

Laser Leveling and Federal Incentives

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Our empirical analysis shows that federal tax and cost-sharing incentives significantly affect the profitability of laser leveling — a new irrigation technology which sharply reduces gravity water applications. However, the structure of the incentives may make slow rather than rapid adoption of the technology most profitable. Methodology plus results for a wide range of physical and economic conditions are given.

Water policy in the West now stresses water conservation in place of federal water supply projects. To encourage water conservation in agriculture, the federal government has introduced cost-sharing and tax depreciation incentives that enhance private returns to conservation investments. However, depending on how the incentives are structured, they may also slow the rate at which individuals invest.

Laser leveling of gravity irrigated fields is an important new water-saving technology,¹

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¹The 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

which, in many instances, cuts water applications by 30 percent or more. The analysis shows, both theoretically and empirically, how federal cost-share and tax incentive programs, along with other factors, affect the profitability and profit-maximizing rate of laser leveling.

Setting

The analysis is based on Arizona data. Laser leveling began in the mid-seventies, and is spreading rapidly in Arizona. Because Arizona has a wide range of water costs (the cost per acre foot to divert or pump plus deliver water), soil and field slope conditions, expected changes in future pumping costs, and other factors, our sensitivity analysis covers conditions found in other regions of the West where high-cost gravity irrigation water may make lasering attractive.

Laser Leveling Benefits and Costs

Farmers can 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

traditional land leveling methods. Laser beam land leveling equipment includes: (1) tractor, (2) drag scraper, (3) laser command post, receiver control box, and (4) hydraulic valve pump, hose and connections [Hinz and Halderman].

Laser technology can also be used to simply smooth a sloping field, but here we consider only the case of laser technology used in conjunction with dead leveling.

deep percolation beyond the root zone and runoff associated with standard flood and furrow gravity irrigation systems. Experts claim that on-farm irrigation efficiencies of 50-65 percent, typical of flood and furrow irrigation, can be increased to over 80 percent [Pachek]. The increase in field efficiencies lowers irrigation costs, reduces saline return flows, and allows for acreage expansion where water is a limiting factor. In addition, the uniform distribution of water may produce yield increases. While no physical crop production data on yield increases are available, estimates from irrigators, Soil Conservation Service field specialists, and state extension agents, all familiar with laser leveling, range from zero to over 20 percent [Parsons].

Although the costs of using the laser beam are not extreme, the complete laser leveling operation can be expensive [Daubert and Ayer]. On many gravity irrigated farms, the full operation requires replacing existing ditch systems and moving sizeable quantities of soil from high to low areas. Initial investment costs to laser level gravity irrigated land vary from \$400 to \$600 per acre in Arizona [Parsons]. Laser leveling also increases the annual operating costs, since basin fields are usually smaller than fields with furrow irrigation. The small field size, added ditches, and roads reduce irrigated acreage by approximately three percent, increase machinery turnaround costs by 10 to 15 percent and, in pump areas, raise labor irrigation costs by 50 percent [Parsons]. In addition, added touch-up of lasered fields is necessary each 3-5 years at a cost of about \$50 per acre, and crop revenue is lost while the field is being smoothed.

Federal Incentive Programs

The Agricultural Stabilization and Conservation Service (ASCS) cost-share program promotes laser leveling by lowering investment costs of water conservation. The program reimburses the farmer for a percentage of investment costs, up to a total farm limit

per year. In most of Arizona, ASCS payments cover 50 percent of investment costs up to \$3500 per year.

Federal tax laws enacted in 1968 indirectly encourage water conservation investment by lowering the farmer's tax liability [Internal Revenue Service]. The soil and water conservation depreciation allowance lets farmers depreciate their laser leveling investment. This depreciation program is quite different from others because the deduction depends on farm gross income rather than asset life. The law allows farmers to depreciate their investment up to 25 percent of gross farm income per year.

Modeling Laser Leveling Investment Decisions

The cost-benefit criteria [Howe] which determines if federal water projects are worthwhile can also apply, with minor modifications, to private water conservation investments. Criterion 1 requires that the present value of the benefits (PVB) equals the present value of the costs (PVC) for the last investment unit, or in this case acres lasered (L) — $dPVB(L) = dPVC(L)$. Criterion 2 requires that the present value of the benefits exceeds the present value of the costs — $PVB > PVC$ at the optimal acres lasered from Criterion (1).

The model of the private decision to invest, developed in this study, is, however, somewhat different from models of optimal public investment. Criteria (1) and (2) use market prices rather than shadow prices, value benefits and costs after taxes rather than before, and include tax and cost-share transfer payments.

The following analysis uses criterion (1) and (2) to determine conditions under which laser leveling is worthwhile without federal incentives. Following that, the impact of current tax incentives and the ASCS cost-sharing program on private profits and the most profitable rate to laser are determined.

*Private Profitability
Without Federal Incentives*

Without federal incentives, the farmer needs to assess only criterion (2). Private laser leveling investments have constant marginal benefits and costs with respect to the amount lasered. Laser leveling the whole farm immediately is profitable when the net present value per acre is positive:

$$PVB > PVC$$

or

$$(1) \sum_{t=1}^T \frac{[(P \cdot B + Y \cdot G) - (C + X)](1 - M)}{(1 + r)^t} - N(1 - M) > I$$

where PVB and PVC are the per acre present value of lasering benefits and costs, P is the farm water cost per acre foot at the head of the field, B is the per acre water savings from laser leveling, Y is the per acre percentage increase in yields, G is the per acre gross crop revenue, C is the per acre maintenance cost, X is the added machinery, labor, and acreage loss costs per acre, I is the per acre initial investment cost, M is the marginal tax rate, N is the per acre net crop revenue loss while lasering, T is the planning horizon, and r is the after tax return on investment the farmer desires. All prices, costs, net and gross revenues are in real 1980 dollars.

Since water prices or costs vary widely for different farm locations and water sources, the model determines the break-even water price per acre foot that just makes lasering privately profitable. At the break-even price the PVB equal the PVC. Following this decision rule, farmers should laser level their farmland immediately if water cost exceeds the break-even water price.

Appendix A shows a cash-flow, and net present value and break-even calculations, for a hypothetical but somewhat typical Arizona lasering situation.

*Private Profitability
With Federal Incentives*

Both federal incentive programs substantially change the per acre break-even analysis. With federal help, more farmers will find laser leveling profitable, since the programs reduce net investment costs. The programs also change the optimal number of acres lasered annually. Without the current soil and water conservation tax deduction (S) or the ASCS cost-share payment (A), and if per acre net benefits are positive, laser leveling the whole farm in the first year maximizes profits. Without the federal programs, marginal benefits and costs remain constant as a function of acres lasered. With the programs, both the marginal benefits and marginal costs per acre per year vary as the farmer laser levels more acres. The decision rule the farmer should follow is:

$$(2) \text{ Maximize } PVB(L) - PVC(L);$$

$$= \left[\sum_{t=1}^T \frac{\beta_t (1 - M)}{(1 + r)^t} \cdot L^1 \right] - \left[N(1 - M) \cdot L^1 + I \cdot L^1 - (S \cdot M) \right] + \sum_{j=1}^K \left[\sum_{t=j}^T \frac{\beta_t (1 - M)}{(1 + r)^t} \cdot L_j^2 \right] - \sum_{j=1}^K \left[\frac{N_j (1 - M) \cdot L_j^2}{(1 + r)^j} + \frac{(I \cdot L_j^2) - (S_j \cdot M)}{(1 + r)^j} \right] + \sum_{t=1}^K \frac{A_t (1 - M)}{(1 + r)^t},$$

where β equals $[(P \cdot B + Y \cdot G) - (C + X)]$ from equation 1, L^1 is the number of acres lasered in the first year outside the ASCS cost-share program, L_j^2 is the number of acres laser leveled in year j under the ASCS program, K is the number of years it takes to laser the whole farm, and all other variables are as previously defined.

*Soil and Water Conservation
Tax Depreciation Program*

The current tax program enters the laser leveling decision via the second and forth set of terms in equation (2). If the farmer lasers less than $\frac{D}{I}$ acres per year, where D equals 25 percent of gross farm income, the profit maximizing rule simplifies to a per acre net present value check, similar to equation (1), because the full investment can be subtracted from taxable income in the first year. Up to $\frac{D}{I}$ acres per year, total costs, including the tax deduction, increase at a constant rate: only the investment costs change from I to $I(1 - M)$ as a result of the program. The tax deduction, by lowering investment costs, will encourage more farmers to laser level their entire farm at once.

Whenever the acres lasered annually exceeds $\frac{D}{I}$, the farmer should continue laser leveling until the $dPVB(L_t) = dPVC(L_t)$, where L_t equals $L^1 + L^2$. While $dPVB(L_t)$ is constant, the marginal net investment costs per acre per year increase as L_t increases. Investment costs that exceed the yearly limit can only be deducted from future tax liability, again subject to the 25 percent of gross farm income rule. Deductions that the farmer carries forward impose a real cost; the farmer could have earned a return on the money invested but not deducted from this year's taxes. Net farm investment costs in year t (NI_t) equal:

$$(3) NI_t = (I \cdot L_t) - (S_t \cdot M) \\ = (I \cdot L_t) - \sum_{w=1}^W \left[\frac{D}{(1+r)^w} \right] M$$

where W, the number of years it takes before the farm depreciates the investment costs in any given year, equals $\frac{(I \cdot L_t)}{D}$. Marginal investment costs in year t increase because an additional acre lasered causes investment costs to rise at the constant rate I, while the

present value of the tax deduction(s) increases at a decreasing rate.² Even though the tax deduction enables more farmers to invest by lowering net investment costs per year, the farmers may laser more slowly if $dPVB(L_t) = dPVC(L_t)$ at a point less than farm size.

ASCS Cost-Sharing Program

The ASCS cost-sharing program also changes the private lasering decision. Because the ASCS payment reduces the break-even price, more farmers will find laser leveling profitable. Like the tax program, cost-sharing programs having a maximum yearly payment affect the most profitable rate to laser. Laser leveling more acres per year increases the present value of total net benefits, the first and third term in equation (2), but decreases the present value of the ASCS payments³, the last term in equation (2). As farmers laser more, the number of future ASCS payments, K (farm size divided by L_t), falls. Farmers should continue to laser an

²The first derivative of per year investment costs in equation 3, with respect to acres lasered per year (L), is the constant I. Using a continuous formula, the first and second derivatives of the tax deduction show the deduction increasing at a decreasing rate:

$$S = \frac{(1 - e^{-rw})D}{r}$$

$$\frac{\partial S}{\partial L} = Ie^{-rw} > 0$$

$$\frac{\partial^2 S_2}{\partial L} = \frac{(-rI^2)e^{-rw}}{D} < 0$$

³Using the continuous formula, the present value of total ASCS payments:

$$PVP = (1 - e^{-rFL^{-1}})A,$$

decreases as the farmer lasers more per year:

$$\frac{\partial PVP}{\partial L} = \frac{-AF}{L^2} e^{-rFL^{-1}} < 0$$

additional acre in the initial year if the present value of the extra water saving and yield benefit minus the operation cost exceeds the present value of the forgone extra ASCS payment. As with tax incentives, the ASCS program makes lasering profitable for more farms, but may slow the rate some farmers laser.

No Government Incentives: Break-even Results for Arizona

The price farmers pay for surface water at the farm headgate, or the variable pumping and delivery costs, are key determinants of the criterion 2 profitability check. Rather than estimate the net present value of lasering, the analysis focuses on the break-even water prices, the variable cost per acre foot to pump or divert plus deliver water to the field, necessary to just make lasering profitable. Break-even prices are computed for a wide range of possible Arizona farm conditions including different yield increases, marginal tax brackets, investment costs, discount rates, time horizons, pumping cost increases, and farm sizes. The break-even analysis assumes that the farmer does not receive any cost-share payments or depreciation deduction, thus eliminating any marginal or timing impacts of federal incentives on the private decision.

The break-even costs, even without federal subsidies, are low relative to water costs on many farms (Table 1). For a typical Arizona farm having investment costs of \$600 per acre, no anticipated increase in the real price of pumping fuel, water savings of 20 acre inches per acre, a marginal tax bracket of 35 percent, a yield increase of 10 percent, a real after tax discount rate of 5 percent, maintenance costs of \$50 per acre every 5 years, net crop revenue loss while lasering of \$150 per acre, farm size of 500 acres, gross farm income of \$700 per acre, added machinery, labor and acreage costs of \$37 per acre, and a time horizon of 25 years,⁴ the break-even water cost is \$30 per acre foot. Many Arizona farmers using groundwater will find laser leveling profitable, since pumping costs for

typical 300-600 foot lifts often exceed the break-even prices. A sensitivity analysis of all variables shows that the potential yield increase, water savings, initial investment costs, real increase in pumping costs, and the planning horizon significantly change the break-even water price.

Yield increases sharply lower break-even prices whenever expected water savings are relatively low (10 acre inches per acre), but have much smaller effects when water savings are great. For low water saving situations, a 5 percent increase in yield often reduces the break-even water price by \$30 per acre foot.

Larger water savings also lower the break-even prices. Laser leveling can reduce water applications from 10 to 30 acre inches per acre by increasing field efficiency on flood irrigated fields. For any particular yield increase, the break-even water price is halved as water savings go from 10 to 20 acre inches per acre.

Initial investment costs in Arizona generally range from \$400 to \$600 per acre. The higher investment cost increases the break-even water price by \$1 to \$50 per acre foot, depending on water savings and yield increase combinations.

A real three percent fuel price increase, in comparison to a real zero percent increase, lowers the break-even price, especially at low water savings (10 acre inches) and small yield increases.

The planning horizon has a substantial impact. The break-even price difference often exceeds \$30 per acre foot as the horizon increases from 10 to 25 years.

⁴Even though laser leveled fields have an infinite life if maintained properly, we use 10, 25 and 50 year horizons because at some point in time farmland may be changed to urban or other uses not requiring leveled fields, or new technologies may make lasered fields economically obsolete.

TABLE 1. Break-even Water Prices for Laser Leveling: Different Investment Costs, Fuel Price Changes, Water Savings, Time Horizons, and Crop Yield Benefits; No Federal Incentives; Arizona, 1980/81.^a

I	\$400/ac																
	0%																
	10 ac in					20 ac in					30 ac in						
Z	10 ac in					20 ac in					30 ac in					3%	
	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50		
B	10 ac in					20 ac in					30 ac in					3%	
	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50		
T	10 ac in					20 ac in					30 ac in					3%	
	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50		
Y	10 ac in					20 ac in					30 ac in					3%	
	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50		
0	170	119	105	85	59	53	40	35	150	80	62	75	44	31	50	29	21
1	160	111	95	80	55	48	54	38	31	142	81	56	71	40	28	47	19
3	143	94	78	72	47	39	48	32	26	127	69	46	64	35	24	42	15
5	126	77	62	63	39	31	43	26	20	113	57	37	56	29	19	38	12
10	84	35	20	44	18	10	29	12	6	76	25	11	38	13	6	25	4
14	51	22	16	26	11	8	18	8	5	46	16	9	23	8	5	15	3

I	\$600/ac																
	0%																
	10 ac in					20 ac in					30 ac in						
Z	10 ac in					20 ac in					30 ac in					3%	
	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50		
B	10 ac in					20 ac in					30 ac in					3%	
	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50		
T	10 ac in					20 ac in					30 ac in					3%	
	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50		
Y	10 ac in					20 ac in					30 ac in					3%	
	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50		
0	218	145	125	109	73	63	73	48	42	192	108	74	96	54	37	64	25
1	209	135	115	105	68	58	70	45	39	184	101	68	91	51	34	61	23
3	193	119	98	97	60	50	65	39	33	169	89	61	84	45	30	56	20
5	176	103	83	89	51	42	59	34	28	154	77	49	77	39	25	51	16
10	134	60	41	68	30 ^b	18	45	20	14	116	44	24	58	23	12	39	8
14	101	39	19	51	14	10	34	9	7	88	20	12	44	11	6	29	4

^aI is investment costs per acre, Z is the percentage increase in the real price of pumping fuel, B is the acre inches of water saved per acre by laser leveling, T is the planning horizon in years, and Y is the percentage increase in yield.

^bBreak-even water price for the example farm.

Government Incentives: Break-even Results and The Optimal Rate of Laser Leveling in Arizona

Soil and Water Conservation Tax Incentive

Even for farmers who laser level the entire farm immediately, the soil and water conservation tax deduction significantly reduces break-even water prices by lowering investment costs. The break-even price on the example farm falls from \$30 to just \$17 with the depreciation allowance. Similarly, the break-even prices of Table 1, for farms with \$600 per acre investment costs and time horizons of 10, 25, and 50 years, decline between \$50 and \$4 per acre foot (Table 2). For farms with \$400 per acre investment costs and time horizons of 10, 25 and 50 years, break-even prices fall between \$40 and \$3 per acre foot. Under the tax program, even more farms in Arizona will find laser leveling profitable.

With the program, a farmer with water costs exceeding break-even prices may increase returns from laser leveling if only part of the farm is lasered each year, rather than lasering the entire farm at once. On the Arizona example farm, for each 145 acre increase in the number of acres lasered, the farmer must wait another year before deducting the additional investment costs from the farm's tax liability. The optimal number of acres to laser each year varies from 145 to 500 depending on how much the farm water cost per acre foot exceeds the break-even water prices from Table 1 minus the \$13 per acre foot adjustment due to the program's existence ($\$30 - \$13 = \$17$). The optimum number of acres to level depends on farm water costs, farm size, gross income, marginal tax rate, real discount rate, and investment cost (Table 3). Changes in yield from the assumed 10 percent increase will change the \$17 per acre foot break-even water price, but not the amount above the break-even water price needed before the farmer should laser more, as shown in Table 3. Different farm sizes or gross farm incomes will not change the decision rule with respect to the difference be-

tween farm water cost and the break-even water price, but will change the optimal number of acres to laser each year. Different marginal tax or discount rates change the decision rule governing the difference between farm water cost and break-even prices, but not the acres lasered each year. Lower or higher investment costs change both the water cost, break-even water price difference, and the acres lasered annually.

The results illustrate that with the tax program profit maximizing farmers, especially those with water costs approximately equal to the break-even price, will laser more slowly. Specifically, if the example farm has a \$31/acre foot water cost ($PVB > PVC$) without the tax deduction the farmer lasers the whole farm, while with the tax deduction the farmer lasers only 290 acres per year to maximize the return from laser leveling.

Federal ASCS Cost-Sharing Programs

Similar to the Soil and Water Conservation Tax program, ASCS cost-sharing enhances the profitability of laser leveling while substantially changing the optimal acreage to laser each year. Assuming that the program will continue at least until the whole farm is lasered, some farms will require ASCS payments in order that the benefits from lasering outweigh costs. Farms that require the ASCS payment to make lasering profitable receive the greatest net benefits by annually leveling the number of acres which maximizes their ASCS payments. If the yearly maximum ASCS payment is \$3,500, there is a 50-50 cost-sharing program, and leveling costs \$600 per acre, then the optimal number of acres to laser each year is

$$\frac{\$3500}{.5(\$600/\text{ac})} = 11.67 \text{ acres.}$$

Although additional lasering might be socially appropriate, lasering more is financially unattractive because for this farm benefits without the ASCS payments are less than costs. Lasering less than the 11.67 acres per year is uneconomic, since the farmer would

TABLE 2. Break-even Water Prices for Laser Leveling: Different Investment Costs, Fuel Price Changes, Water Savings, Time Horizons, and Crop Yield Benefits; With Federal Tax Incentives; Arizona, 1980/81^a

I	\$400/ac															
	0%					3%										
	10 ac in			20 ac in		30 ac in		10 ac in			20 ac in		30 ac in			
Y	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50	
0	130	97	89	65	48	44	43	32	30	114	72	53	57	36	26	38
1	120	89	79	60	44	40	40	30	26	106	65	47	53	32	23	35
3	103	72	62	52	36	31	34	24	21	91	53	37	46	27	19	30
5	86	55	46	43	28	23	29	18	15	77	41	28	38	21	14	24
10	44	13	4	22	7	2	15	4	1	40	9	2	20	5	1	13
14	11	0	0	6	0	0	4	0	0	10	0	0	5	0	0	3
	-----\$/ac ft-----															
	-----\$/ac ft-----															
I	\$600/ac															
	0%					3%										
	10 ac in			20 ac in		30 ac in		10 ac in			20 ac in		30 ac in			
Y	10	25	50	10	25	50	10	25	50	10	25	50	10	25	50	
0	169	120	106	84	60	53	56	40	35	150	89	62	75	44	31	50
1	160	110	96	80	55	48	53	37	32	142	82	56	70	41	28	47
3	144	94	79	72	47	40	48	31	26	127	70	47	63	35	24	42
5	127	78	64	64	39	32	42	26	21	112	58	37	56	29	19	37
10	85	35	20	43	17 ^b	10	28	12	7	74	25	12	37	13	6	25
14	52	14	0	26	1	0	17	1	0	46	1	0	23	1	0	15

^aAbbreviations are defined in footnote a, Table 1.

^bBreak-even water price for the example farm.

TABLE 3. Optimal Number of Acres to Laser per Year Under the Soil and Water Conservation Tax Depreciation Program; Arizona, 1980/81.

Parameter Change	Farm Water Cost (\$/af)	Optimal Acres Lasered (ac./year)
Example Farm ^a	FWC = 17 ^b to 17 + 9	145
	FWC = 17 + 10 to 17 + 19	290
	FWC = 17 + 20 to 17 + 29	435
	FWC = 17 + 30 or greater	500
Farm Size = 700 ac.	FWC = 17 ^b to 17 + 9	204
	FWC = 17 + 10 to 17 + 19	408
	FWC = 17 + 20 to 17 + 29	612
	FWC = 17 + 30 or greater	700
Gross Income per Acre = \$500/ac.	FWC = 17 ^b to 17 + 9	104
	FWC = 17 + 10 to 17 + 19	208
	FWC = 17 + 20 to 17 + 29	312
	FWC = 17 + 30 to 17 + 39	416
	FWC = 17 + 40 to 17 + 49	500
Marginal Tax Rate = 50%	FWC = 17 ^b to 17 + 14	145
	FWC = 17 + 15 to 17 + 30	290
	FWC = 17 + 31 to 17 + 45	435
	FWC = 17 + 46 or greater	500
Real Discount Rate = 10%	FWC = 17 ^b to 17 + 19	145
	FWC = 17 + 20 to 17 + 36	290
	FWC = 17 + 37 to 17 + 52	435
	FWC = 17 + 53 or greater	500
Investment Cost = \$400/ac.	FWC = 7 ^c to 7 + 7	219
	FWC = 7 + 8 to 7 + 13	438
	FWC = 7 + 14 or greater	500

^aInvestment Costs = \$600/ac.; Marginal Tax Rate = 35%; Real Discount Rate = 5%; Gross Income = \$700/ac.; Farm Size = 500 ac.; yield increase = 10%; FWC = Farm Water Cost.

^bThe break-even water price from Table 1 (\$30/af) minus \$13/af.

^cThe break-even water price from Table 1 (\$18) minus \$11/af.

fail to take full advantage of the maximum \$3,500 annual payment.

Some Arizona farmers will find lasering profitable even without the ASCS payment. For these farmers, laser leveling additional acres in the first year is profitable until the present value of the future ASCS payment given up by lasering more today equals the net benefit of lasering one more acre. The optimal amount to laser in the first year will occur somewhere between the number of acres which just exhausts the maximum annual ASCS payment⁵ and farm size, again

assuming that the program continues until the farmer lasers the whole farm. For illustrative purposes, the example farmer lasers 25 acres per year for 20 years if the farm water cost just equals the break-even price. If the farm water cost exceeds the break-even water price by \$5 per acre foot, the farmers should laser 50 acres in the first year and 25 acres per year for 18 years. Scheduling results for different tax brackets and discount rates are shown in Table 4.

In Arizona, the ASCS cost-sharing payment slows the rate at which profit maximizing farmers laser level. Approximately 350,000 acres with groundwater irrigation and 100 to 300 feet pumping lifts could have

⁵In Arizona, farmers seldom laser level less than 25 acres due to the production costs associated with small fields.

TABLE 4. Optimal Laser Leveling Schedule Under the ASCS Cost-Sharing Program Depending on How Much the Actual Farm Water Cost Exceeds the Break-Even Water Price, Arizona, 1980/81.^a

Acres Lasered in 1st Year	No. ^b Years to Laser Farm	Farm Size = 500 ac						Farm Size = 750 ac						Farm Size = 1000 ac					
		M = .35		M = .50		No. ^b Years to Laser Farm	\$/af above break-even water price	M = .35		M = .50		No. ^b Years to Laser Farm	\$/af above break-even water price	M = .35		M = .50		No. ^b Years to Laser Farm	\$/af above break-even water price
		r = .05	r = .10	r = .05	r = .10			r = .05	r = .10	r = .05	r = .10			r = .05	r = .10				
50	19	5.00	3.00	4.30	2.60	29	2.60	1.00	2.10	2.10	.90	39	1.30	.40	1.10	.30			
100	17	5.90	3.80	5.00	3.20	27	2.80	1.26	2.40	2.40	1.10	37	1.50	.50	1.30	.40			
150	15	7.10	4.80	6.00	4.10	25	3.20	1.60	2.60	2.60	1.30	35	1.70	.60	1.40	.50			
200	13	8.70	6.20	7.40	5.30	23	3.70	1.90	2.70	2.70	1.60	33	1.90	.70	1.60	.60			
250	11	10.80	8.30	9.20	7.10	21	4.20	2.40	3.70	2.00	2.00	31	2.20	.80	1.90	.70			
300	9	13.90	11.30	11.30	9.60	19	5.00	3.00	4.30	2.60	2.60	29	2.60	1.00	2.10	.90			
350	7	18.80	16.10	16.10	13.80	17	5.90	3.80	5.00	3.20	3.20	27	2.80	1.20	2.40	1.10			
400	5	27.70	25.10	23.70	21.50	15	7.10	4.80	6.00	4.10	4.10	25	3.20	1.60	2.60	1.30			
450	3	48.60	46.30	41.60	40.00	13	8.70	6.20	7.40	5.30	5.30	23	3.70	1.90	2.90	1.60			
500	1	153.20	153.20	131.00	131.00	11	10.80	8.30	9.20	7.10	7.10	21	4.20	2.40	3.70	2.00			
550						9	13.90	11.30	11.30	9.60	9.60	19	5.00	3.00	4.30	2.60			
600						7	18.80	16.10	16.10	13.80	13.80	17	5.90	3.80	5.00	3.20			
650						5	27.70	25.10	23.70	21.50	21.50	15	7.10	4.80	6.00	4.10			
700						3	48.60	46.30	41.60	40.00	40.00	13	8.70	6.20	7.40	5.30			
750						1	153.20	153.20	131.00	131.00	131.00	11	10.80	8.30	9.20	7.10			
800												9	13.90	11.30	11.30	9.60			
850												7	18.80	16.10	16.10	13.80			
900												5	27.70	25.10	23.70	21.50			
950												3	48.60	46.30	41.60	40.00			
1000												1	153.20	153.20	131.00	131.00			

^aAssuming the farm characteristics for the example farm. The break-even water price from Table 1 equals \$30/af.

^bAssuming that the farmer laser levels 25 acres per year. In Arizona, farmers seldom laser level fields less than 25 acres due to the costs associated with smaller field.

pumping costs about equal to the break-even water price without the program. Farmers in that situation will find laser leveling the whole farm profitable even without the ASCS program, while with the program they should laser level only 10 percent of the farm each year. On 200,000 acres where water depths exceed 300 feet the farm water cost exceeds the typical break-even water price by \$10 to \$20 per acre foot. Again, without the program, those farmers will find laser leveling the whole farm profitable, but with the program the farmer with 500 acres should laser level 50 percent of the farm in the first year and 25 acres per year for 11 years. The farmer with 1000 acres should laser 75 percent in the first year and 25 acres per year for 11 years.

Conclusions

Laser leveling can greatly reduce irrigation applications, and is often a profitable private investment in Arizona where farm water costs often exceed break-even water prices. In other states where groundwater is currently used to gravity irrigate and where lift depths are relatively great, it appears that laser leveling will be profitable.

The results show that the federal tax and cost-sharing incentives significantly affect the private profitability of laser leveling. Other factors — investment costs, water savings, fuel prices, yield benefits, and the planning horizon, also effect investment profitability. However, even without the federal incentive programs there are a wide variety of Arizona conditions under which lasering would be profitable.

The farmer participating in federal cost-sharing and tax programs must also choose how many acres to laser per year. 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. Federal incentive programs that limit yearly tax deductions or ASCS cost-share payments were shown to slow the rate at which land is most profitably lasered. In fact, to maximize

profits the typical farmer in Arizona may take approximately 10 years to laser if the program is expected to continue.

From a policy standpoint, the results indicate that the current structure of federal tax incentives and ASCS cost-share programs to conserve irrigation water has mixed effects on conservation goals. While these programs make lasering profitable on more farms, they may also slow the rate at which each farm lasers.

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Appendix

Cash Flow, Plus Calculations for Present Values and Break-Even Water Prices

A table of cash flows (Table A) may be used to show how the present values and break-even water prices of equation (1) in the text are computed. Assume a hypothetical farm where water savings from dead leveling (B) are 20 acre inches/acre/year; the yield increase (Y) is 10 percent; gross crop revenue before lasering (G) is \$700/acre/year; maintenance costs (C) are \$50/acre every five years; added machinery, labor, and acreage loss costs (X) are \$37/acre/year; initial investment costs (I) are \$600/acre; the marginal tax rate (M) is 35 percent; net revenue crop loss while lasering (N) is \$150/acre; the planning horizon (T) is 25 years,¹ and the inflation-free, after-tax return on investment that the farmer desires (r) is 5 percent.

¹The planning horizon assumes that the costs accrue at the beginning of each year and benefits at the end of each year.

Equation 1 is expanded and set equal to zero to solve for the break-even water price:

$$0 = \sum_{n=1}^{25} \frac{(P \cdot 20.65)}{(1 + .05)^n} + \sum_{n=1}^{25} \frac{(10\% \cdot \$700.65)}{(1 + .05)^n} - \sum_{n=5}^{20^2} \frac{(\$50.65)}{(1 + .05)^n} - \sum_{n=1}^{25} \frac{(\$37.65)}{(1 + .05)^n} - (\$150.65) - (\$600)$$

Substituting the discounted present values from Table A into the equation:

$$0 = \sum_{n=1}^{25} \frac{P \cdot 20.65}{(1 + .05)^n} + \$648 - \$78 - \$338 - \$98 - \$600.$$

Simplifying and solving for P:

$$0 = \sum_{n=1}^{25} \frac{1}{(1 + .05)^n} (P \cdot 20.65) - \$466$$

$$0 = (14.0939)^1 (P \cdot 20.65) - \$466$$

$$P = \$2.54/\text{acre inch}$$

$$= \$30/\text{acre foot (break-even water price for dead leveling example farm).}$$

²n=5, n=10, n=15, and n=20.

$$^3 \sum_{n=1}^{25} \frac{1}{(1 + .05)^n} = \frac{1 - (1 + .05)^{-25}}{.05} = 14.0939$$

is the discount factor determining the present value of \$1 received annually at the end of each year for 25 years. For additional information concerning discounting, present values, and tables of discount factors, see Alpin, et. al.

TABLE A. Cash Flow and Present Value of the Annual Benefits and Costs of Dead Leveling for Hypothetical Farm.

Year	P·B(1 - M) P·20·.65	+ Y·G(1 - M) + (.1·700·.65)	- C(1 - M) - 50(.65)	- X(1 - M) - 37(.65)	- N(1 - M) - 150(.65)	- I - (600)
	-----\$-----					
1	$\frac{P \cdot 20 \cdot .65}{(1.05)^1}$	$\frac{46}{(1.05)^1}$		$\frac{24}{(1.05)^1}$	98	600
2	$\frac{P \cdot 20 \cdot .65}{(1.05)^2}$	$\frac{46}{(1.05)^2}$		$\frac{24}{(1.05)^2}$		
3	$\frac{P \cdot 20 \cdot .65}{(1.05)^3}$	$\frac{46}{(1.05)^3}$		$\frac{24}{(1.05)^3}$		
4	$\frac{P \cdot 20 \cdot .65}{(1.05)^4}$	$\frac{46}{(1.05)^4}$		$\frac{24}{(1.05)^4}$		
5	$\frac{P \cdot 20 \cdot .65}{(1.05)^5}$	$\frac{46}{(1.05)^5}$	$\frac{33}{(1.05)^5}$	$\frac{24}{(1.05)^5}$		
6	$\frac{P \cdot 20 \cdot .65}{(1.05)^6}$	$\frac{46}{(1.05)^6}$		$\frac{24}{(1.05)^6}$		
7	$\frac{P \cdot 20 \cdot .65}{(1.05)^7}$	$\frac{46}{(1.05)^7}$		$\frac{24}{(1.05)^7}$		
8	$\frac{P \cdot 20 \cdot .65}{(1.05)^8}$	$\frac{46}{(1.05)^8}$		$\frac{24}{(1.05)^8}$		
9	$\frac{P \cdot 20 \cdot .65}{(1.05)^9}$	$\frac{46}{(1.05)^9}$		$\frac{24}{(1.05)^9}$		
10	$\frac{P \cdot 20 \cdot .65}{(1.05)^{10}}$	$\frac{46}{(1.05)^{10}}$	$\frac{33}{(1.05)^{10}}$	$\frac{24}{(1.05)^{10}}$		
11	$\frac{P \cdot 20 \cdot .65}{(1.05)^{11}}$	$\frac{46}{(1.05)^{11}}$		$\frac{24}{(1.05)^{11}}$		
12	$\frac{P \cdot 20 \cdot .65}{(1.05)^{12}}$	$\frac{46}{(1.05)^{12}}$		$\frac{24}{(1.05)^{12}}$		
13	$\frac{P \cdot 20 \cdot .65}{(1.05)^{13}}$	$\frac{46}{(1.05)^{13}}$		$\frac{24}{(1.05)^{13}}$		
14	$\frac{P \cdot 20 \cdot .65}{(1.05)^{14}}$	$\frac{46}{(1.05)^{14}}$		$\frac{24}{(1.05)^{14}}$		
15	$\frac{P \cdot 20 \cdot .65}{(1.05)^{15}}$	$\frac{46}{(1.05)^{15}}$	$\frac{33}{(1.05)^{15}}$	$\frac{24}{(1.05)^{15}}$		
16	$\frac{P \cdot 20 \cdot .65}{(1.05)^{16}}$	$\frac{46}{(1.05)^{16}}$	-	$\frac{24}{(1.05)^{16}}$		
17	$\frac{P \cdot 20 \cdot .65}{(1.05)^{17}}$	$\frac{46}{(1.05)^{17}}$		$\frac{24}{(1.05)^{17}}$		
18	$\frac{P \cdot 20 \cdot .65}{(1.05)^{18}}$	$\frac{46}{(1.05)^{18}}$		$\frac{24}{(1.05)^{18}}$		
19	$\frac{P \cdot 20 \cdot .65}{(1.05)^{19}}$	$\frac{46}{(1.05)^{19}}$		$\frac{24}{(1.05)^{19}}$		
20	$\frac{P \cdot 20 \cdot .65}{(1.05)^{20}}$	$\frac{46}{(1.05)^{20}}$	$\frac{33}{(1.05)^{20}}$	$\frac{24}{(1.05)^{20}}$		
21	$\frac{P \cdot 20 \cdot .65}{(1.05)^{21}}$	$\frac{46}{(1.05)^{21}}$		$\frac{24}{(1.05)^{21}}$		
	P·20·.65	46		24		

TABLE A. (Continued)

Year	$P \cdot B(1 - M)$ $P \cdot 20 \cdot .65$	$+ Y \cdot G(1 - M)$ $+ (.1 \cdot 700 \cdot .65)$	$- C(1 - M)$ $- 50(.65)$	$- X(1 - M)$ $- 37(.65)$	$- N(1 - M)$ $- 150(.65)$	$- I$ $- (600)$
-----\$-----						
22	$\frac{P \cdot 20 \cdot .65}{(1.05)^{22}}$	$\frac{46}{(1.05)^{22}}$		$\frac{24}{(1.05)^{22}}$		
23	$\frac{P \cdot 20 \cdot .65}{(1.05)^{23}}$	$\frac{46}{(1.05)^{23}}$		$\frac{24}{(1.05)^{23}}$		
24	$\frac{P \cdot 20 \cdot .65}{(1.05)^{24}}$	$\frac{46}{(1.05)^{24}}$		$\frac{24}{(1.05)^{24}}$		
25	$\frac{P \cdot 20 \cdot .65}{(1.05)^{25}}$	$\frac{46}{(1.05)^{25}}$		$\frac{24}{(1.05)^{25}}$		
Total	$\sum_{n=1}^{25} \frac{(P \cdot 20 \cdot .65)}{(1.05)^n}$	+ 648	- 78	- 338	- 98	- 600