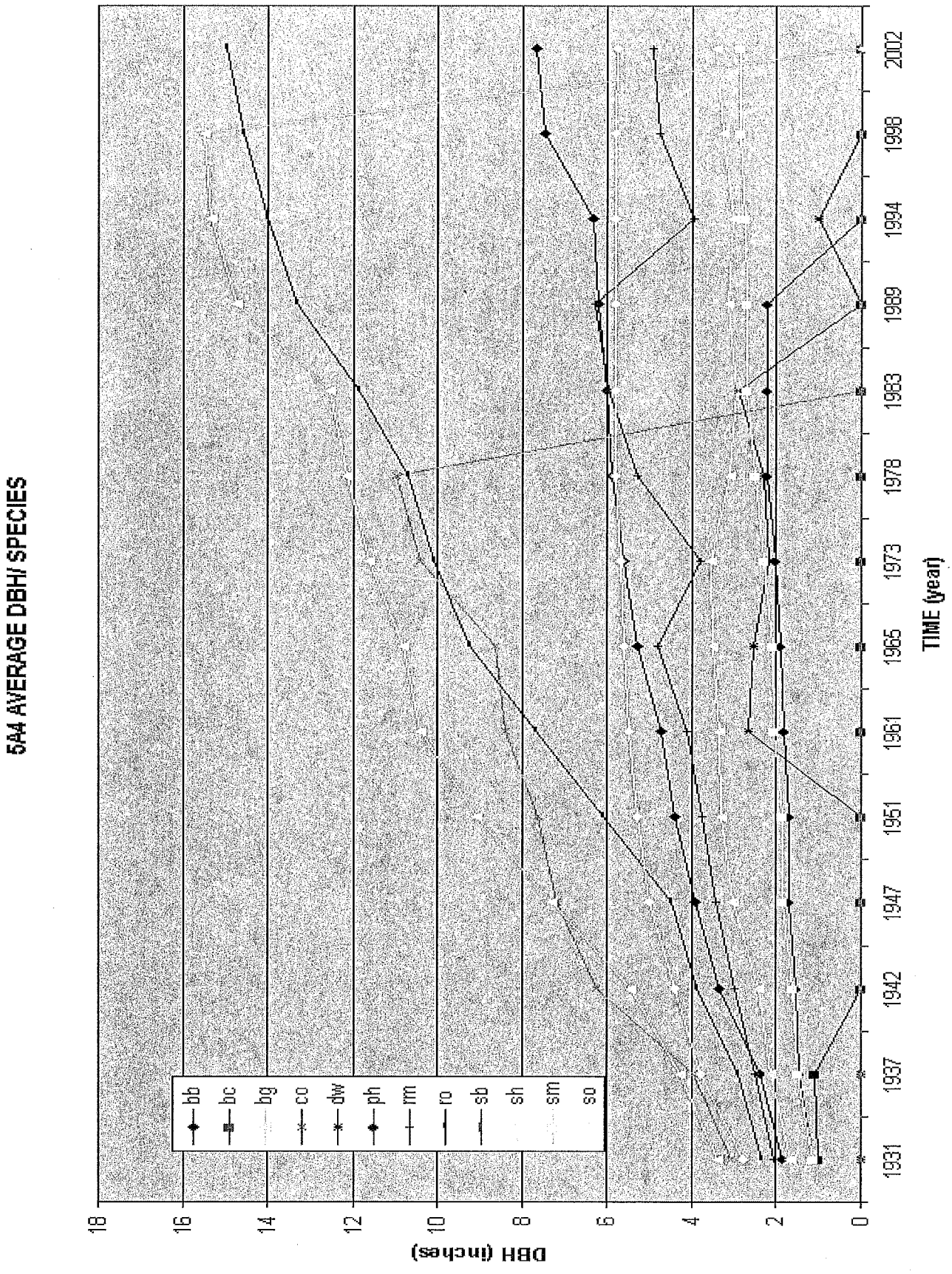
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5a4 DAGBIK Accumulation VS Living Stems
Total DAGBIK
Stems
trendline
y = 110.35x - 211194
R² = 0.9056
DAGBIK (kg)
# of Living Stems
TIME (year)
12000
10000
8000
6000
4000
2000
0
100
90
80
70
60
50
40
30
20
10
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

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5A4C AVERAGE DBH/ SPECIES
DBH (inches)
TIME (year)
bb
bc
be
bg
bo
ch
co
gb
hm
mw
ph
rm
ro
wo
0
2
4
6
8
10
12
14
16
18
20
1931
1937
1942
1947
1951
1961
1965
1973
1978
1983
1989
1994
1998
2002

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5A4 AVERAGE DBH/ SPECIES
DBH (inches)
TIME (year)
0
2
4
6
8
10
12
14
16
18
1931
1937
1942
1947
1951
1961
1965
1973
1978
1983
1989
1994
1998
2002
bb
bc
bg
co
dw
ph
rm
ro
sb
sh
sm
so

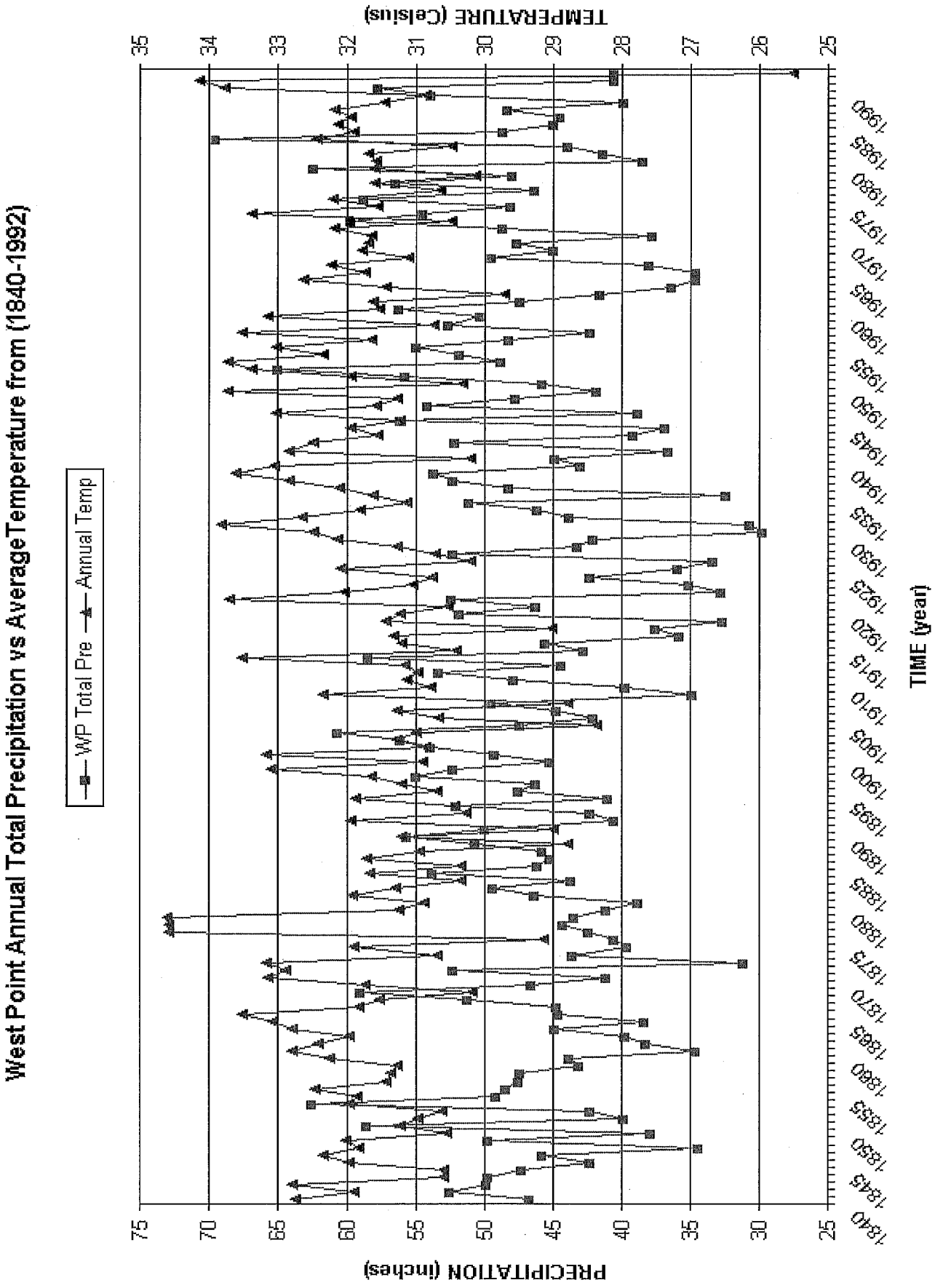
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TABLE 6 Average DBH/ Species

5a4c	AVG DBH / Species (in)													
Species	**1931**	**1937**	**1942**	**1947**	**1951**	**1961**	**1965**	**1973**	**1978**	**1983**	**1989**	**1994**	**1998**	**2002**
bb	2.0846	2.4231	2.9583	3.4	3.6545	3.9909	4.3667	4.45	5.3286	5.4714	5.6571	5.8333	5.2571	5.4106
bc	1.3	1.8	1.9	2	2									
be									2.1	2.3	2.4	2.4	3.6	3.8976
bg	2.5333	2.7	3.6	3.9	4.15	4.7	4.75	8.5	5.35	5.65	6.15	6.2	6.6	6.7717
bo	2	2.1	2.1						1.85			1.1	1.2	
ch														
co	2.9357	3.4385	4.9375	5.5	7.44	8.12	9.925	11.3	11.933	12.367	12.733	14.25	14.6	14.843
gb	2.82	3.05	3.375	3.6857	5.6	5.95	6.1							
hm									1.65	1.8	2.7	2.8	3.4	3.7992
mw												1.5	1.75	1.9291
ph	1.7778	2.0667	1.68	1.45	1.6	1.4	1.5							
rm	2.235	2.4128	2.7457	2.9353	3.2759	3.7409	3.8476	4.1737	4.175	4.3474	4.325	4.2692	4.0364	3.9961
ro	2.2778	2.9	3.325	4.4615	5.3	6.0833	6.5636	10.483	11.3	11.85	13.92	14.64	15.3	15.756
wo	12.3	13.2	13.9	14.6	14.9	16.3	16.5	17	17.2	17.5	17.7	17.9	18.1	18.189
5a4	AVG DBH / Species (in)													
Species	**1931**	**1937**	**1942**	**1947**	**1951**	**1961**	**1965**	**1973**	**1978**	**1983**	**1989**	**1994**	**1998**	**2002**
bb	4.65	5.95	5.5667	9.75	10.95	11.85	10.55	16.8	3.54	6.0333	6.2333	3.8	3.725	5.105
bc	1	1.1	0	0	0	0	0	0	0	0	0			
bg	0.5857	0.6538	1.2125	1.5125	3.3	3.35	4.6667	8.9	12.45	14.8	17.25	19.65	21.2	22.264
co	3.4	4.4144	3.5857	4.7833	15.25	16.75	34.5		32.9	0	0	0	0	0
dw	0	0	0	0	0	5.3	7.6		13.8			0.3333	0	0
ph	1.1333	2.15	3.1	1.7	1.7									
rm	1.7875	2.3138	1.1462	1.372	1.781	2.4294	2.4063	1.52	1.5143	1.2786	1.7182	2.38	3.4143	4.1076
ro	2.7348	3.7429	3.67	4.4944	4.6471	5.4857	5.6923	10.1	8.57	9.2333	9.975	14.017	12.471	12.829
sb	0	0	0	0										
sh	2.8	3.8	4.4	5	5.3	5.5	5.6	5.7	5.8	5.8	5.8	5.8	5.8	5.7874
sm	1.15	1.5	1.6	1.85	1.85	2.05	4.2	4.6	5	5.4	5.4	5.5	5.7	5.7087
so	11.85	14.95	13.6	29.2	27.3	31.2	16.25	34.9	36.4	37.7	29.5	30.7	31	0

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CHART 6 WP Weather Data



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West Point Total Precipitation vs. Annual Temperature								
Year	Total Precipitation	Annual Temperature (F)	Celsius		Year	Total Precipitation	Annual Temperature (F)	Celsius
1840	46.79	50.52	32.74		1916	35.85	49.11	31.33
1841	52.56	49.68	31.90		1917	37.61	46.79	29.01
1842	49.86	50.56	32.78		1918	32.69	49.22	31.44
1843	49.82	48.38	30.60		1919	51.85	49.00	31.22
1844	47.27	48.38	30.60		1920	46.23	48.32	30.54
1845	42.34	49.76	31.98		1921	52.48	51.48	33.70
1846	45.79	50.12	32.34		1922	32.78	49.82	32.04
1847	34.44	49.62	31.84		1923	35.1	48.82	31.04
1848	49.82	49.79	32.01		1924	42.3	48.54	30.76
1849	37.92	48.34	30.56		1925	35.97	49.87	32.09
1850	58.55	49.02	31.24		1926	33.4	47.99	30.21
1851	39.94	48.75	30.97		1927	52.35	48.51	30.73
1852	42.3	48.41	30.63		1928	43.23	49.05	31.27
1853	62.56	49.75	31.97		1929	42.07	49.91	32.13
1854	49.14	49.64	31.86		1930	29.76	50.27	32.49
1855	48.47	50.25	32.47		1931	30.67	51.60	33.82
1856	47.53	49.21	31.43		1932	43.78	50.44	32.66
1857	47.4	49.15	31.37		1933	46.15	49.60	31.82
1858	43.17	49.05	31.27		1934	51.18	48.92	31.14
1859	43.82	50.03	32.25		1935	32.48	49.41	31.63
1860	34.7	50.58	32.80		1936	48.24	49.90	32.12
1861	38.3	50.20	32.42		1937	52.27	50.62	32.84
1862	39.8	49.75	31.97		1938	53.76	51.39	33.61
1863	44.9	50.58	32.80		1939	43.03	50.62	33.04
1864	38.36	50.84	33.06		1940	44.83	47.98	30.20
1865	44.68	51.30	33.52		1941	36.65	50.62	32.84
1866	44.72	49.61	31.83		1942	52.25	50.26	32.48
1867	51.32	49.32	31.54		1943	39.22	49.34	31.56
1868	59.02	47.97	30.19		1944	36.89	49.72	31.94
1869	46.65	49.52	31.74		1945	56.12	49.01	31.23
1870	41.14	50.92	33.14		1946	38.83	50.81	33.03
1871	52.29	50.66	32.88		1947	54.15	49.37	31.59
1872	31.2	50.94	33.16		1948	47.79	49.05	31.27
1873	43.59	48.48	30.70		1949	41.88	51.49	33.71
1874	39.66	49.69	31.91		1950	45.86	48.10	30.32
1875	40.58	46.92	29.14		1951	55.79	49.72	31.94
1876	42.42	52.35	34.57		1952	65.01	51.14	33.36
1877	44.28	52.35	34.57		1953	48.8	51.49	33.71
1878	43.5	52.39	34.61		1954	51.84	50.12	32.34
1879	41.14	49.03	31.25		1955	55.05	50.81	33.03
1880	38.8	48.67	30.89		1956	48.28	49.43	31.65
1881	46.43	49.70	31.92		1957	42.29	51.29	33.51
1882	49.39	49.08	31.30		1958	52.66	48.53	30.75
1883	43.77	48.12	30.34		1959	50.35	50.91	33.13
1884	53.8	49.45	31.67		1960	56.33	49.32	31.54
1885	46.17	48.13	30.35		1961	47.43	49.40	31.62
1886	45.29	49.50	31.72		1962	41.69	47.49	29.71
1887	45.87	48.72	30.94		1963	36.37	49.23	31.45
1888	50.73	46.58	28.80		1964	34.68	50.40	32.62
1889	55.74	48.98	31.20		1965	34.7	49.52	31.74
1890	50.03	46.78	29.00		1966	38.06	50.01	32.23
1891	40.62	49.72	31.94		1967	49.49	48.89	31.11
1892	42.36	48.06	30.28		1968	45.05	49.56	31.78
1893	52.09	48.22	30.44		1969	47.63	49.47	31.69
1894	41.08	49.66	31.88		1970	37.79	49.42	31.64
1895	47.54	48.48	30.70		1971	48.74	49.97	32.19
1896	46.33	48.99	31.21		1972	59.74	48.26	30.48
1897	55.04	49.43	31.65		1973	54.51	51.16	33.38
1898	52.37	50.86	33.08		1974	48.18	49.33	31.55
1899	45.28	48.68	30.90		1975	58.85	49.98	32.20
1900	49.28	50.95	33.17		1976	46.37	48.44	30.66
1901	54	48.64	30.86		1977	56.47	49.38	31.60
1902	56.15	49.06	31.28		1978	47.99	47.92	30.14
1903	60.64	48.78	31.00		1979	62.44	49.39	31.61
1904	47.43	46.15	28.37		1980	38.45	49.36	31.58
1905	42.08	48.45	30.67		1981	41.38	49.48	31.70
1906	44.82	49.05	31.27		1982	44.01	48.26	30.48
1907	49.53	46.58	28.80		1983	69.49	50.22	32.44
1908	34.83	50.13	32.35		1984	48.71	49.68	31.90
1909	39.73	48.58	30.80		1985	44.96	49.92	32.14
1910	47.89	48.91	31.13		1986	44.51	49.72	31.94
1911	53.37	48.75	30.97		1987	48.42	49.96	32.18
1912	44.45	48.94	31.16		1988	39.83	49.25	31.47
1913	58.5	51.28	33.50		1989	53.94	48.64	30.86
1914	42.81	48.20	30.42		1990	57.81	51.55	33.77
1915	45.58	48.99	31.21		1991	40.58	51.91	34.13
					1992	40.61	43.28	25.60

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Year 2000
Weights of Chestnut Oak Bundles

Bundle #	Weight (lbs)
1	138
2	182
3	210
4	150
5	133
6	139
7	116
8	132
9	126
10	148
11	97
12	80
13	25
14	175
15	185
16	142
17	134
18	109
19	42
TOTAL	2463

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