

# Impact of American chestnut blight on forest communities

Research Presentation (data, photos, review, and summary, 60 pages).

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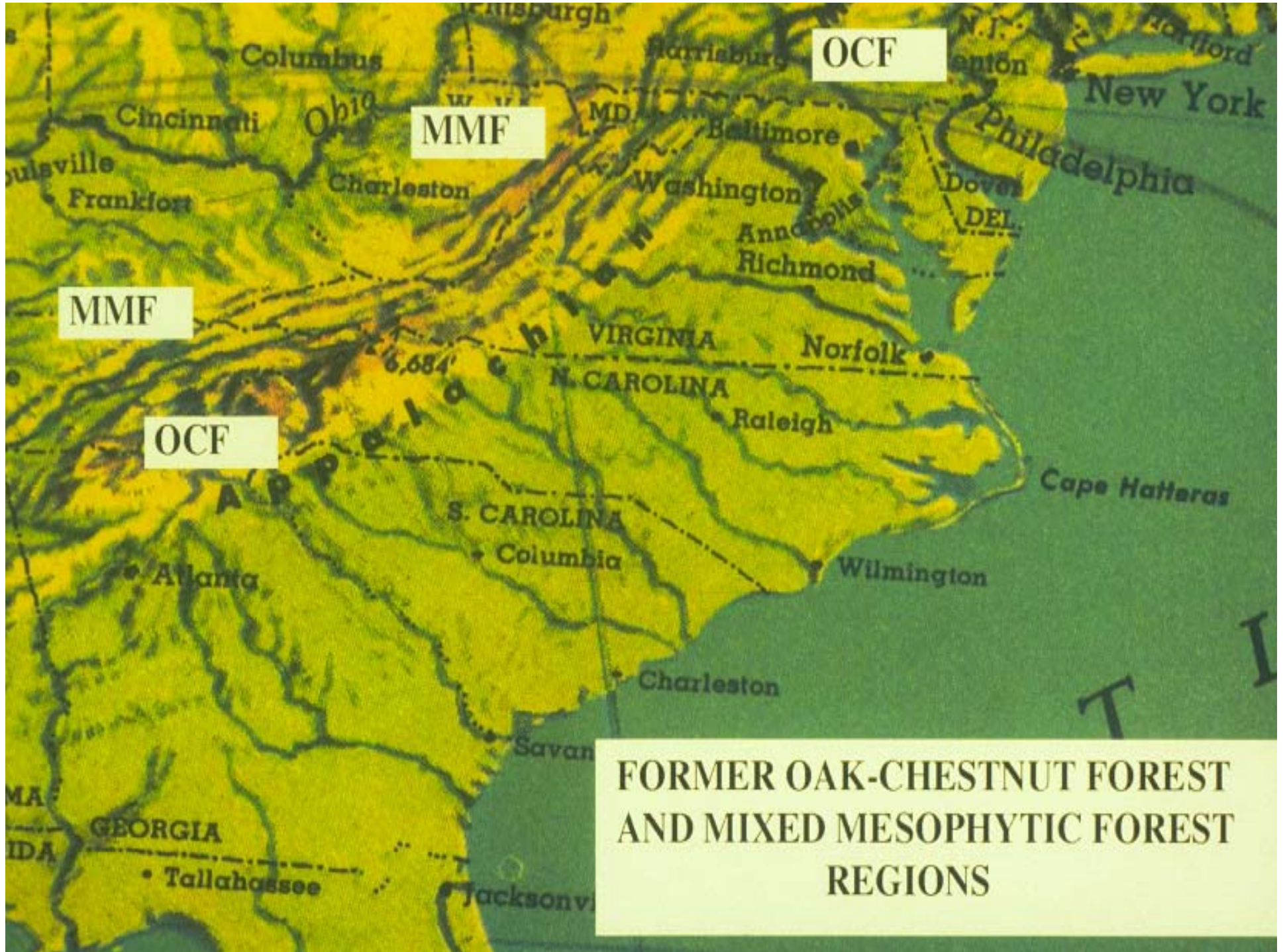
# Outline

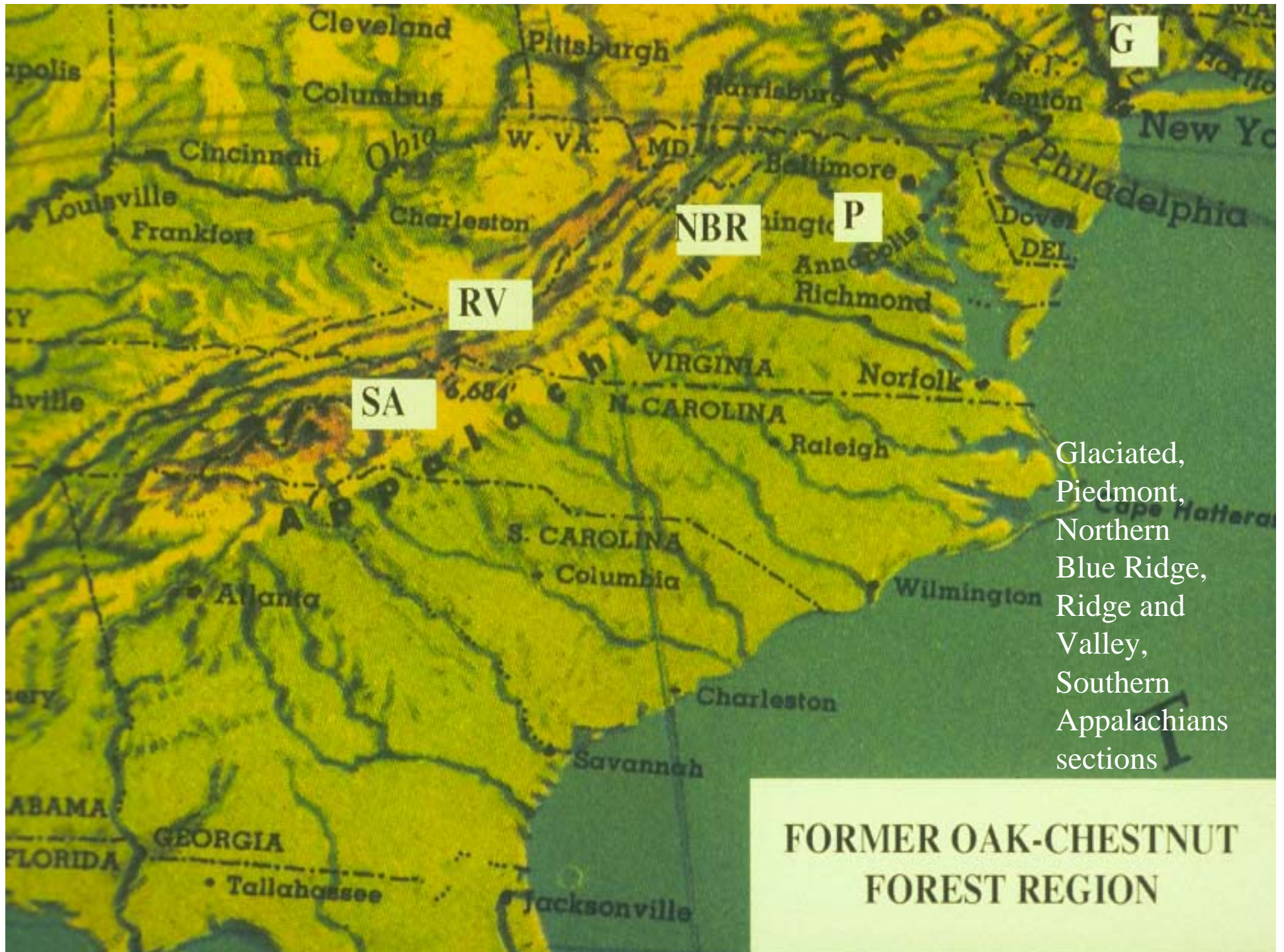
1. Distribution of American chestnut before chestnut blight
2. Replacement of blight-killed American chestnut trees in former Oak-Chestnut and Mixed Mesophytic forest communities
3. Survival of American chestnut in forest understory communities
4. Chestnut blight and survival of American chestnut in forest clearcuts

# Distribution of American chestnut before chestnut blight

This presentation uses the forest classification system of Lucy Braun, former Professor of Plant Ecology, University of Cincinnati, outlined in her outstanding book contribution:

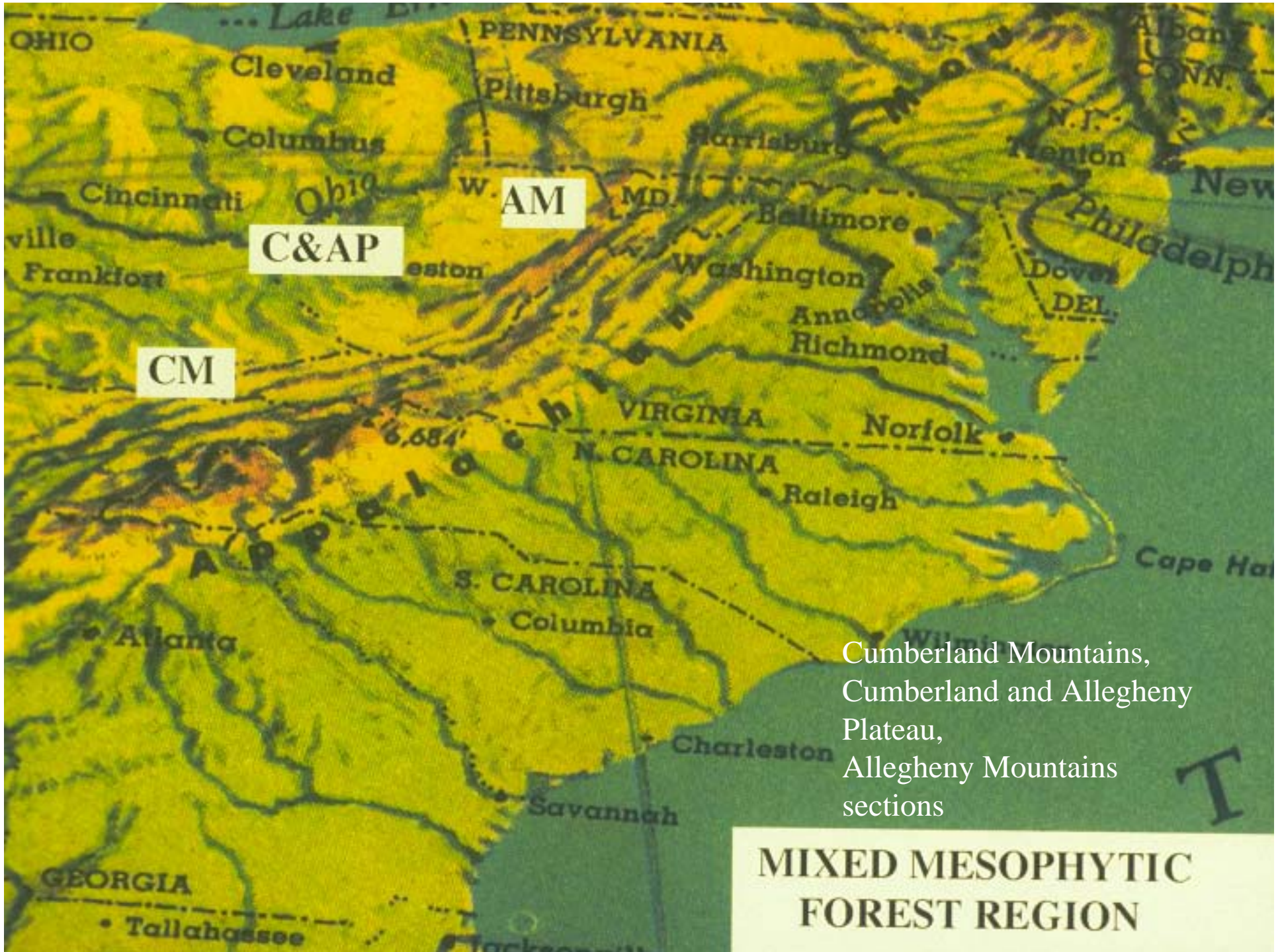
Braun, E. L. 1950. Deciduous Forests of Eastern North America. The Blakiston Co. Philadelphia. 596 p.





Glaciated,  
Piedmont,  
Northern  
Blue Ridge,  
Ridge and  
Valley,  
Southern  
Appalachians  
sections

**FORMER OAK-CHESTNUT  
FOREST REGION**



Cumberland Mountains,  
Cumberland and Allegheny  
Plateau,  
Allegheny Mountains  
sections

**MIXED MESOPHYTIC  
FOREST REGION**

# former Oak-Chestnut Forest communities

## Dominant trees

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1. American chestnut

2. Chestnut oak

3. Red oak

4. White oak

5. Scarlet oak

6. Red maple

7. Pignut hickory

8. Black oak

9. Black birch

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# former Oak-Chestnut Forest region

## American chestnut associates

### Trees present on mesic sites

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1. Hemlock
  2. Yellow poplar
  3. Basswood
  4. Red oak
  5. Sugar maple
  6. Black birch
  7. Silverbell
  8. Fraser magnolia
- Southern  
Appalachians  
section
-

# Mixed Mesophytic Forest climax community<sup>a</sup>

## Dominant trees

---

- |                      |   |
|----------------------|---|
| 1. Beech             | 7. Red oak  |
| 2. Yellow poplar     | 8. White oak  |
| 3. Basswood          | 9. Hemlock  |
| 4. Sugar maple       |   |
| 5. American chestnut | 10. Silverbell (South-<br>ern Appalachians<br>only) |
| 6. Sweet buckeye     |   |
- 

<sup>a</sup>Braun (1950)

# Pre-blight communities

## Mixed Mesophytic Forest region

### Cumberland Mountains section

Canopy trees	Relative density	
	Area 1	Area 2
American chestnut	26.0%	23.8%
Sugar maple	26.6	20.2
Yellow poplar	13.9	8.3
White oak	0	5.5
Red oak	6.3	11.0
Chestnut oak	6.3	0
Beech	1.3	0
Basswood	6.3	5.5
Sweet buckeye	3.2	5.5

Braun (1950). Letcher and Bell Counties, Kentucky.

Canopy  
American  
chestnuts  
are now rare  
in forest  
sites.

Lucille  
Griffin is  
collecting  
American  
chestnut  
pollen  
from a  
large  
survivor  
in a field  
site.



# Impact of chestnut blight on forest communities

## Approaches:

- Determination of tree species colonizing canopy openings following chestnut blight
- Community changes in defined or permanent plots over time following chestnut blight
- Systematic surveys of communities in areas with chestnut stumps (rot resistant), following chestnut blight, or in areas surveyed earlier
- Changes in forest clearcut communities over time following chestnut blight epidemics

# Replacement of blight-killed American chestnut trees in former Oak-Chestnut and Mixed Mesophytic forest communities

In the first half of the last century, chestnut blight, caused by the introduced Ascomycete fungus *Cryphonectria parasitica*, killed nearly all or an estimated 3.5 billion canopy American chestnut trees in the natural range of the species where it comprised 25% of the canopy trees. The pandemic was the most destructive disease ever to strike American forests.

# former Oak- Chestnut Forest region Southern Appalachian section

Processes by which canopy openings occupied<sup>a</sup>

Tree	new seedlings	seedling/sapling release	canopy closure
Chestnut oak		X	X
Red oak		X	X
Red maple	X	X	
<b>Hemlock</b>	<b>X</b>	<b>X</b>	<b>X</b>
Yellow poplar	X		
Black birch	X		
Black locust	X		

<sup>a</sup> Woods and Shanks (1959). Great Smokey Mountains.

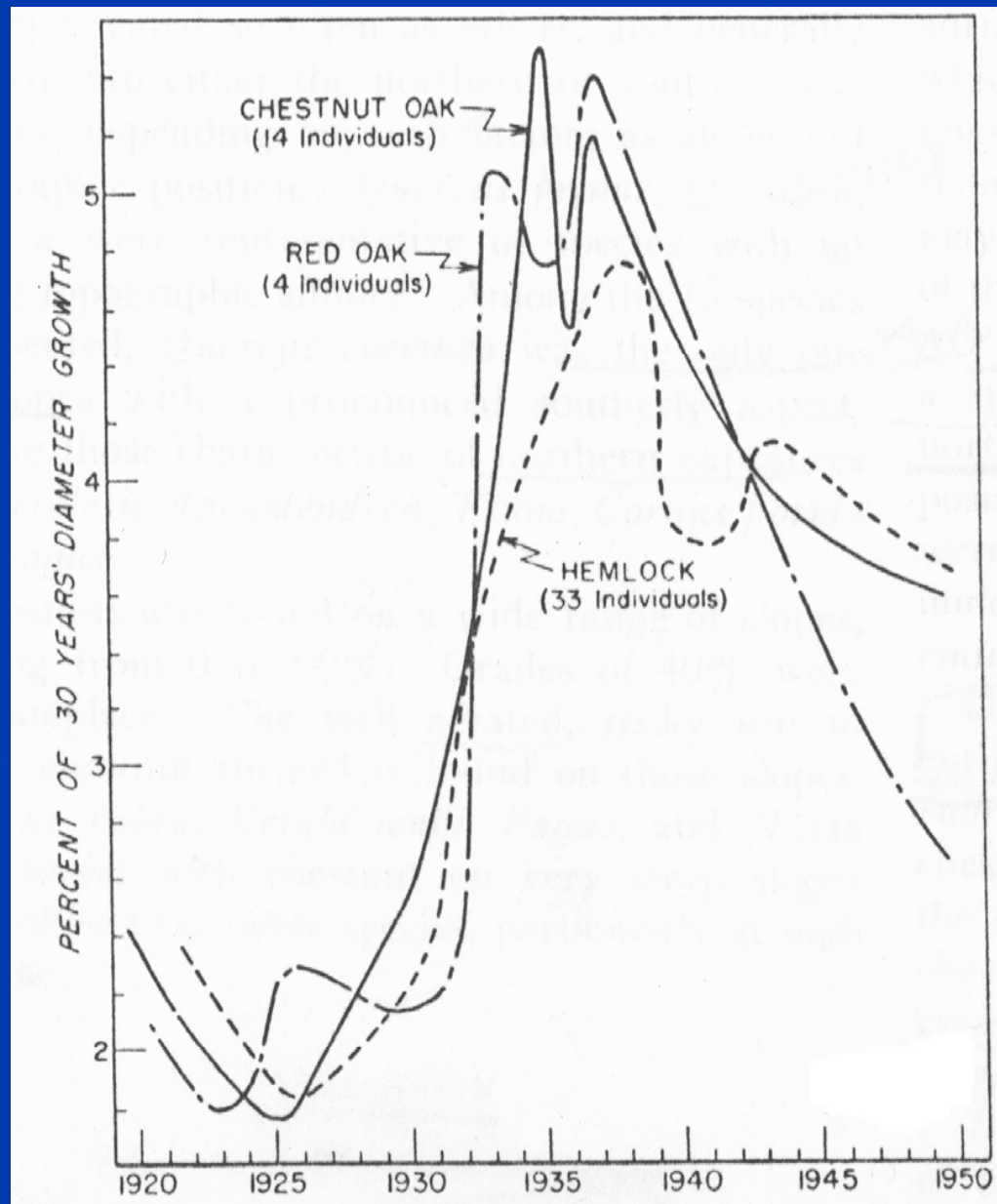
# former Oak-Chestnut Forest region Southern Appalachian section

Replacement tree species in canopy openings

Tree	Percent of openings <sup>a</sup>	Percent of trees <sup>a</sup>
Chestnut oak	24	17
Red oak	24	16
Red maple	22	13
Hemlock	9	6
Sourwood	8	4
Silverbell	7	5
Black locust	7	4
Yellow poplar	6	4
Scarlet oak	6	4
Black birch	5	3

<sup>a</sup> Woods and Shanks (1959). Based on 2,569 openings of different aspect and slope.

Chestnut oak,  
red oak, and  
hemlock growth  
response, 1930-  
1950 after  
removal of  
American chestnut  
by blight (Woods  
and Shanks 1959)



# Poplar Cove, NC

former Oak-Chestnut Forest region

Southern Appalachians section

mixed mesophytic cove forest

- Peak establishment of tree seedlings in 1935<sup>a</sup>
  - Red maple, black birch, silverbell, and yellow poplar had peak numbers in post-blight decade
- Peak release of trees from suppression in 1937<sup>a</sup>

<sup>a</sup>Lorimer(1976).

Poplar  
Cove, NC,  
@1905,  
American  
chestnuts  
in mesic  
community.  
See Braun  
and Lorimer  
data.  
(Photo  
courtesy of  
Museum of  
North Idaho,  
FHS, @1975)



## Canopy trees

## Relative density

Tree	@ 1936-40 <sup>a</sup>	1974 <sup>b</sup>
Basswood	21.8%	17.2%
American chestnut	16.9	0.0
Yellow poplar	16.2	17.5
Beech	12.7	17.6
Silverbell	12.7	12.9
Sugar maple	10.6	7.4
Hemlock	3.5	1.0
White ash	1.4	6.8
Black birch	1.4	3.2
Fraser magnolia	1.4	0.6
Cucumber tree	0.7	6.0
Hickory	0.7	3.7
Red maple	0.0	2.4
Red oak	0.0	1.2
Yellow birch	0.0	1.1

<sup>a</sup> Braun (1950) <sup>b</sup> Lorimer (1976). Nantahala mountains, NC. Poplar Cove.

# American chestnut replacement

former Oak-Chestnut Forest region  
Hemlock-mixed mesophytic community

Tree	pre-blight <sup>a</sup>	post-blight <sup>b</sup>	
	@ 1930	1976	
	frequency	frequency	basal area
American chestnut	2.0%	0%	0%
Yellow poplar	15.9	6.3	17.5
Basswood	16.6	8.1	10.7
Beech	13.9	6.9	7.5
Silverbell	5.3	9.4	2.4
Sugar maple	1.3	8.1	5.2
E. Hemlock	35.1	55.0	55.0
Red maple	0	2.5	0.9

<sup>a</sup> Braun (1950). <sup>b</sup> Lorimer (1976). Poplar Cove, NC.

# American chestnut replacement

## former Oak-Chestnut Forest region

### North oak slope transition community

Tree	pre-blight <sup>a</sup>	post-blight <sup>b</sup>	
	@ 1930	1976	1976
	frequency	frequency	basal area
American chestnut	50.5%	0%	0%
Yellow Poplar	15.4	8.6	29.3
Basswood	2.2	6.0	7.3
Beech	2.2	1.7	1.9
Silverbell	6.6	6.0	1.7
Sugar maple	2.2	0	0
Chestnut oak	6.6	18.1	20.8
Red maple	0	18.1	0.4
Black birch	4.4	14.6	9.5

<sup>a</sup> Braun (1950). <sup>b</sup> Lorimer (1976). Poplar Cove, NC.

# American Chestnut replacement former Oak-Chestnut Forest region Southern Appalachians section <sup>a</sup>

Tree	Relative density	Relative basal area
Red maple	24.5%	18.5%
Chestnut oak	13.4	20.6
Red oak	7.9	15.8
Silverbell	9.0	6.5
Sourwood	9.2	4.7
Hemlock	4.9	2.9
Black birch	4.4	3.4
Fraser magnolia	3.4	2.8
Pitch pine	2.2	3.1
Black gum	2.1	3.0
Yellow poplar	2.0	3.0
American chestnut	<1	<1

<sup>a</sup>Arends and McCormick (1987). Great Smokey Mountains. 33 sites studied.

# American chestnut replacement former Oak-Chestnut Forest region Southern Appalachians section

Tree	Relative basal area			
	1934	1941	1953	1970 <sup>a</sup>
American chestnut	31.1%	22.1%	0.9%	0.1%
White oaks	13.5	14.3	18.3	26.6
Red oaks	25.5	30.0	34.7	22.2
Red maple	2.6	2.9	4.6	10.6
Hickories	4.4	6.3	8.5	9.8
Yellow poplar	0.2	0.6	2.5	7.3

<sup>a</sup> Day and Monk (1974). Pooled data N, S, E, and W aspects. Nantahala Mountains, NC.

# former Oak-Chestnut Forest region Southern Appalachian section

## Successional trends <sup>a</sup>

### Mesic sites

- Most extreme example: “pure” chestnut to **hemlock**
- Oak-chestnut to hemlock with yellow poplar an intermediate stage
- Mesic cove sites are more mesophytic (to basswood, etc.)

### Intermediate or xeric sites

- Oak- chestnut association to **oak association- complex**
- No evidence **red maple** will persist as a climax forest type
- Most xeric stands are more xerophytic (to scarlet oak, sourwood, pitch pine)

<sup>a</sup> Woods and Shanks (1959)

American chestnut replacement  
former Oak-Chestnut Forest region  
Southern Appalachians section

**Successional trends**<sup>a</sup>

(21 years after Woods and Shanks, 1959)

- **Red maple** is the most important replacement species overall, but is considered a successional species
- Conclusion of “**oak association-complex**” of Woods and Shanks (1959) is affected by site conditions
- 50 years of succession is too short; 100 to 200 years of change is possible

<sup>a</sup> Arends and McCormick (1987). 33 sites studied.

American chestnut replacement  
former Oak-Chestnut Forest region  
Southern Appalachian section  
Successional trends  
(21 years after Woods and Shanks, 1959)

Six replacement forests, all successional,  
identified by cluster analysis:

- Almost pure chestnut to 1. Silverbell-red maple and 2. Hemlock-black birch-beech (most mesophytic)
- Oak-chestnut to 3. Northern red oak-silverbell 4. Chestnut oak 5. Red maple-oak and 6. Red maple-sourwood

# American chestnut replacement former Oak-Chestnut Forest region Mesic slope forest, Ridge and Valley section

Tree	1932 <sup>a</sup>	1982 <sup>b</sup>	
	Relative density	Relative density	Relative basal area
American chestnut	70.3%	0 %	0%
Red oak	16.6	57.0	81.0
White oak	12.3	1.4	0.5
Red maple	0.4	11.3	4.1
Black birch	0	5.4	4.7

<sup>a</sup> Braun (1950), <sup>b</sup> Stephenson (1986). Allegheny Mountains, VA.

Mesic  
site in  
area of  
Braun  
study,  
1932. This  
area was a  
northern  
red oak  
decline  
site in  
1990s.

ML  
plot of  
Griffin,  
1992.





Northern red oak decline in 1990  
near Braun 1932 study site

# American chestnut replacement

## former Oak-Chestnut Forest region

### Southwest slope, Ridge and Valley section

#### Relative importance value<sup>a</sup>

Altitude:	low		medium		high	
	1920	1970	1920	1970	1920	1970
Tree						
American chestnut	121	0	46	0	28	0
Red oak	22	32	31	46	74	47
Chestnut oak	9	33	68	55	0	4
White oak	52	17	3	8	53	44
Pignut hickory	0	58	10	50	11	56
Sugar maple	0	10	0	0	0	0

<sup>a</sup> McCormick and Platt (1980).

American chestnut replacement  
former Oak-Chestnut Forest region  
Southwest slope, Ridge and Valley section

Relative importance value<sup>a</sup>

Tree	@ 1920	1970
American chestnut	65	8 <sup>b</sup>
Red oak	42	36
White oak	36	16
Chestnut oak	26	25
Pignut hickory	7	41
Red maple	- <sup>c</sup>	14
Sugar maple	- <sup>c</sup>	11

<sup>a</sup> McCormick and Platt(1980). Sum of relative densities in all permanent plots.

<sup>b</sup> Stump sprouts; not dominant. Allegheny Mountains, VA. <sup>c</sup> No value.

# American chestnut replacement former Oak-Chestnut Forest region Ridge and Valley section Xeric slope forest

Tree	Relative density		Relative basal area	
	1971	1991	1971	1991
Chestnut oak	44.1%	32.7%	37.1%	34.2%
Scarlet oak	34.7	35.7	46.4	50.6
Black gum	4.9	12.2	1.8	3.6
Virginia pine	2.4	4.1	3.5	5.0
Red maple	5.3	5.1	3.2	3.4
Black locust	1.6	0.0	1.8	0.0
American chestnut	0.4	6.1	<0.1	1.1

Rhoades (1992). Allegheny Mountains, VA. Permanent plots.

American chestnut (left, foreground) in xeric study site of Rhoades, Brush Mtn., VA, Ridge and Valley section.



# Transition region

## Mixed mesophytic, Oak-Chestnut and Hemlock Northern Hardwoods regions

### Mesic slope forest

<u>Tree</u>	<u>Relative density</u>	<u>Relative basal area</u>
Black cherry	34.7%	36.1%
Red maple	18.0	13.4
Sugar maple	13.9	8.4
Black oak	10.0	16.9
Black birch	7.3	4.7
Black gum	8.9	5.1
Chestnut oak	2.4	6.5
White oak	1.2	6.5

Mackey and Sivec (1973). Allegheny Mountains, PA.

# American chestnut replacement former Oak-Chestnut Forest region Northeastern Pennsylvania

(1927) Kortstian and Stickel

Species present on slopes which had a pre-blight  
American chestnut relative density of 40%

## Seedlings and sprouts

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Chestnut oak 60%

Black oak 35

White oak 4

Red oak, scarlet oak, white pine, pitch pine, and  
black locust also present

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# American chestnut replacement former Oak-Chestnut Forest region Glaciated section, Southern New England

(1927) Korstian and Stickel.

- Establishment of tree seedlings and canopy expansion into openings by:

Chestnut oak

Red oak

White oak

Red maple

Scarlet oak

Black oak

Sugar maple

Hickories

- Percent basal area increase in post-blight decade vs. pre-blight decade

Red oak- 63%

Chestnut oak- 48%

Scarlet oak- 38%

White oak- 26%

# Summary

- An **oak association-complex** is one of the most common replacement communities developing, but succession is affected by site (e.g. hemlock on mesic sites)
- **Red maple** relative density has increased in most stands, but its successional status is unclear

# Canopy red maple and oak relative densities in 32 pre-blight American chestnut forest communities

Tree	<u>Relative density</u>	
	mean	range
Red maple	3.0%	0- 13.3%
All oak species	26.0	0- 74.6
American chestnut <sup>a</sup>	33.2	9.4-84.6

Braun (1950). <sup>a</sup> Includes stands with more than 9% American chestnut only in the former Oak-Chestnut and Mixed Mesophytic regions.



Two canopy red maples in mesic cove site, Ridge and Valley section, Virginia, 1990s. What is their future status?

# Survival of American chestnut in forest understory communities

Survival of **American chestnut** in understory sites:

**Xeric and intermediate** sites -survival is very high

**Mesic** sites -survival is low

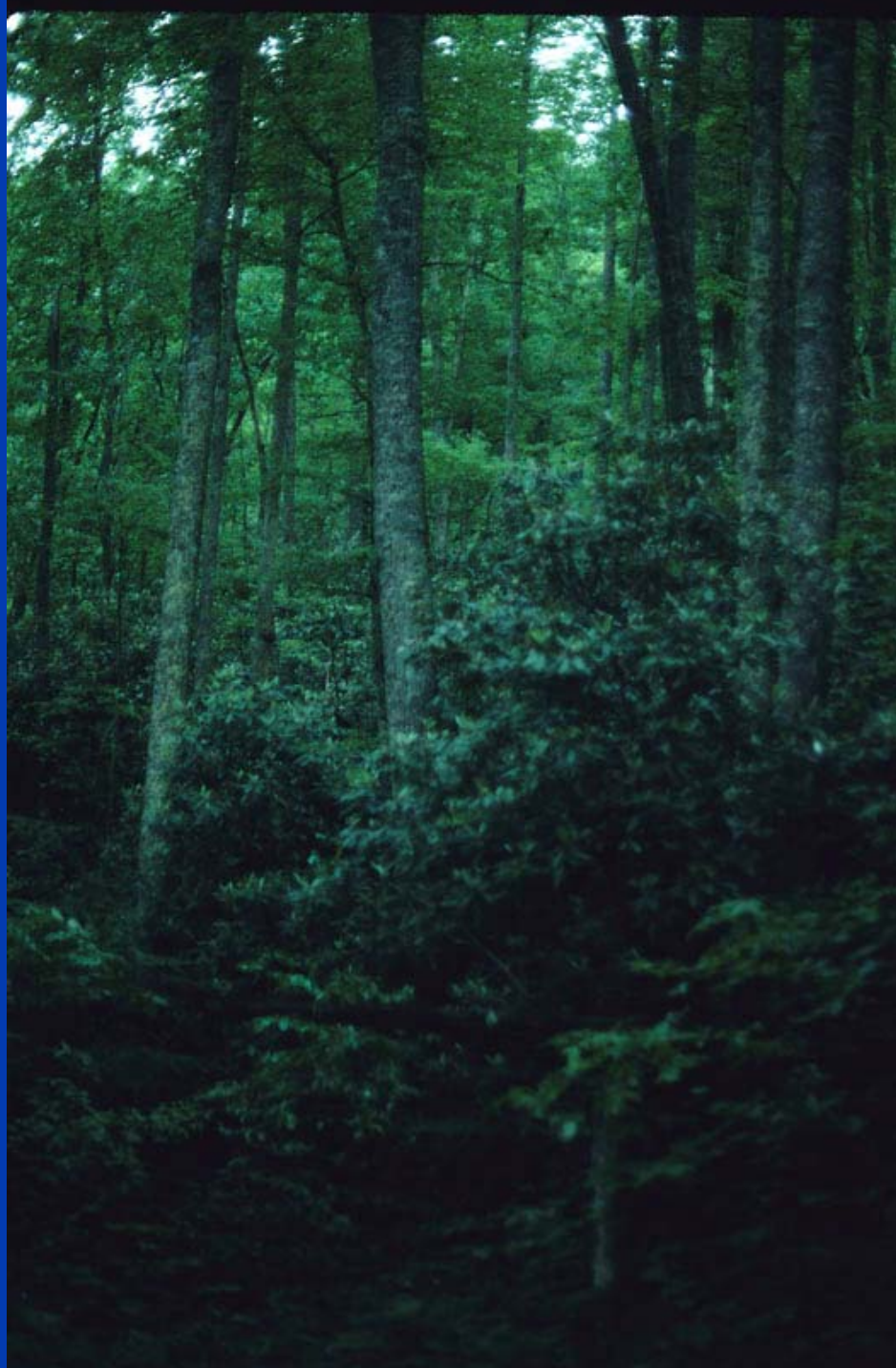
Larger understory  
American chestnut  
(marked with hat)  
stem on intermediate  
site, Ridge and  
Valley section,  
Virginia.





Understory American chestnut with rhododendron in mesic cove site, Ridge and Valley section, Virginia.

Yellow poplar  
and rhododendron  
associates of  
understory  
American chestnut  
in mesic cove  
site, Ridge and  
Valley section.



A photograph of a young hemlock tree in a forest. The tree has a thin, dark stem and a cluster of bright green, flat, needle-like leaves. A yellow measuring tape is placed vertically next to the stem for scale. The background is a dense forest with a forest floor covered in fallen leaves and twigs.

Hemlock in association with understory American chestnut. Note plane or flat arrangement of leaves associated with the way light moves through canopy gaps in the overstory, mesic site, Ridge and Valley section, Virginia.

# former Oak-Chestnut Forest region

## Southern Appalachians section

### Understory trees<sup>a</sup>

Tree	Sapling relative density	Sub-sapling relative density
Red maple	25.7%	10.1%
Chestnut oak	2.0	1.9
Red oak	1.0	<1
Silverbell	1.6	10.4
Sourwood	6.9	5.7
Hemlock	14.3	13.2
Black birch	1.4	<1
Fraser magnolia	3.4	3.9
Pitch pine	<1	0
Black gum	5.9	4.8
Yellow poplar	<1	<1
American chestnut	<1	5.8

<sup>a</sup> Arends and McCormick (1987). Great Smokey Mountains. 33 sites studied.

Poplar Cove  
Former Oak-Chestnut Forest region  
Southern Appalachians section  
Understory trees

Tree	Density (stems/ha) 1974
Sugar maple	149.6
Hemlock	98.3
Beech	85.2
Silverbell	82.4
Red maple	26.1
Basswood	25.0
Sweet buckeye	21.2
Black birch	18.5
Yellow poplar	6.3
American chestnut	0.0

Lorimer (1976). Nantahala mountains, NC.

Poplar Cove  
Former Oak-Chestnut Forest region  
Southern Appalachians section  
**Understory sub-saplings**

<u>Tree</u>	<u>Density (stems/ha) 1974</u>
<b>Beech</b>	<b>227</b>
<b>Basswood</b>	<b>157</b>
<b>Silverbell</b>	<b>94</b>
Sugar maple	82
Hemlock	76
Buckeye	38
White ash	38
<b>American chestnut</b>	<b>6</b>

Lorimer (1976). Nantahala Mountains, NC. Lower cove hardwoods.

In Braun's 1932 study, northern red oak was the principal understory species. This species became dominant following chestnut blight. Oak decline was severe in the area of this site in the early 1990s, releasing the present understory species, but has been less severe in the early 2000s.

# Mesic slope forest, Ridge and Valley section

## Understory trees

Tree	Relative density	
	Area 1 <sup>a</sup>	Area 2 <sup>b</sup>
Sugar maple	6.9%	39.2%
Red maple	3.7	7.8
Red oak	0.2	0.0
Black birch	1.4	0.0
White ash	0.5	0.0
Sweet buckeye	0.2	0.0
Cucumber tree	0.9	3.9
American chestnut	1.8	5.9

<sup>a</sup> Stephenson (1986)    <sup>b</sup> Griffin (1992) Braun 1932 area, Allegheny Mountains, VA.

American chestnut replacement  
former Oak-Chestnut Forest region  
Ridge and Valley section  
Xeric slope forest **understory** saplings

<u>Tree species</u>	<u>stems/ha</u>	
	1971	1991
<b>Scarlet oak</b>	<b>140</b>	110
Chestnut oak	96	80
<b>Red maple</b>	<b>111</b>	<b>150</b>
<b>Black gum</b>	<b>263</b>	<b>1,500</b>
Virginia pine	52	40
<b>American chestnut</b>	<b>28</b>	<b>280</b>

Rhoades (1992). Allegheny Mountains, VA. Permanent plots.

# Transition region

Mixed mesophytic, Oak-Chestnut and Hemlock  
Northern Hardwoods regions

**Understory** species with canopy potential

Tree	Relative density	Relative basal area
<b>Sugar maple</b>	<b>38.4%</b>	<b>48.6%</b>
<b>Red maple</b>	<b>12.6</b>	<b>14.3</b>
Black oak	6.7	6.4
Black gum	5.4	8.3
Black birch	6.4	5.7
Beech	3.0	2.5
Black cherry	1.2	2.4
<b>American chestnut</b>	<b>0.5</b>	<b>0.4</b>

Mackey and Sivec (1973). Allegheny Mountains, PA.

## former Oak-Chestnut Forest region Glaciated section, Southern New England

(1980) Stephens and Waggoner

- Small basal area of **American chestnut** has increased in Connecticut between 1930 and 1980.

(1988) Paillet

- **American chestnut** understory seedling sprout density was negatively correlated with presence of a **hemlock** canopy on mesic sites

# Chestnut blight and survival of American chestnut in forest clearcuts

Understory American chestnuts grow very rapidly following clearcutting. Following this growth, a chestnut blight epidemic develops over a 10-year period. This chestnut blight has a **thinning** effect on the forest community in clearcuts, due to the death of many American chestnut stems, resulting in enhanced growth of other species. On mesic sites, both stems and root systems of chestnut may die due to the combined effects of blight, hardwood competition, and deer browse damage.

Griffin (1989). Griffin, Smith, Dietz and Elkins(1992)

Removal  
of competing  
hardwoods in  
clearcuts by  
cutting  
enhances blight  
control on  
American  
chestnut  
due to natural  
hypovirulence  
(virus-mediated  
biological  
control)  
development.



# American chestnut replacement

## Interfering factors in some areas

- Oak decline
- Gypsy moth
- Storm damage
- Hemlock woolly adelgid
- Butternut canker
- Fire
- Partial harvest
- Beech bark disease
- Dogwood anthracnose
- Oak wilt

**Wildlife impact: Oaks  
alone vs. chestnut plus oaks  
in a forest ecosystem:  
Mast production estimate  
was 34% less in an oak  
alone forest than when  
American chestnut was  
present.**

Diamond, Giles, Kirkpatrick and Griffin  
(2000).

# Summary

- An **oak association-complex** is one of the most common replacement communities developing, but succession is affected by site (e.g. eastern hemlock on mesic sites)
- **Red maple** relative density has increased in most stands, but its successional status is unclear

Clearcutting, oak decline, and other forest pests, such as hemlock woolly adelgid, can greatly modify forest succession.

# Summary continued

- **American chestnut** has survived as an understory species in many communities with survival being highest on xeric and intermediate sites.
- American chestnut root stocks are being lost on mesic sites following clearcutting due to the combined effects of a chestnut blight epidemic, very high hardwood competition, and browse damage by deer.

For literature or other information used for this Research  
Presentation, if needed, please contact Gary Griffin by e-mail.  
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