

2017 High Elevation Forest
Restoration Workshop
Gatlinburg, TN
November 14-16, 2017

*Thirty years of red
spruce restoration
research by the
Appalachian Forest
Experiment Station,
1921-1954*

Jim Rentch
West Virginia University



FHS K1168470

Appalachian Forest Experiment Station

- Established 1921, HQed in Asheville, NC
- 1st (or 2nd) experiment station in the east
- Area = 120 million acres
- Primary research areas were hardwood and pine
- First station leader was Earl H. Frothingham
- Folded into Southeastern Research Station in 1946

Appalachian Forest Experiment Station



Early hire: Clarence Korstian

- 1889-1968
- Forestry, University of Nebraska, Yale
- 1922: USDA Forest Service, AFES, Ashville, NC
- Worked on red spruce and Atlantic white cedar
- 1930: Duke University
- 1947: “Foundations of Silviculture upon an Ecological Basis”



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Beginning in 1923, Korstian began consulting with Champion Paper & Fiber Co. (NC) and West Virginia Pulp & Paper Co. about conditions on cutover spruce lands in North Carolina and West Virginia

1. *What were conditions on spruce lands?*
2. *What were the reproductive characteristics of red spruce?*
3. *What obstacles prevented successful spruce reproduction*
4. *What measures were needed to restore cutover spruce stands?*



1922: Spruce area logged for pulpwood, Pigeon River watershed, Haywood County, NC. Photo by C.F. Korstian, courtesy of Southern Research Station (SRS)



1922: Korstian's picture of Champion Paper land along the Pigeon River (NC), following removal of spruce for timber and pulpwood. No timber of merchantable size left except a few hardwoods. (Forest History Society – FHS 2983)



The same scene after being copied onto glass plates and hand painted.
(FHS K166331)



1938: Spruce reproduction on Black Mountain on the MNF. This area was cut over but not burned. Much of the reproduction was on the ground at the time of logging. (photo courtesy of Fernow experimental Forest, FEF)



1938: Spruce reproduction on the edge of the Black Mountain burn, MNF.
The burn came up to the point where the figure is standing. (FEF)

One year after fire



1922: Cutover spruce land Haywood County, NC. (FHS K1166337)

1922: Two-year old burn on three-year old cutting, coming up in blackberries, fire cherry, and yellow birch.

Pigeon River watershed, Haywood County, NC. (FHS K166334)



3-6 years after fire



1922: Burn on middle prong of Pigeon River, Haywood County, NC. (FHS K166336)

10 years after fire



183000

1923: Mount Mitchell, NC; hardwoods still predominate although they are growing slowly and spruce seedlings are gaining a foothold on the thin rocky soil. (FHS K183000)

20 years after fire



This area has not restocked naturally to conifers in 20 years. Within 2 years after the last fire, blackberry briars, pin cherry, and yellow birch usually spring up on cut-over and burned spruce lands. (Korstian).



20 years after fire

1923: 20 years after burning, the original spruce forest (WV) has been completely replaced by a hardwood stand in which birches predominate. Here, there is no prospect of spruce reestablishing itself within the next generation. (FHS K180051)

Perpetuation of Spruce on Cut-Over and Burned Lands in the Higher Southern Appalachian Mountains

Clarence F. Korstian
Ecological Monographs
January 1937
Vol. 7(1): 125-167

CONTENTS	
	PAGE
INTRODUCTION	127
THE SPRUCE FOREST IN ITS SOUTHERN HABITAT.....	127
MAJOR FACTORS INFLUENCING NATURAL REPRODUCTION	132
Seed supply	132
Soil and moisture conditions	134
Competing vegetation	135
CONDITIONS ON LOGGED, UNBURNED SPRUCE LANDS.....	135
Types of logging and their immediate effect on the stand.....	135
Natural recovery after logging.....	137
Growth of trees left after logging.....	143
CONDITIONS ON BURNED CUT-OVER LANDS.....	148
Immediate effects of fire.....	149
Hardwoods follow fires on cut-over spruce lands.....	150
MEASURES NECESSARY TO RESTORE CONIFER FORESTS IN THE SPRUCE TYPE	155
Protection from fire.....	155
Forest planting to replace spruce.....	156
MANAGEMENT OF SPRUCE FOREST TO INSURE ITS PERPETUATION.....	160
SUMMARY	164

Differences in stocking of burned and unburned lands depends on.....

- Composition of original forest
- Type of logging, severity of cut, and the amount of:
 - Red spruce residuals
 - Red spruce advanced regeneration
 - Hardwood residuals
 - Hardwood advanced regeneration
- Severity and frequency of burn

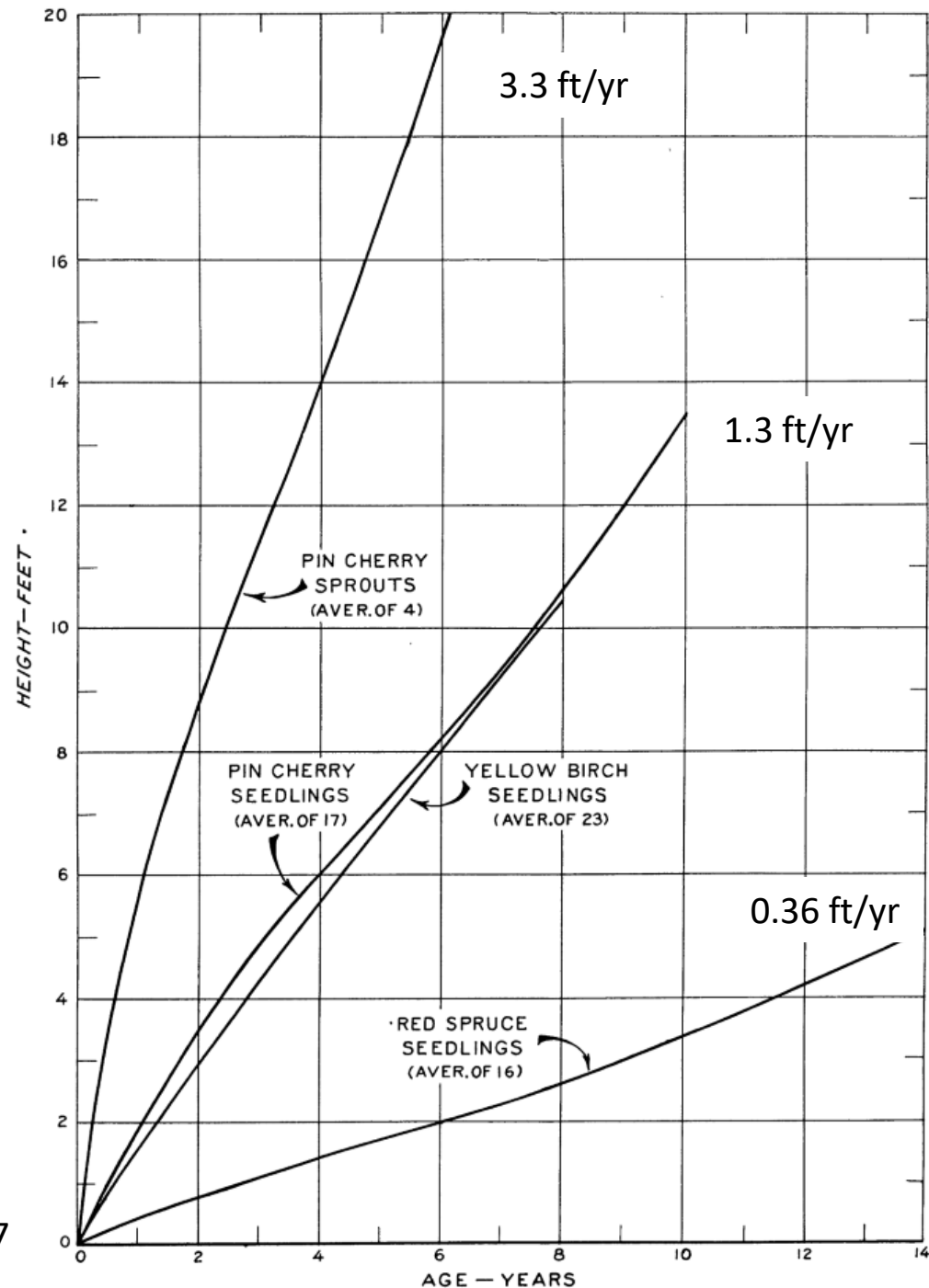
Comparison of 13-year old burned and unburned cutover stands, Plott Balsam Mountains, (Haywood and Jackson Counties) NC

Species	< 1" dbh	2-4" dbh	5-12" dbh	>12"dbh
	<i>TPA, <u>burned</u></i>			
Spruce-fir-hemlock	30	24	2	0
Commercial hardwoods	1,950	113	1	2
Small hardwood trees, shrubs	21,995	1,808	1	2
	<i>TPA, <u>unburned</u></i>			
Spruce-fir-hemlock	399	295	95	10
Commercial hardwoods	3,597	146	44	35
Small hardwood trees, shrubs	3,702	229	21	2

A problem:

Comparative height growth of seedlings and sprouts on burned spruce land Unaka Mountain, Unicoi Co., TN

Korstian. 1937. Ecolo. Mono. 7(1): 125-167



Korstian's recommendations:

1. Protect against slash fires
2. Plant 1/1 seedlings immediately after fire, before hardwood competition occurs
3. If spruce are under-planted, they will have to be released 1 or more times
4. Maintain 60-70% canopy coverage for moderate shade (enough for spruce and too much for intolerant hardwoods) and to avoid windthrow
5. Manage using uneven-aged silviculture

Leon S. Minckler

- 1906-2002
- 1929: PhD, SUNY
- 1930: AFES
- Later worked at Blacksburg, VA and Carbondale, ILL
- Taught at Va. Tech, SUNY, Mich. Tech., and SIU
- 1975: “Woodland Ecology: Environmental Forestry for the Small Owner” (5 eds.)



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- 1975: “Woodland Ecology: Environmental Forestry for the Small Owner” (5 eds.)



RS – AP
Fp (Mts)

1939: Minckler's first
report on red spruce
on the Monongahela
(WV), Pisgah (NC),
and Cherokee (TN)
National Forests

FILE REPORT

SPRUCE TYPE PROBLEM ANALYSIS

Analysis of Problems in the Reforestation of the Spruce Type of
the Southern Appalachians

by

Leon Minckler, Junior Forester

Submitted: March 15, 1939

Approved: June 16, 1939, Leonard I. Barrett
Chief, Division of Forest Management Research

1945: Minckler, L.S.
Reforestation in the
spruce type in the
southern Appalachians.

Journal of Forestry.
43:349-356.

Reforestation in the Spruce Type in the Southern Appalachians

Leon S. Minckler¹

Because of soil and climatic conditions, red spruce is the only timber-producing species available on a considerable portion of the original type. The lack of spruce seed precludes natural reforestation for a very long time. In lieu of complete planting, it is suggested that strategically located seed-source plantations be established. Mainly because of heavy vegetative competition, reforestation is a difficult and costly job. Success has often been poor or indifferent, but may be increased by release treatments and possibly by the use of fire and grazing.

THE task of reestablishing spruce forests on some 1,500,000 acres² of devastated land in the southern Appalachians in West Virginia, Virginia, North Carolina, and Tennessee, originally occupied by red spruce (*Picea rubra*) and southern balsam fir (*Abies fraseri*), has hardly begun. Hardwood reproduction, which now covers much of the spruce type, will develop into a satisfactory timber crop on the better sites and at the lower elevations, but not on the thin-soiled, rocky sites, especially at higher elevations. Planting of spruce on this latter type of site is justified but probably less than 5,000 acres of successful reforestation has been accomplished.

The original stand was destroyed by complete cutting for logs and pulpwood, opportunity for reproduction was eliminated by fire, and usually the organic soil was partly or wholly destroyed by fire and subsequent erosion. Sometimes as much as 2 feet or more of organic soil was lost in this way. Figure 1 shows an area formerly occupied by a dense stand of spruce after steam-skidder logging and pulpwood cutting. After the pulpwood was cut, the area burned over probably 2 or 3 times and soil was completely lost from a portion of the steeper, thinner soiled, upper slopes. The lower and middle slopes are now densely covered with fire cherry and blackberry with some yellow birch on the better sites.

Another striking example of the effect of a severe burn on a clearcut, dense, pure spruce stand at high elevation is shown in Figure 2. The original organic soil is almost completely burned away. Hardly more than a surface of rocks with a few soil pockets remains. On such sites there was virtually no mineral soil. The

organic soil required ages to build, and ages will be required to restore it. However, probably not over 10 percent of the spruce type soils have been so completely destroyed.

As a broad estimate it can be stated that most of the cutover and burned areas in the spruce type, unaided by man, will require 500 to 1,000 years or more to again clothe themselves with spruce or fir. The chief reason for this is a very inadequate or entirely absent source of seed. Natural invasion must proceed by gradual steps from the very few seed-source centers.³

MAJOR PLANTING SITES AND PROBLEMS

During the summer of 1938 a field survey of plantations and planting sites in the spruce type in West Virginia, Virginia, Tennessee, and North Carolina formed the basis for a program of research on reforestation of the denuded lands. The salient fact emerging from the study was the critical effect of vegetative competition on plantation success.⁴ A concept of vegetative density was formulated, and the conditions were determined under which planting is possible without special treatment and under which some treatment is needed to obtain success. Study of methods of reforestation on the latter sites constituted the research problem. Density was expressed in tenths and is the estimated proportion of ground shaded by plants higher than the planted trees.

Three major planting sites are involved:

1. *Sites with dense herbaceous and shrubby vegetation.* The predominant vegetation is chiefly

²The following articles contain additional information on the type:

Korstian, Clarence F. Perpetuation of spruce on cutover and burned lands in the higher Southern Appalachian mountains. Ecol. Monographs 7:125-167. 1937.

Minckler, Leon S. Early planting experiments in the spruce-fir type of the Southern Appalachians. Jour. Forestry 38:651-654. 1940.

⁴Minckler, Leon S. Vegetative competition as related to plantation success in the Southern Appalachians. Jour. Forestry 38:68-69. 1940.

¹Silviculturist in charge of forest planting investigations, Appalachian Forest Experiment Station, Asheville, N. C.

³Hopkins, A. D. Report on investigations to determine the cause of unhealthy conditions of the spruce and pine from 1880-1893. W. Va. Agric. Expt. Sta. Bul. 56. 1899.



Photo, D.H. Ramsey Library Special Collections, UNC Asheville

Species tested by Korstian on Mount Mitchell, 1923-1932, surveyed by Minckler in 1938

- Fraser fir
- Red spruce
- Norway spruce
- Red pine
- Pitch pine
- Scotch pine
- Northern white cedar
- White spruce
- Western white cedar
- Douglas-fir
- Western white pine
- European silver fir
- Japanese red pine
- Japanese larch
- European larch
- Lodgepole pine
- Japanese black pine
- Engelmann spruce
- Sitka spruce
- White fir

1938: Typical spruce tree
in test rows on Unaka
Mountain burn of
Cherokee National Forest.

This tree is in its 6th
growing season and
making good growth.
Vegetative competition is
at a minimum in this
cover type. Stake is
about 18" tall. (FEF)



1938: Norway spruce
under heavy canopy of
fire cherry, Mount
Mitchell project of Pisgah
National Forest

This tree is in its 13th
growing season in the
field and barely managing
to survive. If released it
probably would make
good growth. (FEF)



What is “good growth?”

Korstian, C.F. 1937.
Ecolo. Mono. 7: 125-167

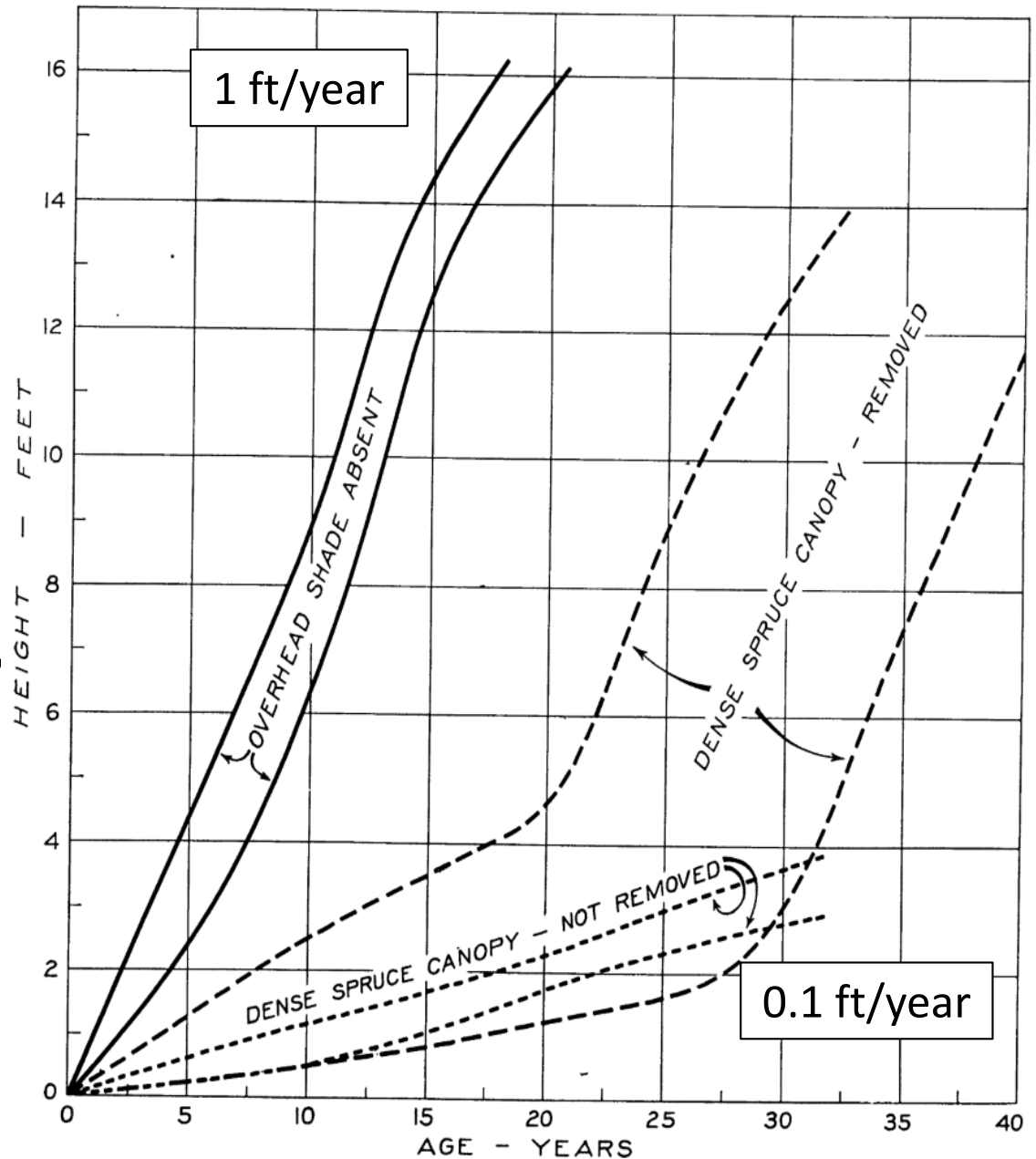


FIG. 6. Relative height growth of typical red spruce seedlings under different cover conditions. Tucker County, West Virginia.



1938: Norway spruce, 13 years old, in heavy competition, PNF. Competition is dense cover of blackberry with a moderate third layer of fire cherry and yellow birch. Surviving spruce are very scattered. (FEF)



1938: Portion of Norway spruce plantation on Clingman's Peak, PNF. This is typical of the best planting sites near Mount Mitchell. These trees are in their 14th growing season. (FEF).

Species composition of spruce competitors:

1st layer

(≤ 6")

- Moss
- Club moss
- Cinquefoil
- Low grass
- Strawberry

2nd layer

(6"-5')

- Bracken fern
- Hay-scented fern
- Blackberry
- Goldenrod
- Tall grass
- Low shrubs

3rd layer

(>5')

- Fire cherry
- Yellow birch
- Red maple
- Rhododendron
- Sumac
- Thorn apple
- Black locust

Minckler's conclusions from Korstian's plantings

- *“It is...apparent that [Fraser] fir, red spruce, Norway spruce, and red pine are the only species that...can be considered successful on the basis of survival and growth.”*
- *“The salient fact emerging from the study was the critical effect of vegetative competition on plantation success.”*
- **Density** more important than species composition

Minckler. 1945. JoF. 43:349-356.

Three major types of spruce restoration sites

1. Sites with dense herbaceous and shrubby vegetation
 - a) Up to 5 ft tall, density of $\geq 80\%$
2. Sites with young stands of undesirable, poor quality hardwoods
 - a) > 5 ft tall, density of $> 70\%$
 - b) Often with dense fern/blackberry underneath
3. Sites that are severely rocky with very thin soil and sparse vegetation
 - a) The most severely burned
 - b) Vegetative density $< 40\%$

Experiment #1: 3 – year height of red spruce seedlings on sites with dense herbaceous and shrubby vegetation

Competing vegetation:

1. Fern predominant
2. Blackberry predominant
3. Goldenrod predominant
4. Low shrubs

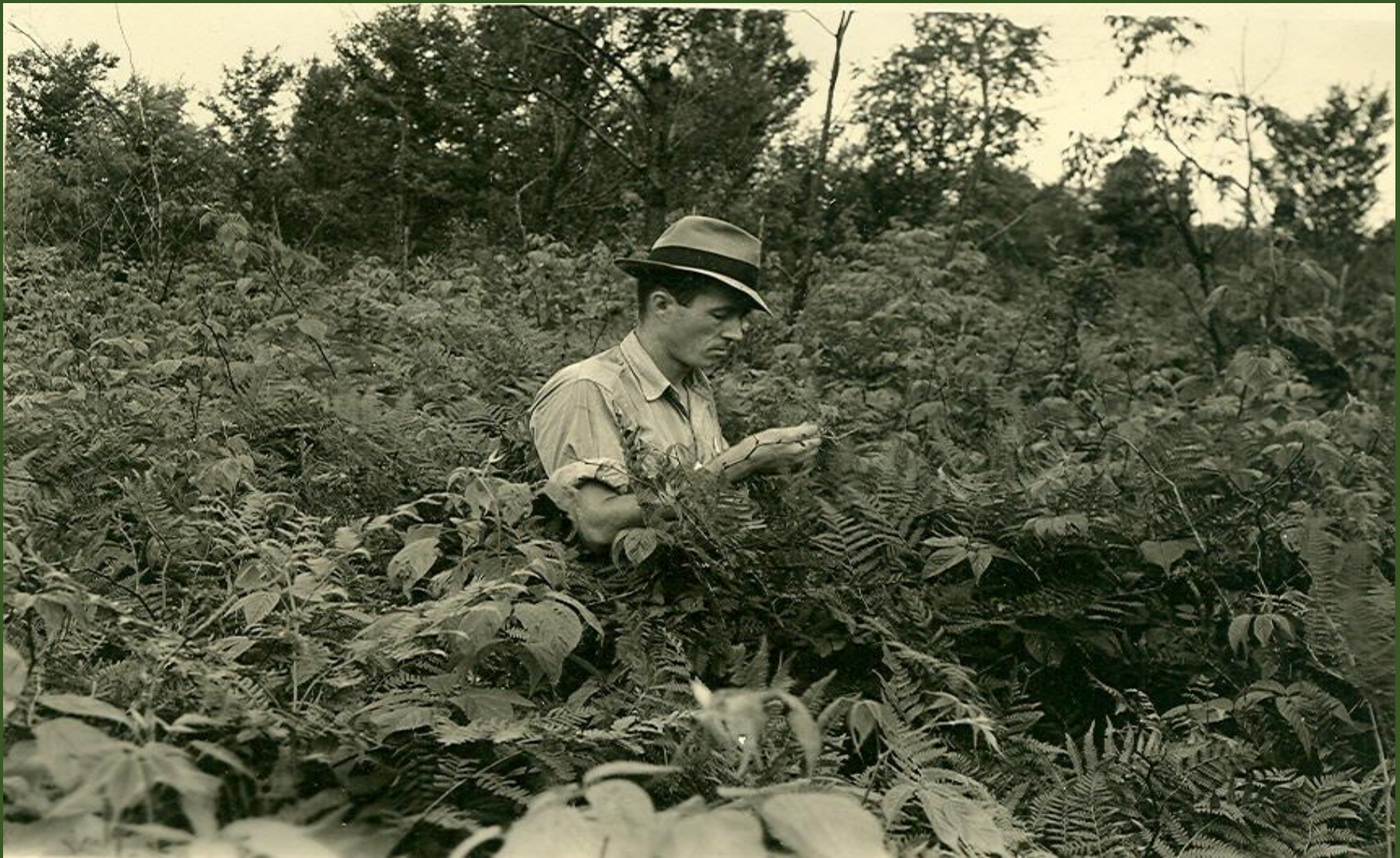
Treatments:

1. Control
2. Fertilizer
3. Superstock seedlings*
4. Direct seeding
5. Seeding + fertilizer
6. 3-4' release cutting
7. Scalp
8. Scalp + trenching
9. Burning

*based on stem caliper and root/shoot ratio



1938: Goldenrod cover in the low density class, Laurel Fork project on MNF.
This type of cover presents a comparatively good planting chance. (FEF)



1938: Dense bracken fern and blackberry, Backbone Mountain, MNF. Spruce seedlings 6-7" tall and in their 2nd growing season planted beneath. This type of cover creates a very difficult planting chance. (FEF)

1938: Vertical profile of a
characteristic dense bracken
fern and blackberry cover.
Backbone Mountain project on
MNF.

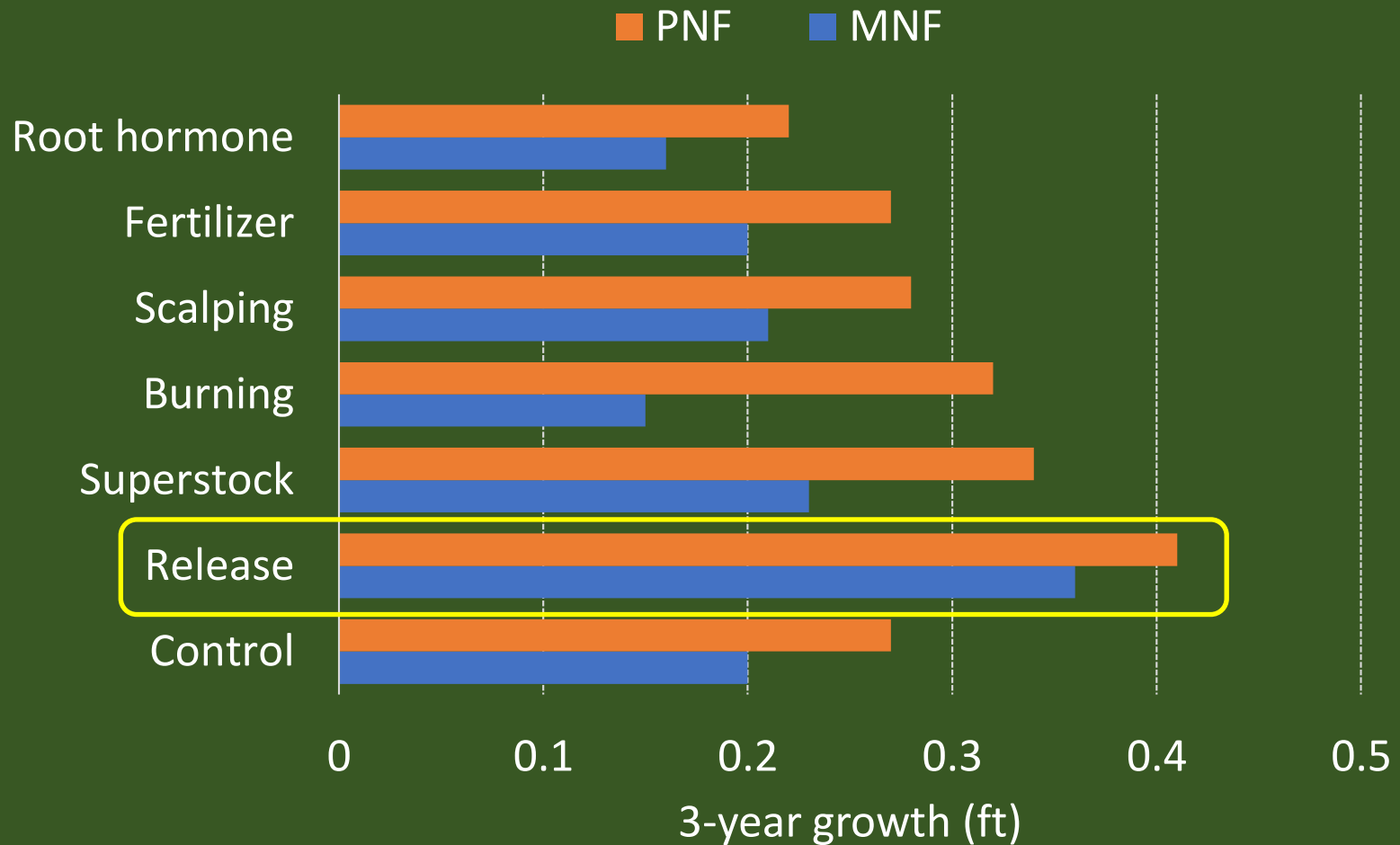
The stake is 1 ft long. (FEF)





1938: Mixture of 2nd and 3rd layer vegetation. Gatewood project on MNF
The 2nd layer is bracken fern, the 3rd layer red maple and black locust. (FEF)

Results: 3 - year height of red spruce on sites with dense herbaceous - shrubby vegetation



Minckler. 1945. JoF. 43:349-356.

Experiment #2: 3 - year height of red spruce seedlings released from young stands of undesirable hardwoods

Competing vegetation:

1. High density
 - a) 20-40 ft tall
 - b) fire cherry, blackberry
2. Medium density
 - a) 15-30 ft tall
 - b) fire cherry, red maple
3. Low density
 - a) 5-15 ft tall

Treatments:

1. Control
2. Small (5-7') opening in 3rd layer, year 1
3. Large (10-12') opening in 3rd layer, year 1
4. #2, year 3
5. #3, year 3



1938: Dense cover of blackberry and fire cherry, Sherwood Forest burn on PNF. Cover types such as this are probably not plantable by ordinary methods. (FEF)

1938: Dense reproduction of yellow birch. Sherwood Forest burn on PNF.

This type of cover is not plantable without treatment. Some of these areas may produce good stands of hardwood timber. Others may need to be “sweetened” with a partial planting of spruce. (FEF)





1938: Characteristic cover on some of the burned over spruce type land on the east slope of the Black Mountains, Mount Mitchell project of PNF. Very difficult to plant. (FEF)

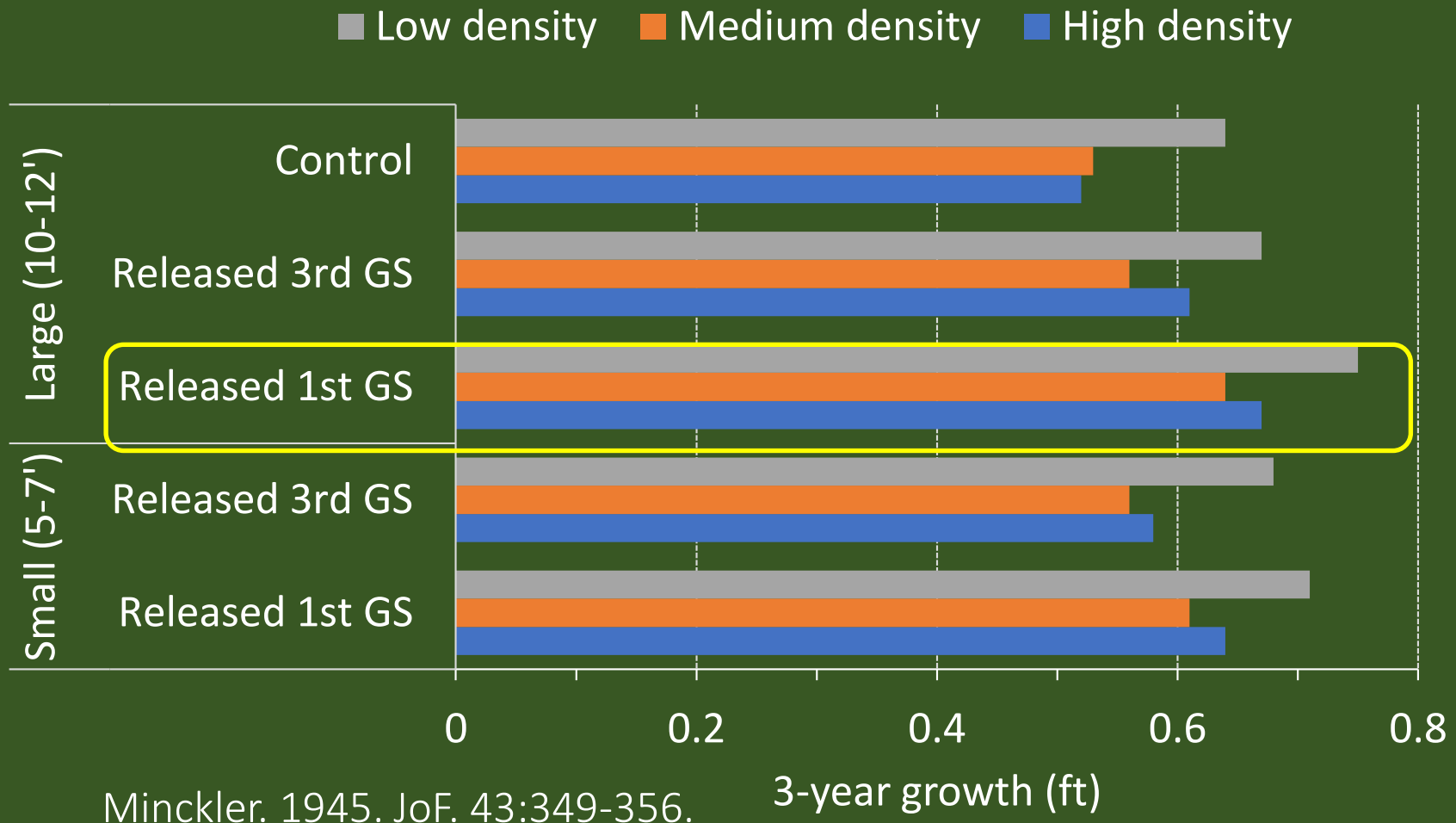


1938: A portion of two staked test rows on the Unaka Mountain burn of the CNF. Six staked trees are shown. The stakes beside each tree are about 18" tall. Fire cherry has been cleared away to make the trees visible in the photograph. (FEF).

1938: Typical cover of rhododendron, Mount Mitchell project of PNF. This type probably constitutes only a small portion of the burned over areas. (FEF)



Results: 3 - year height of red spruce seedlings released from young stands of undesirable hardwoods



Experiment #3: 3 - year survival of direct seeded red spruce and red pine on severe rocky sites

Treatments:

1. Mulched and screened
2. Fertilized, mulched, and screened
3. Fertilized, "osmo" cups, mulched and screened
4. Seeds enclosed in agar pellets, mulched, and screened



1938: Black Mountain burn on MNF. This area is characterized by very thin rocky soil and very sparse vegetation. The original deep organic soil has been burned away. (FEF)



1938: Spruce stump after burning and subsequent erosion on burn, PNF. The stump is in its original position. (FEF)



1938: Characteristic rocky terrain of a portion of Unaka Mountain burn on Cherokee National Forest. Areas such as this occur in local patches on the ridge tops and south slopes. (FEF)

Results: 3 - year survival of direct seeded red spruce and red pine on severely burned, rocky sites, all treatments combined

Pisgah National Forest, planted March 1940

Percent survival

Species	Jul 1940	Oct 1940	Mar 1941
Red spruce	89	84	< 10
Red pine	96	92	< 10

Monongahela National Forest, planted April 1940

Species	1 st spring	2 nd spring	3 rd spring
Red spruce	58	26	10
Red pine	93	75	61

Minckler 1945

Korstian at the
Rothkugel plantation,
September 1922
(FHS K1168470)

“The planting of seed in prepared seed spots has proved successful in one instance only – in West Virginia, where European larch attained a height of 20 to 30 feet in 15 years, and Norway spruce reached a height of 6 feet within the same period.”





An early timber survey party for the B&O RR, at the junction of Tea Creek and Williams River (WV). Bureau of Forestry, 1903. (FHS 1684).

Max Rothkugel

- Austrian-trained forester
- 1902: Cornell Forestry school
- 1903: Bureau of Forestry
- 1905: Burton Lumber Co. (SC)
- 1907: George Craig Lumber Co. (WV); established Norway spruce – European larch plantation from seed
- 1908: Wrote “Management of spruce and hemlock lands in West Virginia”
- 1911: USDA Forest Service
- 1913: Forestry consultant, Argentina





MANAGEMENT OF SPRUCE AND HEMLOCK LANDS IN WEST VIRGINIA.

If the practice of forestry is to be adopted by the lumbermen of this section they must be convinced that the new methods can be adopted without greatly reducing the financial returns from the lumbering. This compels the forester to employ an extremely simple system of management which can be applied without a large increased cost.

In the majority of instances his efforts must be directed toward a satisfactory solution of the following problems:

From Forestry Quarterly, Vol. VI (1908),
by Max Rothkugel



**Planted Norway spruce:
143' tall, dbh 42"**

Rothkugel, Max.

Dancing-charts for self-instruction ... Copyright ...
by Max Rothkugel ... [New York, M. Rothkugel] 1918.

2 v. illus. (incl. music) 23½ x 44^{cm}.

Cover-title.

CONTENTS.—v. 1. For gentlemen.—v. 2. For ladies.

© Oct. 10, 1918; 2c. and aff. Oct. 11, 1918; A 503819; M. Rothkugel, New
York. (18-20177)

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Minckler's recommendations

Sites with dense herbaceous/shrubby vegetation:

1. Use 2/1 superstock
2. June/July release in 1st growing season
3. Additional release depending on density and height of competition
4. Consider burning and light grazing for 2-3 years prior to planting

Sites with young stands of undesirable hardwoods:

1. 3rd layer shade less harmful than 2nd layer
2. In high-medium density stands, release in 1st and 3rd summers, and at least 2 subsequent releases
3. Opening size = 8-12 ft, depending on height of competition

10 - year reviews of Minckler's experiments

Wahlenberg, 1951 (NC)

1. Release the only successful treatment
2. In most situations, at least 2 releases necessary
3. Direct seeding not recommended
4. If large scale plantings not possible, install strategic plantings on upper slopes where they will develop into seed sources for the land below

Clark, 1954 (WV)

1. Density of competing vegetation critical for seedling survival and growth
2. Release in 1st year after planting
3. Release size important only when competition is overtopping hardwoods; release size depends on overstory height
4. Don't cut overtopping hardwoods until seedling is 4-6 feet tall



2010: Current restoration opportunities; understory red spruce in understory of 80-100 year old northern hardwood stand, Randolph County, WV. (Rentch, 2010.)

“Many of the cutover and burned lands in the spruce type, because of soil and climate, are unfitted for growth of any timber species except red spruce, southern balsam fir, and red pine. Hardwoods such as fire cherry, red maple, and birch will not produce timber on many of these sites.

Unaided by man, nature probably will require 500 to 1,000 years or more to restore these stands to timber. Although complete planting may not be possible or desirable, the establishment of strategically located blocks of seed-source plantations will hasten tremendously the attainment of a timber cover.”

Minckler. 1945. JoF. 43:349-356.

Sources cited

Korstian, C.F. 1937. Perpetuation of spruce on cut-over and burned lands in the higher southern Appalachians. Ecol. Mono. 7: 125-167

Minckler, L.S. 1939. Analysis of problems in the reforestation of the spruce type of the southern Appalachians. USDA Forest Service, (unpub) AFES, File Report.

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Wahlenberg, W.G. 1951. Planting in the Appalachian spruce-fir type. JoF. 49: 569-571.

Clark, T. 1954. Survival and growth of 1940-1941 experimental plantings in the spruce type in West Virginia. JoF. 52: 427-431.

Notes on photographic sources:

- Photographs with the abbreviation FHS are available from the Forest History Society, Durham, NC, available at <https://foresthistory.org/> ; Items prefaced by the letter “K” are by Clarence Korstian.
- Photographs with the abbreviation FEF are from an unpublished Minckler report from the Northern Research Station, Fernow Experimental Forest, Parsons, WV
- The photograph on slide 27 is from the UNC-Ashville Ramsey Literary Collection, “National Forests in NC Collection,” <http://toto.lib.unca.edu/findingaids/photo/nfnc/default/nfnc.htm>
- The photograph on slide 62 is by Jim Rentch.
- All others are available on the world wide web.