Management of Pine Seed Production Areas

Donald E. Cole

Continental Can Company, *Inc., Savannah, Georgia*

A great deal of planting and direct seeding is being done with the southern pines and there is every indication that this will be the case for a long time to come. Since the seed used has such a profound effect on the harvest and since we are planting and seeding on such a grand scale, it is vital that we use the best seed available as long as its cost is not excessive.

The fastest way of mass-producing southern pine seed is by means of seed production areas. Where suitable stands are available, substantial quantities of seed may be produced in from two to five years from the time a seed production area is established. This is much quicker production than is possible from grafted or seedling seed orchards and although the degree of improvement from seed production area seed is not as great as may be expected with seed orchard seed, we feel that the combination of rapid seed production and a modest improvement in quality is sufficient to make the establishment of seed production areas worthwhile.

Having thus stated our basic premise, let us consider in more detail what is involved in the establishment and management of seed production areas.

A seed production area is a stand managed specifically for the production of seed; its purpose is to provide, in quantity, seed of known origin from the best phenotypes available. The establishment of seed production areas is a stop-gap measure designed to produce seed of the best possible quality until our seed orchards begin to bear.

The most important single factor in the establishment of a seed production area is the quality of the stand; there is no method by which fertilization, spraying, etc., can produce first class seed from second class trees. Therefore, it is essential that the stand chosen be of the best possible quality (quality being used here primarily with reference to vigor, freedom from fusiform cankers, and form —good bole and crown characteristics—not site). Site quality isn't too important as long as it will permit fair growth and cone production (Thorbjornsen 1960) and the site is fairly representative of the area where the seedlings are to be planted.

The next point to consider is stocking; the larger the number of trees per acre, the more selective you can be regarding the trees you leave and this again has an effect on quality. Therefore, only well-stocked stands are suitable for conversion to seed production areas; 100 trees 10 inches in diameter or 50 feet of basal area per acre should be the minimum acceptable stocking.

The size, in area, of the stand has a bearing on the practicability of the operation; as the size of the area increases, management costs per acre are reduced and the proportion of the total area tied up in the isolation zone decreases. For instance, a 5-acre seed production area will have about 21 acres in its isolation zone; a 20-acre seed production area will have about 48 acres in its isolation zone. In addition, the number of trees on the area has an effect on the frequency with which the area can be harvested economically (if the number of trees is 100, and 20 percent have a crop of harvestable size, it is almost sure to be more expensive to collect them than it would be on an area where the total number of trees is 500, and 20 percent have a crop of harvestable size). We now feel that 10 acres in the seed production area proper is the least that is worth developing and we prefer larger areas.

Tree size has a strong influence on cone production, of course; we try to choose stands where the average diameter of the leave trees will be at least 12 inches. Stands of smaller trees can be used but they will take longer to produce cone crops of harvestable size.

Having selected a stand that meets our requirements for quality, stocking, acreage, and average diameter, the leave trees are marked and everything else is cut. We follow the Georgia Crop Improvement Association's Standards for the Certification of Forest Tree Seed in selecting leave trees even in States which have no provision for the certification of the seed. These give rather stiff specifications for bole and crown characteristics, freedom from fusiform cankers, width of the isolation zone, etc. We have found that these standards give us a good set of reference points to follow in establishing the areas. And the examination of the areas by the Association inspectors, with the attendant culling of sub-standard trees, puts the areas in very good shape. Generally about 10-15 trees are left per acre. This often seems like a very sparse stand, but heavy culling is necessary if much improvement in quality is to be attained.

Matthews (1963) cites research by Florence and McWilliams which showed that the density giving maximum cone production per tree is much lower than the density giving maximum cone production per acre; this has an important effect on the economics of seed-production area management since the size of the cone crop per tree is so closely correlated with cost of cone collection. Pollen production is also greater at wider spacing and is reflected in a higher number of viable seeds per cone. It is possible to have too few trees, of course; eight fair-sized trees per acre is probably close to the lower limit for good cone production and seed-set.

The release furnished by such heavy cut has a stimulating effect on the remaining trees (Allen and Trousdell 1961; Allen 1953; Bilan 1960; Easley 1954; Phares and Rogers 1962). The third season after release they usually will begin producing larger cone crops. This may continue for two or three seasons or longer, depending on the density of the stand on the seed production area.

We do not yet have sufficient data or experience to estimate accurately the number of trees needed to produce a given volume of cones. I am less optimistic in this regard than I once was, however. I now feel that about five trees are needed for each bushel of cones that is required annually. This is necessary because of the irregularity of good cone crops, because many trees do not produce cones in harvestable quantities, and because a buffer is needed against the loss of trees to insects, storms, lightning, etc.

Once a seed production area has been established, we have found that additional cultural practices are beneficial.

Fertilization has been found to be an effective method for increasing cone and seed production by a number of workers (Allen 1953; Hoekstra and Mergen 1957; Timofeev 1959). B. F. Malac, Union Bag-Camp Paper Corporation, is experimenting with the effect of different amounts of a complete fertilizer on cone production on a seed production area. He reported in a personal communication that (1) fertilized trees produced approximately twice as many cones as unfertilized trees in the same seed production area, and (2) approximately 50 percent of the cones were lost between the time of pollination and the time of harvest with no difference in the rate of loss between fertilized and unfertilized trees. However, it has been reported by Asher (1963) that squirrels prefer cones from fertilized trees, that cone losses from all causes were significantly greater on fertilized plots, and that this suggests insects also may prefer cones from fertilized trees. And Hughes and Jackson (1962) say that fertilization, especially with phosphorous, markedly increased damage from Dioryctria and Cronartium in young slash plantations. Fertilization may have other effects; Mergen and Voigt (1960) found that seed from fertilized slash pines produced larger and more vigorous seedlings than did seeds produced on unfertilized control trees.

The cost of fertilizing 1,665 trees on our seed production areas was 63 cents per tree per application of 20 pounds of 8-8-8 (NPK, with sulfate of potash-magnesia) at $47.75 a ton. Of this, 15 cents was for labor, at a rate of $1.50 per hour. It took almost exactly 1 man hour, including loading, unloading, and travel, to fertilize 10 trees. The only seed production areas fertilized are those prepared according to the Georgia Crop Improvement Association Standards where we feel that the extra cost is justified by the quality of the seed to be harvested. The fertilizer is applied in the spring, no later than mid-May.

Root pruning, girdling, and strangulation have been used to increase seed production (Bilan 1960; Grano 1960; Hoekstra and Mergen 1957; Timofeev 1959) but the results have been erratic and have even been reported to give fewer cones, in the long run, than no treatment (Bergman 1955; Girgidov 1960; Klir et al. 1956). Speaking of these practices, Matthews (1963) says "The girdling of stems of fruit trees was in common use one hundred years ago as also was root pruning; both techniques have been superceded in general practice by the use of fertilizers, shoot pruning, and clonal rootstocks, It appears certain that similar treatments will be of greater benefit than root pruning and stem girdling or strangulation in increasing seed production in forest trees."

The control of seed and cone insects is very important to the continued successful management of seed production areas. Thrips, *Laspeyresia* seedworms and Dioryctria coneworms seem to be the worst offenders; they can cause drastic losses of cones and seed from the time of pollination right on up to the time of harvest. And it is in this phase of seed production management, the economical control of cone and seed insects, that I believe the greatest opportunity lies for increasing the yield of our seed production areas.

Edward P. Merkel, located at the Olustee, Fla., unit of the Southeastern Forest Experiment Station, in a personal communication recommends the following formulations for the control of coneworms (Dioryctria spp.) : BHC (gamma isomer) at 4 pounds of active toxicant per 100 gallons of water or Guthion at 1 1/2 pounds of active toxicant per 100 gallons of water. Applications should be made during each of these periods : March 15-31, May 1-15, June 1-15, July 10-20. To lower costs the July application can be omitted with very little loss in cone protection. At these concentrations the cost of the chemicals is about the same for both BHC and Guthion and since the May application of Guthion alone gives good control of seedworm *(Laspeyresia)* it would seem to be the preferred material at least for the May application; it is more toxic to humans than BHC, however. His work was done with a hydraulic sprayer which would reach trees 50 feet tall; about 8.5 gallons of spray was used per tree at a cost of 80 cents per tree for chemicals alone.

More recently Merkel has compared the relative effectiveness of hydraulic sprayers and mist blowers for applying insecticides. In a personal communication he reports that he made applications on April 10, May 5, and June 8 of the following formulations: (1) 0.5 percent BHC hydraulic spray, (2)

2.5 percent BHC mist blower application, and (3) 1 percent Guthion mist blower application. Treatment 1 gave 93 and 85 percent control of Dioryctria on first and second-year cones. Treatment 2 gave only 50 and 69 percent control of Dioryctria on first and second-year cones. Treatment 3 gave 88 and 69 percent control of Dioryctria on first and second-year cones and 70 percent control of *Laspeyresia* (slash pine seedworm). BHC has no effect on *Laspeyresia*. The cost for both the BHC and Guthion mist treatments was 48 cents per tree per application for the chemicals alone. About 1 gallon of spray was applied per tree with the mist blower.

John F. Coyne, of the Institute of Forest Genetics, Gulfport, Miss., in a personal communication reports a cost of $1.72 per tree per application where he was treating individual parent trees with a 0.5 percent BHC water emulsion. He used a Buffalo turbine mist blower mounted on a two-wheel tractor; his cost figures include chemicals, labor, and depreciation of equipment. Three applications were made each season for a total cost of $5.16 per tree per season. Cone survival was 70-80 percent in treated trees and about 30 percent in untreated trees. It is quite likely that these costs could be reduced where similar work was being done on a seed production area or seed orchard where the trees are closer together.

Cone rust can cause heavy losses of slash and longleaf pine conelets on the Gulf Coast and in North Florida. If it is not possible to locate seed production areas outside of the areas where cone rust losses are likely to be heavy, the rust may be controlled by spraying at 5-day intervals during the time of pollination with Ferbam at the rate of 2 pounds per 100 gallons of water plus a Du Pont spreader-sticker (Matthews and Maloy 1960). Adding heptachlor (11/2 pints of a 2-pound-per-gallon emulsifiable concentrate of heptachlor per 100 gallons of ferbam suspension) gave significant control of both cone rust and thrips (Southeastern Forest Expt. Sta. Ann. Rpt. 1961, p. 30).

Regardless of the original condition of the stand, control of understory vegetation sooner or later becomes necessary because the release and fertilization stimulates the understory vegetation as well as the pines. Such control reduces competition and makes harvesting and other operations on the area much easier. The method chosen may be a control burn herbicidal spray, mowing, or a combination of these. But it should be suited to conditions in a given stand and the ideal result would be the lightest vegetative cover that would keep the soil in place.

But in spite of all we do, cone crops are extremely variable. They are not always produced on schedule the third season after release and they do not occur consistently on the same areas even when we fertilize, control competing vegetation, etc. Apparently the number of flowers produced is fairly consistent from year to year in a given stand (but not always), and most of the variation in cone crops is caused by climatic factors, e.g., too little moisture at the time flowers primordia are initiated, too much rain at the time of pollination, untimely freezes and droughts, etc., and variation in the severity of insect and disease attacks. Since we can't control the weather, the control of cone insects becomes even more important in securing harvestable crops more frequently.

Harvesting the cones economically has been a problem in seed production area management. In this connection the first thing to be decided is whether or not the cone crop is heavy enough to be worth harvesting; and an early answer to this question makes orderly arrangements for harvesting operations much easier. The maturing cones are large enough to count by about June 1 and several workers have developed methods of estimating cone yields (Hoekstra 1960; Wenger 1953a). In deciding whether or not to harvest a particular seed production area, we base the decision on the number of trees with a crop worth collecting; on certified slash seed production areas we set a cone count of 100 sound cones per tree as the minimum; on the other slash seed production areas and all loblolly seed production areas the minimum count is 150 cones (the actual number of cones collected is usually about twice the number counted). And we don't collect in areas where less than 20 percent of the trees have a crop of this size. The minimum acceptable cone count can be varied as seems desirable considering the size of the ,crop, how badly cones are wanted, etc. For most purposes this count need not be precise; all you need to know is the number of trees with a harvestable crop. With a little practice most trees can quickly be judged as harvestable or unharvestable and only borderline trees need be checked carefully.

We have done all of our cone collecting from seed production areas by climbing for the cones, rather than by cutting the trees. It is considerable trouble to prepare the areas and we want to keep them in production as long as possible. We feel that the extra cost of collection from standing trees is justified by the continued production of quality seed.

We have tried several methods of collection; climbing with aluminum tree climbing ladders, with a trailer mounted extension ladder, and with spurs and ropes. Climbing with spurs and ropes is the best method; it is cheaper, it is quicker, and so far, after two seasons, there has been no tree mortality that we can attribute to the use of spurs. Any trees which are buggy are removed at the time of harvest, however, so as to get rid of potential sources of infestation. With this system, the men climb into the trees on their spurs and descend on their ropes; this is fastest and minimizes damages to the trees. The trees that have been climbed are marked and are being watched for beetle attacks and to see how often the same trees produce worthwhile crops.

On slash seed production areas, the cones are pushed off with a cone hook with little difficulty or damage to the following season's crop. Loblolly presents more of a problem, however, and on the loblolly seed production areas a pruner is used and the whole twig is clipped off. This means the loss of the next season's cones and the flowers for the following season on these twigs but it seems to be the only economically feasible way of collecting loblolly cones from standing trees.

It is very important that the cones be ripe when collection starts. Immature cones produce less seed and the germination may be reduced (Speers 1962) which increases the cost of seed.

The first two seasons that we collected from our seed production areas, the collection was done by contract with a tree surgery company. The first season climbing was by means of aluminum tree climbing ladders. Our men and the climbers were just learning how to harvest cones; the cost of collecting slash cones was $5.65 per bushel (table 1). This figure includes climbing, moving ladders, picking up, sacking, and loading the cones for shipment to the cone warehouse. Collection costs were considerably lower when the second area (Meadows Tract) was collected that year because climbers and ground crew were more familiar with the job and some excess ground crewmen had been eliminated; but because of the marked difference in seed yield between the two, the cost per pound of seed was nearly the same on both areas.

The next time (1961) we collected from our seed production areas, climbing was done with spurs and ropes (detailed costs and yields are shown in table 2). Collection costs totaled $4.03 per bushel on the certified slash seed production areas and $3.50 per bushel on the uncertified slash seed production areas; the combined average cost was $3.71 per bushel. Costs differed because there was a lower minimum number of cones on the certified areas. Collection costs were $4.98 per bushel on the loblolly seed production areas (costs for certified and uncertified loblolly areas were lumped together since too small a part of the total came from certified seed production areas to permit an accurate comparison). Loblolly collection costs were higher than those for slash because of the greater difficulty of collecting loblolly cones and because the loblolly areas were generally more brushy. Costs were 20 to 60 percent higher whenever climbing methods other than spurs and ropes were used. Seed yields averaged 0.86 pound per bushel for cones from certified slash seed production areas, so collection costs per pound were $4.69. For uncertified slash seed production areas the figures were 0.80 pound of seed per bushel and a collection cost of $4.36. By contrast, the yield from more than 1,000 bushels of purchased slash cones was 0.71 pound per bushel and the cost per pound was $1.97 (purchase price was $1.25 per bushel and supervision, transportation, etc., added about $0.15 per bushel). The difference in seed yield

TABLE 1.—*Slash pine cone collection costs and seed yield, 1958*

Tract	Trees collected from	Quantity		Costs						Seed yields		
				Climbing		Labor		All				
		Total	Per tree	Total	Per bushel	Total	Per bushel	Total	Per bushel	Total	Per bushel	Collection costs per pound
	Number	*Bu.*	*Bu.*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Lbs.*	*Lbs.*	*Dollars*
Newman	136	150	1.1	879.37	5.86	199.50	1.33	1,078.87	7.19	175	1.17	6.16
Meadows	185	200	1.1	760.63	3.80	139.95	.70	900.58	4.50	133	.66	6.77
Total or average	321	350	1.1	1,640.00	4.69	339.45	.97	1,979.45	5.65	308	.88	6.43

TABLE 2.—*Slash and loblolly pine collection costs and seed yield, 1961*

Tract	Trees collected from	Quantity		Costs											Seed yields		
				Climbing			Brush control			Picking up, loading, etc.			All				
		Total	Per tree	Time	Total	Per bushel	Time	Total	Per bushel	Time	Total	Per bushel	Total	Per bushel	Total	Per bushel	Collection cost per pound
	Number	*Bu.*	*Bu.*	*Hours*	*Dollars*	*Dollars*	*Hours*	*Dollars*	*Dollars*	*Hours*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Lbs.*	*Lbs.*	*Dollars*
SLASH PINE																	
Certified:																	
Robinson	189	228	1.2	139.5	592.87	2.60	15.5	43.71	0.19	114.0	171.00	0.75	807.58	3.54	194.0	0.85	4.16
Blundale	52	46	.9	45.0	191.25	4.16	4.0	11.28	.25	31.0	46.50	1.01	249.03	5.41	44.0	.96	5.64
H. and P.	88	95	1.1	76.5	325.13	3.42	12.0	33.84	.36	47.0	70.50	.74	429.47	4.52	81.0	.85	5.32
Total	329	369	1.1	261.0	1,109.25	3.01	31.5	88.83	.24	192.0	288.00	.78	1,486.08	4.03	319.0	.86	4.69
Uncertified:																	
Meadows	71	65	.9	113.0	503.63	7.74	...	...	...	48.0	72.00	1.11	575.63	8.86	68.0	1.05	8.05
Blundale	334	528	1.6	274.5	1,166.62	2.21	12.0	33.84	.06	201.5	302.25	.57	1,502.71	2.85	407.0	.77	3.70
Total	405	593	1.5	387.5	1,670.25	2.82	12.0	33.84	.06	249.5	374.25	.63	2,078.34	3.50	475.0	.80	4.36
Total, all slash areas	734	962	1.3	648.5	2,779.50	2.89	43.5	122.67	.13	441.5	662.25	.69	3,564.42	3.71	794.0	.83	4.47
LOBLOLLY PINE																	
Uncertified	225	306	1.4	260.0	1,121.25	3.66	33.0	90.75	.30	208.0	312.00	1.02	1,524.00	4.98	288.0	.94	5.30
Certified	28	25	.9	...	...	...	...	...	...	...	...	...	...	4.98	31.0	1.24	4.02

between purchased cones and collected cones is due to the better control over cone quality (ripeness, freedom from insect injury, etc.) which is possible on a company job. The difference in yields between certified and uncertified areas is probably due to the fertilization and spraying for cone insects which was done on the certified seed production areas. Similar trends were evident on the loblolly seed production areas; on the certified loblolly seed production areas the seed yield was 1.24 pounds per bushel and collection costs were $4.02 per pound. On the uncertified areas the yield was 0.94 pound per bushel and collection costs were $5.30 per pound of seed (no loblolly cones were purchased so a comparison with the yield from purchased cones is not possible).

In 1962 climbing again was with spurs and ropes but the contract was on a per tree basis rather than a straight weekly rate for the crew as had been the case in the past. The Seelbach Company, of Atlanta, was the successful bidder with a bid of $3.12 per tree for slash and $3.50 per tree for loblolly.

The details of the costs of collection per bushel of cones and per pound of seed for 1962 are given in table 3. Climbing costs ranged from $1.96 to $3.93 per bushel and total collection costs ranged from $2.88 to $5.02 per bushel, depending on the bushels per tree. The collection cost per pound of seed varied from $2.81 per pound to $8.66 per pound; this is a reflection of the combined effect of bushels per tree and pounds of seed per bushel (pounds per bushel varied from $0.58 to $1.16). The yield from ordinary slash cones purchased by Continental Can Company in 1962 was 0.48 pound per bushel; at a cost of $1.40 per bushel (price of cones was $1.25 per bushel plus $0.15 per bushel for transportation, supervision, etc.) the purchased seed cost $2.92 per pound. The combined average figures for the seed production areas are 1.4 bushels of cones per tree, $2.24 per bushel for climbing, total collection costs $3.16 per bushel, average pounds per bushel 0.84, average cost per pound $3.76. There wasn't enough of a crop to make collection worthwhile on the loblolly areas so we haven't any figures on loblolly for 1962. Climbers can collect the cones from about 5 to 12 trees per day depending on the cone crop per tree and whether they are working in slash or loblolly pines.

So far we have only one set of data regarding cone collection from a loblolly seed production area in successive years (from our Hodge, La., district) but it is very interesting (table 4). There are 153 trees on the 11-acre seed production area, and in 1961 an average of 2.3 bushels of cones were collected from 95 trees by clipping the twigs with a pruner. In 1962, on the same area, 437 bushels were collected from 134 trees for an average of 3.3 bushels per tree. Of the 95 trees from which collections were made in 1961, 84 were collected from again in 1962; the average cone yield from these trees was 2.4 bushels per tree for 1961 and 3.1 bushels per tree for 1962. From an examination of yield data from the individual trees, it appears that when 3.5 or more bushels were collected from a given tree in 1961 the 1962 yield from that tree was reduced; but even so, the average 1962 yield from those high yielding trees was 2.9 bushels per tree. Thus it appears that two successive crops of cones may be collected from a loblolly seed production area even when the cones are clipped off. It will be very interesting to see when these trees will produce a crop of harvestable size again; they look rather like plucked chickens now.

TABLE 4.—*Cone yields in successive years from a loblolly pine seed production area (Hodge, La.)*

Year	Trees		Cones		Cones per bushel	Repeaters [1]	
	Total	Collected from	Total	Av. per tree		Trees	Cones per tree
	Number	*Number*	*Bu.*	*Bu.*	*Number*	*Number*	*Bu.*
1961	153	95	221.0	2.3	[2] 600	84	2.4
1962	153	134	437.0	3.3	420	84	3.2

[1] Trees from which successive cone crops were collected.
[2] Estimated.

We like contracting for cone collection on a per tree basis. It is the cheapest method we have yet developed and since payment is on a per tree basis, the pressure to keep the climbers moving is on the contractor which makes supervision easier for us. The contractor was well enough satisfied with the arrangement to have expressed an interest in doing it again; I feel that the costs are reasonable, considering the size of the cone crop.

TABLE 3.—*Slash pine collection costs and seed yield, 1962*

Tract	Trees collected from	Quantity		Costs: Climbing		Costs: Brush control			Costs: Picking up, loading, etc.			Costs: All		Seed yields		
		Total	Per tree	Total	Per bushel	Time	Total	Per bushel	Time	Total	Per bushel	Total	Per bushel	Total	Per bushel	Collection cost per pound
	Number	*Bu.*	*Bu.*	*Dollars*	*Dollars*	*Hours*	*Dollars*	*Dollars*	*Hours*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Lbs.*	*Lbs.*	*Dollars*
Robinson	34	27	0.8	106.08	3.93	2.6	11.23	0.42	12.1	18.15	0.67	135.46	5.02	15.7	0.58	8.66
Blundale	54	56	1.0	168.48	3.01	4.1	17.71	.32	25.2	37.80	.67	223.99	4.00	32.5	.58	6.90
H. and P.	58	82	1.4	180.96	2.21	5.0	21.60	.26	36.9	55.35	.67	257.91	3.15	92.0	1.12	2.81
Sav. Town	34	44	1.3	106.08	2.41	3.0	12.96	.29	19.8	29.70	.67	148.74	3.38	51.0	1.16	2.92
Total certified	180	209	1.2	561.60	2.69	14.7	63.50	.30	94.0	141.00	.67	766.10	3.67	191.2	.91	4.03
Blundale (uncertified)	212	337	1.6	661.44	1.96	16.3	70.42	.21	151.6	227.40	.67	959.26	2.85	207.0	.61	4.67
Grand total	392	546	1.4	1,223.04	2.06	31.0	133.92	.25	245.6	368.40	.67	1,725.36	3.16	398.2	.73	4.33

If the difference in cost between seed from purchased cones and those collected from our seed production areas seems alarming, in view of the combined effect of the costs of fertilization, spraying, and collection, it should be remembered that the cost of seed is only a small fraction of the costs of planting an area, especially if mechanical preparation of the site is required. On areas where site preparation is necessary, and the planting is done by machine, the cost of seed from purchased cones represents less than 1 percent of the total cost of machine planting. Thus a large increase in the cost of seed has only a small effect on planting costs.

On the other hand, a small increase in volume or quality will, by the end of a rotation, have a pronounced effect on the "dollar harvest" from the plantation. On an "average" slash site (70 foot site index at 50 years) a 1 percent increase in volume yield over a 35 year rotation would mean that the cost of seed could be increased about five times and the planter would still break even (this assumes all of the increase is considered to be in sawtimber at $35.00 per M bd. ft. at the end of the period and 5 percent interest is charged). And Perry and Wang (1958) have presented calculations to show that seed is only one-half of 1 percent superior to the average, would, under the conditions they have assumed, be worth an extra $4.52 per pound. There are other factors which eventually should reduce the cost of seed from seed production areas. On our own seed production areas and others certain trees produce most of the cone crop year after year (Hagner 1958; Matthews 1963; Thorbjornsen 1960; Timofeev 1959; Wenger 1953b). Thus, after three or four good cone crops on a seed production area, it should be possible to identify the good producers. Cultural operations could then be concentrated on the cone-producing trees with a proportional reduction in the cost of such operations.

In any case, the most important point is the degree of improvement provided by the seed from seed production areas. Easley (1963) has reported a field test of loblolly pine seedlings from a seed production area in comparison with ordinary seedlings on both sand and clay soils: "After five years in the field the seed production area stock produced 17 percent more height growth than the nursery run seedlings on deep sand. On the heavy clay soil the seed production area stock produced 27 percent more height growth than seedlings from nursery run stock . . . . This study so far indicates that the collection of seed from a local source of selected parent stocks can very well be worth the effort, time, and care required to manage a seed production area." More recently in a personal communication he said that after 8 years in the field, the seed production area stock on the deep sand site was 25 percent ahead of the nursery run seedlings in height growth. However, the difference between the two types of stock was decreasing on the heavy clay soil, indicating that the growth of the seed production area seedlings was beginning to level off on that site. He adds, "This is not unexpected on the heavy clay soil. Slash pine seedlings in the same test on the clay soil are superior in height growth to both sources of loblolly seedlings; heavy clay savannah soil is the only place where I recommend slash pine over loblolly pine in the Georgetown area."

Results such as this lend a most reassuring substance to all the theoretical arguments that have been advanced to justify the establishment of seed production areas and seed orchards. However, it cannot safely be assumed that the establishment of seed production areas will automatically assure us of a 20 percent increase in growth (or any increase at all). Each seed production area and seed orchard is a separate case and must be tested. For this purpose, our company has made test plantings of seedlings from our certified and uncertified seed production areas in comparison with nursery run seedlings on a number of sites and soil types. It will be some time before any definite results can be expected; and the results, for good or ill, will depend on the quality of the stand originally chosen for the seed production area and the care exercised in marking the trees to be left on the area. But we have enough confidence in the outcome that we are continuing to establish seed production areas, and we expect that this seed will be in demand for a long time to come.

In summation, we can say that seed production areas offer the quickest means of producing large quantities of good seed and the cost of such seed is probably quite reasonable if the stand and trees chosen for seed production are of good quality and good cultural practices and methods of harvest are used to maximize cone crops and minimize collection costs. But cone crops are extremely variable and more economical control for cone insects and diseases is needed. Finally, each seed production area needs to be tested to see if it is producing seed worth the extra cost.