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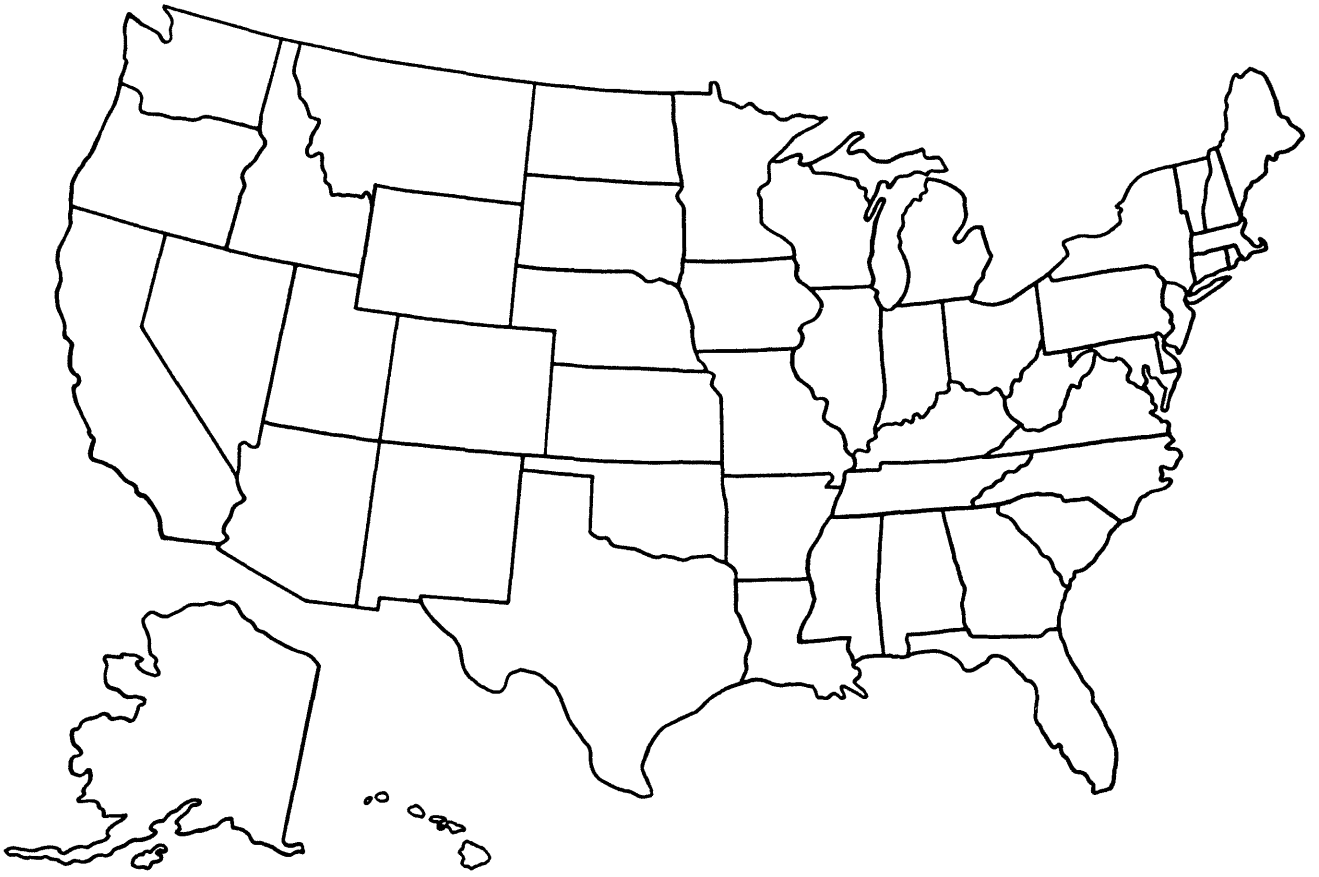
How Effective Are Tree Improvement Programs in the 50 States?

Christopher D. Risbrudt and Stephen E. McDonald



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All 50 States were surveyed to determine the extent of their activities in producing genetically improved trees for timber production. Describes the funds expended, the species being improved, and the use of State and Private Forestry funds provided for genetic improvement. Projects future timber volumes attributable to genetic improvement, and estimates benefit-cost ratios.

KEY WORDS: Benefit-cost analysis, genetic improvement, timber production, tree improvement, forest productivity, timber yields, nonindustrial private forestry.

North Central Forest Experiment Station
Forest Service—U.S. Department of Agriculture
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St. Paul, Minnesota 55108
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HOW EFFECTIVE ARE TREE IMPROVEMENT PROGRAMS IN THE 50 STATES?

Christopher D. Risbrudt, *Director of Policy Analysis*[1]
and **Stephen E. McDonald**, *Timber Management Research, Washington, DC*

Forest tree improvement includes all forest genetics activities designed to produce more desirable forest trees. Large-scale applied tree improvement programs, those with the objective of producing genetically superior planting stock for reforestation, were first begun in the 1950's by forest industries in the southern United States. These programs began slowly, but their continuing success led to initiation of tree improvement efforts throughout the United States. Today, tree improvement is regarded as a powerful tool by many forest managers. Employed in conjunction with good forest management practices, it is one major way to increase wood yield and quality.

The USDA Forest Service, State and Private Forestry, assists State governments with their tree improvement programs as part of its Congressional mandate to protect and to increase the productivity of the Nation's forests. With the current emphasis on governmental effectiveness, most public programs are being closely examined. In order to determine the effectiveness of these State programs, and the associated assistance provided by State and Private Forestry, gains and improvement in tree growth and value must be quantified and subjected to benefit/cost analyses. In this way, the impact of these programs on timber production can be estimated.

Consequently, we examined the genetic tree improvement programs of the 50 States and State and Private Forestry's contribution to those programs. Using the data collected, we estimated the impact of these programs on timber growth on nonindustrial private lands and their economic efficiency. Although State nursery production also goes to public and industrial lands, only the benefits of planting on nonindustrial private forest (NIPF) lands are included here.

[1]*Formerly Project Leader at the North Central Forest Experiment Station, St. Paul, MN.*

APPROACH

Primary data collection was done through the use of a questionnaire sent to all 50 State Foresters. Data on size of program, expenditure category of State and Private Forestry funds, and tree species were collected for the years 1978-1981. Projected increases in growth per acre for each important timber species reported were estimated. Percent of improved seedlings produced relative to total State seedling production was also estimated. These two estimates were made by each State for each species (exceeding 10 percent of program costs) in its program for the years 1982, 1985, 1990, 2000, and 2010.

PROGRAM RESULTS

The State programs result in added acres of seed production areas, progeny tests, seed orchards, and resultant increases in the level of genetic quality of seedlings grown in State tree nurseries. Ultimately the superior growth potential of these seedlings is translated into greater wood production from the forests. This is the final result of the programs—more wood.

By the end of 1982, over 4,400 acres of State seed orchards were in place. And during 1982 alone nearly 200 additional acres were established, a rate of increase of 4.4 percent. Seed production areas increased by 8.3 percent over 1981 (to 661 acres), but additions were made only in the Northeast, North Central, and Rocky Mountain regions[2]. In the same year, progeny test acreage increased by 13.7 percent, up to 2,015 acres.

The objective of the State programs is to produce genetically improved seedlings from seed produced in seed orchards. As the increases in seed production

[2]*Regions are shown in figure 1.*

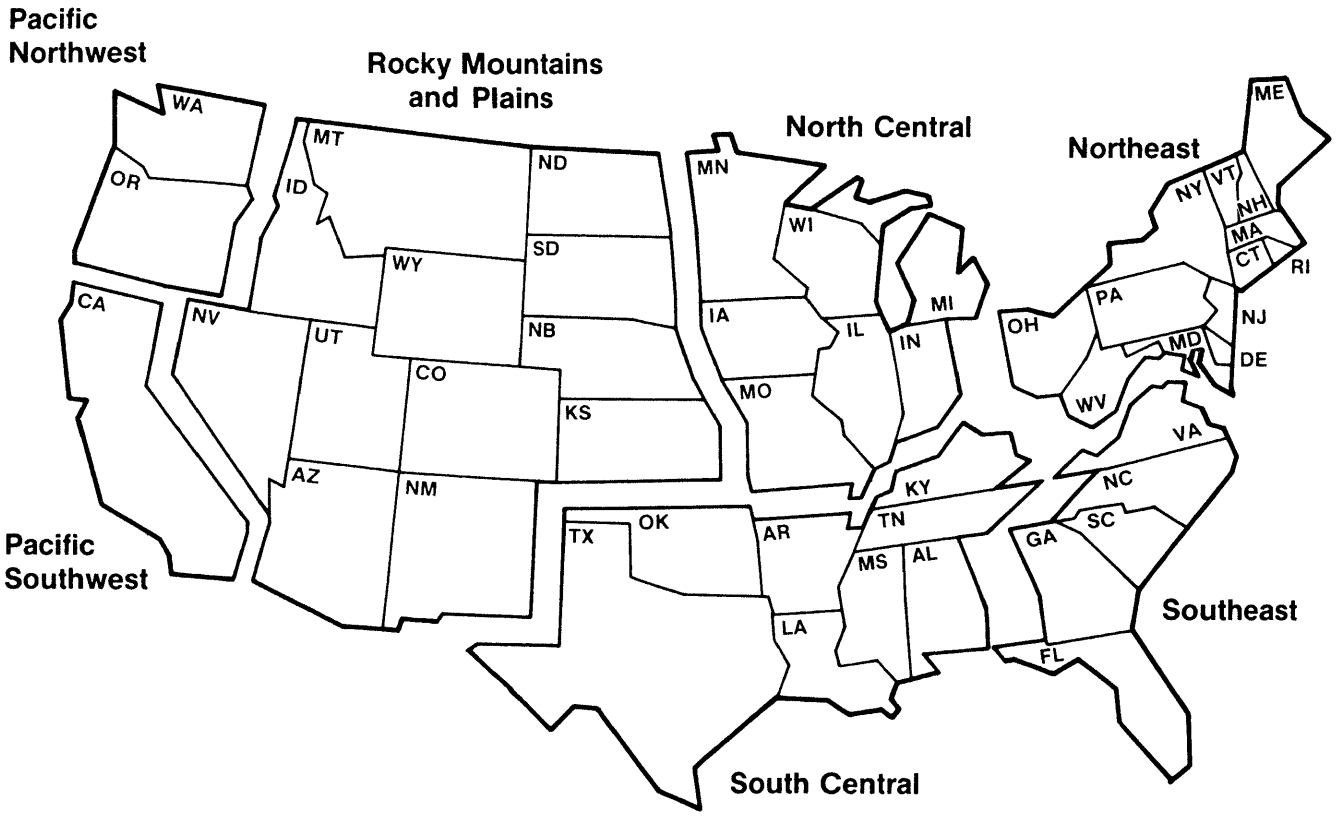

Figure 1.—*Regions of the United States as used in this study.*

areas and orchards show, progress in this preeminent objective is being made. However, in 1982, 32 percent of the nearly 800 million State-produced seedlings were still from unknown sources (table 1). In the South Central region, 54 percent were in this category.

Source identified seedlings, the next higher level of genetic quality above unknown sources, was the

Table 1.—*Number of State-grown tree seedlings by level of genetic quality[1] in 1982*

Region	Source unidentified[2]	Source identified[3]	Selected parentage[4]	Proven superior[5]	Total
			Millions of seedlings		
Northeast	8.6	17.6	2.4	0.2	28.8
North Central	37.0	35.3	[6]	3.4	75.7
Southeast	43.4	126.8	18.1	149.0	337.3
South Central	164.4	101.9	11.2	26.8	304.3
Rocky Mountains and Plains	.1	6.2	.2	0	6.5
Pacific Northwest[7]	0	38.5	.4	[6]	38.9
Pacific Southwest[8]	0	4.7	0	0	4.7
Total	253.5	331.0	32.3	179.4	796.2

[1] "Proven superior" is selected and bred to be genetically superior, when planted on appropriate sites. "Source identified" and "Selected parentage", planted on sites similar to their parents' locations, will result in trees *at least* as good as their parents. "Source unidentified" may result in trees *worse* than their parents, because the tree may not be adapted to the site (although there is not way to know in advance).

[2] Grown from seeds of unknown geographic origin.

[3] Grown from seeds of known geographic origin.

[4] Grown from seeds from parents exhibiting superior characteristics.

[5] Grown from seeds from parents tested and proven genetically superior.

[6] Less than 0.05.

[7] Includes Alaska.

[8] Includes Hawaii.

largest category of production, with 41.6 percent of total State production. Nearly all of the western production was source identified. Selected parentage stock (the third level of improvement) accounted for only 4.1 percent of total State production. Over 90 percent of the nursery stock in this level was grown in the South.

Seedlings from proven superior parentage (the highest quality level) accounted for 22.5 percent of total State production. Eight of every ten of the seedlings in this category were grown in the Southeast. Nearly half of that region's seedlings grown in State nurseries were in this level. Only 8.8 percent of the South Central's seedlings were of this quality. None of the other regions had more than 5 percent of their production from proven superior parentage.

Ten years ago very few seedlings were produced in the "selected parentage" or "proven superior" categories. Progress in State tree improvement programs has increased the proportion of seedlings in the "proven superior" and "selected parentage" categories while shrinking the "source unidentified" category.

STUDY RESULTS

Current and projected levels of softwood supply from NIPF made by the USDA Forest Service (1982) were used to estimate future softwood planting increases (table 2).

Nationally, NIPF planting in 2030 is projected to be 60 percent greater than average 1976-1982 levels. The various regions will maintain their relative positions in acres planted, although the Southeast will gain on the others. More than one-third of the NIPF planting is done in this region, while nearly one-third occurs in the South Central region. Together, these two regions account for 68 percent of the planting on NIPF lands.

Planting stock requirements were calculated using the projections of NIPF acres to be planted, and the data supplied by the States on the numbers of seedlings usually planted per acre (table 3). Requirements were calculated using the projected planted acreages times the regional average number of trees planted per acre. Regional averages of the latter were developed by weighting the number of seedlings per acre reported in the questionnaire by each State, by the size of the State's total genetic program in dollars (three year average).

NIPF lands will require about 450 million seedlings annually over the next three decades. In these projections, it is assumed that the proportion of seeding for regeneration, relative to planting, will not increase significantly. Should this, however, be the case, the need for improved seed will increase (due to probable lower germination and seeding survival in the field than under nursery controlled conditions), while nursery capacity needs would be correspondingly lower. Future nursery capacity for State needs and to supply industry are not included in this analysis.

Also shown in table 3 are the regional totals of State nursery produced seedlings planted on NIPF in 1982. For the two Southern regions, and the Rockies, 1982 plantings are higher than those projected for 1990-2010. Two factors may account for this. First, the projected planting acreages are based on a 7 year average (1976-1982), while the figures for

Table 2.—*Average annual planting on NIPF lands, 1976–1982, and projected planting levels by decade, 1990–2030*

Region	Average 1976–1982	Projected				
		1990	2000	2010	2020	2030
	Thousand acres					
Northeast	45.6	51.3	55.6	59.1	61.8	64.1
North Central	53.6	68.1	80.4	91.3	100.7	109.4
Southeast	168.9	216.4	244.9	262.6	272.1	275.8
South Central	142.1	170.5	190.9	204.8	215.0	220.4
Rocky Mountains and Plains	13.8	13.8	13.8	13.8	13.8	13.8
Pacific Northwest	23.6	26.5	27.3	27.8	27.3	28.9
Pacific Southwest	10.8	12.1	13.2	15.2	17.4	19.8
Total[1]	458.4	558.7	626.1	674.6	708.1	732.2

[1]Excludes Alaska and Hawaii.

Source: Developed from *Seeding and Planting in the U.S.*, annual, and *An Analysis of the Timber Situation in the U.S., 1952–2030*, U.S. Department of Agriculture, Forest Service, Washington, DC.

Table 3.—*Planting stock requirements for NIPF lands 1990–2010, average seedlings per acre, and state produced seedlings planted on NIPF*

Region	Planting stock required for NIPF lands			State produced seedlings planted on NIPF, 1982	Average number of seedlings planted per acre
	1990	2000	2010		
	Millions of seedlings				
Northeast	46.2	50.0	53.2	21.4	900
North Central	54.5	64.3	73.0	45.3	800
Southeast	162.3	183.7	197.0	188.6	750
South Central	115.1	128.9	138.2	134.2	675
Rocky Mountains and Plains	7.6	7.6	7.6	9.2	550
Pacific Northwest	10.6	10.9	11.1	7.9	400
Pacific Southwest	7.3	7.9	9.1	2.8	600
Total[1]	403.6	453.3	489.2	409.4	

[1]Excludes Alaska and Hawaii.

State seedlings planted on NIPF lands are for 1982 only. Production in State nurseries in 1982 was the highest since 1961. Second, the amount of replanting and interplanting done in 1982 is unknown. However, about 20 percent of the plantations in the South in the latest evaluation of the Forestry Incentives Program needed replanting or interplanting to bring them up to satisfactory stocking levels (Risbrudt and Ellefson 1983).

While the largest portion of State nursery production is planted on private lands, others are heavily involved. Nationally, 49.4 percent of the States' seedling production went directly to nonindustrial private ownerships (in 1982). Forest industries received 36.9 percent, State lands received 4.9 percent, Federal organizations took 2.3 percent, and 7.0 percent went to miscellaneous recipients. In the South, the region of greatest planting on NIPF lands, 48.4 percent went to these ownerships, while 44.1 percent went to forest industry.

STATE EXPENDITURES

State expenditures in 1982 on genetic improvement are shown by timber species in table 4. Four species represent 80 percent of the efforts of the States in tree improvement. A total of $1.65 million, or 41 percent of all timber species tree improvement money expended by the States, is spent on loblolly pine. The other three species are Douglas-fir with $717 thousand (18 percent), slash pine with $567 thousand (14 percent), and ponderosa pine with $276 thousand (7 percent).

Thirty other species make up the remaining 20 percent. Eastern white pine is the only other timber species with a total program exceeding $100 thousand annually ($144 thousand was spent by the States in 1982).

BENEFIT-COST RATIOS

Benefit-cost ratios for the State tree improvement programs are given by discount rate and region in table 5. At the four percent discount rate, the regional benefit-cost ratios range from 7.1 to 45.2, among the regions, under current programs. The national average is 31.5. For the Pacific Northwest, Southeast, and South Central regions, the figures represent the estimates of gain for programs that are already well established. For the other regions, on the average, the ratios represent the estimates for smaller, and in many cases, newer programs.

At high discount rates, the benefit-cost ratios rapidly decline. At the ten percent rate, the regions range from 0.1 to 4.3, while the national average is 2.7. This drop is due to the long time periods before benefits of increased growth are captured in thinnings and final harvests. Two time frames are involved: first, the tree improvement process itself is lengthy; and second, rotation lengths are long, even though they are shortened by genetic improvement.

INCREASES IN WOOD PRODUCTION

Estimated increases in NIPF softwood volume are substantial (table 6). For 1982 plantings, the increase over the first rotation for the species included

Table 4.—*Expenditures on genetic improvement of timber species by region, 1982*

Region and species	1982 expenditures
	Million dollars
Northeast	204
Eastern white pine	55
Loblolly pine	33
Larch	25
White spruce	24
Balsam fir	15
Others	52
North Central	182
Black walnut	31
Jack pine	30
Red pine	26
White spruce	23
White oak	22
Others	50
Southeast	1,244
Loblolly pine	701
Slash pine	371
Longleaf pine	109
Sand pine	23
Eastern white pine	40
South Central	1,258
Loblolly pine	916
Slash pine	196
Eastern white pine	35
Longleaf pine	31
Black walnut	21
Others	59
Rocky Mountains and Plains	148
Ponderosa pine	53
Black walnut	40
Douglas-fir	27
Western white pine	23
Western larch	4
Others	1
Pacific Northwest	686
Douglas-fir	615
Ponderosa pine	37
Western hemlock	34
Pacific Southwest	289
Ponderosa pine	186
Douglas-fir	75
White fir	28
Total U.S.	4,011

Table 5.—*NIPF benefit-cost ratios for the State Tree Improvement Programs*

Region	Discount rate		
	4	7 1/8	10
	Percent		
Northeast	13.3	6.4	1.6
North Central	8.8	1.6	.2
Southeast	38.8	11.4	4.3
South Central	40.9	11.0	3.6
Rocky Mountains and Plains	45.2	3.5	.5
Pacific Northwest	39.1	8.0	1.8
Pacific Southwest	7.1	.7	.1
U.S.	31.5	8.2	2.7

amounts to nearly 81 million cubic feet. This averages out to an increase of 145 cubic feet per acre, over the 558 thousand acres planted. For trees to be planted in 2010, the average additional yield per acre is projected to rise to 700 cubic feet compared to current growth and yield. This is an increase of nearly a factor of five, being the result of greater growth per seedling, and a much greater proportion of seedlings improved. However, these figures are only for the timber species for which benefits are calculated, representing 94 percent of the expenditures.

Another consideration in this analysis is that the acres from which benefits were calculated represent only planting on NIPF lands. Nationally, this represents only one-half of State seedling production. The other one-half was planted on forest industry, State, and Federal lands, in that order. More than one-third of the seedlings produced by the States were planted on industry lands. A number of State-produced seedlings sent to industry may be actually planted on NIPF lands through industry Landowner Assistance Programs. Since this quantity is unknown, industry plantings of State-produced seedlings on nonindustrial lands were excluded. Benefits to State tree improvement programs are no doubt higher than the estimates made in this study

Table 6.—*NIPF softwood timber volumes produced by the State Tree Improvement Programs, by program year*

(In million cubic feet)

Product	1982	1985	1990	2000	2010
Pulpwood	37.8	59.2	94.6	168.8	228.6
Saw logs	42.9	75.8	113.8	273.0	244.2

since only one-half of the seeding production is incorporated. The other ownerships were excluded to simplify the analysis, and produce conservative estimates.

On the other hand, growth increases due to genetic improvement are very sensitive to the level of forest management following planting. The estimates incorporated in this analysis are dependent on a reasonably intensive level of management—primarily regular thinnings—to achieve optimum growth. If these thinnings do not occur in a timely manner, as may be the case in many NIPF plantings, the gains in growth due to genetic improvement may not occur. No allowance for this factor has been made in calculating the benefit-cost ratios.

Total expenditures by the States for tree improvement are shown by region in table 7. Total expenditures have increased from about $3.3 million in 1979 to nearly $4 million in 1981, an increase of almost 21 percent. Although in real (1979 dollars) terms, this represents an increase of only 0.6 percent, it does include additional increases to make up for the decline in Federal funds.

Over the three years shown, the two southern regions have accounted for 65 percent of the total expenditures for tree improvement. The three western regions average 26 percent of the total, and the northern regions averaged 10 percent. Relative to the total, the State and Private Forestry funds represent a much higher proportion in the North (62 percent) than in the West (43 percent) or in the South (30 percent).

Table 7.—*Regional totals of State expenditures for tree improvement, 1979–1981*
(In million dollars)

Region	1979	1980	1981
Northeast	172	197	227
North Central	161	211	174
Southeast	1,109	1,167	1,267
South Central	1,002	1,094	1,328
Rocky Mountains and Plains	277	283	303
Pacific Northwest	471	506	556
Pacific Southwest	120	126	138
Total	3,312	3,584	3,993

NOTE: Figures include State and Private Forestry funds.

SUMMARY AND CONCLUSIONS

All 50 States were queried about their tree improvement activities, and about their future tree improvement and nursery needs. About 4 million dollars is expended annually on tree improvement, with one-quarter of this coming from the USDA Forest Service, State and Private Forestry, through grants to States. Loblolly pine improvement accounts for 40 percent of the total, followed by Douglas-fir, slash pine, and ponderosa pine. These four species represent 80 percent of all State expenditures. Thirty other species make up the remaining 20 percent.

Increased timber harvests can be expected due to tree improvement efforts. For softwoods, the 1982 NIPF plantings are projected to yield 38 million cubic feet of pulpwood and 43 million cubic feet of sawtimber, above that which would have occurred with unimproved stock. These increased yields will occur throughout the rotations of the various species in the current budget. By 2010, improved seedlings will yield an additional 229 million cubic feet of pulpwood and 244 million cubic feet of sawtimber over their rotation length.

Finally, the analysis shows the high sensitivity of the benefit-cost ratios to the discount rate. This is due to the long time periods involved in tree improvement before benefits are realized. Because of the long term significant benefits, the Tree Improvement Program is a logical public effort.

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