Survey of Flowering American Chestnut in the Great Smoky Mountains National Park

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Introduction

American chestnut (*Castanea dentata*) was once a dominant tree species throughout the Appalachian mountains. The tree was highly valued for its versatility as a wood product, and for the abundant and annually reliable crop of nuts it produced.
In 1904 the status of American chestnut was drastically altered with the introduction of chestnut blight (*Cryphonectria parasitica*) to the U.S. The blight is a fungal pathogen on the bark of chestnut apparently introduced on Asiatic chestnut . The spread of chestnut blight from its earliest observations in New York City was rapid due to the American chestnut's high susceptibility. By 1925 the blight had reached the area today known as the Great Smoky Mountains National Park (Woods and Shanks 1959).

Historically, American chestnut was the dominant component of the drier slopes and ridges in association with various oak species (*Quercus* spp.), occurring from the lowest elevations of the park up to 5500ft and occasionally 6000ft (Whittaker 1956). At the mid to lower elevations American chestnut occurred primarily with chestnut oak (*Quercus montana*) as the dominant overstory (Whittaker 1956). Northern red oak (*Quercus rubra*) and white oak (*Quercus alba*) became more important canopy associates at higher elevations (Whittaker 1956). American chestnut was also present as a lesser component of the dry ridge top pine forests and occasionally occurred as a dominant tree in cove hardwood forests (Whittaker 1956). The arrival of chestnut blight to the Great Smoky Mountains caused rapid, park-wide decline of American chestnut. By the mid to late 1930's most trees were dead or severely impacted by the blight (Stupka 1964).

The earliest park records of American chestnut decline and persistence through resprouting began in the early 1930’s when Arthur Stupka became the park’s first

naturalist. Stupka made a wealth of natural history observations related not only to American chestnut but also wildlife habits, flowering times for various plants and trees, etc., which continued through his retirement around 1960 .

Dr. Frank Woods and Royal Shanks conducted a study during this period to examine the natural replacement of American chestnut in Great Smoky Mountains. The most abundant species found replacing chestnut were chestnut oak, Northern red oak, and red maple (*Acer rubrum*). Overall, oaks made up the highest percentage of replacement. Rosebay rhododendron (*Rhododendron maximum*) and mountain laurel (*Kalmia latifolia*) were also noted as important understory components in chestnut canopy gaps. In cove hardwood forests chestnuts were being replaced be more mesic species often including Eastern hemlock (*Tsuga canadensis*) (Woods and Shanks 1959). A follow-up study in the early 1980's reported similar findings and stated the red maple and sourwood (*Oxydendrum arboreum*) were the most favored species following the loss of chestnut (Arends 1981).

Following Arthur Stupka's retirement, park records concerning observations of American chestnut became infrequent and usually involved individual sightings by park employees or visitors. In the late 1980's and on into the early 1990's some locations of flowering American chestnut were recorded as part of a blight resistance project using grafts. This project was conducted in cooperation with Dr. Scott Schlarbaum of the University of Tennessee, Department of Forestry.

Currently, with the possible development of a blight resistant chestnut, the park could potentially use flowering chestnut location information to begin a breeding program. The purpose of this study was to expand upon the existing chestnut records

through a park-wide survey of remaining flowering American chestnut. This will provide the park with baseline data concerning chestnut distribution, and it will provide the first step in consideration for possible future restoration of the American chestnut.

Methods

Locations for the survey were selected from the park's existing chestnut location database, which includes early observations by Arthur Stupka, more recent observations by employees and visitors, and all location records from the University of Tennessee chestnut grafting project. Trails with known flowering chestnut locations were surveyed to confirm the presence of existing trees and to look for previously unrecorded trees. Additional surveying was done for trails with similar aspect, elevation, and forest type to areas containing known trees and with natural replacement occurring as suggested in the previous studies. All chestnuts with visible flowers present and all chestnuts trees 10cm in diameter or greater were recorded along each trail. The total survey covered over 800 miles of trail.

Locations and elevations of each individual chestnut were recorded with a Global Positioning System (Garmin GPS 3 Plus) unit. All waypoints were marked in UTM coordinates on the NAD27 map datum, and elevations were recorded in feet. Each tree was numbered using two letters from the trail name, "C" for chestnut, and two digit beginning with "01". The date each tree was observed was also recorded (Example: tree number 1 on Cove Mountain Trail="CMC01").

In addition to location, various measurements were recorded for each tree. Diameter at breast height (dbh) measurements were recorded using a metric diameter

tape. Tree heights were calculated by measuring a level distance with a meter tape far enough from the tree to see the entire length of the stem, and from this point angles to the top and bottom of the tree were measured with the degree scale on a Suunto clinometer. Aspect was measured by using a compass to obtain the general direction of the slope. Percent slope was measured by finding the percent grade of the slope to an eye-level object upslope and downslope from the tree using the percent scale on a Suunto clinometer and averaging the two percentages. Percent canopy of surrounding overstory was measure on four sides of the tree at 90 degrees from each other with a spherical densiometer and averaging the four percentages. A spherical densiometer is a 2 inch diameter reflective, concave circle of stainless steel with a grid etched into it and set into a block of wood. Density of canopy is determined by holding the densiometer level and at a forearm's length away from the body, and determining the percentage of overstory shading on the grid. Presence of flowers, fruit, sprouts, and blight, which is observed by stem cankering, swelling, and dieback were recorded as being present or not present.

Presence of all associate trees and shrubs in the overstory (defined as all dominant and co-dominant size trees) and midstory (defined as all intermediate to sapling size trees and shrubs) were recorded within 20 meters of each chestnut.

Site descriptions were also recorded for each individual tree. The approximate distance from a known point or landmark to the study tree was recorded along with distance and general directions off trail. Trees were noted as upslope or downslope off the trail when the trail ran along a slope. General comments on stem form, severity of blight, and level of bark development were also recorded.

All data were entered into a Microsoft Access database for analysis and UTM coordinates were linked to ArcMap to create a park wide map of the distribution of flowering American chestnut.

Results

There were a total of 288 individual chestnut trees recorded (Figure 1). Observed flowering trees comprised 157 or 54.5% of the total individuals (Figure 2). Observed fruiting trees comprised 31 or 10.8% of the total individuals. Blight was present in 147 or 51.0% of all individual trees observed. Sprouting occurred in 119 or 41.3% of all individual trees observed.

Tree measurement data were analyzed in relation to flowering. The largest dbh recorded for a flowering chestnut was 31.0cm and the smallest recorded was 3.7cm. The average dbh for flowering trees was 11.7cm. The tallest flowering tree recorded was 20.3m and the shortest recorded was 3.1m. The average height for flowering trees was 9.9m.

The densest canopy recorded for flowering trees was 67.8 % and the least dense was 2.5%. The average percent canopy for flowering trees was 22.3%. The greatest slope for flowering trees was 80.0% and the least slope was 2.5%. The average percent slope for flowering trees was 30%.

The elevation for flowering trees ranged from 592m (1943ft) to 1778m (5834ft). The average elevation for flowering trees was 1213m (3981ft).

Table 1 shows the aspect across all 157 locations of flowering individuals. A south aspect was present in the highest percentage of locations at 25.5%. Western aspects

occurred across 10.8% of locations. Eastern aspects occurred across 7.0% of locations. North aspects were only observed across 5.1% of locations.

Table 1. Aspect across 157 locations of individual flowering American chestnut

Direction	Number of Locations	Percent of Locations
S	40	25.5%
SE	22	14.0%
SW	17	10.8%
W	17	10.8%
NW	12	7.6%
E	11	7.0%
SSE	9	5.7%
N	8	5.1%
SSW	7	4.5%
NE	4	2.5%
NNE	2	1.3%
ESE	2	1.3%
WSW	2	1.3%
WNW	2	1.3%
ENE	1	0.6%
NNW	1	0.6%

Table 2 shows presence of associate overstory tree species at all 288 individual chestnut locations. The tree species occurring at the highest percentage of locations were Northern red oak (54.5%), chestnut oak (46.9%), and red maple (37.5%). White oak and scarlet oak were also common associates at 25.3% and 16.7% respectively.

Table 2. Presence of overstory tree species at 288 locations of individual American chestnut

Species	Scientific Name	Number of Locations	Percent of Locations
Northern Red Oak	*Quercus rubra*	157	54.5%
Chestnut Oak	*Quercus montana*	135	46.9%
Red Maple	*Acer rubrum*	108	37.5%
White Oak	*Quercus alba*	73	25.3%
Scarlet Oak	*Quercus coccinea*	48	16.7%
Black Oak	*Quercus velutina*	20	6.9%
Pitch Pine	*Pinus rigida*	17	5.9%
Black Cherry	*Prunus serotina*	15	5.2%
Eastern Hemlock	*Tsuga canadensis*	14	4.9%
Table Mtn Pine	*Pinus pungens*	12	4.2%
Virginia Pine	*Pinus virginiana*	12	4.2%
Pignut Hickory	*Carya glabra*	9	3.1%
Yellow Birch	*Betula allegheniensis*	8	2.8%
Black Locust	*Robinia psuedoacacia*	7	2.4%
Black Gum	*Nyssa sylvatica*	6	2.1%
Sourwood	*Oxydendrum arboreum*	5	1.7%
White Ash	*Fraxinus americana*	4	1.4%
White Pine	*Pinus strobus*	3	1.0%
Black Birch	*Betula lenta*	2	0.7%
Cucumber Magnolia	*Magnolia acuminata*	2	0.7%
Carolina Silverbell	*Halesia tetraptera*	2	0.7%
Red Spruce	*Picea rubens*	1	0.3%
Fraser Fir	*Abies fraseri*	1	0.3%
Fire Cherry	*Prunus pensylvanica*	1	0.3%
Shagbark Hickory	*Carya ovata*	1	0.3%
Mockernut Hickory	*Carya tomentosa*	1	0.3%
Bitternut Hickory	*Carya cordiformis*	1	0.3%
Fraser Magnolia	*Magnolia fraseri*	1	0.3%

Table 3 shows presence associate midstory tree and shrub species at all 288 individual chestnut locations. The tree species occurring at the highest percentage of locations were red maple (78.8%), American chestnut (67.4%), and Northern red oak

(52.4%). The shrub species occurring at the highest percentage of locations were mountain laurel (50.7%) and rosebay rhododendron (37.2%).

Table 3. Presence of midstory tree and shrub species at 288 locations of individual American chestnut

Species	Scientific Name	Number of Locations	Percent of Locations
Red Maple	*Acer rubrum*	227	78.8%
American Chestnut	*Castanea dentata*	194	67.4%
Northern Red Oak	*Quercus rubra*	151	52.4%
Mtn Laurel	*Kalmia latifolia*	146	50.7%
Allegheny Serviceberry	*Amelanchier laevis*	117	40.6%
Sourwood	*Oxydendrum arboreum*	115	39.9%
Rosebay Rhodo	*Rhododendron maximum*	107	37.2%
Eastern Hemlock	*Tsuga canadensis*	105	36.5%
Chestnut Oak	*Quercus montana*	104	36.1%
Striped Maple	*Acer pensylvanicum*	93	32.3%
Azalea	*Rhododendron* spp.	83	28.8%
Blueberry	*Vaccinium* spp.	83	28.8%
Black Gum	*Nyssa sylvatica*	77	26.7%
Black Cherry	*Prunus serotina*	58	20.1%
Mtn Winterberry	*Ilex montana*	52	18.1%
Sassafras	*Sassafras albidum*	52	18.1%
White Oak	*Quercus alba*	45	15.6%
Scarlet Oak	*Quercus coccinea*	39	13.5%
Huckleberry	*Gaylussacia* spp.	39	13.5%
Yellow Birch	*Betula allegheniensis*	35	12.2%
Black Birch	*Betula lenta*	31	10.8%
Black Oak	*Quercus velutina*	29	10.1%
Carolina Silverbell	*Halesia tetraptera*	29	10.1%
Cucumber Magnolia	*Magnolia acuminata*	29	10.1%
Table Mtn Pine	*Pinus pungens*	26	9.0%
Black Locust	*Robinia psuedoacacia*	22	7.6%
Pignut Hickory	*Carya glabra*	22	7.6%
Buffalonut	*Pyrularia pubera*	19	6.6%
Red Spruce	*Picea rubens*	19	6.6%
American Beech	*Fagus grandifolia*	19	6.6%
White Pine	*Pinus strobus*	18	6.3%
Virginia Pine	*Pinus virginiana*	15	5.2%

Table 3 cont.

Sugar Maple	*Acer saccharum*	12	4.2%
Fraser Magnolia	*Magnolia fraseri*	12	4.2%
White Ash	*Fraxinus americana*	12	4.2%
Yellow Buckeye	*Aesculus flava*	12	4.2%
Pitch Pine	*Pinus rigida*	11	3.8%
Yellow-poplar	*Liriodendron tulipifera*	11	3.8%
Catawba Rhodo	*Rhododendron catawbiense*	10	3.5%
Witch-hazel	*Hamamelis virginiana*	9	3.1%
White Basswood	*Tilia heterophylla*	7	2.4%
Shagbark Hickory	*Carya ovata*	5	1.7%
Hawthorn	*Crataegus* spp.	5	1.7%
Mtn Pepperbush	*Clethra acuminata*	4	1.4%
Fire Cherry	*Prunus pensylvanica*	4	1.4%
Elderberry	*Sambucus canadensis*	3	1.0%
Fraser Fir	*Abies fraseri*	2	0.7%
Flowering Dogwood	*Cornus florida*	2	0.7%
Maple-leaved Viburnum	*Viburnum acerifolium*	2	0.7%
Post Oak	*Quercus stelata*	1	0.3%
Blackjack Oak	*Quercus marilandica*	1	0.3%
American Holly	*Ilex opaca*	1	0.3%
Mockernut Hickory	*Carya tomentosa*	1	0.3%
Bitternut Hickory	*Carya cordiformis*	1	0.3%
Alternate-leaf Dogwood	*Cornus alternifolia*	1	0.3%
Mtn Ash	*Sorbus americana*	1	0.3%
American Hornbeam	*Carpinus caroliniana*	1	0.3%
Eastern Hophornbeam	*Ostyra virginiana*	1	0.3%
Sweetshrub	*Calycanthus floridus*	1	0.3%

Discussion

The average measurements for dbh and height could provide useful target dimensions for predicting the flowering potential of chestnuts outside the flowering

season. Site factors such as slope, aspect, canopy cover, and elevation may help in predicting appropriate conditions for flowering. The associate tree and shrub species show a similar pattern to earlier studies on natural replacement of chestnut, and may provide a basis for predicting chestnut occurrence by forest types.

Since this study focused on trailside surveying, many potential off-trail areas have gone unmapped. UTM data could be analyzed through GIS for predictive modeling of American chestnut occurrence in the park. This would provide a set of likely off trail locations, which best fit site factors present at know points such as elevation, slope, and aspect. The advantage of using GIS modeling is the efficiency resulting from having clearly mapped potential sites which could be downloaded into a GPS unit.

Using the current location data on flowering chestnuts and any future off-trail data that may be collected, a harvesting program could be established to create a seed orchard. This would mean a readily available source of Great Smoky Mountains chestnut genotypes for future use in blight resistance breeding programs. Perhaps through these efforts chestnut could restored to the park.

References

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Stupka, Arthur. 1964. *Trees, Shrubs, and Woody Vines of the Great Smoky Mountains National Park*. University of Tennessee Press, Knoxville. 186 pp.

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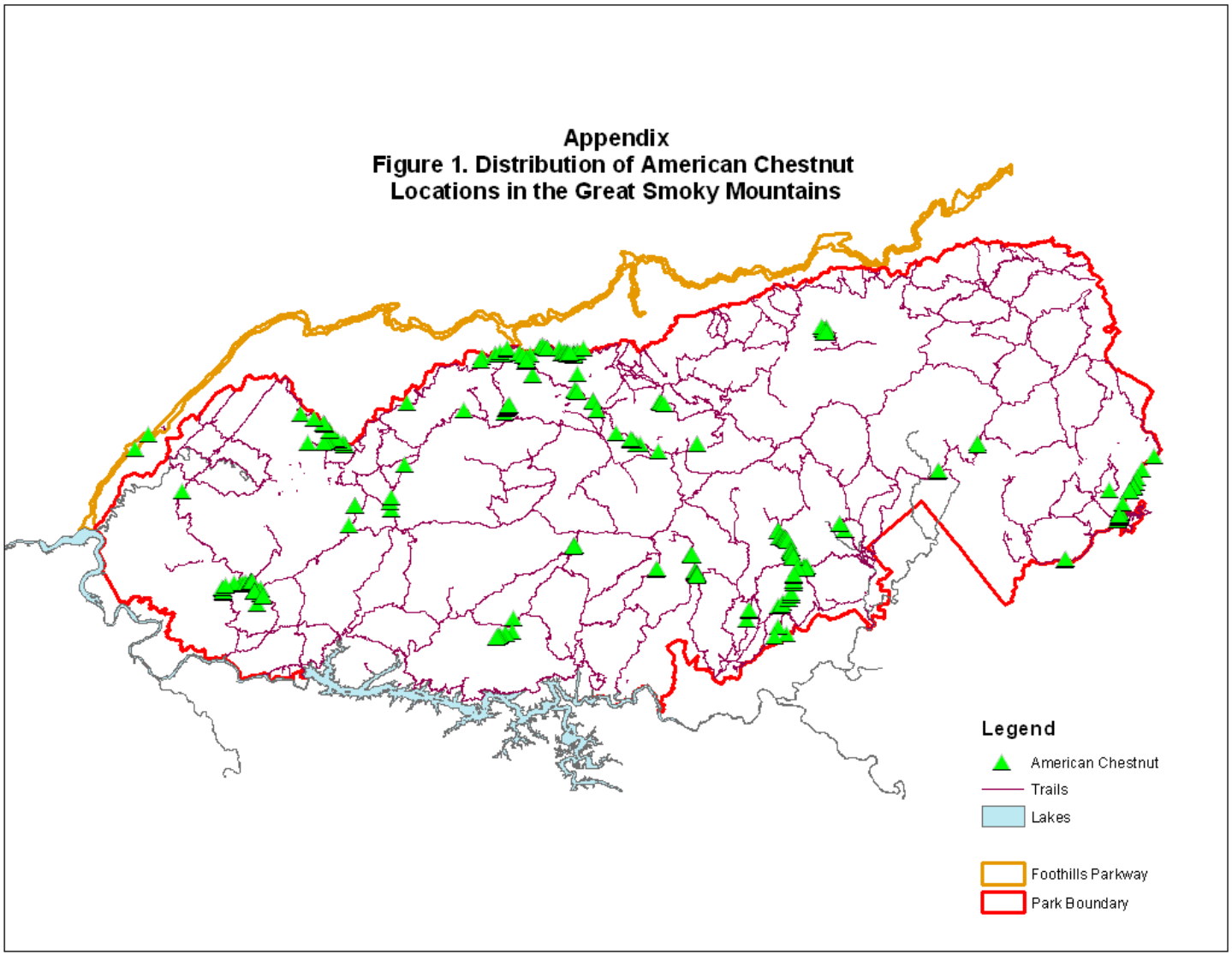
Appendix
Figure 1. Distribution of American Chestnut Locations in the Great Smoky Mountains



Appendix
Figure 2. Distribution of Flowering American Chestnut Locations in the Great Smoky Mountains