PROSPECTS FOR IRRIGATION ELECTRICITY USE
IN THE
PACIFIC NORTHWEST

by

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A) Introduction

Agriculture is a large and growing factor in the electricity supply/ demand picture for the Pacific Northwest. The principal agricultural end use is irrigation pumping. Water is pumped from wells and rivers to the fields, often involving very high lifts. Growing reliance on sprinklers for water application uses additional power for system pressurization.

Figures reported by the Northwest Agricultural Development Project show that irrigation electricity use in the three northwest states increased by over 23 times between 1950 and 1977 (Table 1). This end use has absorbed a steadily increasing share of electricity sales in the three states, rising from 1.3 percent in 1950 up to 5.5 percent in 1977. Note that irrigation sales are relatively much more important in Idaho (20.6 percent of sales) than in either Washington or Oregon (4.3 percent and 2.5 percent respectively).

Clearly agriculture is both an important cornerstone of the Pacific Northwest economy, and an important regional electricity consumer. In this paper I will sketch out both some economic, and some more nearly political issues which relate to the future growth rate for this important sector.

B) Review of Some Basic Issues

1) growing energy intensity of irrigation

One important concept to keep in mind is the increasing energy intensity of northwest irrigated farming. More electricity is being used per acre for new land being irrigated. Since easily developed lands near the water source were developed first, new development involves pumping water longer distances

Table 1: Irrigation Share of Pacific Northwest Total Electricity Sales, 1950 to 1977.

	Idaho	Oregon	Washington	Region
1950	8.7%	0.3%	0.6%	1.3%
1955	12.0	0.8	3.5	3.6
1960	16.8	0.8	3.2	3.8
1965	15.2	1.0	3.6	4.0
1970	14.7	1.5	3.4	4.0
1975	16.8	2.3	3.6	4.6
1976	17.3	2.1	3.9	4.7
1977	20.6	2.5	4.3	5.5

and to greater heights to serve the remaining land. Because of their higher investment in pumping water, farmers are turning more to sprinklers to help them use water more efficiently, further increasing electricity use per acre.

The growing energy intensity of new irrigation can be illustrated by a statistical exercise I did recently using Idaho Power Company data. I used linear regression to fit an equation relating new installed horsepower in each year (HP_τ) to new acres (N_τ) and supplemental acres (S_τ):

$$HP_\tau = -3072 + (-1.517 + .0375\tau)\, N_\tau + (-1.013 + .0204\tau)\, S_\tau$$

New acres are land that was previously not irrigated, and supplemental acres are land previously irrigated (usually by gravity systems) that has become part of the Idaho Power Company electric load, usually because of the addition of sprinklers. The form of the relationship allows horsepower per new acre and horsepower per supplemental acre to be linear functions of time. The model fits very well, explaining 96 percent of the variation in yearly additions to horsepower. The estimates of horsepower per acre that result from this model appear in Figure 1. Estimated horsepower per new acre has grown from .59 per acre in 1958 up to 1.49 per acre in 1980. During the same period horsepower per supplemental acre rose from .13 up to .62.

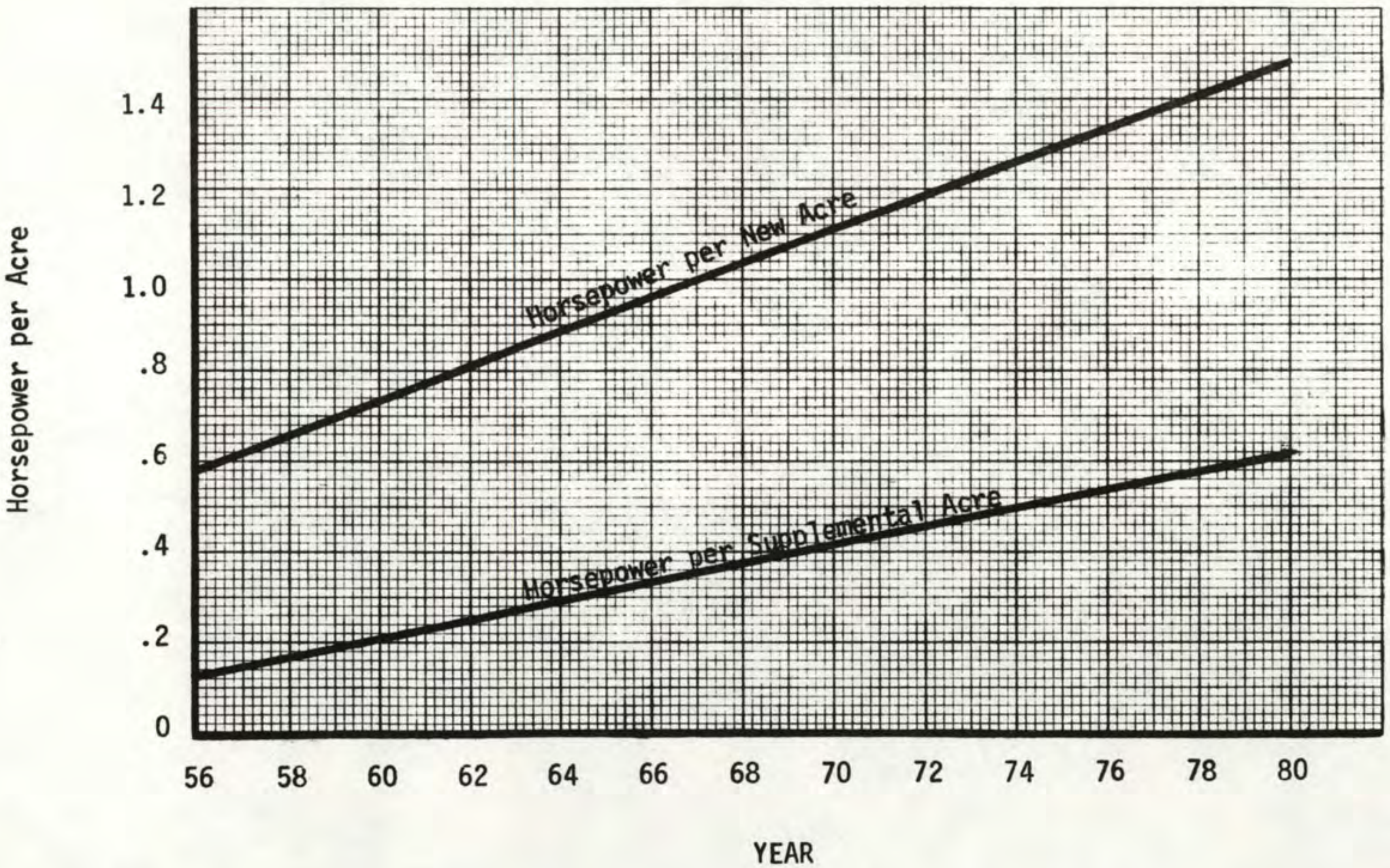
While the above exercise dealt with horsepower per acre, the relationship for electricity consumption per acre should be similar. I don't have Idaho Power Company data on kilowatt-hours per irrigation horsepower, but I suspect this measure has held steady or even increased as larger pumping plants are more carefully engineered and optimally sized. It is very important that this increasing electricity use by newly developed acreage be recognized in any attempt to project irrigation electricity use for the future.

Regression Equation for Horsepower Per New Acre

and Horsepower per Supplemental Acre for IPC System

$$HP_\tau = -3072 + (-1.517 + .0375\tau) N_\tau + (-1.013 + .0204\tau) S_\tau$$

Figure 1: Estimated Horsepower per acre for Additions to Idaho Power Company Irrigation Land.



2) Trade-offs between irrigation and hydropower

I understand that many of you heard Professor Norman Whittlesey's remarks last year at this conference concerning work that he and I have done on the costs of irrigation development. While I won't go into detail, I want to remind you of the thread of our argument.

The idea is that new irrigation not only consumes large amounts of electricity for pumping water, it also consumes water which then is not available for downstream hydorelectric generation. New thermal generation is needed to supply pumping power and also to replace the lost hydrogeneration. Table 2 shows the replacement cost of hydropower losses due to irrigation water use at various points in the Pacific Northwest. For example an acre foot of water taken from American Falls Reservoir in southern Idaho could potentially have been used at 21 existing downstream hydroelectric dams having a cumulative head of 2094 feet. This acre foot of water could have generated 1821 kilowatt-hours of electricity at these dams. Using a new thermal powerplant with a 5¢ per KWH cost to replace this lost hydropower would cost $91.05 per year for each acre-foot used. A typical farm development in the central Snake region of southern Idaho might use 3000 KWH per acre for pumping, and by diverting about 2 acre feet per acre cause hydro losses of another 3000 KWH. Using the 5¢ cost of new generation, these 6000 KWH would cost $300 to replace -- a $300 annual cost per acre which new development imposes on users of electricity in the region. Even if irrigators paid 2¢ per KWH for the electricity used to run pumps, they would pay only $60 per acre -- and the remaining four-fifths of the development electricity costs would be paid by other customers in the form of higher electric rates.

Table 2. Potential Energy Lost by Consumptively Diverting an Acre-foot of Water from the Snake-Columbia System.

	Cumulative Head (feet)	Cumulative Energy at .87 KWH/acre ft./ft. (KWH)	Cumulative Value at 5¢ per KWH (dollars)
Columbia River (Wash.-Oregon)			
Bonneville	59	51	2.55
The Dalles	142	124	6.20
John Day	242	211	10.55
McNary	316	275	13.75
Columbia River (Washington)			
Priest Rapids	393	342	17.10
Wanapum	470	409	20.45
Rock Island	504	439	21.95
Rocky Reach	591	514	25.70
Wells	658	573	28.65
Chief Joseph	825	718	35.90
Grand Coulee	1167	1015	50.75
Snake River (Washington)			
Ice Harbor	414	360	18.00
Lower Monumental	514	447	22.35
Little Goose	612	532	26.60
Lower Granite	710	618	30.90
Snake River (Idaho-Oregon)			
Hells Canyon	920	800	40.00
Oxbow	1040	905	45.25
Brownlee	1312	1141	57.05
Snake River (Idaho)			
Swan Falls	1336	1162	58.10
C.J. Strike	1424	1239	61.95
Bliss	1494	1300	65.00
Lower Salmon Falls	1553	1351	67.55
Upper Salmon Falls "A"	1599	1391	69.55
Upper Salmon Falls "B"	1636	1423	71.15
Shoshone Falls	1850	1610	80.50
Twin Falls	1997	1737	86.85
Minidoka	2045	1779	88.95
American Falls	2094	1821	91.05

3) Politics of Development

It is easy enough to identify the costs involved when more land is developed for irrigation. It is much harder to identify what these costs mean for the pace of future irrigation development in the Pacific Northwest, since that requires that we face the realities of the political process. Agriculture is a very powerful political block in the region. Irrigation development made the region's agriculture what it is today. Under present conditions development of new land is often still very profitable. In spite of growing recognition of the kinds of costs noted above, development of new irrigation remains immensely popular.

The electricity costs of development arise from two causes. First, farmers pay rates for electricity which are well below the cost of new generation. Second, farmers usually pay only for the cost of delivering water, and nothing for the water itself, so they bear none of the cost of lost hydropower.

The divergence between price and marginal generation cost is not unique to irrigation. The virtues of marginal cost pricing have been debated by public utilities commissions for years. Recently many commissions have been moving tentatively in the direction of marginal cost pricing. The move has been tentative because energy intensive industries, including irrigation, have generally argued against the required rate increases. What is important for us to note today is that the portion of the marginal cost of new generation which irrigators are required to pay in the future will be made by politically sensitive rate making bodies. If political sentiment shifts in the direction of making marginal electricity users pay more of the marginal costs they impose on the system, the added costs could severely curtail development of new irrigation.

The second source of development costs -- where farmers are able to divert water away from hydroelectric generation without cost is what economists call an externality. One persons actions impose external costs on someone else. Society often deals with externalities in one of two ways -- either by charging people for their actions, or by prohibiting the action. In the case of irrigators this would mean either charging enough for water to pay for the lost hydropower, or outright prohibiting irrigation development. Being realistic, there are enough constitutional and political barriers that water charges of this magnitude are unlikely in the forseeable future. However, state and federal agencies do have some control over the pace of development. It is not hard to see the slow pace of Bureau of Land Management processing of Desert Land Entry and Carey Act applications in southern Idaho as partly motivated by recognition of the costs of development. Again the important point is that such restraints on development are determined by political processes and subject to political pressures. Note that BLM is beginning to actively process southern Idaho development applications. Both Oregon and Washington have authorized use of their bonding authority to help subsidize irrigation development. Idaho Power Company's attempt to use an irrigation hookup moratorium to protect its flow right claims was not viewed favorably by the courts. The current environment is clearly pro development. Whether public perception of the costs of development will cause this to change is an open question.

C.) Factors Affecting the Private Decision to Irrigate New Land

So far we have looked at some of the issues involved in development of new irrigated land. Lets shift the focus a bit and look more closely at factors which determine a farmer's private decision whether or not to go ahead with development.

We can start by looking at results obtained by one of my graduate students a few years ago.[1/] He studied the area along the Snake River in southern Idaho between Boise and Twin Falls. He wanted to know how high above the river water source and how far away from the river farmers could afford to pump water. He developed farm budgets for crop rotations typical of the area and computed the costs for building and operating the high lift pumps needed to get water from river to field, and the costs of on farm water application systems. He did all this in terms of 1977 dollars, 1977 input prices and 1977 electric rates. Initially his calculations were based on land 550 feet above and 5 miles back from the river. Once he developed this basic model, he could examine the effect of changes in crop prices, electric rates, and lift and distance on the feasibility of developing land.

His criterion for feasibility was whether or not there were any residual returns to land left over after subtracting all other costs including payments for electricity and a return on the operators' labor and investment. Figure 2 shows that the base case farmer with a 550 foot lift and 5 mile distance would make residual returns above costs of between $60 and $90 depending on size of farm. However these returns were extremely sensitive to crop prices -- a 10 percent decline making development quite marginal and a 20 percent decline making it infeasible. Figure 3 shows what happens as real electric rates go up. A 100 percent real increase above 1977 Idaho Power Company rates would make development rather marginal and

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[1/] Barranco, Gary S., The Feasibility of Irrigation Development in High-Lift Pumping Areas of Southwest Idaho. MS thesis, Univ. of Idaho, 1978.

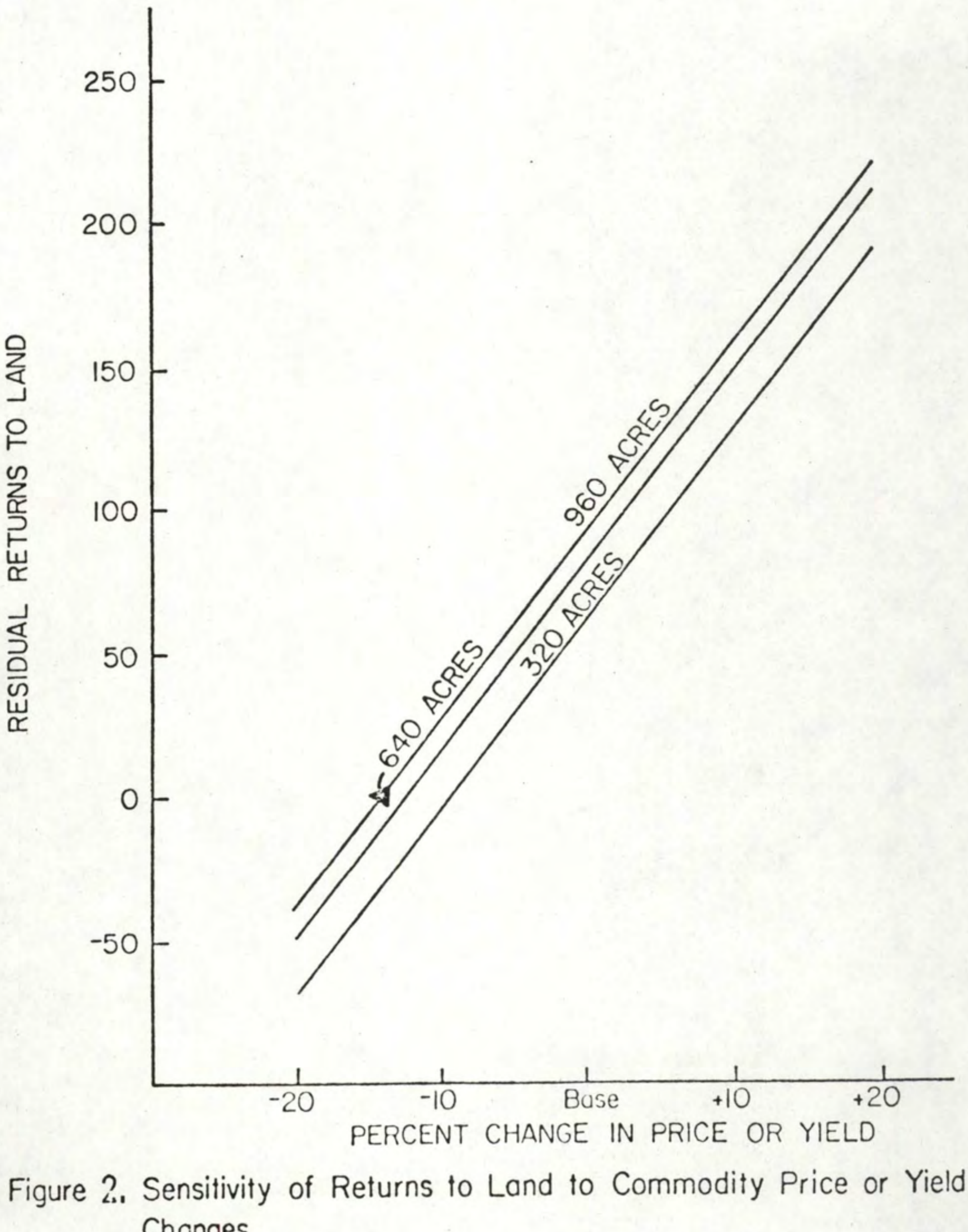

Figure 2. Sensitivity of Returns to Land to Commodity Price or Yield Changes.

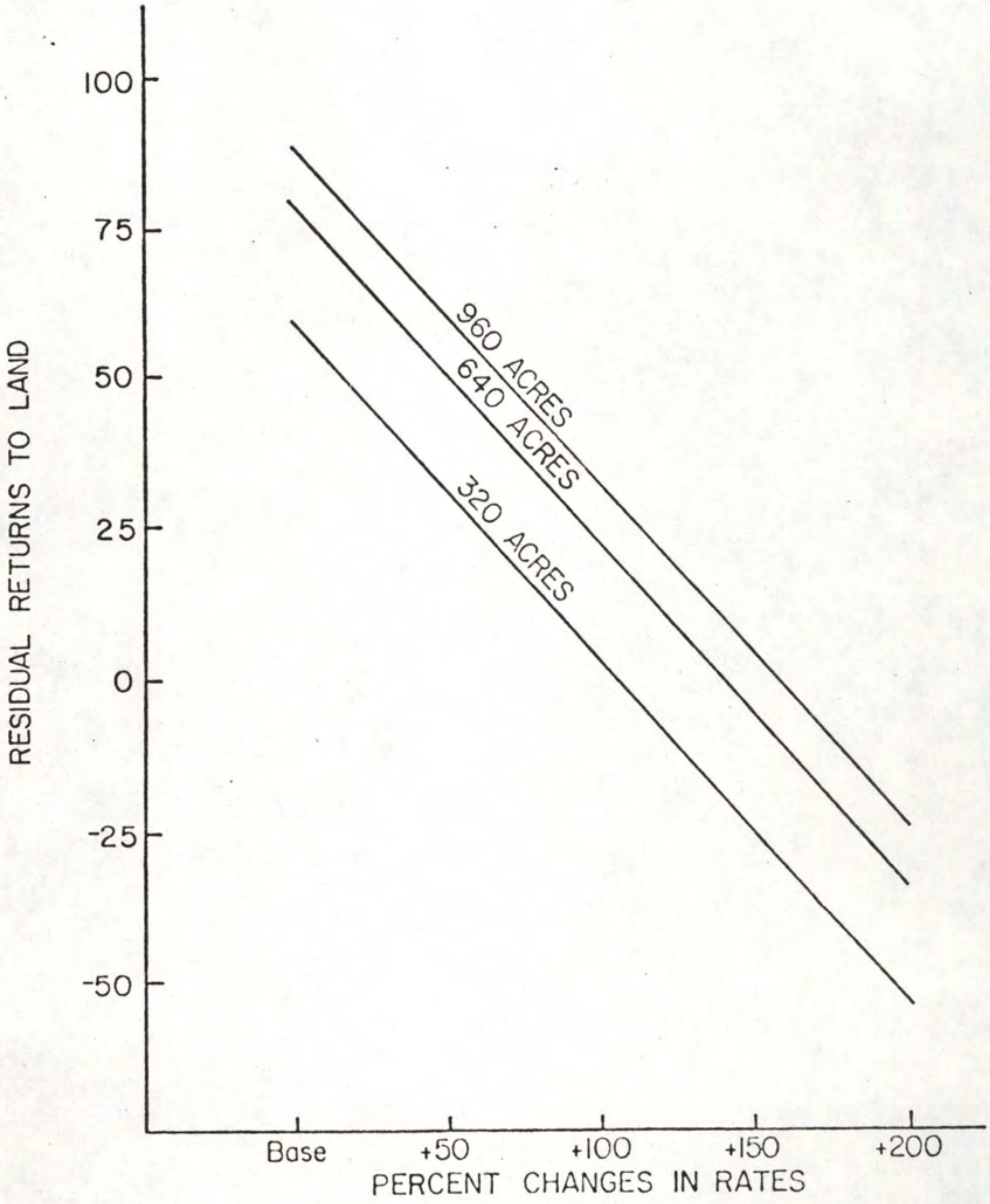

Figure 3. Sensitivity of Returns to Land to Electricity Rate Schedule Changes.

a 150 percent increase would make such development infeasible.

Joint variation in lift, distance, and electric rates for the 640 acre farm case are examined in Figure 4. The X's below and to the left of rate increase boundaries represent feasible combinations of lift and distance. With 1977 IPC rates farmers could lift water above 900 feet and transport it more than 10 miles. A 50 percent real rate increase would make development of land 7.5 miles away infeasible if lift approached 900 feet. Land 10 miles away could not be developed if lift exceeded 650 feet. Higher electric rates progressively squeeze out higher and more distant land. My student applied this method to the 111,000 acres in southwestern Idaho studied for development potential by BLM for a recent environmental statement[2/]. Based on the lift and distance data reported by BLM, Figure 5 shows how developable acreage falls as real electric rates increase above the 1977 Idaho Power Company rates.

Consider the three factors whose importance was highlighted in my student's study -- the lift/distance characteristics of potentially developable land, electric rates, and crop prices. Since low lift lands adjacent to a water source were developed first, the greater lifts and distances of remaining development are inescapable facts. We have already given some attention to electric rate trends and it is hard to see them going any way but up. Both factors can be expected to restrict the pace of development.

On the other hand, the future of crop prices is notoriously difficult to predict, particularly for northwest crops, because of the degree to which we depend on markets elsewhere in the country and world. Recent studies such as the Northwest Agricultural Development Project[3/]

[2/]U.S. Bureau of Land Management, <u>Boise District Agricultural Environmental Statement for Southwest Idaho</u>, Boise District Office, 1979.

[3/]<u>Northwest Agricultural Development Project, Final Report</u>, Pacific Northwest Regional Commission, Vancouver, Washington, June 1981

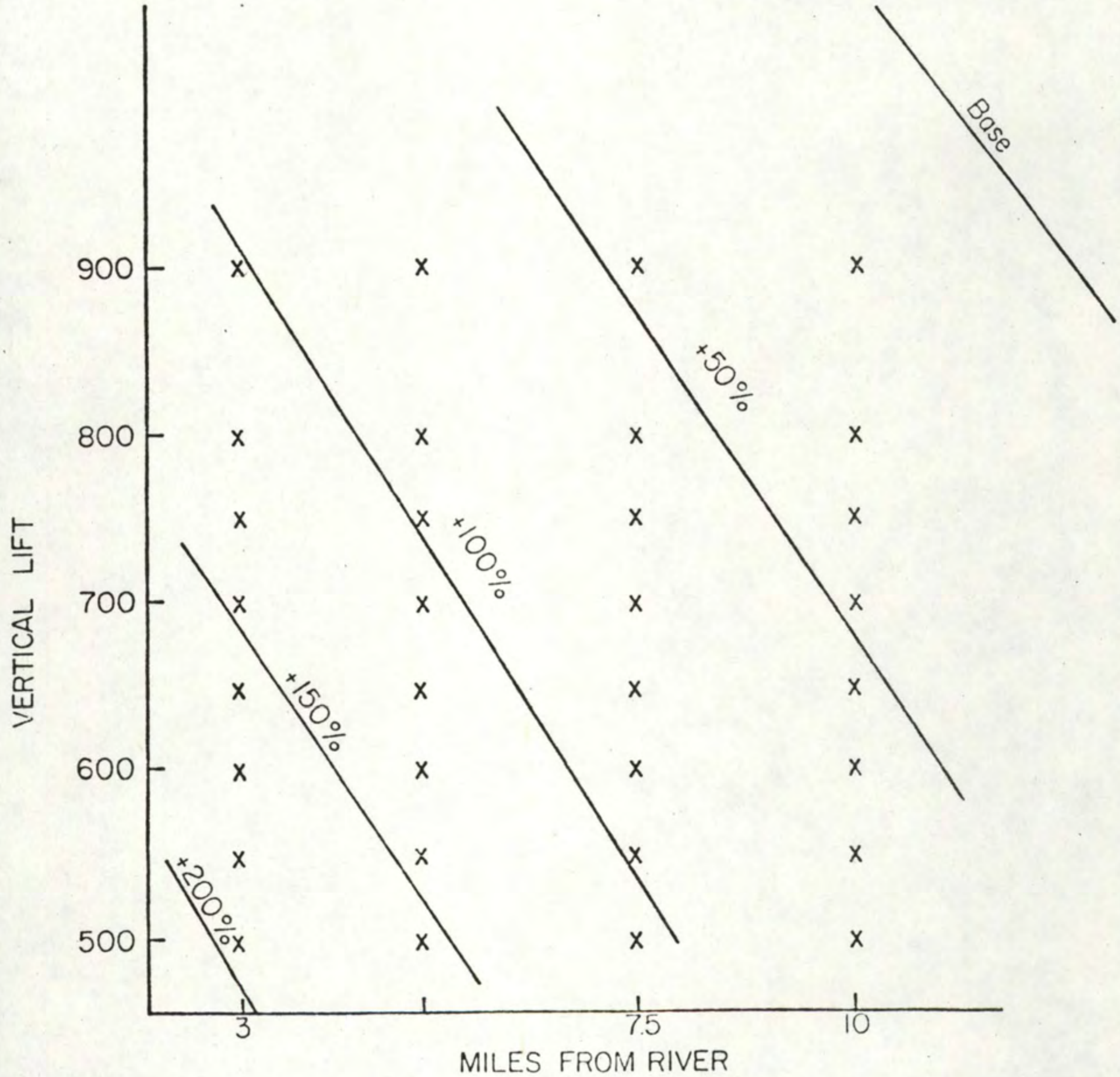

Figure 4 The Effect of Lift, Distance and Electricity Rates on Project Feasibility for 640 Acre Farms.

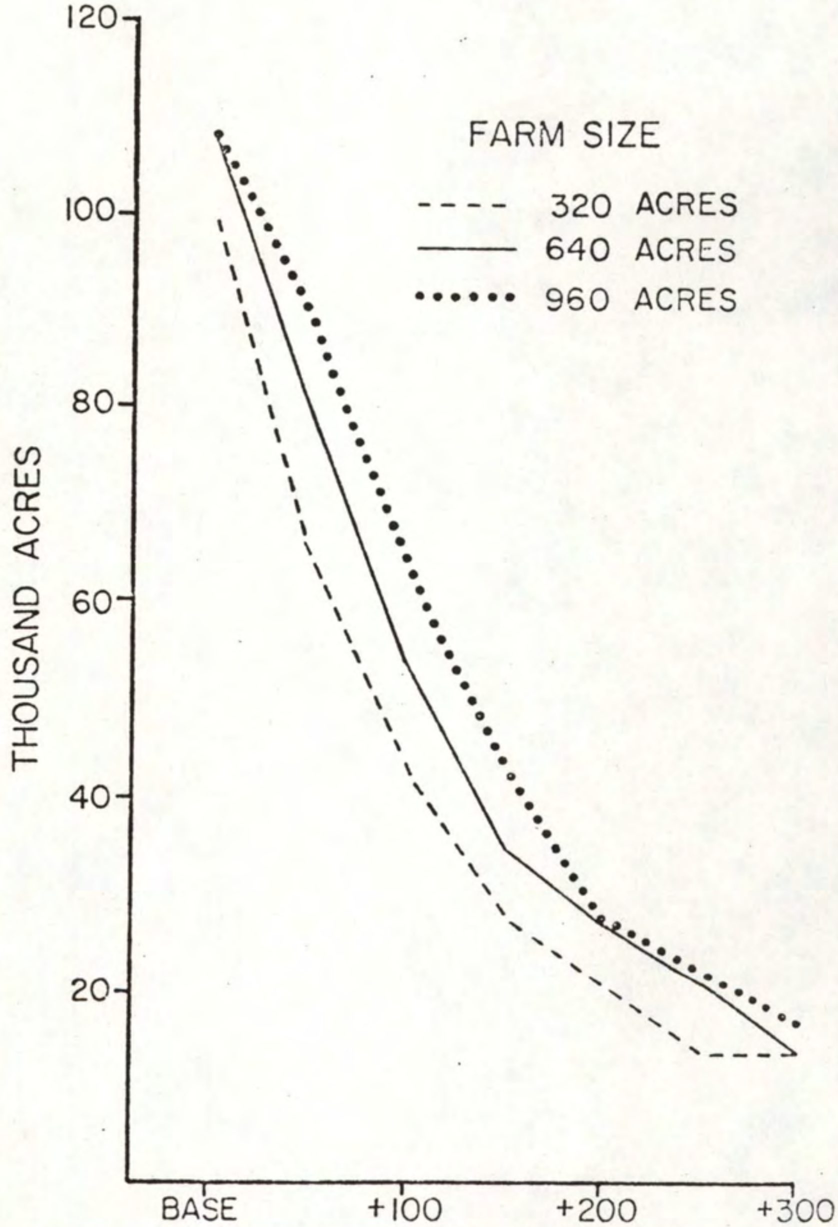

Figure 5. The Effect of Electric Rate Increases and Farm Size on Feasible Development Acreage in the BLM Study Area.

(which I believe you heard a report on last year at this conference), while generally optimistic about demand for northwest crops, have recognized that such demand growth is dependent on growing incomes both here and abroad. Moreover cheap transportation is vital if we are to serve this demand. While trying not to sound too pessimistic, I want to point out that our own economy is hardly booming, and the economies of some of our good export customers are reeling under the effects of high imported energy prices. At the same time the energy cost of reaching distant markets is increasing. So the medium term demand and price picture is a bit hazy. I would be very reluctant to project any near term increases in demand and prices that could fuel a boom in irrigation of new land. I think it is much more likely that, except for short term variations, crop prices and prices of inputs other than energy will maintain their present relative levels. Crop prices will probably not reach the development stimulating relatively high levels they reached in the early 1970's. It is up to you to project whether the world economies will get straightened out enough in the longer run for demand and prices to strengthen.

There are two factors which my graduate student didn't include in his model which now seem increasingly important. The first is inflation. The second is tax policy. In the years since 1977, inflation has accelerated and with it the interest rates which must be paid on borrowed capital. Most irrigation development proceeds with borrowed money -- a lot of it. High lift pumping stations often cost $1500 per acre or more. Sprinkler systems run $300 or more per acre. To this must be added the investment cost of other machinery and operating capital. Only a person with substantial income from other sources is likely to have the cash flow needed to meet loan payments at today's rates on an investment of over $2,000 an acre.

High interest rates are choking off investment in irrigation in just the same way they are choking off investment in other businesses. I would argue that high interest rates are a main cause of the current sluggish pace of irrigation development. I will go out on a limb a bit further and say that the current administration has not yet demonstrated that inflation is about to slow down.

Tax policy has always had some aspects which stimulate investment. The fact that interest and depreciation are tax deductable expenses encourages investment especially if the developer has other income to write off against land development expenses. The same is true of investment tax credit and capital gains treatment of income. While I am not sure even the tax lawyers have figured out all the implications of the recent changes in tax laws, the changes seem to favor increased investment. Certainly the increases in investment tax credit, accelerated depreciation, and more favorable treatment of capital gains would have stimulating effects. At the moment the high interest rates overshadow any stimulus from tax changes. If and when interest rates come down the tax changes will increase the rate at which land is developed.

D) Conclusions About the Rate of Increase of Irrigated Land

Table 3 summarizes the forces determining the rate of development of new irrigated land. I am inclined to conclude that the restrictive forces will dominate for at least the next few years. My guess is that new irrigation development will proceed at rates well below that seen in the last few years. I vote for a .5 percent annual rate of increase in the 1981 to 1986 time period. Because I expect pumping costs for high lift and

Table 3: Forces Affecting the Rate of Irrigation Development in the Pacific Northwest.

Forces Stimulating Development	Forces Restricting Development
1) Political power and popularity of irrigation	1) Pressures for electric rate increases and rate reform
2) Subsidies and other stimulus from state and federal agencies	2) Restrictive policies of state and federal agencies
3) Changes in tax laws	3) High interest rates
	4) Same relative crop prices and costs as now -- prices less stimulating than in the early 1970's.
	5) High lift and distance for remaining developable land
	6) Recognition of the hydropower generation and electric rate impacts of irrigation development.

distance situations to become more restrictive in the later periods, I vote to cut this to .4 and .3 percent in the 1986 to 1991 and 1991 to 2001 periods, respectively.

E) Comments About Sprinkler Saturation

Many of the same factors which influence new irrigation development also influence sprinkler saturation. The large per acre investment makes sprinkler adoption subject to interest rates. Also, since most sprinklers operate at 50 to 90 pounds per square inch, they involve substantial pumping costs so they are sensitive to rising real electric rates.

However several forces encourage sprinkler adoption. Since sprinklers often improve irrigation efficiency they may cut the amount of water that must be pumped. For high lift and deep well applications, adoption of sprinklers can actually lower power bills. Lower labor costs and potential for automation characterize most sprinkler systems. Several agencies have siezed on sprinklers as a way to cut erosion related water pollution and to improve water use efficiency. A recent study of mine looked at how farmers reacted to the 1977 drought. One conclusion was that drought program subsidies, cost sharing, and concessional interest rates helped many Idaho farmers install sprinklers during that summer.

I am worried that some of this focus on improved water use efficiency may be misplaced. At least in parts of southern Idaho, the water wasted by one farmer is the water source of the next farmer. In these cases sprinklers may save labor -- but they will not make any more water available for anyone. We may simply be trading a highly efficient but seemingly sloppy system for a highly energy intensive application system that benefits mainly the utilities and the sprinkler manufacturers and salesmen.

In addition to inflation and energy costs there are several other factors that may restrict saturation of sprinklers. Foremost is that other low energy, high efficiency application systems are being developed. Just one example is the "cablegation" system being developed at the USDA Snake River Conservation Center. This is a fully automated, low cost, low energy, highly efficient automatic cutback gated pipe system. As alternatives like this are perfected, energy intensive sprinkler systems will be viewed with less favor for some crops and soils.

I project that saturation of sprinklers in the Pacific Northwest will increase only moderately -- an increase of about 5 percent in each of the ballot periods. Starting with the 53 percent saturation given for 1980, this means 58 percent saturation in 1986, 63 percent in 1991, and 68 percent saturation in 2001.