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Economics of direct seeding and planting for establishing oak stands on old-field sites in the South.

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ship between residual density in all trees and sawtimber growth would be expected. This result indicates that if thinning trials are installed primarily to study sawtimber production, the treatment variable should focus on a sawtimber density measure rather than on one for all trees.

These results should provide forest managers knowldege about the effect of density and volumes on the growth and development of even-aged shortleaf pine stands and help them in prescribing treatments for their stands. The equations can be used to obtain basal area and volume projections for specific combinations of initial and final age and initial basal area or volume. Users, however, should apply results within the limitations of the study—a narrow site index range and a single thinning. □

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Economics of Direct Seeding and Planting for Establishing Oak Stands on Old-Field Sites in the South

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ABSTRACT. On old-field sites in the South, oak stands may be established by direct seeding of acorns, or by planting seedlings. Planting seedlings costs approximately 2½ times the cost of direct seeding on a per acre basis, and based on our study of overall costs and returns, we conclude that in most cases the additional costs of planting are not justified by the additional benefits. Direct seeding is therefore an economically viable alternative to planting, although success with seeding requires careful selection of species/site combinations and proper seed handling and storage.

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Demand for oaks and other hardwoods has increased greatly in recent years. In the pulp and paper industry, for example, hardwoods increased from 14% of all pulpwood consumption in the United States in 1950, to 31% in 1989 (Slinn 1990). Demand for hardwoods has also risen due to increased production levels in traditionally important markets such as fuelwood, furniture, pallets, flooring, and veneer and panel products (Nolley 1990, USDA Forest Service 1988).

While demand for oaks and other hardwoods has increased, processors of hardwood timber have expressed serious concerns about the future availability of hardwoods that are of desirable species, size, and quality, and that are both available and suitable for commercial harvest. At the 1989 annual convention of the National Hardwood Lumber Association, for example, "concern about future timber supply was the major issue discussed" (Miller and Miller 1989).

In the South, oaks are a domi-

nant part of the hardwood resource—they comprised almost 50% of all hardwood sawtimber in the region in 1987 (Barrett 1990). The commercial importance of oaks and their relative dominance in the region's hardwood resource, coupled with concerns about future hardwood timber supplies, have increased the attention devoted to regeneration and management of oak species in the South. Direct seeding and planting are important methods of oak regeneration, since hardwood stands resulting from natural regeneration often have relatively few oak seedlings (Johnson and Krinard 1985a). Oak stand establishment has also received much more attention in recent years, particularly on old-field sites, due to preferences for oaks and other hardwoods for wildlife habitat, and due to increased regeneration of hardwoods through the federal Conservation Reserve Program (Allen and Kennedy 1989). Continued emphasis is expected for hardwood regeneration. The Conservation Reserve Program, for example, is now included in an overall "Environmental Conservation Acreage Reserve Program" that, subject to funding, will provide incentives for seeding and planting of old-fields through 1995.

We compare costs and projected returns for direct seeding and planting for establishing oak stands on old-field sites in the South. Our comparison of direct seeding and planting generally applies to old-fields suitable for southern, bottomland hardwoods, rather than applying to upland areas. Costs and returns are evaluated on an after-tax basis, with and without state or federal cost-share assistance, and also for areas placed in hardwood production under provisions of the Conservation Reserve Program.

PREVIOUS WORK

Recent research in direct seeding of oaks has established guidelines for best results in seed germination, seedling survival, and longer term stand growth and development. Direct seeding of oaks is a relatively recent practice, however, and studies have not been designed and conducted specifically to compare the advantages and disadvantages of direct seeding and planting. The most common practice for artificial regeneration of oaks in the South is planting of 1- to 3-year-old seedlings (Johnson and Krinard 1985a). Research has shown direct seeding of oaks to be a viable alternative to planting, however, and guidelines for direct seeding of oaks have been presented by Johnson and Krinard (1985a, 1985b). As with planting, species should be selected that are most appropriate for specific sites. Broadfoot (1976) and Baker and Broadfoot (1979) present site-suitability information for commercially important southern hardwoods. For both timber and wildlife purposes, preferred oaks for artificial regeneration in southern bottomlands include Nuttall (*Quercus nutallii* Palmer), Shumard (*Q. shumardii* Buckley), cherrybark (*Q. pagoda* Raf.), water (*Q. nigra* L.), willow (*Q. phellos* L.), and swamp chestnut (*Q. michauxii* Nutt.).

General recommendations for oak seeding are that seeded areas be at least 2.5 ac in size, and that acorns be sown 2–3 in. deep, 2–3 ft apart, and in rows that are 10–15 ft apart (approximately 30 ft^2 of space per seed-spot, or about 1450 seeds/ac). Direct seeding may be done in the fall or the spring, and if necessary may be done in the summer after water recedes from lower bottomlands. Seeding may be done manually or with the use of modified agricultural equipment such as soybean planters.

Advantages and disadvantages of direct seeding for oak regeneration are presented in Table 1. In general, direct seeding of oaks is faster, more flexible, and less expensive than planting on old-field

Table 1. Advantages and disadvantages of direct seeding for oak stand establishment [see Johnson (1981, 1984), and Johnson and Krinard (1985a, 1985b)].

	Advantages
1.	Direct seeding of acorns is generally more flexible than planting oak seedlings. If properly done, for example, direct seeding can be successfully accomplished any time of year. Direct seeding may be the only means available to establish oak stands on sites that are frequently flooded during winter and spring planting periods.
2.	Direct seeding of acorns by hand is much faster than planting by hand, and direct seeding by machine is faster than planting by machine.
3.	Since the cost of growing seedlings in a nursery is eliminated, direct seeding of oaks is typically much less expensive than planting. For old-field sites, where site preparation costs are similar to planting, direct seeding of acorns may cost one-third to one-half the cost of planting oak seedlings.
4.	Microsite conditions are very important in the survival and longer-term competitiveness and development of individual oak trees. Since direct seeding typically involves 1400–1500 seed-spots per acre, trees which succeed in becoming dominant and codominant are much more likely to benefit from the best microsite conditions.
	Disadvantages
1.	The overall likelihood of success in establishing adequate oak regeneration in a given year, on a specific site, may be somewhat less with direct seeding than with planting. Our statement is qualified since areas planted and seeded with oaks for research and commercial purposes in the South have not differed greatly in the overall rate of success.
2.	To avoid excessive rodent damage, old-fields or other areas to be seeded should be at least 2.5 ac in size. In smaller openings or in forested areas, rodents are a major impediment to direct seeding.
3.	Following harvest of existing stands, oak regeneration by direct seeding may require more site preparation than would be necessary with planting. By providing cover for rodents, excessive logging slash may lower the likelihood of success for direct seeding.
4.	Direct seeding is generally not equally successful with all oaks. In research trials, direct seeding has generally been more successful with red oak species than with white oak species.

sites. Based on research trials and our knowledge of direct seeding on public and private lands in recent years, however, the overall likelihood of regeneration success with oaks in a given year is somewhat less with direct seeding than with planting.[2] Acorns may be more sensitive than seedlings to extreme moisture conditions on the site, although success is only influenced if extremely wet or extremely dry conditions occur for an extended period of time. Only 1 year in the last 5 years has resulted in generally poor germination and survival of direct-seeded acorns in Mississippi, for example. The spring and early summer months of 1989 were extremely wet, and many of the areas direct-seeded with oaks in the state, particularly lower bottomland areas, had relatively poor rates of germination and survival. Many bottomlands in the state that were *planted* during the 1989 season to oak species other than Nuttall were also adversely affected by extended periods of flooding, however.

METHODS

We compare direct seeding and planting for oaks by: (1) estimating costs for each practice on a before-tax basis; (2) converting costs to their after-tax present value; and (3) comparing after-tax cost differences between practices to potential revenue differences.

Costs for oak direct seeding and planting have not been widely investigated or published. Our cost estimates are therefore based on personal communication with landowners, foresters, and vendors of forestry services in the South, as well as information from private tree nurseries and seed suppliers. Our base-year for cost estimates is 1989. Costs were converted to their after-tax present value, i.e., the present value of federal income tax savings from reforestation-related deductions were discounted to the present and subtracted from initial costs as discussed by Bullard and Straka (1985) for reforestation expenses, and Fazzari (1987) for depreciation deductions for capital assets in general.

Opportunities for state or federal cost-share assistance were included in the analysis, and where appropriate, it was assumed that all relevant conditions for participation were met (size of ownership, total expenditures per year, etc.). We also assumed that cost-share recipients would claim a 10% tax credit and amortize 95% of seeding and planting costs. For a complete description of current federal income tax incentives for reforestation, see Hoover et al. (1989). We use after-tax discount rates, and all values are in real terms, i.e., net of inflation. We present results for both 15 and 28% marginal income tax rates, but did not include state income taxes in the analysis.

Costs for direct seeding and planting were estimated by personal communication with individuals involved with oak stand establishment in the South in recent years. Differences in expected returns, however, are more difficult to assess. Studies of oak direct seeding are relatively recent, and plantation yield information is not available for a formal projection of returns. We therefore compare the marginal costs of planting to the *potential* marginal returns—our overall method of analysis is to assess the before- and after-tax cost differences of direct seeding and planting, and to compare the additional costs of planting to the practice's potential, marginal benefits.

RESULTS

Before-Tax Costs

Establishing oak stands on old-field sites typically involves the cost of site preparation, the cost of acorns or seedlings, and the cost of the seeding or planting activity. We estimated 1989 costs of $10/ac for site preparation (bush-hogging or disking), $35/ac for seeding/planting, and acorn costs of $12 to $25/ac versus seedling costs of $115/ac. The estimated total cost for direct seeding of oaks is therefore $57 to $70/ac, while total costs of planting are about $160/ac. Each cost component is described below.

Site preparation is the first requirement for establishing oaks on most old-field sites in the South. Although not necessary for areas that were in crops immediately prior to planting or seeding, most areas to be regenerated have had at least one growing season for grasses, weeds, and other vegetation to flourish. In many cases, such vegetation is sufficient to severely restrict the survival and growth of oak seedlings, whether planted or established by seeding. Burning, bush-hogging, or light disking is therefore recommended prior to oak planting or seeding. We assumed that bush-hogging or disking would be done—in many cases burning is not an option due to timing, weather conditions, or lack of sufficient, dry vegetation. Our estimate of $10/ac for bush-hogging or light disking in 1989 is based on experience and personal communication rather than published information.

The direct seeding or planting cost estimate of $35/ac is also based on experience and contacts with many landowners and vendors of planting/seeding services. The value also coincides with the published southwide average of $35.46/ac for hand-planting of old-fields in 1988 (Straka et al. 1989). The published value primarily reflects hand-planting of southern pines, however, since the biennial, southwide survey of forest industry, forestry consultants, and public agencies reflects the most widely practiced type of old-field reforestation in the region. Oak direct seeding is generally faster and more easily accomplished than planting, but since the practice is still relatively new to

[2] This conclusion is supported by Allen (1990), who determined that "planting seedlings is a better method for establishing bottomland forest habitat *quickly* on old-field sites" (emphasis added). Allen further stated, however, that the number of uncontrolled variables in his study "rules out definitive conclusions," and that studies to evaluate the "relative benefits and costs of these two methods would be useful."

most vendors and landowners, at present there is little or no difference in the price charged for seeding and the price charged for planting.

The only truly significant difference in costs between oak seeding and planting on most old-field sites is the cost of acorns versus the cost of oak seedlings. Our estimated seedling cost of $115/ac assumes a 10 × 10 ft spacing, or about 435 trees/ac, and therefore reflects a cost of 26–27 cents per seedling (actual costs normally vary based on the quantity and size of oak seedlings ordered). For areas to be direct seeded to oaks, meanwhile, approximately 1450 acorns are needed per acre. Relatively small-seeded species such as water oak, willow oak, and cherrybark oak require 3–4 pounds of seed per acre, while much larger-seeded species such as Shumard oak, Nuttall oak, and swamp chestnut oak may require 15 pounds of seed per acre (based on average numbers of seed per pound published by the USDA Forest Service 1974). Acorn prices also vary by species, based on size and availability. Minimum costs per acre are $12 to $15 for water, willow, or cherrybark oaks; maximum costs are up to $25/ac for pure stands of Shumard, Nuttall, or swamp chestnut oaks. Species mixtures are normally recommended, however, and most direct seeding of oaks on old-fields in the South therefore involves acorn costs between the $12 and $25 per acre extremes.

Cost-Share and Conservation Reserve Program Assistance

Government programs that provide assistance for timberland owners were recently described by Gunter and Ogden (1989). The federal Forestry Incentives Program and various state programs provide cost shares for reforestation and other approved practices, and the federal Conservation Reserve Program (CRP) also has provided payment of up to 50% of the costs of oak seeding and planting on old-field sites. In addition to initial cost-sharing, CRP also provides annual rental payments for 10 years. The CRP provisions of the 1985 Farm Act were in part designed to establish permanent cover on erodible cropland, and oak direct seeding and planting are approved practices for many bottomland hardwood sites in the South.

Government programs and their funding vary over time, and state-sponsored programs also vary in eligibility requirements and practices approved for cost-shares. It has been our experience, however, that many of the private, nonindustrial landowners that have established or intend to establish oaks on old-field sites in the South have received or intend to receive cost-share assistance in some form. A relatively common rate of state and federal assistance is 50%, and we therefore include 50% cost-shares (with and without) in the cost estimates presented for oak seeding and planting.

After-Tax Present Value of Costs

Since federal income tax incentives are provided for qualified reforestation expenses, tax savings from oak planting or direct seeding must be considered to accurately reflect the true differences in costs between practices. All of the tax benefits from reforestation do not occur in the first year, however, and tax savings in future years must therefore be discounted to the present. The effective cost of planting or seeding is the after-tax present value of costs—the original expense minus the present value of all income tax savings.

For qualified reforestation expenses, individuals, estates, partnerships, and corporations are eligible for a 10% investment tax credit and for deduction of expenses over a 7-year period (Hoover et al. 1990). A maximum of $10,000 of reforestation expenses are eligible per year for the credit and series of deductions. Where a 10% tax credit is applied, 95% of the planting or seeding expenses can be deducted. In the year the costs are incurred, 1/14 of the amount is deducted, for the 2nd through 7th tax years, 1/7 is deducted, and in the 8th tax year the remaining 1/14th is deducted. Haney and Siegel (1988) provide a concise description of the tax incentives and the specific forms necessary for noncorporate timberland owners to claim the credit and deductions.

Potential tax savings from the reforestation tax credit and deductions are significant, as shown by the example in Table 2. The column of Table 2 titled "Item" includes the tax credit and the series of deductions; to determine their tax savings, each deduction is multiplied by 0.28 (the marginal tax rate for most forest landowners) since each dollar deducted from

Table 2. Example calculation of effective direct seeding or planting costs: before-tax cost = $10,000, marginal tax rate = 28%, discount rate = 10% (after-tax discount rate = 7.2%).

Year	Item	Tax savings	Present value of tax savings ($)
		($)	
0	10% credit	1,000	1,000.00
0	(1/14) (9500) (0.28)	190	190.00
1	(1/7) (9500) (0.28)	380	354.48
2	(1/7) (9500) (0.28)	380	330.67
3	(1/7) (9500) (0.28)	380	308.46
4	(1/7) (9500) (0.28)	380	287.74
5	(1/7) (9500) (0.28)	380	268.42
6	(1/7) (9500) (0.28)	380	250.39
7	(1/14) (9500) (0.28)	190	116.79
		Total present value of tax savings =	$3,106.93
		Effective cost = $10,000 − $3,106.93 =	$6,893.07

taxable income reduces taxes owed by 28 cents. If all other factors are unchanged, the after-tax present value of costs for landowners in the 15% marginal tax bracket would be higher (tax savings are less and the after-tax discount rate is higher). Individuals with lower before-tax discount rates, however, would have lower effective costs since the present value of tax savings would be greater.

Effective costs may also be stated *per dollar* of planting or direct seeding expense. In Table 2, for example, the after-tax present value of costs is $6,893 or about 69 cents per dollar for the $10,000 of expenses incurred. After-tax present values per dollar of reforestation expenses are presented in Table 3 for 15 and 28% marginal tax rates, and for before-tax discount rates of 6, 8, 10, and 12%. We also distinguish between reforestation toward the beginning or toward the end of a tax year. If planting or direct seeding is done toward the beginning of an individual's tax year, tax savings begin nearly a year later than if expenses are incurred toward the end of the tax year.

The estimated cost of planting oaks on old-field sites in the South is two and one-half times greater than the midpoint of estimated costs for direct seeding (Table 4). The planting/seeding cost ratio is the same with and without cost-share assistance, and before and after taxes.

The absolute cost difference between oak planting and seeding does change, of course, with cost-shares and on an after-tax basis.

Table 3. The after-tax present value per dollar of total reforestation expense toward the end of the tax year (values in parentheses are if expenses are toward the *beginning* of the tax year).

Before-tax discount rate*	Marginal tax rate	
	15%	28%
6	0.7796 (0.7903)	0.6697 (0.6834)
8	0.7858 (0.7994)	0.6799 (0.6973)
10	0.7914 (0.8077)	0.6893 (0.7102)
12	0.7965 (0.8154)	0.6980 (0.7221)

* After-tax discount rate was used in each computation: After-tax discount rate = (before-tax rate) (1 − tax rate).

Table 4. Summary of cost differences for planting and direct seeding of oaks, with and without cost-shares, and before- and after-taxes.

	Planting (a)	Direct seeding (b)	Marginal cost of planting [(a) minus (b)]
	($1/ac)		
1. Before-taxes, without cost-shares	160.00	57–70 (Midpoint = 63.50)	96.50
2. Before-taxes, with 50% cost-shares	80.00	28.50–35.00 (Midpoint = 31.75)	48.25
3. After-taxes, without cost-shares*	110.29	39.29–48.25 (Midpoint = 43.77)	66.52
4. After cost-shares *and* after-taxes*	$55.14^{non\text{-}CRP}$	$19.64–24.12^{non\text{-}CRP}$ (Midpoint = 21.88)	$33.26^{non\text{-}CRP}$
	77.54^{crp}	$27.62–33.92^{CRP}$ (Midpoint = 30.77)	46.77^{CRP}

* Values on lines 3 and 4 apply to a landowner in the 28% marginal tax bracket, with a 10% before-tax discount rate, with expenses incurred toward the end of the tax year. For other comparisons (15% marginal tax rate, other discount rates, or expenses toward the beginning of the tax year), multiply the values in columns (a) and (b), line 1 or 2, by the appropriate value from Table 3. The "non-CRP" and "CRP" designations on line 4 are necessary because taxes must be paid on CRP cost-shares.

The marginal cost of planting in Table 4 is the estimated cost of planting minus the midpoint of the range of costs estimated for direct seeding. On a before-tax basis, are the benefits from planting oak seedlings worth $96 per acre more than the results obtainable with direct seeding? Or, where cost-shares are received and income tax incentives are applied, is planting worth $33 per acre more than direct seeding? To address these questions, the potential marginal benefits of planting must also be considered.

Marginal Costs Versus Potential Marginal Benefits of Planting

There are two broad types of potential marginal benefits from oak planting instead of direct seeding on old-field sites in the South. First, a common perception with foresters and landowners is that planted oak seedlings have a "head start" on trees that were direct seeded. If an advance on growth is obtained by planting, planted areas would generally produce greater yields, or would produce merchantable timber at an earlier age. The second potential benefit of oak planting is that in a given year, the overall likelihood of success in obtaining adequate numbers of surviving trees may be greater than with direct seeding.

Regarding the first potential advantage, we conclude that planted oaks do not have a significant "head start" in growth and eventual yield. Studies have not been conducted specifically to investigate potential growth differences from oak planting and seeding, but research trials of both methods show no clear difference in tree size after several years (see Krinard and Kennedy 1987, for example). Also, since oak stands are not merchantable for 30-plus years after regeneration, if a marginal difference in growth existed initially, the difference would be insignificant at harvest.

There *is* a very significant *cost* difference for planting, however, and the longer such costs are compounded, the greater the marginal benefits of planting would have to be to merit the extra initial expense. Marginal costs of $33/ac after cost-shares and taxes, for example, would require an after-tax harvest revenue *increase* from planting of $266/ac after 30 years or $532 after 40 years (if the $33 is to earn a pretax rate of return of 10% and the landowner is in the 28% marginal tax bracket). Potential extra harvest revenues are not a valid reason to incur the added costs of oak planting on old-fields in the South. If regeneration is successful, direct seeding of oaks should provide essentially equivalent benefits at harvest at one-third to one-half the cost of planting.

The second potential benefit from planting is the improved like-

lihood of successfully establishing an oak stand on a given site in a particular year. This potential benefit cannot be measured, however, and thus can only be assessed qualitatively. Differences in the overall likelihood of success between oak planting and seeding are not great if important factors in the seeding activity are properly done (acorns have been stored properly, the species/site combination is appropriate, etc.). Properly done, success in establishing oak stands on old-field sites by seeding approaches the likelihood of success with planting. Also, since oak seeding costs are less than one-half the cost of planting old-fields, seeding can be redone if unsuccessful in the first attempt, with total costs still less than for one attempt at planting.

Rates of Return from Direct Seeding and Planting

What rates of return can be expected from oak direct seeding and planting on old-field sites? Potential rates of return vary for different sites and oak species and would also be highly sensitive to the assumed timing, intensity, and frequency of harvests and projected yields, and to speculations about future prices for oak timber. For one category of oak planting and direct seeding, however, rates of return can be estimated with greater certainty; landowners whose old-field sites were enrolled in the Conservation Reserve Program are eligible for annual rental payments for 10 years as well as the initial 50% cost-share. Through August of 1988, the average CRP rental payment for southern states ranged from $48.81/ac in Arkansas to $39.45 in Texas (McMullen 1989). Assuming landowners enrolled in CRP are foregoing $10/ac in net annual income from soybeans (Harris 1987), and assuming a conservative $40/ac annual CRP rental payment, marginal returns to landowners are $30/ac for 10 years before taxes, or $21.60/ac after taxes (28% rate). From a private (nonsocietal) standpoint, aftertax returns of $21.60/ac yr for 10 years from an aftertax net investment in oak seeding of $30.77/ac (from Table 4) represents an internal rate of return of 70%. For planting at $77.54/ac, the aftertax rate of return estimate is 25%.

The above estimates are marginal rates of return to seeding and planting expenditures versus soybean production, since the only costs and returns considered were the extra costs of oak stand establishment and the extra revenues in CRP rental payments (versus net crop-related income). Although the estimated rates of return are very high compared to most investments, the basic assumptions are conservative, and end-point values were not included. Ten years after the initial expense, for example, planting or seeding would result in a 10-year-old oak stand, while continued soybean or other crop production would maintain the land as an agricultural field. The oak stand would have value from the standpoint of potential revenues from future timber sales, but would not be attractive in terms of flexibility for reintroducting agricultural crops.

CONCLUSIONS

Direct seeding is a viable alternative to planting for establishing oak stands on old-field sites in the South. Direct seeding of oaks is generally faster and more flexible than planting, and total costs are about one-third the cost of planting. The primary advantage of planting is that in a given year, the overall probability that the regeneration attempt will produce an adequate number of free-to-grow trees may be somewhat greater than for seeding.

Estimated direct seeding costs (1989 basis) are $57–$70/ac, depending on the mix of oak species, compared to $160/ac for planting seedlings. The absolute cost difference between the practices is less if cost-shares are received, and is also less on an after-tax basis. With 50% cost-shares, for example, oak planting costs about $48/ac more than direct seeding (before taxes). If the tax advantages of incurring reforestation expenses are considered, and 50% cost-shares are received, the average cost difference is about $33/ac for non-CRP areas and $47/ac for areas in the Conservation Reserve Program. We conclude that the potential advantages of oak planting do not merit the additional cost on most old-field sites in the South. If cost considerations are not important, however, planting should be recommended due to the practice's greater overall likelihood of establishing an oak stand in a given year.

For both seeding and planting, landowners and foresters should be aware of the potential for significantly lowering the effective cost per dollar of reforestation expense. After considering the tax advantages, for example, the cost of seeding or planting is 68 to 82 cents per dollar of expense incurred, depending on the landowner's tax rate, discount rate, and the timing of expenses. The cost of reforestation is further reduced if cost-shares are received—50% cost-shares, for example, lower the effective costs by half to 34 to 41 cents per dollar of planting or seeding expense on non-CRP areas. The costs are somewhat higher on areas where CRP cost-shares are received because the cost-shares are included as taxable income. On an after-tax basis, direct seeding can be done for as little as $22/ac if 50% of the cost is shared by a federal or state agency. For lands receiving CRP rental payments, the after-tax rate of return on the landowner's initial investment in oak direct seeding may be 70% or more per year for the 10-year period.

Many factors are involved in reforestation decisions, particularly on private nonindustrial lands. Direct seeding of oaks is a low-cost alternative to planting, but just as with planting seedlings, proper techniques are extremely important to overall success. To ensure greatest success in establishing oak stands on old-field sites by direct seeding, acorns must be properly stored and handled, appropriate species/site combinations must be used, and important guidelines on site preparation, size of opening, spacing, and sowing depth should be followed closely. □

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An Economic Evaluation of the Use of Oust for Herbaceous Weed Control in Loblolly Pine Plantations[1]

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*ABSTRACT. Herbaceous weed control using Oust (sulfometuron methyl[2]) is economically efficient in loblolly pine (*Pinus taeda *L.) plantations given reasonable expectations about the long-term effect of the treatment on stand growth. Increases in the sizes of the growth increments following treatment that have been reported in the literature, and the economic returns this analysis shows are possible, indicate that investment in herbaceous weed control can be a prudent silvicultural option.*

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[2] Use of trade names is for the reader's information and convenience. Use in these studies does not constitute official endorsement or approval by the U.S. Department of Agriculture to the exclusion of any other suitable product.

Herbaceous weed control (HWC) is an intensive management tool available to forest plantation growers. Despite its relatively recent development, there is a growing body of literature concerning the biological effectiveness of the technique. However, the economics of HWC has not been thoroughly investigated. To partially fill the gap in economic knowledge, this study examined the economic implications of using Oust (sulfometuron methyl) for HWC in loblolly pine plantations over a broad range of conditions; results for a case study were reported previously (Busby 1989).

Oust is a chemical that effectively controls a wide range of forbs and grasses, Michael (1985). It is applied to herbaceous plants that invade planted pine sites and compete with the young trees for available moisture, sunlight, and other finite resources of the site.

On both cutover acreage and abandoned agriculture cropland, these weeds must be controlled before loblolly pine plantations can be successfully established. On cutover sites, herbaceous weeds as well as hardwoods compete with the pine. Former agricultural lands often have a dense cover of herbaceous weeds that interfere with the growth of pine seedlings.

The direct physical effects of