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12-3-73

Energy Use in Northwest Agriculture

Events of the past year have made residents of the Northwest extremely aware that most aspects of their lives depend on an abundant supply of energy. Northwest agriculture is just one of many industries which have had to weigh the impact of an energy shortage. The fuel shortages of the summer months of 1973 and the talk of shortages of energy this winter are hopefully a temporary crisis. Yet in the longer run with which this report is concerned, energy availability can no longer be taken for granted.

This report focuses on the dependence of agriculture in the Northwest (the states of Oregon, Idaho, and Washington) upon energy use. Implicit in the study are attempts to answer two questions. First, what changes can we see coming in Northwest agriculture; and consequently, what changes are foreseen for agricultural energy use? Second, what would be the consequences of a shortage of energy and what policies or changes in practices would be available to deal with these consequences?

A.) Agriculture in the Northwest

Agriculture is a very important economic sector in the Northwest--a point illustrated in table 1.[1] Cash receipts from farm marketing totaled over 2 billion dollars in 1970, with the total quite evenly divided among the states. These sales represented per capita receipts

[1] For further details on agriculture in Idaho and the Northwest see: Hamilton, J. R., "Agriculture - Idaho's Economic Cornerstone," Agr. Expt. Station Bulletin 536, University of Idaho, March 1973.

Table 1: Measures of the Importance of Farming in the Three Northwest States

	Cash Receipts from Farm Marketing-1970	Population-1970	Per Capita Receipts from Farm Marketing-1970	Total Personal Income-1970	Personal Income from Farming 1970	Percent of Total Personal Income Arising From Farming-1970
	$ million	thousand	dollars	$ million	$ million	percent
Idaho	664.0	713	931.3	2,310	278	12.03
Oregon	561.9	2,091	268.7	7,777	174	2.24
Washington	792.6	3,409	232.5	13,671	324	2.37
Three States	2,018.5	6,213	324.9	23,758	776	3.27

*Net income of farm proprietors, farm wages and "other" labor income, less personal contributions under the old-age, survivors, disability and health insurance program.

Source: Hamilton, J. R., "Agriculture - Idaho's Economic Cornerstone," Agr. Expt. Station Bulletin 536, University of Idaho, March 1973.

of almost 325 dollars per Northwest region resident. Farming contributed just over 3¼ percent of total Northwest personal income in 1970. Within the region there are wide differences in the degree of economic dependence on agriculture. For Idaho in 1970, farming contributed over 12 percent of total personal income.

These figures may not seem to impressive, yet when one adds on the extensive agricultural processing sector which depends on farms for its source of raw materials, and the various industries which provide inputs and services to farms, the agricultural sector is a truly important one.

Good data on energy consumption by agriculture in the Northwest is difficult to obtain, but some U.S. figures will give the reader a feel for orders of magnitude. In 1969, U.S. farmers used about 6 billion gallons of petroleum fuel--or just less than 3 percent of all petroleum used in that year.[2] In 1971, the nation's farmers used about 40 billion kilowatt-hours of electricity (excluding use for home heating), or about 2.7 percent of total electricity consumption.[3] These percentages are undoubtedly a bit lower than the corresponding figures for the Northwest, since the Northwest is slightly more agriculture dependent than the rest of the country. Yet these figures do give a ballpark idea of the extent of agricultural energy use in the area. It is a significant user--but not a major user.

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[2]Gavett, E. E., "Agriculture and the Energy Crisis," delivered at the National Conference on Agriculture and the Energy Crisis, University of Nebraska, Neb., April 10-11, 1973, page 7.

[3]Ibid., page 8.

Most of agriculture's energy consumption is associated with crop production, so we should look at the crops which are grown in the Northwest. An overall view of types of farming in the region is found in Figure 1. Table 2 gives 1969 Census of Agriculture figures on the acreage of some crops in the three state region. Wheat and other small grains accounted for just over half of the total harvested acreage in that year, with the more intensively cultivated crops such as potatoes, vegetables, and fruit crops occupying a much smaller acreage. As for the future, the Office of Business Economics[4] has made projections of total harvested cropland (Figure 2) and value of crop production (Figure 3).

This report concentrates on two aspects of energy consumption for crop production in the Northwest--use of electric power for irrigation pumping and use of petroleum fuel for crop tillage and harvest operations.

Table 2: Crops Harvested in 1969

	Ida.	Ore.	Wash.	N.W.
Field Corn & Sorghum	90,298	30,464	77,367	198,129
Wheat for Grain	960,758	734,097	2,272,782	3,967,637
Other Small Grains	846,536	478,465	453,116	1,778,117
Hay	1,179,630	946,631	791,340	2,917,601
Potatoes	273,814	46,486	63,688	383,988
Vegetables & Melons	44,461	129,001	166,313	339,775
Berries	181	22,507	9,251	31,939
Land in Orchards	14,868	96,353	153,951	265,172
Other Crops	557,213	425,724	401,397	1,384,334
Total Harvested Acreages	3,954,957	2,893,632	4,366,906	11,215,495

Source: 1969 Census of Agriculture

[4] U.S. Water Resources Council, "Office of Business and Economics Research Service Projections for Regional Economic Activity in the United States," Washington, D.C., 1972.

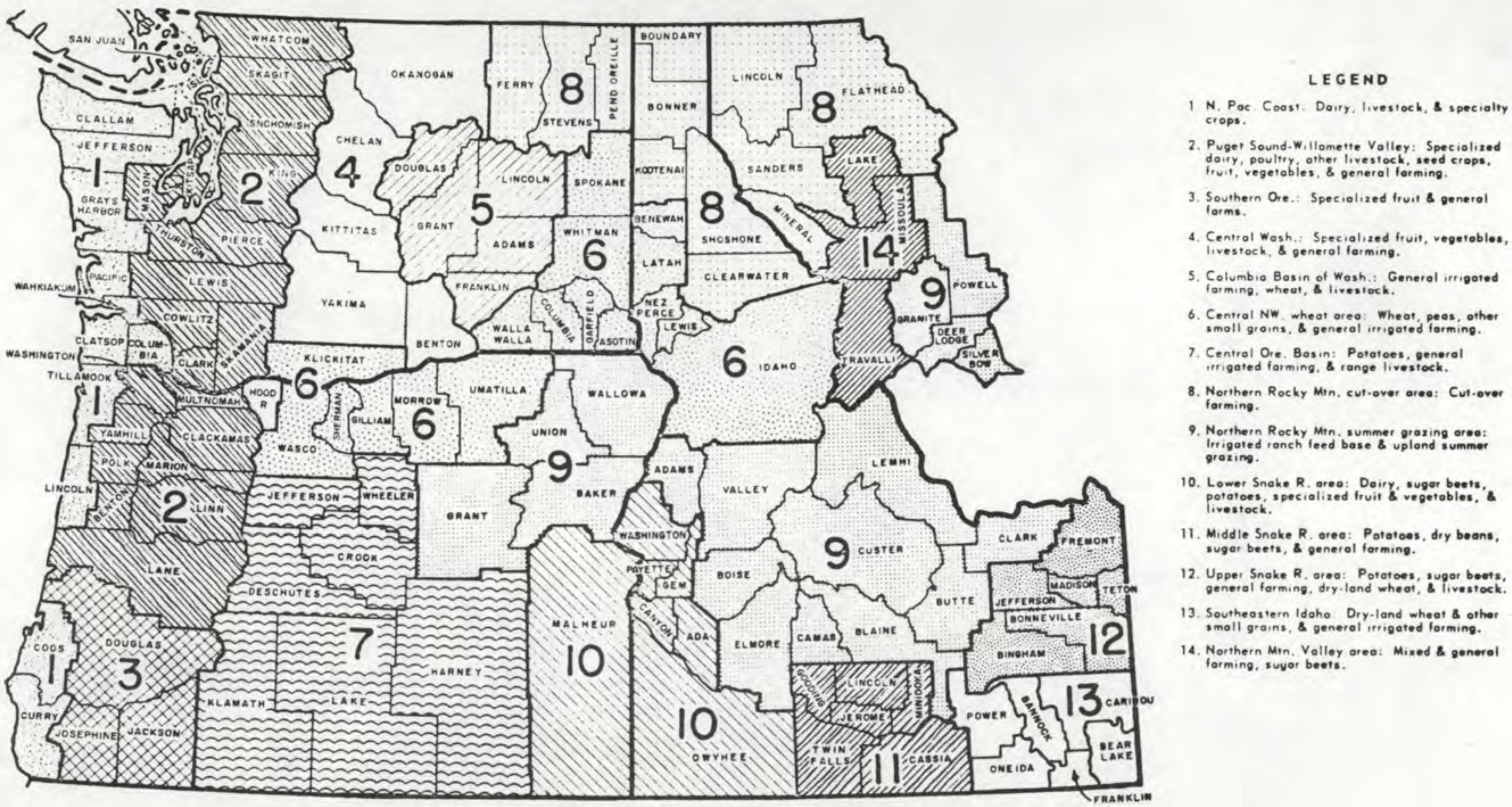
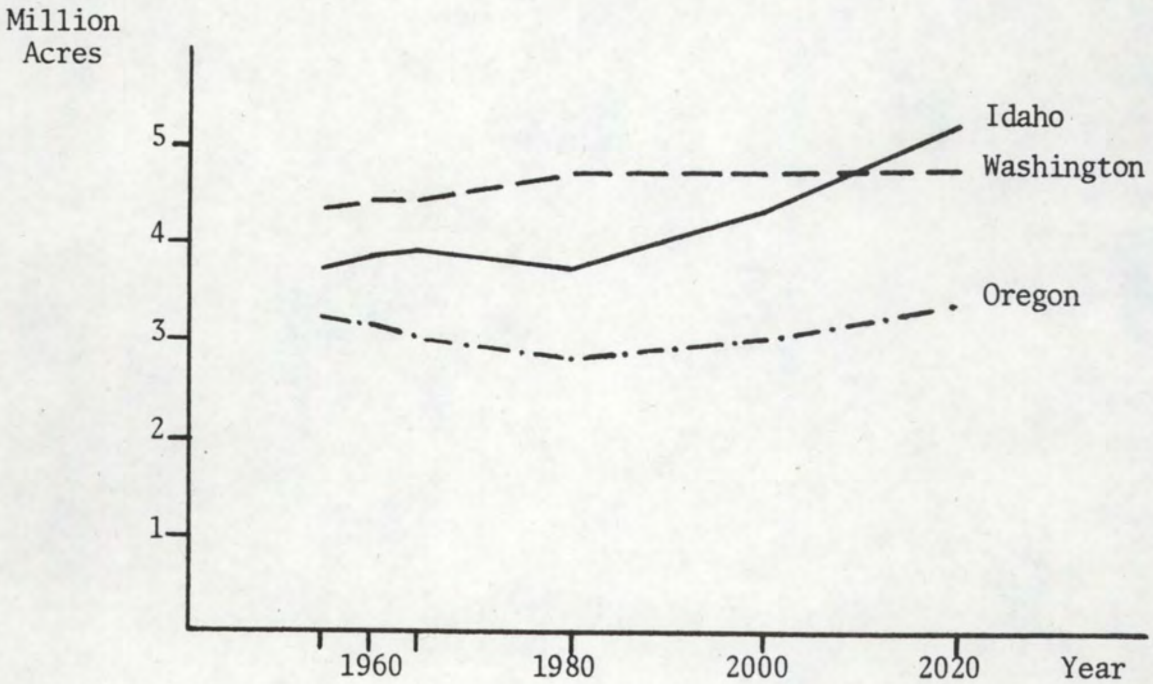


Figure 1. Subdivision of the Columbia River Basin into Generalized Type-of-Farming Areas

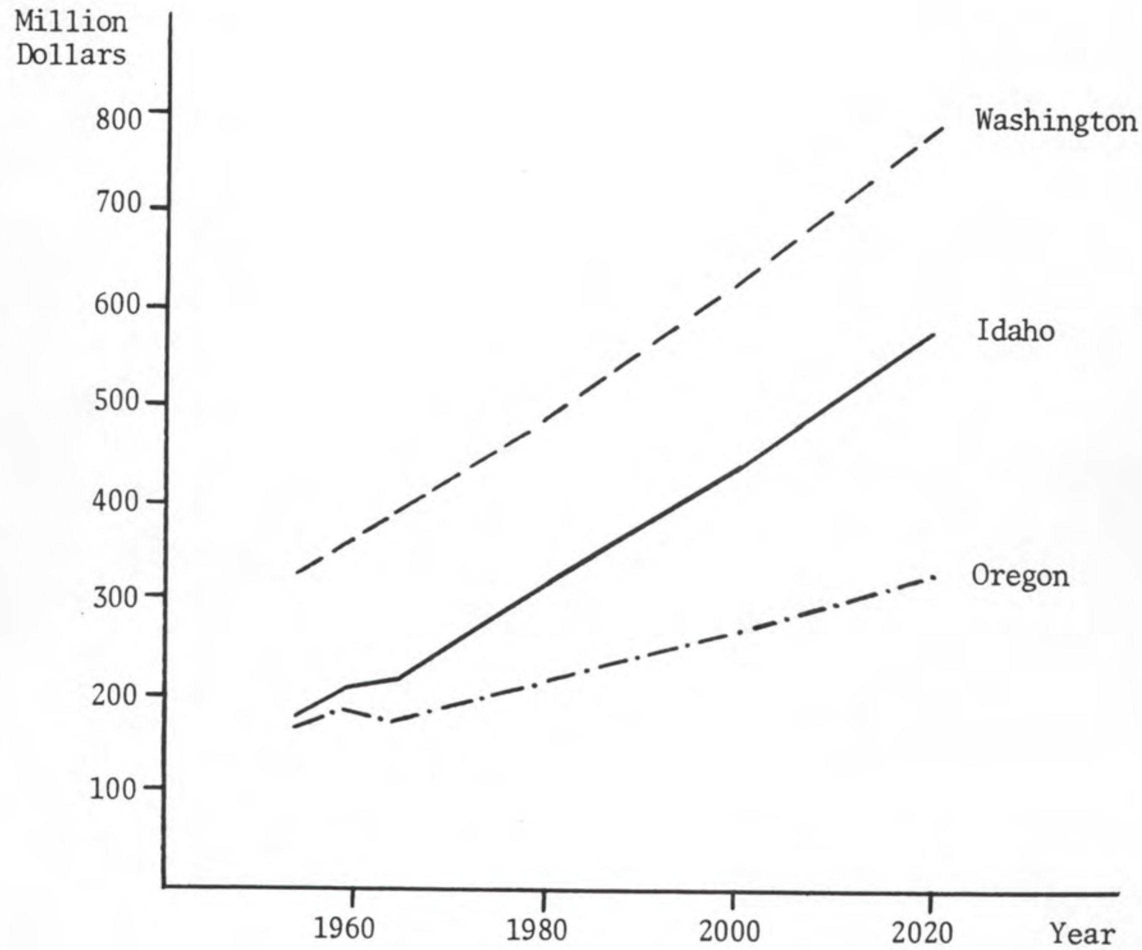
Source: Columbia-North Pacific Region Comprehensive Framework Study, Pacific Northwest River Basins Commission, Vancouver, Washington, 1970.

Figure 2: Cropland Harvested in Pacific Northwest Historical and Projected 1954-2020



Source: U.S. Water Resources Council, "Office of Business and Economics Research Service Projections for Regional Economic Activity in the United States," Washington, D.C., 1972.

Figure 3: Value of Crop Production in Pacific Northwest
Historical and Projected 1954-2020



Source: U.S. Water Resources Council, "Office of Business and Economics Research Service Projections for Regional Economic Activity in the United States," Washington, D.C., 1972.

B.) Electricity Use for Irrigation Pumping

Northwest agriculture is heavily dependent on irrigation of its cropland. Table 3 gives Census of Agriculture figures on acreage of irrigated land in the census year 1969. About half of the land irrigated in this year was located in Idaho, with Oregon ranking next. Of total irrigated land, over 96 percent was found on commercial farms, those farms with over $2,500 annual sales of farm products. Between 70 and 80 percent of the total irrigated land was harvested with most of the rest being pastured cropland or pastured non-cropland. The location of this irrigated land is shown in Figure 4. The most intensively irrigated areas are found in Southern Idaho, Central Washington, and in Central and Eastern Oregon.

A number of projections of future irrigated acreage are available. The OBERS has projected irrigated harvested cropland to the year 2020. The OBERS projection agrees acceptably with the 1954-69 Census of Agriculture figures, and is supported in part by projections for Idaho made for the Idaho Water Resources Board by the University of Idaho Agricultural Engineering Department.[5] Two Bonneville Power Administration projections of irrigated acreage are also available.[6]

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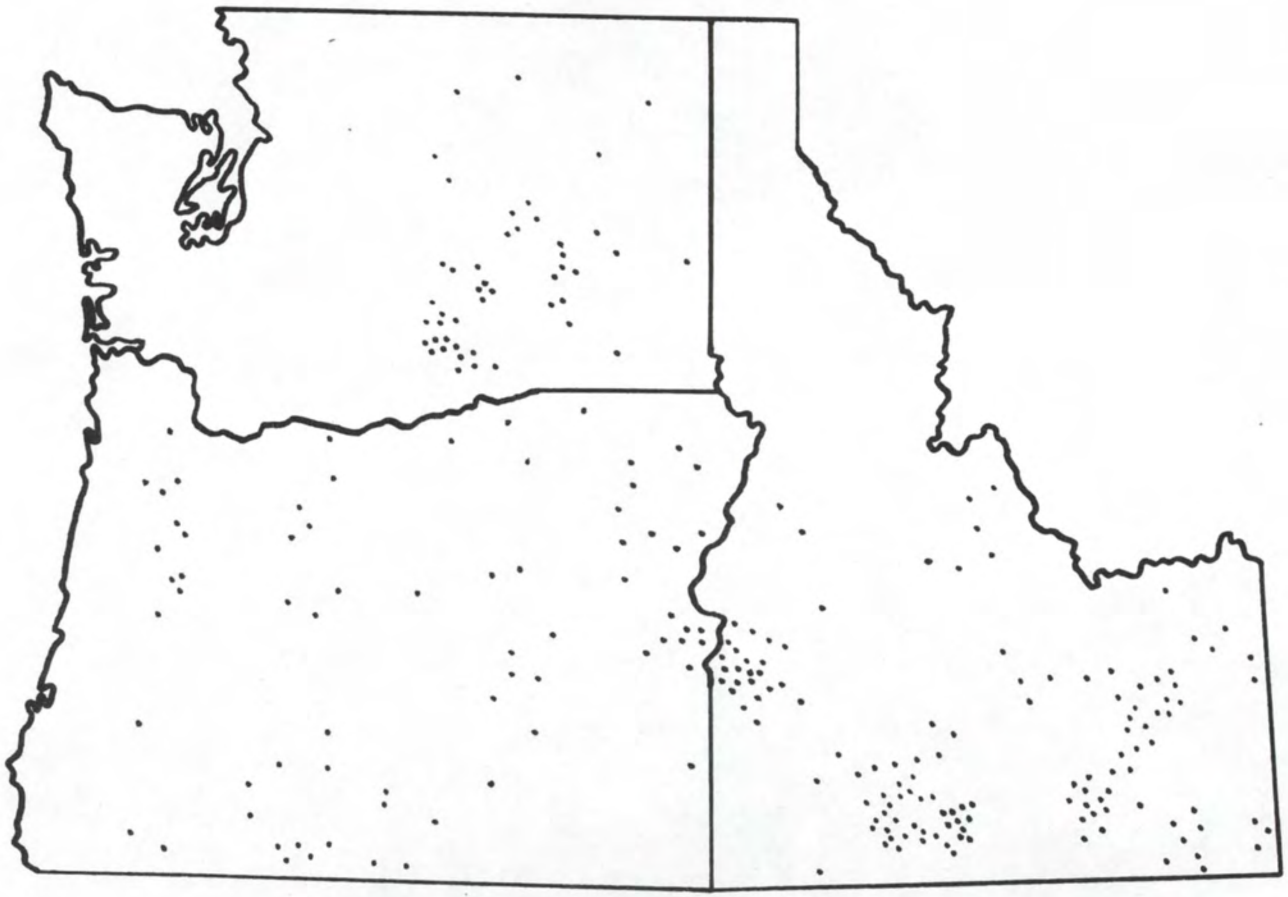
[5] Idaho Water Resource Board,"Agricultural Water Needs: Consumptive Irrigation Requirements," (prepared by University of Idaho, Dept. of Agricultural Engineering), Boise, 1971.

[6] Bonneville Power Administration - Branch of Power Marketing, "Irrigation Power Requirements (position paper)," 1971, and Bonneville Power Administration with Economic Research Service, USDA, "Pacific Northwest Economic Base Study for Power Markets: Agriculture and Food Processing," Volume II, Part 5, Corvallis, Oregon, 1966.

Figure 4: Location of Irrigated Land in the Northwest



Source: Water Information Center, Water Atlas of the United States, Port Washington, N.Y., 1973.

Table 3: Irrigated Land on all Farms, 1969

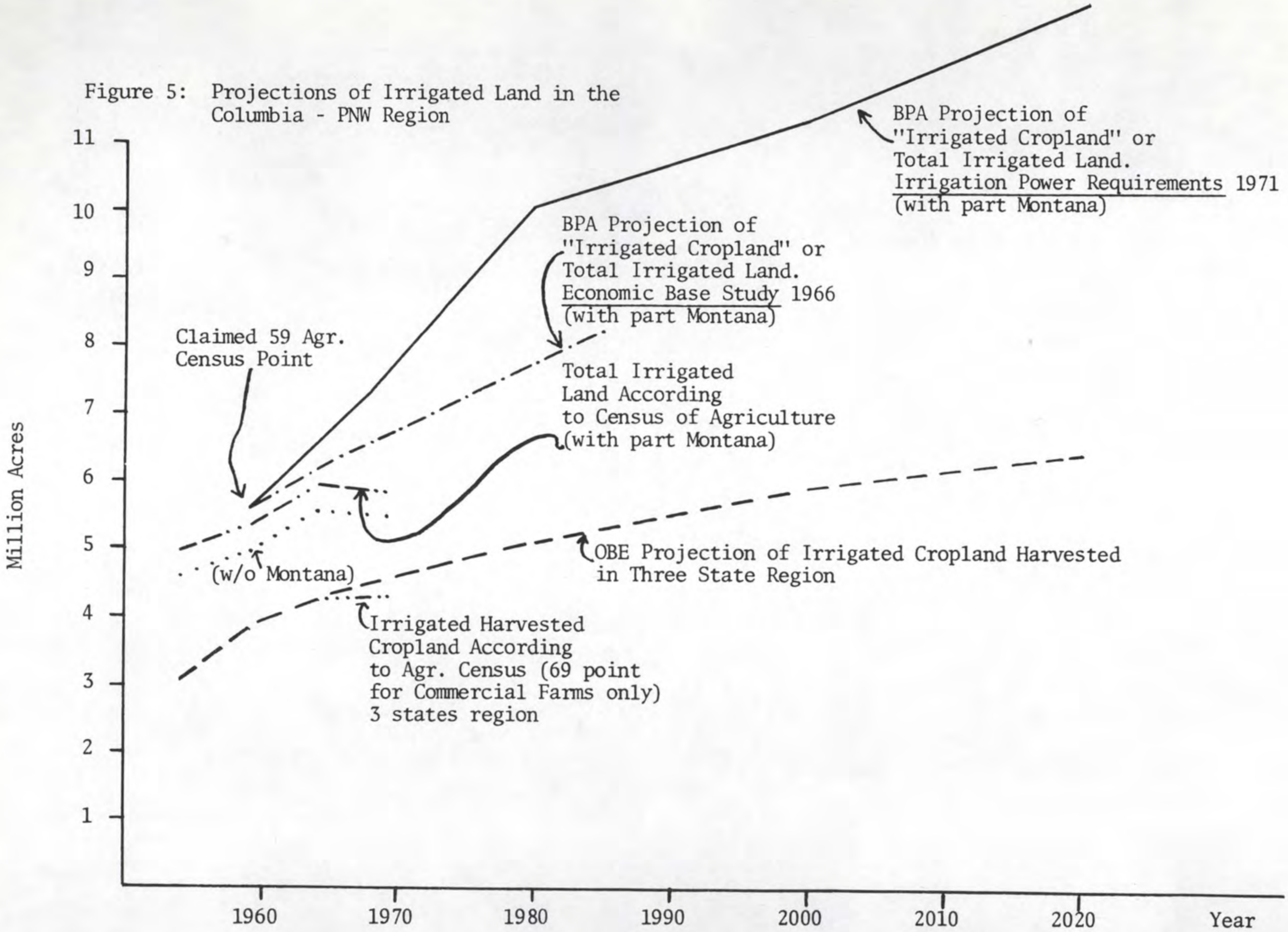
	Total	Irrigated Land on Commercial Farms				
		Total	Cropland			Other Pasture
			Total	Harvested	Pastured	
Idaho	2,760,852	2,670,503	2,568,352	2,218,588	315,176	102,151
	100.0	96.7	93.0	80.4	11.4	3.7
Oregon	1,519,421	1,458,257	1,338,408	1,071,059	245,023	119,805
	100.0	96.0	88.1	70.5	16.1	7.9
Washington	1,224,238	1,179,963	1,156,037	993,416	128,137	23,975
	100.0	96.4	94.4	81.1	10.5	2.0
3 States	5,504,511	5,308,723	5,062,797	4,283,063	688,336	245,931
	100.0	96.4	92.0	77.8	12.5	4.5

Source: Census of Agriculture

The BPA projections refer to total irrigated land, a figure larger than what the OBERS was using since it includes some non-harvested cropland and grazed pasture which received water. Two other factors also enter into the greater height of the BPA projections--the inclusion of a number of counties from Western Montana in the BPA figures, and what appears to be a data error where their 1959 acreage figure does not agree with the quoted census source (possibly they used preliminary data?).

The BPA and OBERS projections seem to reflect some differences in underlying assumptions. Much of the land which might be added to

Figure 5: Projections of Irrigated Land in the Columbia - PNW Region



irrigated acreages is located in Idaho. The higher BPA figure from the 1971 report would seem consistent with another Idaho Water Resource Board report.[7] The two Water Board reports differ in that the one done by the University deletes large areas of land with under 90 days growing season which had been classed as potentially irrigable in the other study. The more conservative Water Board report, the OBE estimates and the 1966 BPA figures seem most reasonable to the author as projections of what would happen to irrigated area under an assumption of no energy shortage.

No matter which of the projections is used, the disagreement is one of magnitude, not one of direction. That is, all of the projections agree that irrigation of farmland will increase in the future. The OBE report puts the increase in irrigated harvested cropland at about 50,000 acres per year (for the three state region) between now and 1980, while the 1966 BPA report sees an increase (for the region including Western Montana) of about 100,000 acres per year in the total area receiving water. Such an increase of 50,000 to 100,000 acres per year would have several important energy effects. First, the increase in intensively cropped acreage requires increased amounts of gasoline and diesel fuel for tillage and harvest operations (petroleum use is discussed in a later section of this paper). Second, since most of the land to be irrigated lies higher than the water source, and because many of the new systems are sprinkler irrigated, the newly irrigated land requires electricity for pumping and pressurizing. Third, because these new developments remove water from the streams, to be

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[7] Idaho Water Resource Board, "Potentially Irrigable Lands in Idaho, 1970," Boise, 1970.

Table 4: Present and Projected Yields Per Acre for Selected Crops in Actual Units*

Crop		Unit	Year 1966	1980	2000	2020
Barley	Irrigated	bu.	56.0	75	85	100
Barley	Non-irrigated	bu.	35.0	40	50	60
Corn for Grain	Irrigated	bu.	77.0	90	120	150
Winter Wheat	Irrigated	bu.	60.2	90	110	130
Winter Wheat	Non-irrigated	bu.	32.9	40	45	55
Spring Wheat	Irrigated	bu.	55.7	75	85	110
Spring Wheat	Non-irrigated	bu.	20.6	25	30	35
Oats (all oats). . . .		bu.	46.5	50	60	70
Rye (all rye).		bu.	27.0	35	40	45
Small Grain for Hay. .	Irrigated	bu.	1.3	1.6	1.8	2.0
Corn Silage.	Irrigated	ton	17.0	20	26	33
Alfalfa Hay.	Irrigated	ton	2.75	4	5	6
Alfalfa Hay.	Non-irrigated	ton	1.50	2.0	2.3	3.0
All Other Hay.	Non-irrigated	ton	1.15	1.5	1.9	2.5
Dry Beans	Irrigated	lbs.	1760	2100	2500	3000
Dry Peas	Non-irrigated	cwt.	16.0	18	22	25
Potatoes	Irrigated	cwt.	226	250	310	360
Sugar Beets.	Irrigated	ton	18.9	22	24	26
Hops	Irrigated	lbs.	1810	2200	2600	3000
Mint	Irrigated	lbs.	65.0	75	110	120
Forage Seeds	Irrigated	lbs.	312	350	400	500
All Vegetables	Irrigated	ton	3.25	3.5	4.0	4.5
Sweet Green Peas . . .	Irrigated	cwt.	18	24	27	30
Onions	Irrigated	ton	24	27	30	36
Sweet Corn	Irrigated	ton	5.16	8	12	15
Apples	Irrigated	ton	7.4	12	17	21
Pears	Irrigated	ton	1.7	9	13	15
Sweet Cherries	Irrigated	ton	1.3	4	6	8
Prunes	Irrigated	ton	2.91	10	12	15
Peaches.	Irrigated	ton	2.8	9	12	14

*Developed by the Idaho Agricultural Experiment Station for the CNP Comprehensive Framework Study.

Source: Idaho Water Resource Board, "Agricultural Water Needs: Consumptive Irrigation Requirements," (prepared by University of Idaho, Dept. of Agricultural Engineering), Boise, 1971.

used consumptively on the land, there is a reduction in hydroelectric power yield downstream.

A related phenomenon which must be considered is the conversion of older gravity irrigation systems to pressurized sprinkler systems. Two impacts of this conversion are important to us. First, electric power is usually needed to pressurize and operate the sprinklers. Second, the greater precision of sprinkler systems allow water use to be reduced to nearly the consumptive use of the plants--an increase in water use efficiency. The latter effect might mean a saving in pumping costs if the water is pumped. It might also mean that less water is diverted, meaning some increase of downstream hydroelectric potential (depending of course on the groundwater and return flow characteristics of the area).

The water needed on irrigated land depends on what crop is grown and on the climate of the area. Table 5 shows mean annual consumptive irrigation requirements for various crops at a number of Idaho locations. Since there are conveyance losses and percolation losses, a field irrigation efficiency of perhaps 60 percent is reasonable. The result is that in the range of 3 acre feet per acre of water is needed per acre of irrigated land if reasonably efficient irrigation methods are used.

The effect of increased irrigated acreage can be illustrated by use of an admittedly extreme example--the high lift pumping systems located along the Snake River below Twin Falls. Here pump lifts may approach 1000 feet, especially after one includes sprinkler operating pressure which is effectively equivalent to between 100 and 200 feet of lift. The energy cost of water pumping follows the

Table 5: Mean Annual Consumptive Irrigation Requirements (Acre-inches Per Acre)

Station	Sugar Beets	Dry Beans	Corn Silage	Corn Grain	Spring Grain	Potatoes	Small Grain	Winter Grain	Alfalfa	Grass Pasture	Orchards
Aberdeen	18.1	--	14.4	--	13.5	17.7	9.5	18.4	19.6	15.7	--
Ashton 1S	12.1	--	9.6	--	10.0	12.3	--	13.7	13.5	10.1	--
Bonners Ferry 1SW	--	--	11.8	--	13.0	15.1	--	15.1	16.7	12.0	--
Caldwell	24.4	16.9	18.8	19.8	13.7	23.4	10.7	19.9	26.1	20.3	21.4
Cascade 1NW	--	--	9.9	--	10.3	11.4	--	13.8	13.7	10.3	--
Challis	17.4	--	13.6	--	15.2	15.3	--	16.3	19.3	14.7	--
Coeur d'Alene RS	--	--	13.5	--	13.9	17.2	8.2	16.1	19.1	13.5	--
Council	20.4	--	16.2	--	13.4	20.3	--	17.1	22.5	16.5	--
Driggs	11.3	--	9.4	--	9.2	11.5	--	13.5	12.7	9.5	--
Dubois Exp. Station	--	--	12.4	--	12.6	16.1	--	16.0	17.5	13.5	--
Fairfield	--	--	11.9	--	12.3	14.4	--	15.6	15.7	12.2	--
Grace	12.8	--	10.2	--	10.5	12.4	--	14.2	14.4	10.6	--
Grandview	28.7	18.8	22.6	22.9	16.2	26.9	13.0	21.1	31.6	24.1	26.1
Grangeville	--	9.3	9.5	--	6.4	12.7	4.6	11.5	14.1	8.5	--
Hailey RS	16.3	--	12.7	--	13.1	14.9	--	16.3	17.5	13.7	--
Hollister	18.5	13.3	14.0	15.2	11.8	18.3	8.1	17.1	20.4	15.2	--
Idaho Falls AP	18.6	--	13.9	--	12.9	17.9	--	17.1	19.4	15.5	--
Idaho Falls 46W	15.6	--	12.9	--	13.5	16.6	--	16.2	17.3	13.5	--
Island Park Dam	--	--	5.6	--	4.6	7.0	--	9.3	8.2	5.7	--
Kooskia	--	--	13.4	--	11.0	17.4	--	14.6	19.2	12.0	--
Lewiston	--	--	18.2	--	14.8	21.4	5.1	14.4	25.8	18.2	20.7
Mackay RS	15.2	--	11.5	--	13.3	13.2	--	15.7	16.3	12.8	--
Malad	19.1	--	14.8	--	15.0	18.9	--	16.6	20.8	15.5	--
Montepelier RS	13.0	--	10.8	--	11.1	13.3	--	15.1	14.5	11.2	--
Moscow U of I	--	--	12.8	--	11.0	16.2	7.7	15.0	18.2	12.6	--
Mountain Home	25.1	17.0	19.1	20.7	16.6	24.1	11.9	21.5	26.7	21.1	22.1
Ola 4S	--	--	15.1	--	10.0	19.4	7.6	17.6	21.2	15.7	--
Owyhee, Nevada	15.5	--	12.6	--	13.0	15.5	--	16.5	17.3	13.1	--
Pocatello WB AP	21.3	--	16.2	--	13.8	20.2	9.6	17.3	22.6	17.5	--
Preston 2SE	18.4	--	14.3	--	14.8	18.0	--	16.8	20.1	14.8	--
Riggins RS	--	--	18.5	--	14.6	22.2	--	14.6	26.5	17.2	--
Rupert	23.3	16.2	18.1	19.2	12.7	21.9	10.2	19.1	24.9	19.5	--
St. Maries	--	--	12.8	--	13.1	16.0	8.4	15.9	17.9	12.8	--
Salmon	--	--	12.2	--	13.0	16.5	--	16.4	17.0	13.3	--
Sandpoint Exp. Station	--	--	10.2	--	11.6	13.4	--	14.4	14.6	10.2	--
Saylor Creek	26.9	17.5	20.5	21.9	17.8	25.3	12.1	19.3	28.7	22.0	23.7
Sheaville, Oregon	16.4	--	13.9	--	13.7	17.0	9.3	17.5	18.0	14.3	--
Shoshone 1WNW	21.9	16.1	17.2	17.8	12.8	21.6	10.2	20.6	23.6	18.8	--
Strevell	16.2	--	13.0	--	13.5	16.6	--	16.5	18.0	13.6	--
Three Creek	9.8	--	9.5	--	7.5	11.5	--	12.2	11.3	8.7	--
Twin Falls 2NNE	21.9	15.6	16.8	17.4	13.2	21.3	9.7	19.2	23.2	18.3	18.9
Weiser	25.6	17.9	19.3	21.2	14.5	23.7	7.3	21.4	26.8	21.2	22.0

Source: Idaho Water Resource Board, "Agricultural Water Needs: Consumptive Irrigation Requirements," (prepared by University of Idaho, Dept. of Agricultural Engineering), Boise, 1971.

formula:[8]

$$\frac{\text{Field Head x 0.00314}}{\text{Wire to Water Efficiency}} (325.9) = \frac{\text{Kilowatt Hours}}{\text{Acre Foot}}$$

At 100 percent efficiency this would imply the use of just over 1 KWH per acre ft./ft. of lift. For most systems, efficiency would be more nearly half that level, implying an electricity use of about 2 KWH/acre foot/foot. Thus the electric energy cost of pumping irrigation water up the 1000 feet of field head would approach 6000 KWH per acre of irrigated land per season. To make the 6000 KWH figure more meaningful it is sufficient to note that per capita consumption of electricity in the U.S. was about 6,800 KWH per year in 1970 (1.39 trillion KWH divided by 203 million people).

If three acre feet of water are removed from the river in the vicinity of Twin Falls, Idaho, and used for irrigation, much of the water will be transpired or evaporated and lost from the basin, while some of the excess will run off or percolate down, but remain in the basin. Hence, perhaps two acre feet will be consumptively used, and will not be available for downstream hydropower generation. The altitude of the River at Twin Falls is about 2000 feet above sea level. The entire head of the Snake - Columbia River system is not, however, developed, the main undeveloped reach being from Hells Canyon to Lewiston. The developed head of the River is about 1300 feet in the dams between Twin Falls and the mouth of the Columbia. Electricity

[8]Schatz, Lee, "An Economic Analysis of Optimal Ground Water Utilization in the Raft River Basin," M.S. thesis, University of Idaho, in progress.

generating follows a relationship similar to that shown above for water pumping. If the system were 100 percent efficient, the electric yield would be about 1 KWH per acre foot per foot of head. These systems are not perfectly efficient, so a reasonable figure for electricity generation is about .87 KWH per acre foot per foot of head.[9] Using the assumptions of 1300 feet of effective head and 2 acre feet of consumptive use per acre, the hydroelectric power lost amounts to a bit over 2,250 KWH per acre irrigated.

The total electrical energy cost associated with high lift pump irrigation in the Twin Falls, Idaho region is in the range of 8,250 KWH per acre irrigated. Of course not all of the irrigation in the Northwest follows the high lift pattern shown above. If the lift is less high, then less electric power will be used. If the diversion point is further along the River, say Central Oregon or Washington, then less potential hydro power will be lost. Certainly, much newly irrigated land receives its water from medium depth wells at an energy cost of from 200 to 500 KWH per acre foot or from 600 to 1500 KWH per acre irrigated.[10]

Sprinkler irrigation has been mentioned as a large energy user. Data on the extent of sprinkler systems is very inadequate. One BPA report gives probably the best data available, but must be interpreted carefully because of what seems to be overoptimistic projections of future irrigation.[11]

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[9] Mann, P., "A Methodology Study to Develop Evaluation Criteria for Wild and Scenic Rivers: Hydroelectric Power Subproject," University of Idaho Water Resources Research Institute, 1973.

[10] Schatz, op. cit.

[11] BPA (1971), op. cit.

The BPA projections are reproduced as tables 6 and 7. BPA estimated that over 1.7 million acres or about 24 percent of total irrigated land was sprinkled in 1968. This figure is probably too high, but does give a ballpark estimate. The energy use per acre figures shown in table 6 show the added power needed for pressurizing the sprinkler system, and also reflect the fact that sprinklers tend to be used with higher lift pumping systems.

Additional confirmation of these trends is found in table 8, which shows the added irrigation load by year for the Idaho Power service area. The Idaho Power area covers a large part of Southcentral and Southwestern Idaho, along with adjacent parts of Oregon. This covers much of the irrigated farming area in Southern Idaho and Eastern Oregon, but does miss a large segment of Utah Power service area in Southeastern Idaho, and also misses some fairly large REA districts in the region. Idaho Power has been adding an incremental irrigation load for between 47 and 77 thousand acres a year in recent years. One interesting point to note is the trend in horsepower per acre shown in figure 6. In the early 1950's the systems being added to the Idaho Power grid had around .3 or .4 horsepower per acre. Twenty years later the incremental systems had between two and three times as much horsepower per acre. It seems safe to assume that this growth in horsepower per acre is associated with an increase in electrical energy use per acre. The most obvious explanation of this trend is a confirmation of what was stated above--that pump lifts are increasing and that pressurization is needed for sprinkler systems.

There are some interesting trade-off aspects of the trend to greater use of sprinklers. The most obvious is a trade-off between water use efficiency and energy use efficiency. Much of the motivation to sprinkler

Table 6
Pacific Northwest Region
Relationship of Irrigated Cropland to Total Cropland

	1959	1968	1980	2000	2020
Cropland (000 acres)	20,290	20,804	21,552	21,407	21,642
Irrigated Cropland (000 acres)	5,605	7,300	10,100	11,400	13,500
Percent of Total Cropland	28	35	47	53	62
Rill Irrigated (000 acres)	4,620	5,520	5,050	4,105	3,375
Percent Rill Irrigated	72	76	50	36	25
Sprinkler Irrigated (000 acres)	985	1,780	5,050	7,295	10,125
Percent Irrigated by Sprinkler	18	24	50	64	75

Source: Bonneville Power Administration - Branch of Power Marketing, "Irrigation Power Requirements (position paper)," 1971.

Table 7
Pacific Northwest Region
Power Requirements for Irrigation
1968 and Projected 1980, 2000, and 2020

	1968			1980			2000			2020		
	Million Acres	Energy Use Per Acre kwh	Total Use gwh	Million Acres	Energy Use Per Acre kwh	Total Use gwh	Million Acres	Energy Use Per Acre kwh	Total Use gwh	Million Acres	Energy Use Per Acre kwh	Total Use gwh
Total	7.3	---	3,000	10.1	---	8,100	11.4	---	12,810	13.5	---	21,140
Sprinkler	1.8	950	1,710	5.5	1,200	6,600	7.3	1,600	11,680	10.1	2,000	20,200
Other	5.5	235	1,290	5.5	275	1,500	4.1	275	1,130	3.4	275	940

Source: Bonneville Power Administration - Branch of Power Marketing, "Irrigation Power Requirements (position paper)," 1971.

Table 8: Number of Pumping Installations, HP and Irrigated Acreage as of September, 1972.

Year	No. of Pumps	HP	No. of Acres
Total in 1949	1,903	* 33,131	* 132,259
Added 1950	385	10,339	33,327
Added 1951	351	12,971	34,552
Added 1952	352	16,541	35,608
Added 1953	361	21,989	34,915
Added 1954	390	18,115	36,731
Added 1955	462	22,321	48,639
Added 1956	330	23,064	45,952
Added 9-1957	249	16,681	30,913
Added 9-1958	248	14,985	30,748
Added 9-1959	315	18,672	36,476
Added 9-1960	286	20,702	38,236
Added 9-1961	440	21,825	55,605
Added 9-1962	352	23,504	41,406
Added 9-1963	311	36,019.5	47,720
Added 9-1964	329	31,982.5	45,845
Added 9-1965	371	50,605.5	64,038
Added 9-1966	396	39,948.5	61,435
Added 9-1967	460	57,603	76,783
Added 9-1968	399	28,215.5	52,153
Added 9-1969	335	36,086.5	56,027
Added 9-1970	441	48,052.5	56,035
Added 9-1971	381	39,662.5	46,707
Added 9-1972	505	46,408.5	53,164
Totals to Date	10,352	689,424.5	1,195,274

* Estimated Figures

Source: General Marketing Department, Idaho Power Co., Boise, Idaho, 10/11/72.

Figure 6: Horsepower per Acre for Annual Increments to Idaho Power Co.'s Irrigation Load

use is an attempt to increase the efficiency of water use--a very powerful incentive when the amount of water available becomes restrictive or when the cost of pumping the water becomes significant. Because water is scarce in much of the Northwest, and because energy was previously available in abundance, the move to sprinklers has been viewed as good.

The labor trade-offs of a move toward sprinklers is less clear. Gravity irrigation systems require large amounts of labor for moving siphons and controlling water flow. Hand moved sprinkler systems are also very labor intensive, perhaps more so than the gravity systems. The more advanced, capital intensive systems such as the center pivot sprinklers require much less labor, but are only adaptable to large plots and smooth topography.

It is even less clear what effect the move toward sprinklers might have on basin groundwater patterns and then indirectly on energy use. At first glance it would appear that the increased water use efficiency of a sprinkler system would allow reduced water diversions from streams and hence increased downstream hydroelectric potential. Upon closer examination, the picture becomes less clear. The inefficiency of gravity systems results from excess application, which either runs off or percolates down. That which runs off returns quickly to the stream, and results in minimal hydropower loss since the water bypasses at most one or two dams. Water which percolates in and enters the underground aquifer follows one of several paths. It may emerge downstream in a natural spring--the thousand springs area near Twin Falls seems to be an example of this. Alternatively the aquifer may be tapped by irrigation wells, whose water level might be lowered and pumping energy requirement raised if aquifer recharge is reduced by the use of sprinklers. The overall situation, then, is far from clear, but it appears that conversion to sprinklers would have only minimal effect on hydropower potential of the stream, but that the conversion would cost energy both for pressurization and for well pumping from a lowered water table.

Several conclusions about energy use and Northwest irrigated agriculture seem to follow from the above discussion:

a.) Continuation of present patterns would imply the continual addition of between 50,000 and 100,000 acres of irrigated farmland per year--with much of this growth occurring in Southern Idaho.

b.) Much of this new land will be watered by high lift pumping of surface water or by deep wells, with a high associated electric energy cost.

c.) The conversion of land to sprinkler irrigation will continue, causing an increase in electric energy use but allowing an increase in the efficiency of water use.

In light of the current and projected energy situation, it is relevant to ask what effect an energy shortage would have on irrigated agriculture. If adjustment is left to the price mechanism, changes in the short and intermediate run will probably be very slight. Even massive increases in electricity price will not effect the acreage currently being irrigated because the fixed investment in facilities on this land is very large relative to any reasonable change in energy costs. The marginal effect might be more significant. Increased energy cost would probably slow the development of new lands and reduce the incentive to use sprinklers.

If the energy shortage becomes severe enough, then manditory electricity use controls might be considered. However, a proportional cutback of any size by all irrigators is not a reasonable plan. While some small savings might be realized by most users from more efficient water utilization, any cutbacks beyond that point would severely injure production. If restrictions were judged to be necessary, they should occur first as a prohibition against accepting any new irrigation electric load, either fornew land or for sprinkler conversion. A more severe policy to accomplish load reduction would have to involve selective shut-off of existing users based on some priority system.

C.) Petroleum Use in Crop Production

The electric energy used in Northwest agriculture goes disproportionately to supply the pumping needs of irrigated agriculture. In contrast, petroleum fuel is used by all segments of production agriculture. Table 9 shows the purchases of petroleum products on Northwest farms found by the 1964 and 1969 Census of Agriculture.

Trends in fuel use are difficult to discover based on just two observations, but it would appear that fuel use in agriculture has not changed too markedly over the recent years. Farm petroleum usage consists principally of gasoline and diesel fuel used for tillage, harvest and farm transportation purposes. Obviously then, most of the petroleum usage is associated with crop production.

The relatively stable fuel use is indicative of the relatively stable harvested cropland acreage for the region. If the increases in irrigated acreage indicated in the previous section do, in fact occur, then this would be a factor tending to increase fuel use.

Table 9: Purchases of Gasoline, and Other Fuel and Oil for the Farm Business

	All Farms	Commercial Farms				
		Total	Gasoline	Diesel Oil	LP Butane, Propane	Oil Grease, Other
Idaho						
1964	26,308,500	24,994,568	17,399,334	4,570,199	568,793	2,456,242
1969	26,308,882	25,181,541	15,975,661	6,258,742	715,626	2,231,512
Oregon						
1964	20,420,500	18,402,644	12,623,849	3,260,441	448,619	2,069,735
1969	20,983,955	19,333,441	12,619,871	4,006,021	600,087	2,107,462
Washington						
1964	27,223,500	25,087,760	16,203,727	5,204,539	530,413	3,149,081
1969	28,075,281	26,241,071	15,991,694	6,417,611	673,603	3,158,163
3 States						
1964	73,952,500	68,484,972	46,226,910	13,035,179	1,547,825	7,675,058
1969	75,368,118	70,756,053	44,587,226	16,682,374	1,989,316	7,497,137

Source: Census of Agriculture

Shorter run factors like the current drive to "plant fence to fence" in response to high prices will undoubtedly put an upward pressure on fuel use.

Two apparent trends in the composition of fuel use are noteworthy. The amount of gasoline used seems to be declining while the use of diesel fuel is increasing. This trend could be cited as a move toward greater energy use efficiency. Diesel fuel is a less refined fuel, hence there is less energy wastage associated with its production than with the production of gasoline. The move toward diesel power, away from gasoline seems likely to continue in the future.

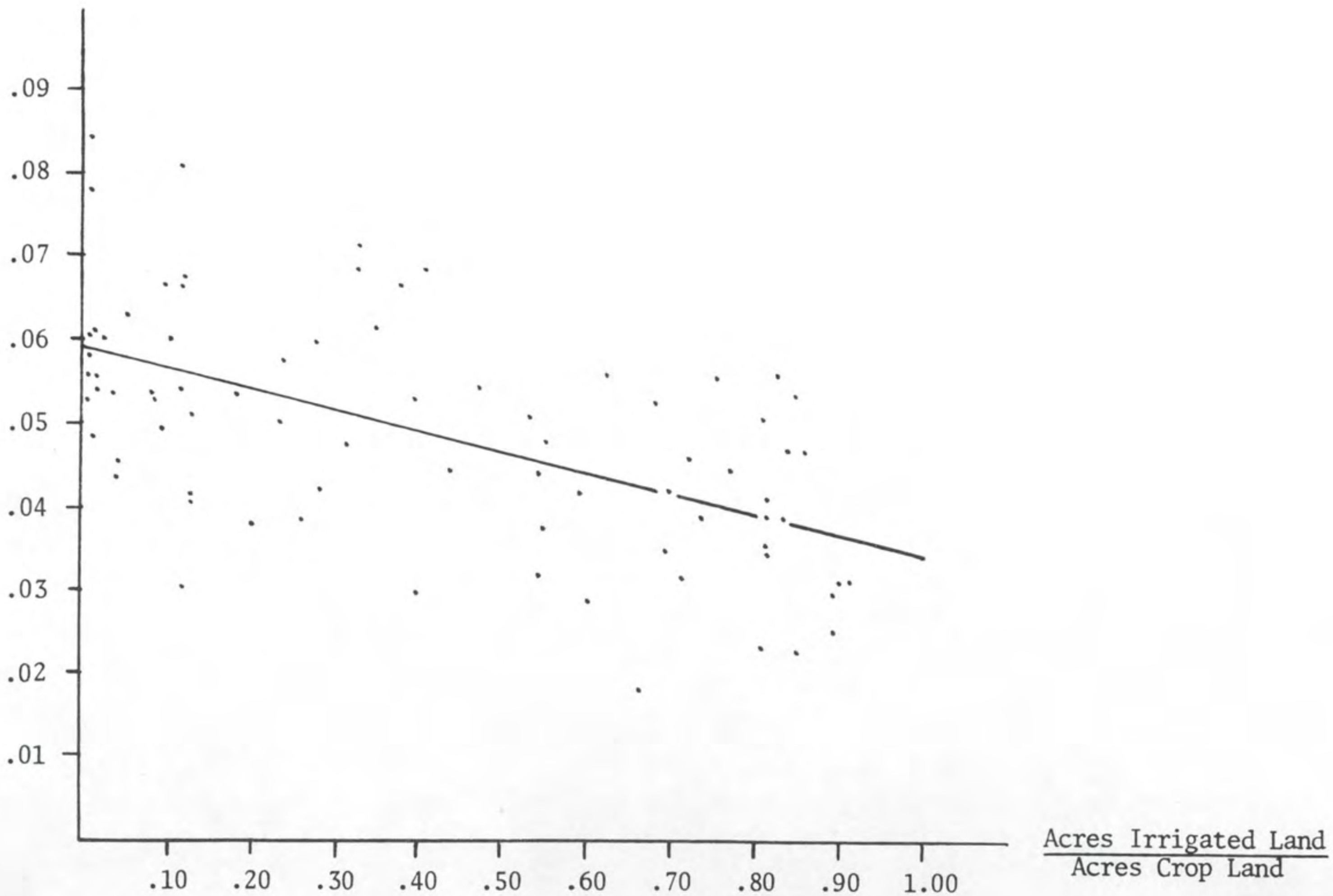
There is little available information to use in assessing the energy impact of some of the technical innovations taking place in agriculture. The switch-over to diesel mentioned above probably has a beneficial energy impact, but the size of that impact must be left to speculation. The increasing size of machinery will also have an unknown energy impact. Larger size machinery may be more efficient when actually working with properly matched load and power, but the opportunity for mismatch is also increased. (What farmer hasn't taken a ride on his big tractor to go patch a fence or do some other such task?)

Figure 7 illustrates another point which is relevant to consideration of fuel use efficiency. The vertical axis in the graph is a measure of the proportion of the value of agricultural products sold which goes to pay for petroleum purchases on farms in each county. The horizontal axis shows the relative intensity of irrigation in the county. The points plotted on the graph correspond to the 82 counties east of the Cascade Divide in Oregon, Idaho, and Washington. The west slope counties follow different petroleum use patterns because of the more humid climate. The indicated linear relation was fitted by ordinary least squares resulting in the following equation:

$$\frac{\text{Petroleum Purchases}}{\text{Value Ag. Products Sold}} = .058 - .025\,\frac{\text{Acres Irrigated Land}}{\text{Acres Crop Land}}$$

The R^2 for this regression was only .34 which indicates that the data points are quite widely distributed around the regression line. The regression coefficient had a t-statistic of 6.38 so we can say with 99 percent confidence that the coefficient -.025 does differ significantly from zero. These results suggest that relative to the value of output, Gasoline, Fuel, & Oil Purchases / Value of Agr. Products Sold

Oregon, Washington, and Idaho Counties East of Cascade Divide



Source: Census of Agriculture.

petroleum purchases are lower in irrigated areas than in non-irrigated areas. Such results are entirely plausible. Yields are higher, and higher value crops are produced on irrigated land. In contrast, it takes more nearly the same amount of fuel to cultivate irrigated land or dry land.

This points out a rather interesting trade-off between two energy forms--electricity and petroleum. A move toward irrigation results in the use of more electricity, but less petroleum relative to output value. In the Northwest with its relative abundance of low cost hydropower, the historic move toward irrigated farming was a logical trend. In the future with possible shortages of both electric power and petroleum, the efficient development pattern depends on the relative scarcity of these energy sources.

Since most petroleum is consumed in tillage or harvest trips over the land, an obvious way to reduce energy consumption is to reduce the number of trips. Minimum tillage has been around for many years--as an erosion-reducing practice, as a labor and time-saving procedure, and only marginally as a way to save fuel. Related to minimum tillage is the practice of coupling machinery to perform more than one job in a single pass over the field. A shortage of fuel, in the face of pressures to increase acreage, will serve as an incentive for coupled machinery and for minimum tillage. Fuel savings from such practices would, however, probably be less than 5 percent of agriculture's consumption of petroleum fuels.

There may be trade-offs associated with these innovative cropping systems. Minimum tillage, for example, results in a rougher seed bed which for Palouse wheat may increase the risk of poor germination. For most crops there are some penalties or risks associated with such practices, but as energy becomes scarcer, more farmers will accept these penalties and risks.

The conclusions about petroleum use in Northwest agriculture, which follow from the discussion above are that:

a.) The trade-off between electricity and petroleum use means that a move toward irrigation results in a savings of fuel relative to the value of output, but at a cost of increased electric energy use.

b.) There are many pressures for increased cropland acreage which would imply a need for increased petroleum energy for farm use.

c.) Practices such as minimum tillage and machinery coupling do exist which would cut down petroleum fuel use per acre, although these practices do involve some risks and yield penalties and would not save enough to significantly alter the total energy picture.

An energy shortage, if adjustment is left to the price mechanism, would probably result in widespread adoption of minimum tillage and machinery coupling systems. However, the total fuel savings from such changes would be quite small relative to total petroleum fuel use in the Northwest. Severe fuel shortages or rationing might well hold down cropland acreage, and might even result in abandonment of marginal cropland now cultivated.

Holding agricultural fuel use in check is more nearly an educational problem than a regulatory one. Price hikes or rationing would provide incentives to more efficient fuel usage; however, a strong education - extension program will be necessary to make farmers aware of the technologies that are available to them. Providing the incentives without also providing knowledge of the options available would be a disastrous course.

Implications for the Northwest Energy Picture

This paper has indicated that energy use is a vital part of Northwest agriculture. If energy is relatively abundant, then the consumption of energy by agriculture will increase in the future. If energy is short, then agriculture will adjust to that fact, first by energy conserving practices and then if necessary, by reducing output.

It is useful to note however, that agriculture is not a large consumer of energy. Energy shortage could have a very profound effect on the agricultural industry; however, any energy squeezed from agriculture by regulation or conserving efforts will have only a minor effect on total energy availability.