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LASER LEVELING: A PRIVATE INVESTMENT ANALYSIS

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ABSTRACT

Laser leveling farmland is a profitable water savings technology in many areas of the West. Capital cost, irrigation field efficiencies, potential yield increase, energy prices, planning horizon, and the future certainty of federal cost-sharing programs significantly affect the decision to laser. If federal programs continue, farmers also need to decide how fast to laser their farms, since payments are a function of time along with acres lasered. Given existing water costs for a typical farm in Arizona and federal subsidies, the farmer should laser part of the farm each year over a ten year period.

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Introduction

Even though farmers have practiced water conservation for generations, several new technologies, in particular laser leveling farmland to dead or basin level[1], can significantly reduce per acre water applications in arid environments. Farmers first lasered in the Wellton-Mohawk Valley near Yuma, Arizona for salinity control and found that it also reduced water applications. Currently, farmers throughout Arizona, Southern California, and Utah are laser leveling to lower water costs. The Federal Government has introduced cost-sharing, loan subsidy, and accelerated investment tax deduction programs that reduce private investment costs to further promote water conservation in agriculture. While these incentives make investment in lasering profitable on more farms, they may cause the farmer to laser only a few acres per year.

Objectives

Our analysis focuses on two farm investment questions: (1) should the farmer invest in laser leveling and (2) how many acres should be lasered per year? The first question involves estimating a break-even water price ($ acre-foot) that equates the per acre benefits to the costs. The net gain from laser leveling will be positive if farm water costs exceed the break-even price. In the absence of government subsidies the second question concerning how fast to invest is not important: whenever per acre net benefits are positive, the farmer should laser the whole farm. But with cost-sharing programs lasering over several years may be more profitable than lasering all acres today. Specifically, the ASCS and the tax write-off programs, both a function of time in addition to acres lasered, encourage farmers to laser only part of the farm each year, even though without the payment all would be lasered now.

Laser Leveling Benefits and Costs

Farmers use laser technology to bring their irrigated fields to a zero slope, sometimes referred to as dead or basin level. Laser leveled fields save water by reducing the runoff and deep percolation associated with standard flood and furrow gravity irrigation techniques. Experts claim that laser leveling increases on-farm irrigation efficiencies from 50-65 percent,typical for flood and furrow irrigation, to over 80 percent [Pachek]. Higher field efficiencies lower irrigation costs, reduce saline return flows, and where water is limited, allow acreage increases. In addition, the uniform distribution of water may produce yield increases. "Best guess" yield increase estimates from irrigators, Soil and Water Conservation field specialists, and state extension agents familiar with laser leveling range from zero to 10 percent.

Although lasering costs per se are not great, the complete leveling operation can be expensive, since most farms must move sizeable quantities of soil from high to low areas. Also, the full operation usually requires removal of old and construction of new ditch systems. For flood irrigated land in the Southwest with values between $2000 and $3000 per acre, complete laser leveling costs vary from $400 to $600 per acre.

Cost-Sharing Programs and Water Conservation Policies

Federal and state conservation policies promote laser leveling. In the Wellton-Mohawk area of Arizona, federal subsidies pay 75 percent of laser leveling costs. In other areas, Agricultural Stabilization and Conservation Service (ASCS) cost-share programs typically cover 50 percent of the investment costs, up to a total per farm payment of $3500 per year. Federal income tax laws permit a "fast write-off" for laser leveling. In addition to financial incentives, the Soil Conservation Service (SCS) offers technical information to farmers who laser while some groundwater legislation designed to limit pumping and encourage water conservation may specifically require farm level leveling practices [Arizona Groundwater Study Commission].

Is Lasering Profitable? Break-Even Models and Results

The analysis in this paper uses a net present value criterion to evaluate investment alternatives [Bierman and Smidt]. This method reduces benefit and cost streams to a single number. If the laser leveling net present value (NPV) is positive, then lasering is profitable:

$$NPV = \sum_{n=o}^{T} \frac{(PW \cdot WS + Y \cdot GR + ASCS)(1 - MTR)}{(1 + r)^{n}} -$$

$$\sum_{n=o}^{T} \frac{(IC - SWC)MTR + (NR + OM)(1 - MTR)}{(1 + r)^{n}} \qquad 0 \qquad (1)$$

where:

PW = on-farm water cost,

WS = on-farm water savings,

Y = yield increase,

GR = crop gross revenue,

ASCS = government cost-share payment,

MTR = marginal tax rate,

IC = initial laser and leveling costs,

SWC = soil and water conservation tax deduction,

NR = net revenue crop loss while lasering,

OM = maintenance costs,

r = discount rate, and

T = planning horizon.

(See the appendix for extensions of this net present value model.)

Rather than estimating numerous net present values to reflect different water costs for each farm region, the break-even analysis solves equation (1) for a water price, WP, that equates the discounted benefit stream to the discounted cost stream (WP = PW, when NPV = 0). Also, due to uncertainty concerning federal help, we estimate break-even water prices for (1) farmers expecting the ASCS payment to continue until they laser their whole farm, and (2) those expecting payments to end after the initial investment year.

Case 1. Continuing ASCS Payments

The break-even water price for farmers lasering just enough acres to receive the maximum ASCS payment per year is small. The benefits from lasering must exceed only part of total investment costs not covered by the ASCS payment plus the crop net revenue loss in the first year and periodic maintenance. For a typical 50 percent investment cost-sharing program, the minimum break-even water price occurs when the farmer lasers,

$$AL = \frac{ASCS}{1/2IC}$$

where AL is the lasered acreage producing the greatest total ASCS payment. For example, lasering a typical Arizona farm (Farm A) having IC = $600/acre, water saving = 20 ac.in./ac., MTR = 35%, yield increase = 1%, gross farm income = $700/ac., r = 5%, maximum ASCS = $3500/year, OM = $50/ac., NR = $150/ac., and 500 total acres is profitable if farm water costs are $11/acre-foot or greater. Since water costs in the arid Southwest generally exceed $11/af., the private benefits along with government incentives should result in farmers laser leveling at least a few acres per year (12 acres/year for Farm A).

Case 2. Uncertainty over Future Payment

Given the current governmental attitude toward spending, Case 1, which assumes that federal programs will continue, may not be appropriate. Case 2 determines the break-even water price, $\overline{WP}$, for farmers laser leveling their whole farm and receiving just one ASCS payment in the first year. Case 2 break-even water prices exceed those in Case 1, due to lower per acre ASCS payments and soil and water conservation tax deductions. For Farm A, the break-even water price is substantially higher--$24/af. vs. $11/af.,--but still lower than the current price of irrigation water in much of Arizona.

Sensitivity Analysis (Case 2)

A sensitivity analysis of all variables in equation (1) found that the initial investment cost, water savings, pumping cost inflation, planning horizon and the yield increase will change the break-even water prices

(Table 1). The percentage increase in yield has a large impact on the break-even water prices, even when the yield gain seems minor. At low levels of water savings, even a 1 percent yield increase substantially changes break-even water prices, often reducing the break-even price of water by $10/af. to $20/af. If medium (20 acre inches) or high (30 acre inches) levels of water can be saved, then the influence of yield on break-even water price diminishes.

Greater on-farm water savings also significantly reduce $\overline{WP}$. Lasering can lower water applications from 10 to 30 acre inches per acre by increasing field efficiency on flood irrigated fields from 50 or 65 percent to over 80 percent. Seasonal consumptive water use for cotton, wheat, sorghum and alfalfa in Arizona are about 41, 24, 24, and 75 acre inches per acre, respectively (Erie, et al.). Using cotton as an example, a farm which increases field efficiency from 55 to 80 percent cuts irrigation applications by 23 acre inches. If no yield increase is expected, then reducing water use by 10 to 20 acre inches per acre halves the break-even water price. Even though the water savings effect on break-even prices is reduced if lasering increases yields, the impact is still sizeable.

Initial investment costs (IC) in Arizona, estimated to be $400, $500, or $600 per acre on respectively 25, 50 and 25 percent of the acreage subject to lasering [Parson], will change $\overline{WP}$. As IC goes from $400 to $600 per acre, the break-even water price can increase by $5/af. to $13/af., depending on the specific water savings and yield increases.

Even though the rate of increase in fuel prices for pumping (z) has been greater than the general inflation rate, current projections [Data

Table 1. Case 2 Break-Even Water Prices for Different Investment Costs (IC), Fuel Price Changes (z), Water Savings (WS), Time Horizona (T) and Yield Changes.

Investment Cost, Fuel Price, Water Savings and Time Horizon combination				Percentage Yield Increase					
				Dollars/af.					
IC ($/ac)	Z (%)	WS (ac.in.)	T (years)	0%	1%	3%	5%	7%	10%
$600	10	10	25	70	49	35	29	24	18
			50	57	39	29	24	19	15
		20	25	35	29	23	21	18	15
			50	29	24	19	17	14	12
		30	25	23	21	18	16	14	12
			50	19	17	14	13	12	10
	13	10	25	52	40	30	26	21	17
			50	35	28	22	19	16	13
		20	25	26	23	19	17	15	13
			50	18	16	14	12	11	9
		30	25	18	16	14	13	12	10
			50	12	11	10	9	8	7
$400	10	10	25	53	37	27	22	18	14
			50	44	31	22	18	15	12
		20	25	27	22	18	16	14	11
			50	22	18	15	13	11	9
		30	25	18	16	13	12	11	9
			50	15	13	11	10	9	8
	13	10	25	40	30	23	20	16	13
			50	27	21	17	15	12	10
		20	25	20	17	15	14	12	10
			50	14	12	11	10	9	7
		30	25	13	12	11	10	9	8
			50	9	8	7	7	6	6

Resources] suggest that electricity (most Arizona pumps use electricity) rates may level off as coal and hydro power replace petroleum as the primary energy source. We assumed that fuel prices would increase at an annual rate equal to the general inflation, 10%, and a rate exceeding the general inflation, 13%. The sensitivity analysis indicates that a 13 percent fuel price increase will effect the break-even price at low water savings (10 acre inches) and small yield increases. Under these conditions, higher fuel prices mean a decrease in the current break-even price of water by $10/af. to $20/af.

The planning horizon (T) varies from 25 to 50 years. Shorter planning horizons are probably not appropriate because (1) lasering should have an infinite physical life, and (2) if water becomes more scarce, as expected, lasering should not become economically obsolete. The planning horizon has a substantial impact on $\overline{WP}$, often exceeding $10/af., when the water savings equal 10 acre inches, but much less for greater water savings.

Optimal Acreage to Laser Per Year - Model and Results

In addition to deciding whether or not to laser, the farmer must decide how many acres to laser each year. Since ASCS payments and tax write-offs are a function of time, the farmer whose water costs exceed the break-even price must determine an optimal lasering schedule (ac./year). The optimal number of lasered acres will depend on the certainty of future ASCS payments. Farmers certain that the ASCS program will continue must weigh the net gain from lasering an extra acre against the loss in future ASCS payments by lasering more now. Farmers counting on just one ASCS payment should plan to laser until the extra benefits from lasering one more acre (water savings and yield) equal the extra costs.

In general, lasering decisions under either ASCS assumption requires comparing the present value of marginal gains and losses from lasering additional acres. Using the previous Case 1 and Case 2, farmers deciding to laser will either need the ASCS payment to make lasering profitable or laser even without the payment. In Figure 1, the farmer with MC_2 marginal costs needs the ASCS payment to make any lasering schedule profitable, since the marginal costs exceed the marginal water saving plus marginal yield benefits ($MC_2 > MWSB + MYB$). The farmer with MC_1 would laser even without federal subsidies, while the farmer with MC_3 wouldn't laser at all.

Case 1. Continuing ASCS Payments

The farmer expecting cost-sharing program to continue indefinitely must decide how fast to laser the farm [Chisholm]. For farmers needing the ASCS payment, (MC_2), determining the optimal lasering schedule is straight-forward. Up to AL_1, the net benefits per acre lasered are positive (WP_4-MC_2); after AL_1 the net benefits are negative (WP_2-MC_2). The farmer lasering more than AL_1 will lose future ASCS payments without gaining any additional return today. For Farm A, AL_1 is that amount lasered per year that maximizes the ASCS payment year (12 acres lasered/year).

The optimal sequencing rule is slightly more complicated when the benefits from lasering exceed the costs without ASCS payments. Each additional acre lasered past AL_1 produces a net gain equal to marginal water savings plus marginal yield benefits minus marginal net revenue losses, marginal operation and maintenance costs, and marginal investment costs net of tax savings (MWSB + MYB) - M(IC - SWC) - MNR - MOM, distance

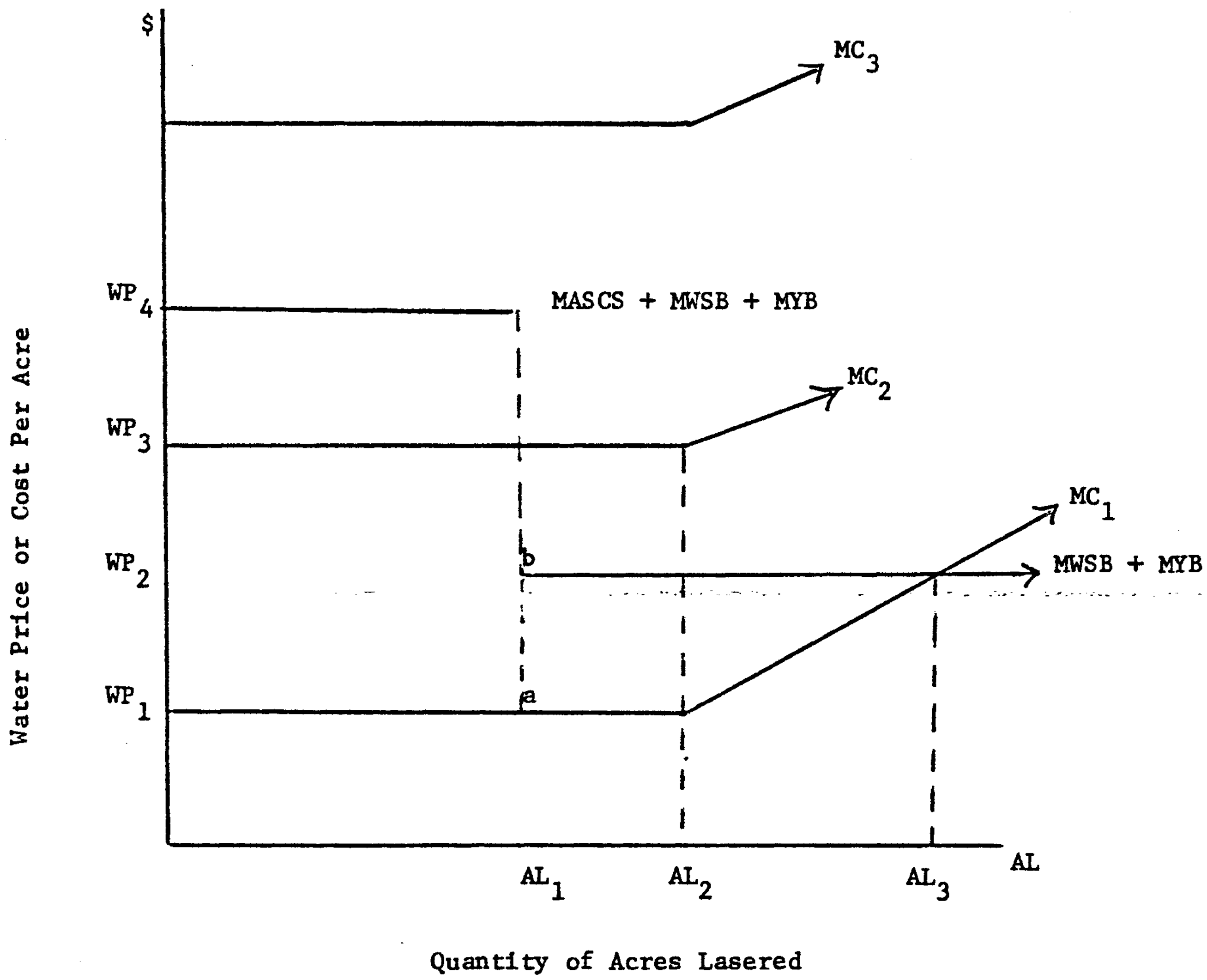

Figure 1: Laser Leveling Marginal Benefits and Costs Per Acre.

ab. But lasering past AL_1 also reduces future ASCS payments. The optimal sequencing occurs when the present value of the ASCS payment loss equals the extra net benefit as the farmer lasers more. The optimal will occur somewhere between AL_1 and the farm size. Table 2 shows the minimum farm water cost savings that would make lasering at least 40 ac./year profitable. For Farm A, the net marginal return from lasering more today must be at least \$27 above the lowest WP (water cost equal to \$38/ac.ft.) before the farmer should laser 40 acres/year. Even though the ASCS payment encourages more farmers to laser, they laser only a few acres per year in order to receive future ASCS payments.

Similar to the break-even water prices, optimal sequencing is sensitive to yield benefits, which can substantially increase the investment net return. Farm A with no yield increase should have a water cost equal to or exceeding \$118/af. to laser 41 ac./year. However, if Farm A has a 3 percent yield increase and just a \$12/af. pumping cost, the optimal acres lasered per year increases to 54.

The discount rate and farm size both influence the per year lasering decision by reducing the present value of future ASCS payments that the farmer loses as he lasers more per year. But changing the discount rate alters the decision only slightly while changing the farm size causes a significant impact. Farm A, with a 3 percent increase in yield benefits, doubling the discount rate from 5 to 10 percent causes only a 4 acre per year change (54/year to 59/year). Doubling the farm size results in the farmer lasering almost twice as much per year. Farm A, again with a 3 percent yield benefit, should laser 49 ac./year when FS = 500 acres, 67 ac./year when FS = 750 acres, and 88 ac./year when

Table 2. Optimal Acres Lasered per Year and Required Waters Cost Savings Given Different Yield Benefits, Marginal Tax Rates, Discount Rates, and Farm Size.*

Discount Rate		5%						10%					
Marginal Tax Rate		35%			50%			35%			50%		
Yield Benefits		0	1%	3%	0	1%	3%	0	1%	3%	0	1%	3%
Farm Size (ac.)	500	$118	$38.	$12.	$173	$81.	$12.	$118.	$38.	$12.	$173.	$98.	$12.
		41 ac.	41 ac.	54 ac.	41 ac.	41 ac.	49 ac.	41 ac.	41 ac.	59 ac.	41 ac.	41 ac.	53 ac.
	750	$67.	$12.	$12.	$98.	$12.	$12.	$73.	$12.	$12.	$118.	$34.	$12.
		41 ac.	53 ac.	73 ac.	41 ac.	41 ac.	67 ac.	41 ac.	53 ac.	74 ac.	41 ac.	41 ac.	73 ac.
	1000	$41.	$12.	$12.	$67.	$12.	$12.	$50.	$12.	$12.	$89.	$12.	$12.
		41 ac.	71 ac.	89 ac.	41 ac.	55 ac.	88 ac.	41 ac.	71 ac.	97 ac.	41 ac.	41 ac.	89 ac.

*Assuming the farmer would like to laser at least 40 acres per year, capital costs of $600/acre and no pumping cost inflation.

FS = 1000 acres.

Other factors that alter the decision to invest, such as the fuel price savings, investment costs, and marginal tax rate, have no or only a minor impact on the optimal sequencing decision. Specifically, changes in fuel prices and investment costs will not alter the decision at all, while changes in the marginal tax rate are significant if yield benefits are less than 3 percent.

Case 2. Uncertainty over Future ASCS Payments

The final lasering rule involves how many acres per year the farmer should laser if ASCS cost-sharing programs are expected to stop after one year. As Figure 1 illustrates, after AL_2 the marginal costs increase as the farmer lasers more, since the soil and water conservation tax rules limit the tax deduction to a maximum per year amount of 1/4 times the gross farm income. When lasering investment costs exceed the maximum farmers must wait until the next year to claim the additional expense, thus they incur an interest opportunity cost on the amount paid but not deducted immediately from their tax liability. In Figure 1, the optimal number of acres to laser is AL_3 where marginal costs equal marginal benefits.

For Farm A, the maximum per year tax deduction occurs when the farmer lasers 145 acres per year ($\frac{GFI \cdot FS \cdot 1/4}{IC}$). Each 145 acre increase in the per year lasering schedule causes the marginal net investment to increase, as the tax code forces farmers to spread the full tax expense over an additional year versus only the first. The optimal number of acres to level depends on the farm water cost, investment costs, gross farm income, farm size, marginal tax rate, and the discount rate (see Table 3).

Table 3. Optimal Lasering Schedule Assuming no Future ASCS Payments.

Parameter Change	Farm Water Cost ($/af)	Optimal Acres Lasered (ac./year)
Example Farm*	FWC = $\overline{WP}$ to $\overline{WP}$ + 9	145
	FWC = $\overline{WP}$ + 10 to $\overline{WP}$ + 19	290
	FWC = $\overline{WP}$ + 20 to $\overline{WP}$ + 29	435
	FWC = $\overline{WP}$ + 30 or greater	500
FS = 700 ac.	FWC = $\overline{WP}$ to $\overline{WP}$ + 9	204
	FWC = $\overline{WP}$ + 10 to $\overline{WP}$ + 19	408
	FWC = $\overline{WP}$ + 20 to $\overline{WP}$ + 29	612
	FWC = $\overline{WP}$ + 30 or greater	700
GFI = $500/ac.	FWC = $\overline{WP}$ to $\overline{WP}$ + 9	104
	FWC = $\overline{WP}$ + 10 to $\overline{WP}$ + 19	208
	FWC = $\overline{WP}$ + 20 to $\overline{WP}$ + 29	312
	FWC = $\overline{WP}$ + 30 to $\overline{WP}$ + 39	416
	FWC = $\overline{WP}$ + 40 to $\overline{WP}$ + 49	500
MTR = 50%	FWC = $\overline{WP}$ to $\overline{WP}$ + 14	145
	FWC = $\overline{WP}$ + 15 to $\overline{WP}$ + 30	290
	FWC = $\overline{WP}$ + 31 to $\overline{WP}$ + 45	435
	FWC = $\overline{WP}$ + 46 or greater	500
r = 10%	FWC = $\overline{WP}$ to $\overline{WP}$ + 19	145
	FWC = $\overline{WP}$ + 20 to $\overline{WP}$ + 36	290
	FWC = $\overline{WP}$ + 37 to $\overline{WP}$ + 52	435
	FWC = $\overline{WP}$ + 53 or greater	500
IC = $400/ac.	FWC = $\overline{WP}$ to $\overline{WP}$ + 7	219
	FWC = $\overline{WP}$ + 8 to $\overline{WP}$ + 13	438
	FWC = $\overline{WP}$ + 14 or greater	500

*IC = $600/ac., MTR = 35%, r = 5%, gross farm income (GFI) = $700/ac., farm size (FS) = 500 ac., $\overline{WP}$ = break even water price, FWC = farm water cost.

Farmers with water costs substantially greater than $\overline{WP}$ should laser more per year. On Farm A, if water costs exceed $\overline{WP}$ by $10/af, the optimal lasering schedule is 290/year, but if water costs exceed $\overline{WP}$ by $30/af, the optimal lasering schedule is 500/year. Different farm sizes or gross farm incomes will not change the decision rule with respect to the difference between farm water cost and $\overline{WP}$ but will change the optimal number of acres to laser. Different marginal tax or discount rates change the decision rule governing the difference between farm water cost and $\overline{WP}$ but not the acres lasered per year. Lower or higher investment costs change both the water cost break-even water price difference and the acres lasered decision points.

Conclusions

Laser leveling is often a profitable private investment in the Southwest, where farm water costs generally exceed the break-even water prices. Five factors, investment costs, water savings, fuel prices, yield benefits, and planning horizon affect the break-even water prices and thus change the decision to invest in laser leveling. Interestingly, even farms facing the conditions of high investment costs, no real increase in fuel prices, low yield benefits, low water savings, and a short planning horizon will often find laser leveling profitable even without future ASCS payments. For example, lasering most farms in Arizona is profitable, since the variable costs of pumping and applying water often exceed $30/af.

The farmer participating in federal cost-sharing programs must also choose how fast to laser. The type of program, yield benefits, farm water costs, farm size, investment costs, gross farm income, and marginal tax rates affect the optimal number of acres to laser per year. Even though the ASCS program and the soil and water conservation tax deduction reduce private investment costs, few will laser their whole farm at once. In fact, to maximize profits the typical farmer in Arizona may take approximately 10 years to laser if he expects the programs to continue. In western regions where water conservation is an important objective, the Federal cost-sharing programs both help and hinder water savings. Assuming that farmers can't expand irrigated acreage, federal policy encourages water savings by lowering the costs of laser leveling, but it also causes farmers to laser over several years rather than immediately.

FOOTNOTES

1. The laser beam is transmitted from a rotating command post generating a light plane on the level or at predetermined grade. A receiver is mounted on a mast attached to a scraper. The signal received keeps the scraper blade on the desired grade by operating hydraulic control valves automatically. Results obtained have been within plus or minus five hundredths (.05) of a foot. This is greater accuracy than can be obtained with traditional land leveling methods.
   Laser beam land leveling equipment includes: (1) tractor, (2) drag scraper, (3) laser command post, receiver and control box, and (4) hydraulic valve, pump, hose and connections (Hinz and Halderman).
2. In the sensitivity analysis the real water price (PW) may increase at 3 percent/year or not at all, depending on assumptions about change in the price of energy for pumping.

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APPENDIX 1:

Break-Even Model

The price farmers pay for water (either the variable costs of pumping and applying water or the opportunity cost of water on additional acreage) is an important factor determining laser leveling benefits. The break-even price of water, (WP), equates the discounted stream of benefits (PVB) to the discounted stream of cost (PVC). The PVB and PVC, each in dollars per acre, are given in equations 1A - 1D and 2A - 2D respectively:

$$PVB = \sum_{n=o}^{T} \frac{[WP(\frac{1+z}{1+i})^{n}(1+i)WS][1-MTR_{n}]}{(1+r)^{n}(1+i)^{n}} \quad (1A)$$

$$+ \sum_{n=1}^{T} \frac{(Y_{j,o})(GR_{i,o})(\frac{1+m_j}{1+i})^{n}(1+i)^{n}](1-MTR_{n})}{(1+r)^{n}(1+i)^{n}} \quad (1B)$$

$$+ \frac{ASCS(1-MTR)_{n}}{AL_{o}} \quad (1C)$$

$$- \sum_{n=E}^{T} \frac{[WP(\frac{1+z}{1+i})^{n}(1+i)^{n}WS][1-MTR_{n}][.40]}{(1+r)^{n}(1+i)^{n}}$$

$$+ \sum_{n=E}^{T} \frac{[(Y_{j,o} \cdot GR_{j,o})(\frac{1+m_j}{1+i})^{n}(1+i)^{n}](1-MTR_{n})(.40)}{(1+r)^{n}(1+i)^{n}} \quad (1D)$$

$$- \sum_{n=E}^{T} \frac{(OM_{o})(\frac{1+s}{1+i})^{n}(1+i)^{n}(1-MTR_{n})(.40)}{(1+r)^{n}(1+i)^{n}}$$

$$PVC = IC \tag{2A}$$

$$- \sum_{n=o}^{R} \frac{.25GI_o(\frac{1+b}{1+n})^n(1+i)^n(MTR_n)]AL_o}{(1+r)^n(1+i)^n} \tag{2B}$$

$$+ NR_{w,o}(1-MTR_n) \tag{2C}$$

$$+ \sum_{n=o}^{\overline{T}} \frac{(OM_o)(\frac{1+s}{1+i})^n(1+i)^n(1-MTR_n)}{(1+r)^n(1+i)^n} \tag{2D}$$

Subscripts refer to either the year (n) or crop (j), and superscripts are exponents.

Lasering Benefits

The first component (1A) in the benefit equation is the water savings benefit (WS) showing the present value, net of taxes, of decreased pumping cost over the planning horizon (T). The terms $(\frac{1+z}{1+i})^n(1+i)^n$ adjust the break-even price of water ($\hat{WP}$) for both general inflation (i) and the nominal rate of change in the price of water (z) over time. Water savings in year n are specified as Wn. Taxes are deducted from the benefits by $(1-MTR_n)$ where (MTR_n) is the marginal tax rate. The terms $(1+r)^n(1+i)^n$ discount the stream of future benefits to their present value--$(1+r)^n$ is the real rate of discount and $(1+i)^n$ adjusts for inflation.

The second component (1B) is the yield benefit (Y) of increased yield. Agricultural engineers indicate that farmers realize yield increases, due to a more even distribution of water, only after one or two years after the initial lasering. Therefore, these benefits begin in year n+1 or 2 and end in year T. The percentage increase in yield of crop j ($Y_{j,o}$) is multiplied by the gross revenue for crop j in year zero ($GR_{j,o}$). Future net revenues are adjusted for projected changes in net revenues of crop j (m_j) and the general rate of inflation (i). Added revenues from yield increases are also adjusted downward for taxes by $(1\text{-}MTR_n)$, and discounted to present values by $(1+r)^n(1+i)^n$.

The third term (1C) shows the ASCS payment received by farmers who invest in conservation measures such as dead leveling. Currently, the payment is limited to $3500 per year per farm, and for this reason the per acre payment depends upon the number of acres lasered (AL_o) in any one year. The payment is subject to taxes and thus reduced by $(1\text{-}MTR_n)$.

The fourth component (1D) is a capital gains tax (CGT) payment on the added value of land, due to lasering, should the land be sold in year E. The added value of land is assumed to equal the sum of the discounted stream of benefits, components 1A and 1B, less the discounted value of the stream of operation and maintenance costs (discussed later), all from the time of sale (E) until the end of the planning horizon (T). Since capital gains taxes are 40 percent of the tax on ordinary income, annual components of 1D are multiplied by .40.

Lasering Costs

The first component of the cost equation (2A) is the initial capital cost (IC) of lasering. The second component (2B) is a Soil and Water Conservation (SWC) tax savings on the investment costs of lasering. Federal tax law permits capital expenditures for soil and water conservation to be deducted up to a maximum of 1/4 of gross income in any year. Nominal gross farm income may increase over time, here shown as rate (b). The product of gross farm income in year zero (GI_o), the adjustment for nominal changes in gross farm income and inflation over time $(\frac{1+b}{1+i})^n(1+i)^n$, the allowed 25 percent, and the farmers tax bracket (MTR_n) are divided by acres lasered (AL_o) to estimate annual, per acre, tax savings on the investment. Annual savings are discounted by $(1+r)^n(1+i)^n$ and summed from the year the investment is made (n=0) until the year (R) in which the sum of the deductions equal the maximum deduction.

Component (2C) represents the net revenue sacrificed ($NR_{w,o}$) by taking a field out of production during lasering. In Arizona, the crop sacirficed would often be one of the small grains in the crop rotation, such as wheat (subscript w). The forgone net revenue is adjusted for income tax by ($1-MTR_n$).

The final term (2D), is the cost of operation and maintenance. Laser leveled fields require periodic lasering to maintain slope and surface evenness. Operation and maintenance costs in year zero (OM_o) change over time at nominal rate. Costs are reduced by the tax bracket (MTR_n) and discounted by $(1+r)^n(1+i)^n$ to present values. Since relasering is not usually done each year, $\overline{T}$ indicates not only the years of the planning horizon, but also the interval between operation and maintenance expenditures, usually 3 to 5 years.