An Investigation of Institutional Impacts on Allocation of Water Supplies for Irrigation: An Oregon Example

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AN INVESTIGATION OF INSTITUTIONAL IMPACTS ON ALLOCATION OF WATER SUPPLIES FOR IRRIGATION: AN OREGON EXAMPLE

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ABSTRACT

The Fort Rock-Christmas Valley Basin, an arid subregion of south-central Oregon, was considered unsuitable for long-run agricultural production except for rangeland livestock until the early 1970s. Low interest loans for groundwater development coupled with cheap land encouraged potential farmers, especially U.S. veterans, to migrate to the Basin.

High protein alfalfa, the only crop capable of withstanding the harsh climate, was initially a success. However, increased migration of hopeful agriculturalists resulted in surplus alfalfa and, consequently, lower alfalfa prices. Low revenues and skyrocketing energy prices forced public and private loan default rates to more than 50 percent. In addition, escalating water demands of alfalfa growers with newer, deeper wells were a cause for concern of livestock operators with older, shallower wells. Their efforts and state worries over groundwater overdraft culminated in a moratorium on new irrigation development in the Basin.

The institutional changes which first increased, then decreased, the availability of water to Basin irrigators is examined in this paper. A model of institutional change as related to the producing behavior of two users of a resource is presented, and an economic analysis determines whether overdraft of the Basin is justifiable.

Results show that the institutional barrier to additional groundwater development in the area, while effective, was unnecessary. Economic conditions in the long run are not conducive to farming for profit. Since no conclusive evidence of overdraft was found, political pressure may have played a significant role in establishing the moratorium in this Basin as a prelude to groundwater management in more critical parts of the state.

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INTRODUCTION

Institutions are assumed to be fixed in neoclassical economics although they do change and impact the behavior of individuals and groups of individuals in an economic sector. Changes in economic behavior can modify the institutions, setting in motion an interdependent system of one change inducing another.

When one resource user is a threat, either real or perceived, to another, the institutional structure is often used to remedy the situation. Institutions may preclude an economically efficient solution as political power frequently determines changes in the prevailing institutional structure. However, economic theory can be used to determine a range of solutions.

In this paper, the nature of political and institutional changes is examined in a theoretical framework. The economic feasibility of groundwater overdraft is also investigated. Finally, the rationale for government intervention and underlying reasons for legal action to resolve a water conflict are explored. The case for a declared groundwater moratorium in Lake County, south-central Oregon, is used as an example.

HYDROLOGY

The remote Fort Rock-Christmas Valley area in northern Lake County of south-central Oregon is a high desert characterized by rainfall of 7 to 10 inches per year, extremes in temperature of -10°F to 100°F and a growing season of 90 or fewer days per year (King et al., 1977). There are no reliable sources of surface water or irrigation; groundwater is pumped for domestic, stock, and irrigation use.

The two primary water-bearing strata in the Basin are The Picture Rock Basalt, about 200 to 1,000 feet below the land surface, and The Fort Rock Formation, about 10 to 200 feet (Hampton, 1964). The Fort Rock Formation is composed of four rock types: tuff, diatomite, basaltic agglomerate, and basaltic lava, listed in decreasing order of abundance. The yield directly from the tuff and diatomite desposits is low and more appropriate for domestic and stock use. Yields from the basalts are moderate to large.

For example, well 26/15-1C1 drilled in 1957 descends 361 feet to The Fort Rock Formation. Its 12-inch casing extends to 123 feet. The static water level was 32 feet in April 1957 and a two-hour test yielded 2,000 gpm with a 25-foot drawdown. Well 27/17-27L1 is 220 feet deep. It has a 16-inch casing and the static water level was 42.2 feet when first tested in 1952. During the drilling, it was tested at about 50 feet, but yielded little water in the tuff-diatomitic layers of The Fort Rock Formation. A decision was made to deepen the well 220 feet to basalt layers. The Picture Rock basalt portion of the well yielded 4,800 gpm with a 40-foot drawdown in a six-hour test on June 18, 1952 (Hampton, 1964). Current well conditions have changed little in the last 30 years (site visit, June 1984).

Although no extensive on-site research has been done on the source and discharge of the groundwater in the Basin, hydrographs of several older wells such as the Fremont Well (257 feet deep, 16 to 8 inches in diameter, tapping the Fort Rock Formation) indicate a strong, 10-year lagged correlation between precipitation and groundwater levels in the Fort Rock Formation (Hampton, 1964). The relationship between precipitation and groundwater in the Picture Rock Basalt is unknown, but obviously would be one that extended over a much longer period of time.

Outflow is thought to be subsurface to the Deschutes system to the north and/or Summer Lake and the Ana River to the south (Waring, 1908; Hampton, 1964). Hampton describes a 1953 calculation by Newcomb of the U.S. Geologic Survey based solely on precipitation. Of approximately 125,000 AF of recharge as precipitation, 50,000 were transpired by vegetation given known characteristics of local plants. The remaining 75,000 AF must then be subsurface discharge since static water levels had been stable for as long as measurements had been taken. The 75,000 remaining for use necessarily would be larger if there were subsurface inflow to the area in addition to the recharge from precipitation (recall that the nature of the water-bearing Picture Rock basalt is less understood). The amount available for pumping could also be increased if some of the water attributed to evapotranspiration could be put to beneficial use.

Pumping in 1960 was estimated at only 12,000 AF, which means that up to "60,000 acre-feet of additional water could be pumped annually without overdraft...if the subsurface outflow could be salvaged completely (Hampton, 1964, p. B23)." Annual withdrawals in 1982-83 were estimated at nearly 90,000 AF, but static water levels still have not declined significantly. In fact, increases in the static water level have been reported in some wells. State officials, however, claim that recent levels of precipitation have been abnormally high; the groundwater level should be approximately 0.5 feet lower (site visit, April 1984).

GROUNDWATER LAW IN OREGON

Applications for groundwater permits must be filed by any individual or public agency requiring water for beneficial use. Stock, domestic, and small commercial uses are exempt from the standard application process. The priority date of a groundwater permit is the date the application was filed in Salem. Fees are composed of two parts, $40 for examining the permit, and variable charges for filing and recording the permit. All permit fees received by the Department of Water Resources are credited to the State's General Fund. The application process is described in ORS 537.615 (Oregon Water Laws, 1982).

All groundwater used for any purpose remains appurtenant to the land upon which it is used. Any requests for changes in use or place of use must be filed with the Director of Water Resources, who then gives notice of a public hearing. The notice is published in a newspaper having general circulation in the county listed on the groundwater certificate. Objections to the change must be addressed to the Director at least 10 days before the hearing. Costs of the hearing are borne by the individual requesting the change. The Director makes his decision after the hearing.

If groundwater levels decline or are threatened, wells interfere with one another, aquifers become polluted, or geothermal resources are endangered, proceedings may be initiated to determine whether that area should be declared a Critical Groundwater Area (ORS 537.730-537.735). The Director may act at his or her own discretion, or upon receipt of a petition from the State Geologist or any groundwater claimant or appropriator in the affected area. A moratorium on new applications for groundwater use is established and an investigation of the problem ensues. Stock and domestic wells may be exempted from the moratorium depending on the nature of the complaint. If the area is declared a Critical Groundwater Area, the Director may take any one or combination of several corrective measures from closing the area to further appropriation to forbidding the operation of more junior wells in order of their priority dates.

Permits for irrigation specify the maximum amount of water that may be withdrawn for use on a particular piece of land. A description of the land to be irrigated with the number of acres irrigated in each 40-acre legal subdivision is included in the certificate. Transfer of unused water to lands not specified in the description is prohibited. Thus, there is no incentive to conserve the water by investing in water-saving technologies or create a water market aside from reducing pumping costs.

Groundwater certificates for irrigation in the Fort Rock-Christmas Valley Basin allow a maximum of three acre-feet per acre of land under permit. Limits are overseen by the district watermaster who monitors the wells and aquifer. State water statutes require each well registration statement to include annual groundwater withdrawals.

HISTORICAL BACKGROUND

The Fort Rock-Christmas Lake area was bypassed as undesirable by the original settlers on their way to the fertile Willamette Valley. Although some tried to farm the region in the 1800s, none were successful (Lewis, 1984). A "locater" brought a small group of Willamette Valley residents to the Fossil Lake area of northern Christmas Valley in early 1905 (Waring, 1908). By November 1906, 120 claims had been filed in Christmas and Fossil Lake under the Homestead or Desert Land Act. However, farming conditions in 1906 proved to be unusually good for the harsh valley, and when normal temperatures returned the area was all but abandoned by cash-crop farmers. The Fossil Lake area was later referred to as "Sucker Flat"; raising livestock became the agricultural base.

With the passage of the Rural Electrification Act of 1956, the cheap electrical power of the Bonneville system became available to the Basin. The feasibility of resettlement was studied. Castle and Dwyer (1956) concluded that the cheap power for irrigation would make it possible for livestock operators to expand their feed base, but considerable risk would continue to be associated with the adverse growing conditions. Cash-crop agriculture remained an exceedingly speculative venture.

In the late 1960s and early 1970s, land speculators became interested in promoting Christmas Valley as a resort, retirement, and "gentleman farmer" area. Although some individuals did purchase tracts, the effort to develop the area, was unsuccessful. Interest on private loans was too high to encourage groundwater development for commercial farming, and government-sponsored loans were as yet unavailable, or difficult to obtain.

The agricultural situation up to the mid-1970s remained as it had for many years: cattlemen of the Fort Rock Basin grew alfalfa for their live-stock; what was left over was stored or sold to coast dairymen. Alfalfa grown in the area is about 20 percent protein (Obermiller, 1981). The export demand by coast and Willamette Valley dairies in the late 1970s for this high quality Lake County alfalfa induced a price rise for the local hay. Potential profits encouraged farmers to move to Christmas Valley, but local financing of farmlands and irrigation systems was not yet available.

By 1976, government-sponsored loan programs--Farmers' Home Administration (FmHA) and Oregon Veterans' Affairs (OVA)--allowed farmers to borrow money for farmland water development (Jackson, 1981). In addition, the Oregon Department of Water Resources (ODWR) initiated its water development loan program in 1979 after approval in the 1977 November election. Between 1974 and 1978, irrigated acreage in Lake County increased 50 percent, and by 1982 it had increased 72 percent. As of 1982, $3.1 million had been granted to Lake County in 34 low-interest ODWR loans alone, double that of the next most indebted county (Oregon Water Resources Department, 1983). The population of Lake County grew 20 percent between 1970 and 1980 with virtually all the increase in the Christmas Valley area (World Almanac, 1977, 1981; Jackson, 1981). These government-sponsored loans provided the financing needed by growers to develop groundwater resources; without the financing, the expansion of alfalfa production would have been considerably less impressive. For simplicity, individuals entering the area under these financing programs are defined here as alfalfa growers while the more established group is referred to as cattlemen. The classification is intended to reflect the primary source of income of an operation, when it was established, and the development of the groundwater resource. It is acknowledged that many ranchers also grow alfalfa, but this hay production is primarily for on-farm use as opposed to the cash-crop agriculturalists.

The low-interest government-sponsored loans were perceived by incoming alfalfa farmers to be an indication that groundwater development should be encouraged. The established cattlemen had drilled relatively shallow wells for livestock watering and side roll and gravity irrigation systems for their on-farm alfalfa needs. However, the commercial alfalfa growers invested in much deeper wells to support their more extensive center pivot systems.

The enormous amount of water--90,000 AF in 1983 (site visit, April 1984) versus 12,000 AF in 1960 (Hampton, 1964)--pumped from the aquifer and the influx of alfalfa growers demanding even more groundwater from the aquifer were a cause of concern for the cattlemen: if the water table was overburdened, their shallow wells would be the first to have problems (Lewis, 1984). At the same time, alfalfa growers believed that the 3 acre-feet per acre per year allowance in the permit, while adequate for production levels in an average year, might be insufficient for acceptable alfalfa quality and yield in drier years (local meeting, April 1984). Currently, net irrigation application for alfalfa in the area rarely exceeds 2.5 acre-feet for the three-month season for an average farm (U.S. Department of Agriculture, 1982).

The Oregon Legislature refused to confirm the incumbent Director of Water Resources and a new director took office in November 1983. The issue of persistent and unresolved groundwater problems in other parts of the state was partially to blame for the change in the directorship. The new director examined data on the groundwater table in the Basin and determined that a moratorium on new irrigation permits was needed. An investigation during the moratorium would determine if the water table was being depleted, stable, or capable of supporting additional development. One stated rationale for the decision was to protect the interests of the well owners with the more senior water rights. Secondly, the groundwater policy in Oregon is essentially one which strives to preserve aquifer levels; groundwater overdraft is inconsistent with this policy. The moratorium on groundwater permits was instituted without advance notice on March 29, 1984; no new permits for irrigation would be granted until a final decision was made and new ODWR water development loans would not be approved. Wells for domestic and stock purposes would, however, continue to be processed under the moratorium. A hearing to explain the reasons and investigation before the final decision was held in Christmas Valley on April 17, 1984, and in Lakeview, the county seat, on April 18. After the hearing, a move to overturn the moratorium was submitted by three alfalfa growers to a Salem court. Arguments were heard in May 1984, but the case was referred to another court. As of July 1984, the case had not been decided.

There are, then, two institutional changes of interest in the Fort Rock-Christmas Valley area. The first is the introduction of low-interest loans to farmers to develop water resources. This change resulted in a six-fold increase in permitted irrigated acreage from 5,694 acres in 1970 to 36,273 acres in 1980, with an additional 4,195 acres in application process as of 1981 (Jackson, 1981). Second, the moratorium stopped approval of any new irrigation permits for the area and all Department of Water Resources loans to Basin growers were suspended. Land without access to water is worthless in agriculture, and land values have correspondingly fallen (site visit, April 1984; real estate agent's claim). Future irrigation development has been legally arrested such that an upper limit exists on alfalfa production.

THE MODEL

The conceptual model of Livingston (1984), when examined in a welfare theoretic framework, provides a clear basis for including institutions as an endogenous variable in resource allocation decisions. Two groups involved in the exploitation of a resource for production are at opposite vertices of an Edgework Box in Figure 1. A contract curve, the locus of tangencies of producer isoquants, exists. Initial equilibrium at some point on the contract curve is assumed. Physical, institutional, social, economic, or other changes cause one vertex to move with respect to the other. A new contract curve exists, and initially, there is competition over where the groups will settle on the new curve. The new allocation is ultimately a function of the relative economic and political bargaining power of the groups and prevailing prices and policies. The outcome may be legislated, or agreed upon as described by Coase (1977).

The Edgeworth Box in the figure is constructed to read cash-crop alfalfa from left to right on the bottom from vertices O_A and livestock from right to left along the top from vertex O_C

There is OL land and OW corresponding groundwater available in the entire Basin. Basin Alfalfa growers originally posses O_AL^* land for commercial production of alfalfa while cattlmen have O_CL^* land for their

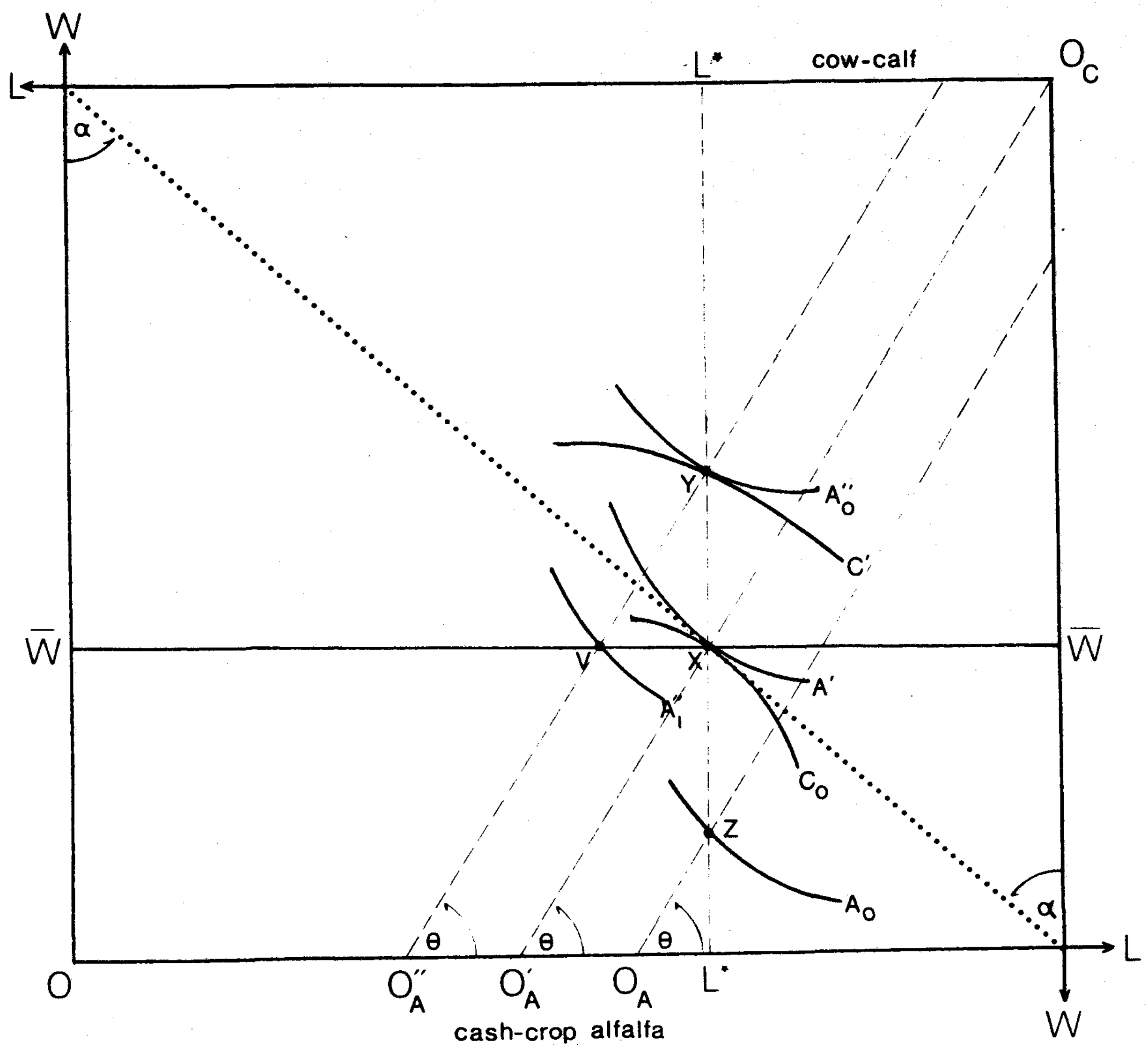

Figure 1

Edgeworth Box of

Cow-Calf and Cash-Crop Alfalfa Resource Use stock and on-farm alfalfa use. All remaining land from 0 to 0_A is unutilized such that there is room for additional irrigation development of the Basin. Angle α represents the ratio of land to water at which withdrawal equals recharge, and withdrawal rates greater than α mean a lowering of the groundwater table. The associated ray ($\tilde{\alpha}$) is downward-sloping; as more wells are dug to bring additional land into production, less water may be withdrawn per well to maintain the aquifer. Angle θ, on the other hand, represents the legal withdrawal rate as specified by the groundwater permit, i.e., three acre-feet of water per acre of land under permit. Since the rays corresponding to natural recharge and legal withdrawal intersect, the resource is legally depletable when pumping permits in excess of $0\bar{W}$ are granted to 0_A' 0_C land.

Isoquants at the intersection of water right with land owned represent full utilization of inputs and consequently greatest output, ceteris paribus. Initial isoquants A_0 alfalfa and C_0 cattle are, therefore, maximum and there is no conflict in resource use as neither production process uses inputs at the expense of the other; neither is depleting the water table at these output levels.

As more alfalfa growers move into the area, some of the unutilized land is acquired through purchase or lease of public lands. The vertex 0_A is pushed to $0'_A L^*$ and A' output, just tanget to C_0 cattle. Although there is still excess land, the groundwater resource is fully utilized; further appropriations imply depletion. Pressure by alfalfa growers expanding to $0_A''L^*$ and A" is met with resistance by cattlemen who fear their livelihood threatened.

If alfalfa growers--in the absence of the moratorium and given appropriate conditions--were to expand unchecked, their demands for water would cause sufficient drawdown to threaten the shallower cattlemen's wells. Their production to A_0'' given livestock isoquant C_0 results in aquifer overdraft. Shallower wells would be either abandoned or redrilled. Ranchers unable to finance deeper well construction would suffer higher water costs and, as the more marginal operations are forced out of production, total output would diminish. Livestock-alfalfa production would drop to C' for 0_cL land. As groundwater conditions worsened, less land would finally be used and the isoquants would shift to even lower level.

The moratorium has the theoretical effect of limiting withdrawals to $\bar{W}$. Cattle production remains at C_0 but alfalfa production is limited to A'. Any plans to develop $0_A''0_A'$ to obtain A" are blocked. If this land were purchased pending approval of a groundwater application, the land must remain idle. The speculation is a loss if the purchase price was based on the value of the land, assuming a permit would have been granted.

The moratorium preserves long-run sustainability of both production processes while allowing maximum use of the land and groundwater resources only if it is associated with the allocation levels corresponding to the intersection of rays $\tilde{\alpha}$, $\tilde{\theta}$, and L* at point X as seen in the figure. If a moratorium goes into effect at some combination of land and water inputs below ray $\tilde{\alpha}$, then long run sustainability of both resources is preserved but those resources are less than fully utilized. However, above ray $\tilde{\alpha}$ neither production process is possible in the long-run and shallower livestock and older irrigation wells are jeopardized. The two-year investigation is intended to provide the information necessary to mandate the efficient allocation.

Suppose court battles eclipse the state's efforts. Alfalfa growers push to $0_A''L^*$, A" output, and depletion is inevitable. Withdrawals lower the aquifer, some cattlemen faced with higher pumping costs are forced to reduce their scale of operation or are driven out of production, and L* shifts rightward. Alfalfa growers may expand into the vacated area (recall that some of the acreage is already in alfalfa production) and wells are renovated. Assuming a market for the alfalfa exists, the expansion of the alfalfa industry would accelerate the rate of groundwater depletion.

Efficiency at X would be reached through negotiations provided the groups would not only be willing to bargain, but also were fairly homogeneous. Although they are homogeneous in production, they are not in an institutional sense. Each individual has a different bargaining position because of the priority dating system. Since state water rights cannot be bought or sold, the legal system may interfere with an economic solution. Also, the unequal legal footing of individuals within a group does not contribute to group cohesiveness. For example, the alfalfa growers as a group are not junior rights holders and individuals within the group may be ranked according to seniority. While a Coase solution is possible in theory, it is unlikely to occur in the Lake County case because of the institutional barriers of water appropriation.

There is, therefore, a range of theoretical solutions. Long-run sustainability with A' and C_0 production at X given the moratorium is one possibility. Alfalfa expansion to A_0" reduces cattle production to C" at point Y if the moratorium is lifted. Also, production of the two may be at point V with A_1" alfalfa and C_0 cattle if some alfalfa growers decide to allow the investment in O_A' - O_A" land to lie vacant. Thus, the range of solutions is area VWXY where only X implies maximum production of both operations and preserved groundwater levels.

AN ABBREVIATED ECONOMIC ASSESSMENT OF THE ALLEGED OVERDRAFT

The Fort Rock-Christmas Valley aquifer system does not appear to be facing critical demands. However, it is useful to know whether overdraft is economically warranted. Newcomb's 1953 estimates of the aquifer's characteristics are assumed reasonable for lack of more recent information. Current average water use of two acre-feet of water on approximately 45,000 acres implies a total aquifer withdrawal of 90,000 acre-feet per year for all uses--domestic, stock, and irrigation. A maximum of 75,000 acre-feet was assumed to be available. Thus, there exists an overdraft of 15,000 acre-feet per year over those 45,000 acres, or an average annual overdraft of one-third acre-foot per acre. Drawdown was estimated to be in the neighborhood of 0.5 feet per year. Thus, drawdown per acre-foot of overdraft per acre is 1.5 feet per annum.

Figure 2 shows how annual adjusted alfalfa prices per baled ton changed from 1975 to 1984 (Oregon County and State Agricultural Estimates). Lake County prices were equal to or greater than Oregon average prices in all but two years, 1975 and 1984 (preliminary). Prices have been volatile ranging from lows in the $50 range to highs approaching $100 in only a two-year period from 1978 to 1980. After 1980, however, prices have declined. One should note that alfalfa prices for Fort Rock-Christmas Valley alfalfa in northern Lake County are higher than those for the county as a whole, and prices for hay which has been protected by sheltering are higher than that which has not been shielded.

A worksheet developed by Moore (1984) is used to determine whether the return per acre-foot of pumped water exceeds the present value true cost of pumping that water. If it does, then groundwater mining is economically justifiable. Dividing net gain (adjusted for the true cost of pumping by the energy cost expended per year because of the drawdown) yields the number

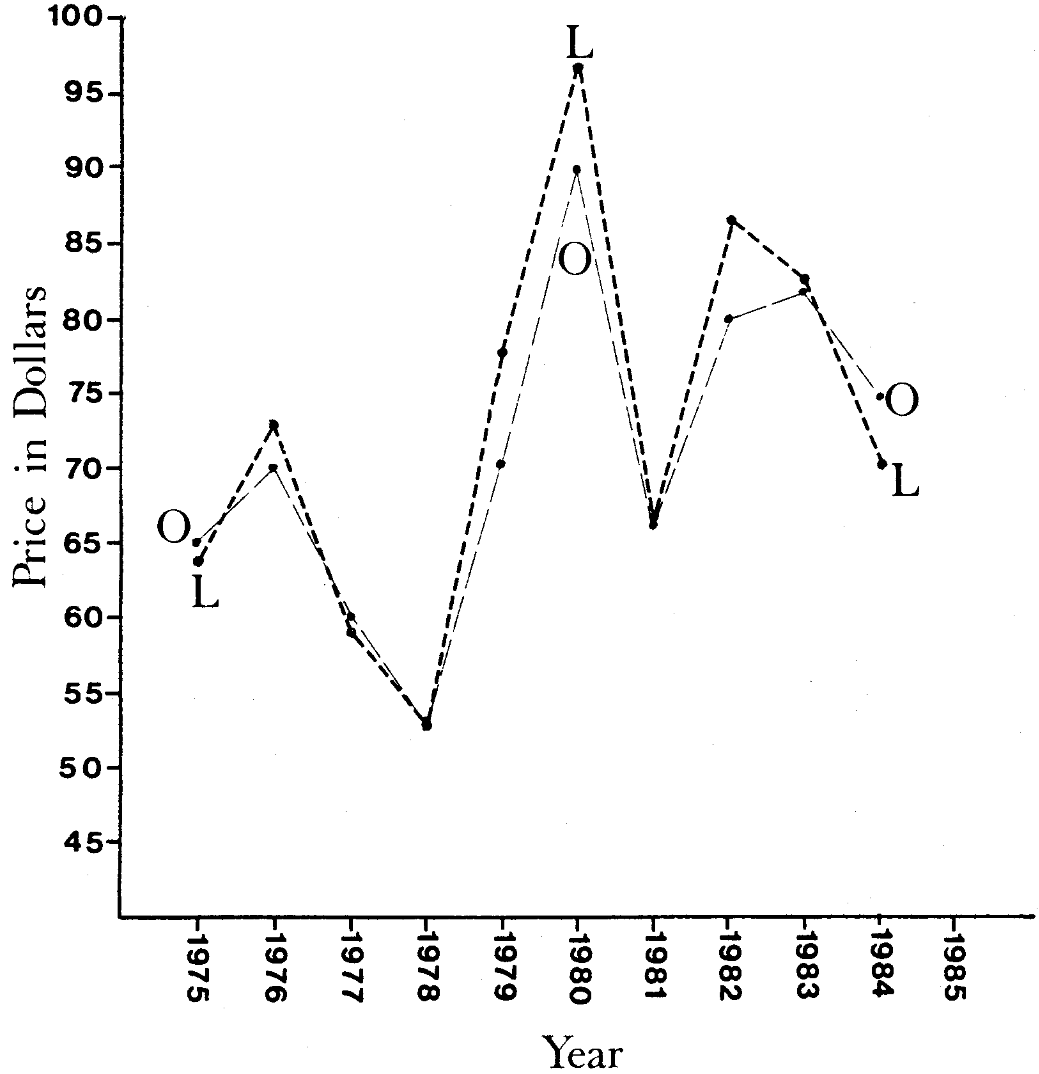

Figure 2

Annual Adjusted Alfalfa Prices Per Baled Ton,

Lake County (L) and Oregon State Average (O),

1975 - 1984

of years the mining should continue. From this, the additional number of feet that can be drawn while preserving the economic integrity of an operation can be determined. Overdraft information described above was used with available cost and price data (Obermiller, 1981; Oregon County Enterprise Sheet, Lake County Alfalfa, 1984; site visits, 1984). Calculations were made for three price conditions: (1) $120 per baled ton, representing the highest average price received in 1980; (2) $80 per ton, reflecting more adverse conditions of 1983; and (3) $105 per ton, an optimistic goal for 1984 as voiced by a grower. Actual 1984 prices were about $80 per baled ton in Lake County. The enterprise data reflected expected costs and prices, but do not include a 4% return to management or reflect wide variations in profits.

One should note that 1979 prices were unusually high. Even higher 1980 prices were the result of the Mt. St. Helen's destruction of hay crops in the Columbia Basin. When hay-producing areas in the Columbia Basin recovered, prices declined. Since the government-sponsored loans became available in 1976 for the 1977 establishment year, many farmers' first crops in 1979 supplied unusually high revenues. These high revenues were the basis for many additional loans. When alfalfa prices dropped to lower levels, loan delinquency rates skyrocketed and financing became nearly impossible to obtain by 1984.

Results of the worksheet for the three price conditions are found in the following three tables. As expected, 1979-1980 conditions were enough to justify near exhaustion of the groundwater resource. Circumstances changed dramatically by 1983; negative returns were realized even before adjusting for the true cost of pumping, making not only overdraft but alfalfa production itself an uneconomical option. Early price expectations for 1984 were better, but still insufficient to justify continued pumpage. However, preliminary estimates for 1984 indicate a continued decline in prices received by farmers.

Table 1. Groundwater Overdraft Feasibility for Fort Rock-Christmas Valley Alfalfa, \$120 Per Ton, 1980

1. Energy cost per acre-foot per foot of lift. KWH/ac. ft. = 1.024 x $\frac{1}{0.60}$ = 1.70667 (1a)

(pumping plant efficiency)

1.70667	x	\$0.01980	=	\$0.03379
(1a) KWH/ac. ft. Enter value from (1a).		(1b) Cost/KWH from power company.		(1c) Energy cost per ac. ft. per foot lift.

2. Present value of cost savings from NOT overdrafting

\$0.03379	x	1.50	x	7.469	=	\$0.37857
(1c) Energy cost per acre-foot per foot lift		(2a) Estimated draw down per acre-foot of overdraft		(2b) Discount coefficient 20 years at 12%		(2c) Present value of savings per acre-foot

3. Calculate current private and true cost of pumping per acre-foot pumped.

Current cost of pumping	\$0.034	x	74*	=	\$2.52
	Enter value from (1c)		(3a) Total lift		(3b) Cost/ac. ft.

add Present value cost savings of not overdrafting — enter value from (2c). \$0.38 (3c)

True cost of pumping (3b + 3c) \$2.90 (3d)

Estimated return per acre-foot of water applied on farm or basin \$ 25.31 (3e) per acre-foot

Subtract	(3e) \$25.31	-	(3d) \$2.90	=	\$22.41
	Net return acre-foot		True cost of pumping per acre-foot.		Net gain or loss. (3f)

If 3(f) is negative, pumping should be reduced. If the value in 3(f) is positive, it is economical to continue to overdraft.

*water level plus pressurization

Table 1. Continued

4. Calculate optimal additional overdraft:

$0.034	x	1.50	x	1/3	=	$0.017
(4a) Enter value from (1c) energy cost.		(4b) Enter value from (2a) drawn down per ac. ft. of overdraft.		(4c) Average overdraft in acre-feet per acre per year.		(4d) Energy cost per year due to draw down.

$22.41	÷	$0.017	=	1318
(4a) Enter value from (3f) Net gain per ac. ft. pumped.		(4f) Enter value from (4d) Energy cost per year due to drawdown.		(4g) Number of years overdraft should continue at existing rate of drawdown.

5. Convert to additional pump lift:

1318	x	0.5	=	659
(5a) Enter value from (4f) Number of years overdraft to continue.		(5b) Enter average annual overdraft in feet per year.		(5c) Additional feet of total lift to reach equilibrium.

Source: Adapted from Moore (1984).

Table 2. Groundwater Overdraft Feasibility for Fort Rock-Christmas Valley Alfalfa, $80 Per Ton, 1983

1. Energy cost per acre-foot per foot of lift. KWH/ac. ft. = 1.024 x $\frac{1}{0.60}$ = 1.70667 (1a)

(pumping plant efficiency)

1.70667	x	$0.035	=	$0.05973
(1a)		(1b)		(1c)
KWH/ac. ft. Enter value from (1a).		Cost/KWH from power company.		Energy cost per ac. ft. per foot lift.

2. Present value of cost savings from <u>NOT</u> overdrafting

$0.05973	x	1.50	x	7.469	=	$0.669
(1c)		(2a)		(2b)		(2c)
Energy cost per acre-foot per foot lift		Estimated draw down per acre-foot of overdraft		Discount coefficient 20 years at 12%		Present value of savings per acre-foot

3. Calculate current private and true cost of pumping per acre-foot pumped.

Current cost of pumping	$0.060	x	75*	=	$4.50
	Enter value from (1c)		(3a) Total lift		(3b) Cost/ac. ft.

add Present value cost savings of not overdrafting — enter value from (2c). $0.67 (3c)

True cost of pumping (3b + 3c) $5.17 (3d)

Estimated return per acre-foot of water applied on farm or basin - $ 25.66 (3e) per acre-foot

Subtract	(3e) -$25.66	-	(3d) $5.17	=	-$30.83
	Net return acre-foot		True cost of pumping per acre-foot.		Net gain or loss. (3f)

If 3(f) is negative, pumping should be reduced. If the value in 3(f) is positive, it is economical to continue to overdraft.

*water level plus pressurization

Table 3. Groundwater Overdraft Feasibility for Fort Rock-Christmas Valley Alfalfa, $105 Per Ton, 1984, Optimistic Scenario

1. Energy cost per acre-foot per foot of lift. KWH/ac. ft. = 1.024 x $\frac{1}{0.60}$ = 1.70667 (1a)

   (pumping plant efficiency)

1.70667	x	$0.038	=	$0.06485
(1a) KWH/ac. ft. Enter value from (1a).		(1b) Cost/KWH from power company.		(1c) Energy cost per ac. ft. per foot lift.

2. Present value of cost savings from NOT overdrafting

$0.06485	x	1.50	x	7.469	=	$0.72655
(1c) Energy cost per acre-foot per foot lift		(2a) Estimated draw down per acre-foot of overdraft		(2b) Discount coefficient 20 years at 12%		(2c) Present value of savings per acre-foot

3. Calculate current private and true cost of pumping per acre-foot pumped.

Current cost of pumping	$0.0.065	x	76*	=	$4.94
	Enter value from (1c)		(3a) Total lift		(3b) Cost/ac. ft.

add Present value cost savings of not overdrafting — enter value from (2c). $0.73 (3c)

True cost of pumping (3b + 3c) $5.67 (3d)

Estimated return per acre-foot of water applied on farm or basin $ 3.51 (3e) per acre-foot

Subtract	(3e) $3.51	-	(3d) $5.67	=	-$2.16
	Net return acre-foot		True cost of pumping per acre-foot.		Net gain or loss. (3f)

If 3(f) is negative, pumping should be reduced. If the value in 3(f) is positive, it is economical to continue to overdraft.

*water level plus pressurization

A six-year average result is found in Table 4. Costs per acre for 1983 were reduced by power costs and storage building cost. Power costs were then adjusted for the 1978-83 period, based on actual changes in electrical rates; other costs were adjusted by the index of prices received over the same period. The two costs were summed. Average prices were multiplied by average yields per acre (Oregon Commodity Data Sheets) to obtain an average revenue per acre. Costs were subtracted from revenues yielding average net returns per acre, and the result was divided by the water allotment to derive the average net returns per acre-foot of \$1.71. This return is insufficient to justify the withdrawal of groundwater by a typical alfalfa enterprise in the Christmas Valley area since the true cost of pumping is \$3.68; i.e., the true cost of overdraft for the six-year period is \$1.97.

The excellent conditions of 1979-80 were incorrectly perceived by some lending institutions to be indicative of circumstances over a longer period of time. The average alfalfa price listed by the FmHA for interested potential farmers was \$120 per ton with an average yield of 3.5 tons per acre for an expected revenue of \$420 (Obermiller, 1981). Given 1980 costs of \$344.07 excluding a return to management and a 20-year lease on lessee-developed land, a \$75.93 return per acre or \$25.31 return per acre-foot of water is anticipated. The Oregon Department of Water Resources Water Development Loan Program, quoting a much more conservative price of \$90-\$100 per ton in 1980, used an expected long-run price of only \$64.22 in its feasibility analysis with a yield of 4.0 tons per acre for an expected revenue of \$256.88. This significantly lower expected revenue suggests that an aspiring farmer would require substantial investment capital of his or her own to qualify for such a loan.

Suppose, then, that a grower met the more stringent standard above. That is, he or she could be expected to earn no less than \$256.88 and

Table 4. Six-Year Average Results of Groundwater Overdraft Feasibility for Fort Rock-Christmas Valley Alfalfa

1. Energy cost per acre-foot per foot of lift. KWH/ac. ft. = 1.024 x $\frac{1}{0.60}$ = 1.70667 (1a)

   (pumping plant efficiency)

1.70667	x	$0.025	=	$0.042667
(1a) KWH/ac. ft. Enter value from (1a).		(1b) Cost/KWH from power company.		(1c) Energy cost per ac. ft. per foot lift.

2. Present value of cost savings from <u>NOT</u> overdrafting

$0.042667	x	1.50	x	7.469	=	$0.47802
(1c) Energy cost per acre-foot per foot lift		(2a) Estimated draw down per acre-foot of overdraft		(2b) Discount coefficient 20 years at 12%		(2c) Present value of savings per acre-foot

3. Calculate current private and true cost of pumping per acre-foot pumped.

Current cost of pumping	$0.042667	x	75*	=	$3.20
	Enter value from (1c)		(3a) Total lift		(3b) Cost/ac. ft.

add Present value cost savings of not overdrafting — enter value from (2c). $0.48 (3c)

True cost of pumping (3b + 3c) $3.68 (3d)

Estimated return per acre-foot of water applied on farm or basin $1.71 (3e) per acre-foot

Subtract	(3e) $1.71	-	(3d) $3.68	=	-$1.97
	Net return acre-foot		True cost of pumping per acre-foot.		Net gain or loss. (3f)

If 3(f) is negative, pumping should be reduced. If the value in 3(f) is positive, it is economical to continue to overdraft.

*water level plus pressurization

cover all costs. Would the conditions of 1982-84 still warrant groundwater mining by this seemingly viable long-run operation? Revenues of \$80 x 3.5 = \$280 per acre for a net return of \$280 - 256.88 = \$23.12 per acre or \$7.71 per allocated acre-foot. As seen in Table 5, this corresponds to an additional 85 years or 42.3 feet of overdraft. Thus, some operations, notably those with low debt service, could continue to pump as before on economic grounds. Operations unable to break even at an alfalfa price of \$65 are not feasible long-run operations.

Extension specialists have always doubted the long-run viability of the cash crop irrigated alfalfa enterprise in Christmas Valley. Analyses have supported their suspicions. Only sustained high prices, high yields, and low and stable costs can justify the average cash crop operation. Thus, even if the water table were endangered, it is likely that some irrigators would abandon production over the long run and prevent a critical situation from developing. This reduction of irrigated land could be facilitated by higher electricity rates which will continue to rise throughout the state and region. (Bonneville Power Administration 1983; site visit, June 1984).

The moratorium has already had an adverse economic impact on the area. The land market is very slow. Buyers of agricultural land are justifably avoiding the Basin, while sellers are finding it impossible to find a market for arid agriculture lands without water rights. All work associated with drilling has come to a virtual standstill in the already economically depressed area. The results of Tables 2 and 3 along with imminent increases in electricity indicate that the land, on average, has been overpriced with respect to the value of the land in alfalfa production given current conditions. In addition, the reduction of milk price supports could result in even lower prices for Basin alfalfa. In this case, the moratorium may have expedited the inevitable. However, a few efficient and economical farms are being

Table 5. Groundwater Overdraft Feasibility for Fort Rock-Christmas Valley Alfalfa, 1983 Conditions, and a Viable Long-Run Operation

1. Energy cost per acre-foot per foot of lift. KWH/ac. ft. = 1.024 x $\frac{1}{0.60}$ = 1.70667 (1a)

(pumping plant efficiency)

1.70667	x	$0.035	=	$0.05973
(1a)		(1b)		(1c)
KWH/ac. ft. Enter value from (1a).		Cost/KWH from power company.		Energy cost per ac. ft. per foot lift.

2. Present value of cost savings from <u>NOT</u> overdrafting

$0.05973	x	1.50	x	7.469	=	$0.066918
(1c)		(2a)		(2b)		(2c)
Energy cost per acre-foot per foot lift		Estimated draw down per acre-foot of overdraft		Discount coefficient 20 years at 12%		Present value of savings per acre-foot

3. Calculate current private and true cost of pumping per acre-foot pumped.

Current cost of pumping	$0.06	x	75*	=	$4.50
	Enter value from (1c)		(3a) Total lift		(3b) Cost/ac. ft.

add Present value cost savings of not overdrafting — enter value from (2c). — $0.67 (3c)

True cost of pumping (3b + 3c) — $5.17 (3d)

Estimated return per acre-foot of water applied on farm or basin — $7.71 (3e) per acre-foot

Subtract	(3e) $7.71	-	(3d) $5.17	=	$2.54
	Net return acre-foot		True cost of pumping per acre-foot.		Net gain or loss. (3f)

If 3(f) is negative, pumping should be reduced. If the value in 3(f) is positive, it is economical to continue to overdraft.

*water level plus pressurization

Table 5. Continued

4. Calculate optimal additional overdraft:

0.060	x	1.50	x	1/3	=	$0.03
(4a) Enter value from (1c) energy cost.		(4b) Enter value from (2a) drawn down per ac. ft. of overdraft.		(4c) Average overdraft in acre-feet per acre per year.		(4d) Energy cost per year due to draw down.

$2.54	÷	$0.03	=	84.6
(4a) Enter value from (3f) Net gain per ac. ft. pumped.		(4f) Enter value from (4d) Energy cost per year due to drawdown.		(4g) Number of years overdraft should continue at existing rate of drawdown.

5. Convert to additional pump lift:

84.6	x	0.5	=	42.3
(5a) Enter value from (4f) Number of years overdraft to continue.		(5b) Enter average annual overdraft in feet per year.		(5c) Additional feet of total lift to reach equilibrium.

Source: Adapted from Moore (1984).

aggregated with farms which are marginal or near foreclosure. These lands are undervalued in the face of the moratorium. Many operators with permits are economically unaffected by the moratorium. These include cow-calf operators and fully established farms with supplemental income. The decision assures them that their wells and water rights are protected to some degree whether the wells were ever in danger.

What about the premium alfalfa market? Prices are low because demand is low relative to supply. One might hypothesize that the supply curve has been shifting rightward for a stable demand, driving prices even lower. The moratorium will prevent further expansion of alfalfa production in the Basin for at least three years. With production stabilized, Basin alfalfa prices may cease their downward spiral assuming that the demand for this high protein crop does not change substantially in the face of the reduced price supports for milk. Given crop budgets and output prices, it is reasonable to assume that the marginal cost of producing one more unit of alfalfa exceeds its value.

Thus, the moratorium may actually benefit Basin growers: alfalfa prices will stablize and potentially poor investments will be averted. Only those caught in the process of expansion are adversely affected.

DISCUSSION AND CONCLUSION

The theoretical framework shows how administrative action or inaction causes underutilization, equilibrium use, or exhaustion of a resource. Non-use may, in fact, be the "best" use of a resource in terms of maximum economic welfare of society. Conversely, mining a resource to exhaustion may be economically justifiable.

In the case of The Fort Rock-Christmas Valley aquifer, research by the U.S. Geologic Survey and Oregon Department of Water Resources is underway to determine what maximum level of groundwater withdrawals is allowable so the water table remains at equilibrium. In Figure 1, this is represented by point X. Unfortunately, without economic analysis, one cannot know whether point X is optimal in a welfare economic sense. The typical cash-crop alfalfa operation in Christmas Valley is not economically feasible under expected market conditions in the long run, although there are a few farms for which even an overdraft situation may be economically justified. This was seen in Tables 2 through 5. Thus, movement to point Y is doubtful since so few farms can expand to that point. Point X is probably not sustainable in the long run as marginal farms are driven from the area because of adverse economic conditions. A more likely situation is movement to Z provided alfalfa prices do not improve and electricity costs continue to rise as predicted. Of course, this may change if prices increase, costs decrease, or institutions change once again.

The moratorium, which was enacted to arrest groundwater development, may have been unnecessary. Economic conditions over the longer run will force many farms to exit the market, and provide no incentive for new individuals to enter it. Simply suspending government-sponsored financing on the basis that cash-crop alfalfa is too risky for the Department of Water Resources Water Development Loan Program would have been as effective and less controversial. Other government-sponsored and private sources of funding have lately been difficult to obtain (Lewis, 1984). Also, providing accurate information on agro-climatic hazards and economic conditions of cash-crop alfalfa in the Basin to any interested parties may also be a deterrent.

There will always be a group of individuals with a preference for the rural, isolated lifestyle which the Basin provides. Even if these individuals had the self-financing to initiate an operation, an outside source of income or diversification would almost be mandatory to sustain the operation. The Basin provides few opportunities for off-farm employment.

This precedent has unsettling implications for long-run investment in groundwater development elsewhere in the state. Since the moratorium process may be initiated at the request of area claimants, current users may simply petition to put future development on hold. Even if the claim is unsubstantiated, the hype of potential groundwater problems may be sufficient to discourage any development plans.

Finally, irrigation wells are the first affected by the proclamation. Domestic and stock well applications are not included until or unless the situation becomes extreme. This provides livestock operators with an advantage over irrigators in terms of both water right priority and water use. It is easy to see how the petition process may be abused by one group at the expense of another.

The moratorium process is capable of being misused, wrought with inequity, and lacking in sound economic sense. This is not to say that the policy of groundwater protection should be abolished. Rather, decision-makers should consider a process which would be equitable, have checks and balances, and allow for efficient use of groundwater resources for optimal social benefit. Alternative policies should be adopted, especially when there is not proof of overdraft.

The Fort Rock-Christmas Valley case is an example of government intervention in a conflict over groundwater use. No real groundwater crisis was in evidence; a crisis only appeared to exist to users with shallow wells in the area. As has been shown, economic conditions alone were sufficient to limit additional groundwater development. In fact, a strong possibility exists that future groundwater use for cash-crop alfalfa will decline as power costs continue to rise. The moratorium cannot be justified on purely economic grounds. However, the moratorium is an effective political tool to create the appearance of government action and may have been used to set a precedent for a policy of groundwater protection. Politically, then, the moratorium may have been a success--a process of groundwater protection was initiated in October of 1984 to resolve the long-standing severe overdraft situation in the Butter Creek area of North-Central Oregon (Hayes, 1984).

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