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Nitrogen Fertilization Effects on Growth and Value of Eastern White Pine Sawlog Stands on Till and Outwash Soils

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ABSTRACT

Diameter growth response functions were developed using 4-yr data collected from nitrogen fertilization study plots in eastern white pine stands on till and outwash soils. These functions were combined with height measurements and used to evaluate stand volume and value growth. White pine diameter growth functions were developed for application rates of 0, 50, 100, and 200 lb of nitrogen/ac, but only those for the 0 and 100 lb/ac treatments were compared because it was evident that the 100 lb/ac treatment would provide a larger financial return than either 50 or 200 lb/ac. The mean increase in sawtimber volume due to fertilization with 100 lb of N/ac was 1,226 bd ft/ac for stands on the till soils and 775 bd ft/ac for stands on the outwash soils. Increases in studwood volume were 293 and 172 bd ft/ac, respectively. Pulpwood volume increase was small and apparently not affected by fertilization. The average stand value increase due to fertilization, with a sawtimber price of $100/thousand bd ft and a studwood price of $50/thousand bd ft, was $135/ac on the till soils and $87/ac on the outwash soils. Ranges were $108 to $165 and $66 to $106 on till and outwash soils, respectively.

INTRODUCTION

Eastern white pine (*Pinus strobus* L.) is the most valuable conifer, expressed as dollars/thousand board feet ($/M bd ft), in the northeastern U.S. In Maine, its monetary value is exceeded only by that of white and yellow birch, red and white oak, and white ash. Stumpage rates as high as $180/M bd ft have been reported recently, and the average statewide stumpage price is approximately $98/M bd ft (Maine Forest Service 1989).

White pine grows on a wide range of soils from poorly drained glacial tills to excessively drained outwash sands. However, the area presently in young white pine stands in Maine is declining. A recent forest survey of Maine revealed that white pine sapling and seedling stands decreased from 368,000 ac in 1971 to 62,000 ac in 1982 (Powell and Dickson 1984). This suggests that in the future a shortage of white pine could occur and that the price of white pine stumpage and lumber may rise considerably. This implies, in turn, that it would be desirable to increase growth in some sawtimber and poletimber stands while intensifying efforts to increase white pine regeneration and reduce hardwood competition in younger stands. Fertilization offers potential as a way to increase growth of managed stands.

Nitrogen fertilization was emphasized in the work reported here, because nitrogen is the nutrient most commonly deficient and limiting to growth of conifer stands in the northeastern U.S. and Canada (Armson et al. 1975) and elsewhere in the U.S. (Bengtson 1979; Allen 1986). Schomaker (1973) found that foliar nitrogen concentrations of white pine stands in southern Maine were generally below those required for optimum growth and concluded that many stands should respond to nitrogen fertilization.

The major objectives of the study were to determine:

1. growth response to different application rates,
2. differences in response between stands on outwash soils and stands on till soils, and
3. increases in stand value due to fertilization.

Results based on 4 yrs of growth response from eight stands are presented.

PROCEDURE

Five stands were selected on somewhat excessively and excessively drained, deep, outwash sands that originated in glaciofluvial material derived from crystalline rock. Mean pretreatment diameter at breast height (dbh), height of dominant trees, and basal area of stands on these soils were 12.0 in., 87 ft, and 108 ft^2/ac, respectively. Average stand ages ranged from approximately 60 to 75 yrs. Three stands were selected on deep, well-drained, and moderately well drained, fine sandy loams that have developed in compact basal till derived from schist and granite. Mean pretreatment dbh, height of dominant trees, and stand basal area were 10.8 inches, 78 ft and 128 ft^2/ac, respectively; average stand ages ranged from approximately 50 to 65 yrs. Locations of all stands are shown in Figure 1.

Eight plots were established in each of five stands. The remaining three stands were considerably smaller in area and contained species other than white pine, which precluded establishing plots in certain portions of those stands. Consequently, seven plots were established in two stands and six in one stand. Plots were circular and ranged from 0.07 ac to 0.25 ac; plots were smaller in the denser stands. All plots in a given stand were of the same size.

All trees in each plot were numbered and marked at breast height. Diameter at breast height (dbh) was measured after the growing season preceding treatment and after the second and fourth growing seasons following treatment. Pretreatment height and height 4 yrs after treatment were measured for 15 to 30 trees in each stand. The trees selected in each stand for height measurement were distributed across the range of dbh classes; the number selected depended upon the number of dbh classes.

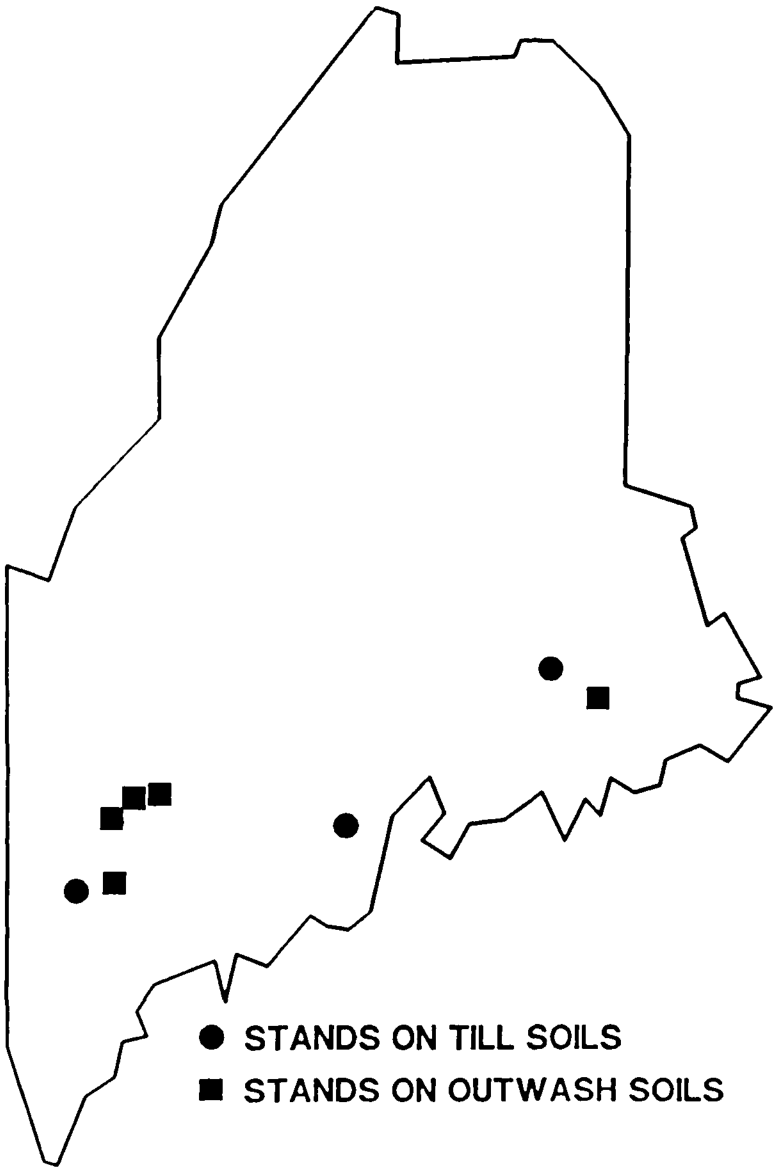

Figure 1. Locations of white pine stands.

Equations of the form:

$$\text{Total tree height} = a + b\,(1/[\text{dbh}]) + \varepsilon$$

where height = total tree height, dbh = diameter at breast height, a and b are regression coefficients, and ε is a random error term, were developed for each stand for use in volume calculations. The height equations do not provide for the possible effect of fertilization on height growth. Any effect on height growth at the stage of development of these stands is likely to be small and difficult to determine given the error normally associated with height measurements.

Nitrogen (N) was applied as urea at rates of 0 (0N), 50 (50N), 100 (100N), and 200 (200N) lb/ac of elemental N. Each treatment was replicated twice in those stands containing eight plots. In the remaining stands, one or more non-zero treatments was replicated only once or did not appear. (All stands contained two control plots.) Nitrogen was applied by hand to the measurement plots and outward to a distance of 5 ft beyond the perimeter of the measurement plot. The number of plots by treatment on the outwash soils was: 0N—10, 50N—9, 100N—10, 200N—9. On the till soils the number of plots by treatment was: 0N—6, 50N—4, 100N—6, 200N—6.

Stepwise regression was used to test for the significance of treatment, pretreatment dbh, pretreatment $(\text{dbh})^2$, and pretreatment basal area/ac on diameter growth at breast height. The analyses were performed for data from all stands on the outwash soils and all stands on the till soils separately, because previous analyses revealed a statistically significant difference in growth without fertilization between stands on the two soil groups (Shepard, Reams, and Lemin—manuscript in preparation). Orthogonal contrasts were used to test for differences in dbh growth among treatments.

Prediction equations of dbh growth as a function of the above variables were determined for each N application rate. The equations for 0N and 100N, in combination with the height equations, were used to estimate merchantable volumes from equations developed by Honer (1965). The 100N treatment was selected because it was the treatment that provides the most favorable financial return.

Examination of dbh distributions by stands and plots within stands revealed no "typical" or "representative" distribution(s) on either soil group. Therefore, to compare and evaluate the stand volume growth and value increase to be expected from fertilization, dbh growth projections for 0 and 100 lb of N/ac were made for all trees on each of the study plots. Tree heights for a given stand were predicted from the equation derived for that stand only.

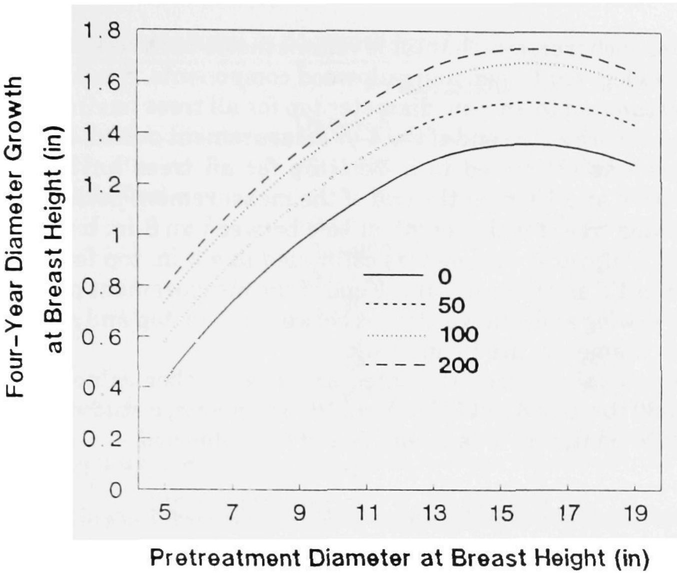

Figure 2. Diameter growth of white pine on till soils. (0, 50, 100, and 200 represent the nitrogen application rates in lb/ac.)

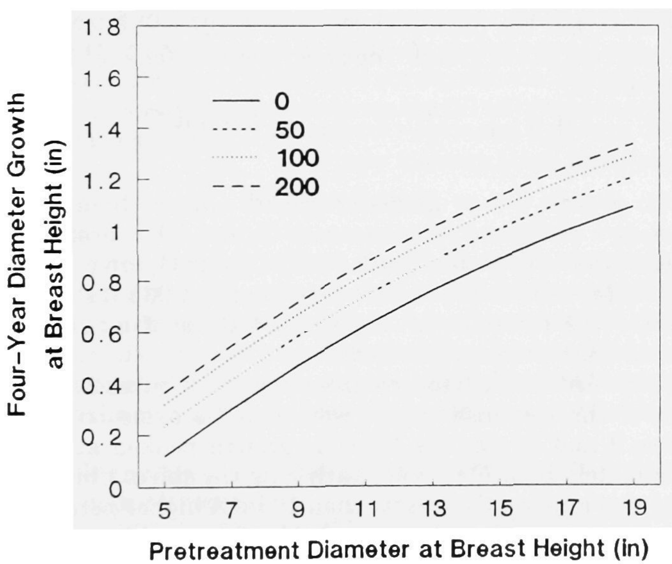

Figure 3. Diameter growth of white pine on outwash soils. (0, 50, 100, and 200 represent the nitrogen application rates in lb/ac.)

For each tree, merchantable volume inside bark was partitioned into sawlog, studwood, and pulpwood components. Sawlog volume was estimated to an 8-in. diameter top for all trees having a dbh of 10 in. or more at the end of the 4-yr measurement period. Studwood volume was estimated to a 4-in. top for all trees having a dbh between 6 and 10 in. at the end of the measurement period and for all sawlog trees for the length of bole between an 8-in. top and a 4-in. top. Pulpwood volume was estimated to a 2-in. top for all trees between 4.5 and 6 in. dbh at the end of the measurement period and for all sawlog and studwood trees between a 4-in. top and a 2-in. top. All top diameters are inside bark.

Stand values were estimated using sawtimber values ranging from \$80 through \$120/M bd ft in \$10 increments, a studwood value of \$50/M bd ft, and a value of \$5/cord for pulpwood.

RESULTS AND DISCUSSION

Diameter Growth

The effects of treatment, pretreatment dbh, pretreatment $(dbh)^2$, and pretreatment basal area/ac on 4-yr dbh growth were highly significant ($P \leq 0.01$) on both soil groups. The difference between 0N and 50N and between 50N and 100N was highly significant on both soil groups, but the difference between 100N and 200N was not significant for either group. The general model for predicting 4-yr dbh growth is:

Dbh growth = intercept + treatment + C_1 (dbh) + C_2 $(dbh)^2$ + C_3 (pretreatment basal area/ac) where,

Dbh growth = 4-yr diameter growth (in.) at breast height, treatment = nitrogen application rate (lb/ac), dbh = pretreatment diameter (in.) at breast height, and C_1, C_2, and C_3 are coefficients. The model for the outwash soils was based on 935 trees and the model for the till soils on 495 trees. Values of estimates and coefficients are presented in Table 1.

Dbh growth on each soil group is shown in Figures 2 and 3. The shapes of the response curves were not the same on each soil (Figures 2 and 3). On the till soils growth peaked at a dbh of approximately 16 in. On the outwash soils, the dbh at which growth peaked was apparently greater than 19 in. A higher percentage of trees on the outwash soils were of dbh 16 in. and larger, and an examination of the data indicated that growth continued to increase as dbh increased. In contrast, larger trees in the stands on the till soils did not show the same tendency, perhaps because of the higher stand densities. It should be emphasized that the dbh growth values estimated from the response functions become less reliable as the

Table 1. Estimates used in response functions.

	Soil Group	
Parameter	Outwash	Till
Intercept	0.15082	0.76085
Treatment (lb N/ac)		
0	-0.11643	-0.15212
50	0.00000	0.00000
100	0.08463	0.15731
200	0.13063	0.20312
Coefficients[a]		
C_1	0.11371	0.26634
C_2	-0.00185	-0.00844
C_3	-0.00357	-0.01104

[a] C_1 (dbh), C_2 (dbh)^2, C_3 (basal area/ac)

upper and lower limits of the data are approached, and the functions should not be used for a dbh of less than 4 in. or greater than 20 in.

The actual estimates of the 4-yr increases in growth over the control due to the nitrogen treatments are presented in Table 2. The largest increase, 0.36 in., occurred at 200N on the till soils, which was 0.05 in. greater than the increase at 100N. The largest increase on the outwash group, 0.25 in., also occurred at 200N and was 0.05 in. greater than the increase at 100N. As stated previously, differences between 100N and 200N were not significant. Growth at both 100N and 200N was 0.11 in. greater on the till soil group than on the outwash soil group.

Volume Growth

Sawtimber

Four-year sawtimber volume growth/ac at 0N was greater on the till soils than on the outwash soils (5,326 bd ft vs. 3,802 bd ft) (Table 3) and averaged 1,332 bd ft/yr on the former and 951 bd ft/yr on the latter. The superior growth on the till soils was evident in that the mean growth at 0N on those soils was 749 bd ft more than growth at 100N on the outwash soils. Mean increases in 4-yr growth due to

Table 2. Increase in 4-year dbh growth (inches) due to fertilization with nitrogen.

	Application Rate (lb/ac)		
Soil Group	50	100	200
Till	0.15	0.30	0.36
Outwash	0.11	0.20	0.25

fertilization with 100N were 1,226 bd ft/ac on the till soils (23%) and 775 bd ft/ac on the outwash soils (20%).

There was a wide range in both volume/ac after 4 yrs and in 4-yr growth/ac (Table 3). Response ranged from 516 to 1,055 bd ft/ac on the outwash soils and from 816 to 1655 bd ft/ac on the till soils. Results from individual stands are presented in Table 1 of the Appendix.

Studwood

Volume and volume growth of studwood were small compared to sawtimber volume and volume growth (Table 3). Studwood volume was actually less after 4 yrs except for the 100N treatment on the till soils, where the mean increase was a modest 77 bd ft/ac (Table 3). Although studwood volume growth at 100N on the outwash soils was negative, it was less so than growth at 0N (-376 bd ft/ac vs. -548 bd ft/ac).

A reduction in studwood volume occurred with three of the four treatment combinations because the volume gained from trees that moved into the sawtimber category more than offset the volume increase of trees that remained in the studwood category and the volume gained from trees that moved into the studwood category from pulpwood-size during the 4 yrs.

There was a wide range in studwood volumes/ac after 4 yrs and in 4-yr growth/ac (Table 3). Response ranged from 32 to 365 bd ft/ac on the outwash soils and from 52 to 558 bd ft/ac on the till soils. The 558 bd ft/ac "response" was actually the difference between a 1,184 bd ft/ac decrease at 0N and a 626 bd ft/ac decrease at 100N. Studwood volume growth by stand is presented in Table 1 (Appendix).

Pulpwood

Pulpwood volume (pretreatment) and 4-yr pulpwood volume growth were both relatively small (Table 3). Fertilization did not increase pulpwood volume, and in fact, there is an indication that fertilization may have caused a slight decrease. A decrease due to fertilization would result primarily from more trees of less than 6 in. dbh at the beginning of the study growing into the studwood category due to fertilization.

Value Increase

Sawtimber

Sawtimber values/ac, based on a stumpage price of $100/M bd ft, increased considerably, with or without fertilization, and there were large differences between soils and treatments (Table 4). The mean increases in value without fertilization were $380 on the

Table 3. Volume increases in eastern white pine stands on two soil groups fertilized with nitrogen.

	Treatment[a]			
Volume Category[b]	0C	100C	0T	100T
Pretreatment Sawlog	14758 (5550–22802)[c]	14758 (5550–22802)[c]	14578 (5550–22802)[c]	14758 (5550–22802)[c]
Sawlog Four Years After Treatment	18560 (8095–27730)	19335 (8611–28785)	20084 (9301–29142)	21310 (10117–30797)
Sawlog Growth	3802 (2545–4928)	4577 (3061–5983)	5326 (3751–6340)	6552 (4567–7995)
Pretreatment Studwood	2333 (614–5199)	2333 (614–5199)	2333 (614–5199)	2333 (614–5199)
Studwood Four Years After Treatment	1785 (390–3824)	1957 (422–4189)	2117 (457–4015)	2410 (509–4573)
Studwood Growth	-548 (-1653–2)	-376 (-1348–178)	-216 (-1184–559)	77 (-626–852)
Pretreatment Pulpwood	8.17 (5.62–12.53)	8.17 (5.62–12.53)	8.17 (5.62–12.53)	8.17 (5.62–12.53)
Pulpwood Four Years After Treatment	9.36 (6.31–14.67)	9.31 (6.24–14.58)	9.23 (6.05–14.56)	9.17 (5.04–14.40)
Pulpwood Growth	1.19 (0.69–2.14)	1.14 (0.62–2.05)	1.06 (0.43–2.03)	1.00 (0.32–1.87)

a/ 0 = 0 lb N/ac; 100 = 100 lb N/ac; C= outwash soils; T = till soils
b/ Sawlog and studwood volumes are in bd ft/ac; pulpwood volumes are in cd/ac.
c/ Range

outwash soils and $533 on the till soils. The mean increases at 100N were $458 on the outwash soils and $655 on the till soils, and the increases due to fertilization were $78 on the outwash soils and $122 on the till soils. The range of increases among stands on the outwash soils was from $51 to $106 and on the till soils, $82 to $166. By comparison, at a stumpage price of $80/M bd ft the mean increases due to fertilization were $62 on the outwash soils and $98 on the till soils, with ranges of $41 to $84 and $66 to $133. At a stumpage price of $120/M bd ft the mean increases due to fertilization were $93 on the outwash soils and $148 on the till soils; ranges were $61 to $127 and $98 to $199, respectively.

It is readily apparent, based on the increases in sawtimber value, that fertilization would be much more attractive on the till soils than on the outwash soils. Sawtimber values and value increases for individual stands are presented in Table 2 in the Appendix.

Studwood

Except for 100N on the till soils, where the increase in studwood value was $4/ac, studwood values were less 4 yrs after treatment than before (Table 4). This is a reflection of movement of some studwood trees into the sawtimber category and growth of the remaining studwood trees not being sufficient to offset the loss. Fertilization led to a mean "increase" in studwood value of $9/ac on the outwash soils; in reality it was a smaller decrease ($-19 vs. $-28). The increase on the till soils was $15 ($+4 at 100N vs. $-11 at 0N). Results for individual stands are presented in Table 2 in the Appendix.

Table 4. Value[a] increases in eastern white pine stands on two soil groups fertilized with nitrogen.

	Treatment[b]			
Volume Category	0C	100C	0T	100T
	$/ac			
Pretreatment Sawlog	1476 (555–2280)[c]	1476 (555–2280)[c]	1476 (555–2280)[c]	1476 (555–2280)[c]
Sawlog Four Years After Treatment	1856 (810–2773)	1934 (861–2879)	2008 (930–2914)	2131 (1012–3080)
Sawlog Increase	380 (255–493)	458 (306–599)	533 (375–634)	655 (457–800)
Pretreatment Studwood	117 (31–260)	117 (31–260)	117 (31–260)	117 (31–260)
Studwood Four Years After Treatment	89 (20–99)	98 (21–107)	106 (23–126)	121 (25–141)
Studwood Increase	-28 (-82–0)	-19 (-67–8)	-11 (-59–27)	4 (-31–42)
Pretreatment Pulpwood	41 (28–63)	41 (28–63)	41 (28–63)	41 (28–63)
Pulpwood Four Years After Treatment	47 (37–73)	47 (31–73)	46 (30–73)	46 (30–72)
Pulpwood Increase	6 (3–16)	6 (2–16)	5 (1–15)	5 (0–16)
Average	358 (189–484)	445 (255–590)	529 (342–629)	664 (450–794)

[a] Sawtimber value = $100/M bd ft, studwood value = $50/M bd ft, pulpwood value = $5/cd.

[b] 0 = 0 lb N/ac; 100 = 100 lb N/ac; C = outwash soils; T = till soils

[c] Range

Pulpwood

Pulpwood values were not appreciably affected by fertilization (Table 3). Pulpwood value increased by $6/ac on the outwash soils and $5/ac on the till soils.

Total value

With an assumed sawtimber value of $100/ac, fertilization increased average total stand value on the outwash soils by $87/ac (from $358 to $445) and on the till soils by $135/ac (from $529 to $664) (Table 4). The range in total value increases on the outwash soils due to fertilization was from $60/ac to $120/ac, and on the till soils it was from $78/ac to $165/ac. With a sawtimber stumpage price of $80/M bd ft, average increases were $72 on the outwash soils and $110 on the till soils with ranges of $49 to $109 and $59 to $156. At a $120/M bd ft stumpage price, increases were $101 on the outwash soils and $159 on the till soils, with ranges of $71 to $141 and $97 to $217. The increase in total value of some stands was less than the increase in sawtimber value because of the movement of trees from the studwood category into the sawtimber category.

The most recent average stumpage price for white pine in Maine was $98/M bd ft (Maine Forest Service 1989), an increase of $20/M bd ft since 1987. Zone averages ranged from $94 to $107/M bd ft. Highest prices were substantially greater, averaging $139/M bd ft and ranging from $110 to $180/M bd ft. Thus, many stands have values exceeding $100/M bd ft, especially those thinned to favor the best trees and those with pruned crop trees and located close to a mill. Under existing stumpage prices, 4-yr value increases of $100/ac or more may be anticipated in many stands following fertilization with 100 lb of N/ac.

The price of urea purchased locally (May 1990) is $292/ton ($0.32/lb of N), which means that the cost of urea to provide 100 lb of N/ac is $32/ac. Based on size, distance between stands, terrain, and density (stems/ac), it appears that many white pine stands are more amenable to treatment from the ground, using a spreader mounted on a skidder or tractor, than from the air. By treating from the ground, it would also be easier to avoid areas that should not be treated, such as areas adjacent to streams and portions of the stand where many stems may not be white pine. Because white pine stands in Maine have not been treated from the ground (or from the air) no figures are available for all costs associated with fertilizer application. Although several cost scenarios could be proposed, given the hourly operational costs of a skidder and the likely speed of movement through the stand, it does not appear that all costs in addition to the fertilizer cost should be more than $28/ac, making a total cost of $60/ac. Costs of aerial fertilization elsewhere (Wells and Allen 1985; Foster et al. 1986; Binkley 1986) suggest that all costs including fertilizer, would have been about $45 to $50/ac in the mid-1980s. Where ground application is feasible, costs/ac are less than costs of aerial application (Pritchett and Fisher 1987). In view of the above a total cost of $60/ac appears reasonable, and perhaps conservative, for ground application.

Using a total cost of $60/ac, calculations of net present value indicate returns of 10% for stands on outwash soils and 23% for stands on till soils, with a sawtimber stumpage price of $100/M bd ft. Even with a total cost of $70/ac, returns would be 6% and 18%, respectively.

Even though fertilization seems attractive on both soil groups overall, it appears that there is a greater risk that some stands on outwash soils will not produce sufficient additional growth following fertilization to provide an attractive return, while the case for stands on till-derived soils appears favorable. This would be especially true for stands having sawtimber values of less than $100/M bd ft.

An important consideration is the current trend toward land application of municipal and paper mill secondary sludges. These residuals are relatively high in nitrogen and have been shown to increase tree growth substantially (Zasoski et al. 1983; Cole et al. 1986). It must be emphasized, however, that in Maine application of sludges to stands on soils overlying aquifers or aquifer recharge areas is not permissible at present. This means that most stands on outwash soils would be off limits to landspreading of residuals.

As data from more stands in this study become available, it is likely that differences between soils will become better defined. However, the overall average will probably change less than the average for stands on each soil. The average increase in value for the stands in this report was $111/ac. Thus, it seems reasonable to expect a 4-year value increase of approximately $100/ac across a large number of sawtimber stands fertilized with 100 lb of N/ac and having a sawtimber stumpage price of $100/M bd ft.

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APPENDIX

Table 1. Volume growth of eastern white pine stands on two soil groups fertilized with nitrogen. (Stands 1 through 5 are on outwash soils; Stands 6 through 8 are on till soils.)

	Stand 1				Stand 2			
	Treatment[a]							
Volume[b] Category	0C	100C	0T	100T	0C	100C	0T	100T
Pretreatment Sawlog	10813	10813	10813	10813	17935	17935	17935	17935
Sawlog Four Years After Treatment	14187	14760	16409	17335	22130	23000	23336	24704
Sawlog Growth	3374	3947	5596	6522	4195	5065	5401	6769
Pretreatment Studwood	1458	1458	1458	1458	1943	1943	1943	1943
Studwood Four Years After Treatment	908	989	1215	1353	1725	1909	2007	2306
Studwood Growth	-550	-469	-243	-105	-218	-34	64	363
Pretreatment Pulpwood	5.62	5.62	5.62	5.62	9.27	9.27	9.27	9.27
Pulpwood Four Years After Treatment	6.31	6.24	6.05	5.94	10.12	10.16	10.17	10.25
Pulpwood Growth	.69	.62	.43	.32	.85	.89	.90	.98

[a] 0 = 0 lb N/ac; 100 = 100 lb N/ac; C = outwash soils; T = till soils
[b] Sawlog and studwood volumes are bd ft/ac; pulpwood volumes are cd/ac.

Table 1. (Continued)

	Stand 3				Stand 4			
	Treatment[a]							
Volume[b] Category	0C	100C	0T	100T	0C	100C	0T	100T
Pretreatment Sawlog	14676	14676	14676	14676	13853	13853	13853	13583
Sawlog Four Years After Treatment	18613	19389	20878	22121	17514	18193	19737	20828
Sawlog Growth	3937	4713	6202	7446	3661	4340	5884	6975
Pretreatment Studwood	2049	2049	2049	2049	1970	1970	1970	1970
Studwood Four Years After Treatment	1957	2123	2470	2745	1972	2148	2529	2822
Studwood Growth	-92	74	421	696	2	178	559	852
Pretreatment Pulpwood	8.27	8.27	8.27	8.27	7.09	7.09	7.09	7.09
Pulpwood Four Years After Treatment	8.76	8.68	8.51	8.41	7.60	7.55	7.40	7.33
Pulpwood Growth	.49	.41	.24	.14	.51	.46	.31	.24

Table 1. (Continued)

	Stand 5				Stand 6			
	Treatment[a]							
Volume[b] Category	0C	100C	0T	100T	0C	100C	0T	100T
Pretreatment Sawlog	15572	15572	15572	15572	22802	22802	22802	22802
Sawlog Four Years After Treatment	18865	19586	19783	20915	27730	28785	29142	30797
Sawlog Growth	3293	4014	4211	5343	4928	5983	6340	7995
Pretreatment Studwood	1028	1028	1028	1028	614	614	614	614
Studwood Four Years After Treatment	753	820	808	1034	390	422	457	509
Studwood Growth	-275	-208	-220	6	-224	-192	-157	-105
Pretreatment Pulpwood	5.60	5.60	5.60	5.60	9.58	9.58	9.58	9.58
Pulpwood Four Years After Treatment	6.97	6.91	6.89	6.82	9.93	9.82	9.76	9.60
Pulpwood Growth	1.37	1.31	1.29	1.22	.35	.24	.18	.02

Table 1. (Continued)

	Stand 7				Stand 8			
	Treatment[a]							
Volume[b] Category	0C	100C	0T	100T	0C	100C	0T	100T
Pretreatment Sawlog	16865	16865	16865	16865	5550	5550	5550	5550
Sawlog Four Years After Treatment	21343	22356	22084	23662	8095	8611	9301	10117
Sawlog Growth	4478	5491	5219	6797	2545	3061	3751	4567
Pretreatment Studwood	5199	5199	5199	5199	4404	4404	4404	4404
Studwood Four Years After Treatment	3824	4189	4015	4573	2751	3056	3439	3934
Studwood Growth	-1375	-1010	-1184	-626	-1653	-1348	-965	-470
Pretreatment Pulpwood	12.53	12.53	12.53	12.53	7.42	7.42	7.42	7.42
Pulpwood Four Years After Treatment	14.67	14.58	14.56	14.40	10.54	10.57	10.48	10.57
Pulpwood Growth	2.14	2.05	2.03	1.87	3.12	3.15	3.06	3.15

Table 2. Value[a] increase of eastern white pine stands on two soil groups fertilized with nitrogen. (Stands 1 through 5 are on outwash soils; stands 6 through 8 are on till soils.)

	Stand 1				Stand 2			
	Treatment[a]							
Volume[b] Category	0C	100C	0T	100T	0C	100C	0T	100T
	$/ac							
Pretreatment Sawlog	1081	1081	1081	1081	1794	1794	1794	1794
Sawlog Four Years After Treatment	1419	1476	1641	1734	2213	2300	2334	2470
Sawlog Growth	338	395	560	653	419	506	540	676
Pretreatment Studwood	73	73	73	73	97	97	97	97
Studwood Four Years After Treatment	45	49	83	68	86	95	100	115
Studwood Growth	-28	-24	10	-5	-11	-2	3	18
Pretreatment Pulpwood	28	28	28	28	46	46	46	46
Pulpwood Four Years After Treatment	32	31	30	30	51	51	51	51
Pulpwood Growth	4	3	2	2	5	5	5	5
TOTAL	314	374	572	650	413	509	548	699

[a] Sawtimber value = $100/M bd ft, studwood value = $50/M bd ft, pulpwood value = $5/cd.
[b] 0 = 0 lb N/ac; 100 = 100 lb N/ac; C = outwash soils; T = till soils

Table 2. (Continued)

	Stand 3				Stand 4			
	Treatment[a]							
Volume[b] Category	0C	100C	0T	100T	0C	100C	0T	100T
	$/ac							
Pretreatment Sawlog	1468	1468	1468	1468	1385	1385	1385	1385
Sawlog Four Years After Treatment	1861	1939	2088	2211	1751	1819	1974	2083
Sawlog Growth	393	471	620	743	366	434	589	698
Pretreatment Studwood	102	102	102	102	99	99	99	99
Studwood Four Years After Treatment	98	106	124	137	99	107	126	141
Studwood Growth	-4	4	22	35	0	8	27	42
Pretreatment Pulpwood	41	41	41	41	35	35	35	35
Pulpwood Four Years After Treatment	44	43	43	42	38	38	37	37
Pulpwood Growth	3	2	2	1	3	3	2	2
TOTAL	392	477	644	779	369	445	618	742

Table 2. (Continued)

	Stand 5				Stand 6			
	Treatment[a]							
Volume[b] Category	0C	100C	0T	100T	0C	100C	0T	100T
	$/ac							
Pretreatment Sawlog	1557	1557	1557	1557	2280	2280	2280	2280
Sawlog Four Years After Treatment	1887	1959	1978	2092	2773	2879	2914	3080
Sawlog Growth	330	402	421	535	493	599	634	800
Pretreatment Studwood	51	51	51	51	31	31	31	31
Studwood Four Years After Treatment	38	41	40	52	20	21	23	25
Studwood Growth	-13	-10	-11	1	-11	-10	-8	-6
Pretreatment Pulpwood	28	28	28	28	48	48	48	48
Pulpwood Four Years After Treatment	35	35	34	34	50	49	49	48
Pulpwood Growth	7	7	6	6	2	1	1	0
TOTAL	324	399	416	542	484	590	629	794

Table 2. (Continued)

	Stand 7				Stand 8			
	Treatment[a]							
Volume[b] Category	0C	100C	0T	100T	0C	100C	0T	100T
	$/ac							
Pretreatment Sawlog	1687	1687	1687	1687	555	555	555	555
Sawlog Four Years After Treatment	2134	2236	2208	2366	810	861	930	1012
Sawlog Growth	447	549	521	679	255	306	375	457
Pretreatment Studwood	260	260	260	260	220	220	220	220
Studwood Four Years After Treatment	191	209	201	229	138	153	172	197
Studwood Growth	-69	-51	-59	-31	-82	-67	-48	-23
Pretreatment Pulpwood	63	63	63	63	37	37	37	37
Pulpwood Four Years After Treatment	73	73	73	72	53	53	52	53
Pulpwood Growth	10	10	10	9	16	16	15	16
TOTAL	388	508	472	657	189	255	342	450