Summer Fallow in North Dakota—An Economic View

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In 1979, North Dakota had 6.3 million acres or about 22 percent of total crop land under summer fallow (3). Summer fallow is a desirable practice for several reasons. Primarily, its value lies in the increased yield due to a greater supply of moisture and nitrogen to a subsequent crop. Other benefits include stability in production, distribution of work load, and weed control. The cost of fallowing is the loss of production for a year and the cost of fallow tillage. In addition, losses in soil productivity, mainly through soil erosion or acceleration of saline seep development which in turn increase water pollution, can be regarded as added long-term costs of fallowing.[1] The economic benefits of summer fallow are short-term and accrue to farmers, while some costs of fallowing are long-term and accrue to society.

This report evaluates wheat summer fallow cropping systems within an economic framework from the short-term perspectives of the farmer. Water storage and economic aspects of summer fallow by area in North Dakota were reported in 1968 by Bauer (2). The four major economic factors studies are: (1) relative yields, (2) price wheat, (3) price of nitrogen fertilizer, and (4) income variability. The analysis is presented for wheat production for four farming areas of North Dakota (Figure 1): West, Northwest Central (NWC), Southwest Central (SWC), and East Central (EC).[2] The Red River Valley area is excluded because little summer fallow is used.

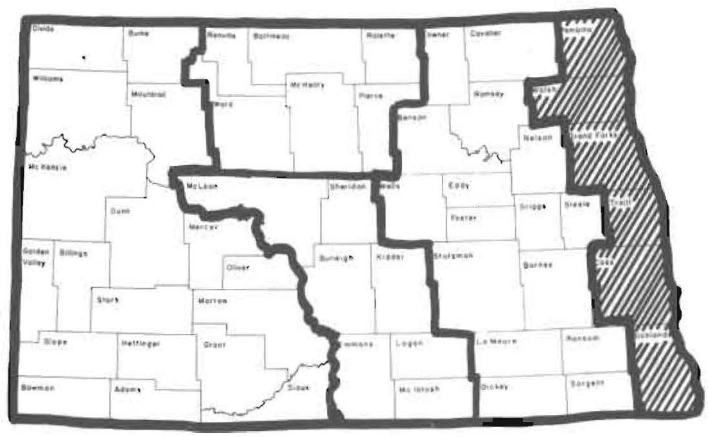

Figure 1. Boundaries of Four Farming Areas, North Dakota (Shaded Area not included)

Relative Yields

Technological developments have had different effects upon wheat yields produced on fallowed and nonfallowed land. For example, increased use of nitrogen fertilizer and selective herbicides tend to favor nonfallow yields. Whereas, development of high-yield potential varieties favors fallow yields. This is due to the fact that moisture is generally not as limiting on fallow land.

The North Dakota Crop and Livestock Reporting Service has been reporting county average yield for fallow and previously cropped land separately since 1949. Previously cropped land in western parts of the state is usually the second crop after fallow in a recropping system. Wheat yield estimation models for the four farming areas were developed based on county yields per harvested acre (1949-1977). An equal weight was given to the data from each county. Independent variables in the model were: (a) time as a proxy for technology, (b) annual precipitation (September through August), (c) county average acres of wheat planted on nonfallow land, and (d) a variable for nonfallow and fallow systems. Average annual precipitation data were developed for each county based on National Weather Service data for weather stations in or near each county.

Several logical relationships and interactions were estimated using least squares regression to find the best model. Regression coefficients for the selected model for each farming area are given below (all coefficients are significant at the 1 percent level).

West

$$Y = -5.8942 + .3032\,t + 3.1408D + .1526\,tD + 18.1242 \text{ Log } P - 2.2991 \text{ Log } X \qquad R^2 = .7318$$

Southwest Central

$$Y = -60.7484 + .3201\,t + 4.2302\,D + .0924\,tD + 86.2772 \text{ Log } P - 1.7212\,P - 2.0903 \text{ Log } X \qquad R^2 = .7288$$

Northwest Central

$$Y = -48.3380 + .4091\,t + 4.8775\,D + .0926\,tD + 82.9683 \text{ Log } P - 1.9880\,P - 34726 \text{ Log } X \qquad R^2 = 7.663$$

East Central

$$Y = -43.3696 + .5293\,t + 4.3767\,D + .0632\,tD + 78.0604 \text{ Log } P - 1.5655\,P - 5.6058 \text{ Log } X \qquad R^2\,.7252$$

Where:

Y = wheat yield (in bushels per harvested acre)
t = year; 1949 = 0
D = a variable for cropping systems, D = 1 if fallow, D = 0 if nonfallow
tD = interaction between year and cropping practice
P = annual precipitation, September through August (in inches)
X = acres of nonfallow wheat (in hundreds), average of counties in area

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Wheat yields in 1950, 1960, 1970, 1980, and 1990 were estimated for fallow and nonfallow practices by substituting the average annual precipitation (1950-1977) and the county average acres of nonfallow wheat in 1979 into the model. Yields per harvested acre were converted to yields per planted acre by multiplying by the average percent of acres harvested. Trends in wheat yields per planted acre on fallow and nonfallow for the four farming areas are shown in Figure 2. Each year wheat yields on fallow are increasing by .43, .40, .49, and .57 bushels and yields on nonfallow by .28, .30, .39, and .51 bushels in the West, SWC, NWC, and EC areas, respectively.

Wheat production budgets for 1980 were developed to compare returns per acre of land between the fallow and nonfallow systems. Cropping systems comparison assumed a decision criterion based on maximizing returns to land. Wheat yields that give equivalent returns to land under fallow and nonfallow systems were calculated using the area 1980 target price and the target price plus $1.00. Farmers would maximize return to land by using the fallow system if the point of intersection of yields on fallow and nonfallow falls to the left of the equivalent return line. When wheat yields fall to the right of the equivalent return line, farmers would maximize return from wheat under a reduced fallow system. The slope of the equivalent return line indicates that for every bushel increase in nonfallow yields, yields on fallow need to increase by about two bushels. Based on the yield trend line, wheat yields on fallow are actually increasing by 1.54, 1.33, 1.26, and 1.12 bushels for every bushel increase in nonfallow yields in West, SWC, NWC, and EC areas, respectively. Based on these trends the fallow system is becoming less and less desirable

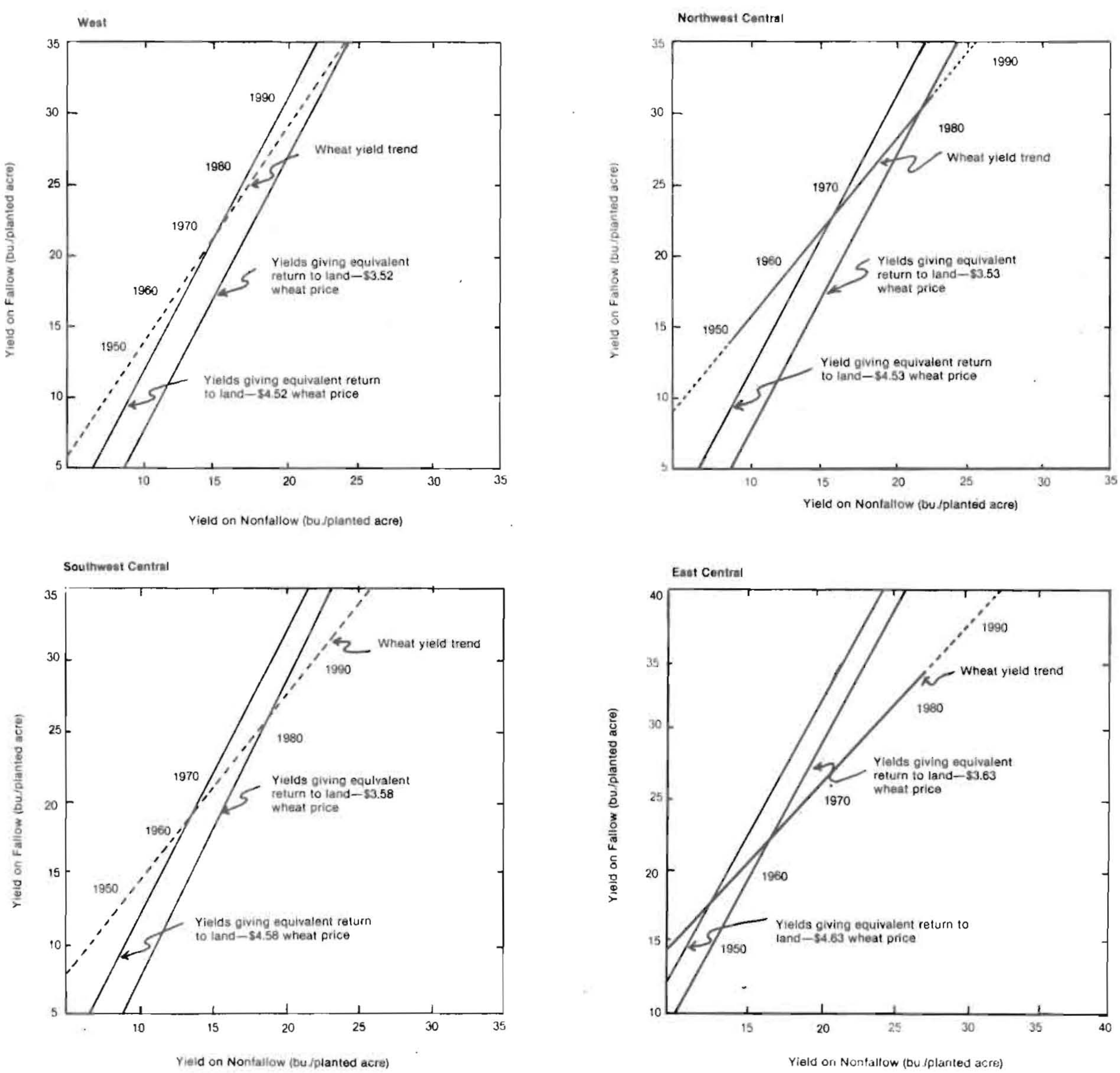

Figure 2. Trend in Wheat Yields Per Planted Acre and Yields Giving Equivalent Return to Land Under Two Cropping Systems for Four Farming Areas of North Dakota, 1980 Costs and Two Wheat Price Levels.

economically. Continuation of the trend toward increased yields will favor reduction of fallow relatively more in eastern than western areas of the state.

Price of Wheat

Figure 2 shows that the price of wheat has an effect upon the economics of summer fallow. Based on 1980 costs and target prices, a fallow system maximized return to land in West and SWC areas. Whereas, in NWC and EC areas, a reduced fallow cropping system maximized the return. Effects of wheat prices on the return to land under fallow (F-W), recropping, (F-W-W), and continuous cropping systems are shown in Figure 3.

Returns on recropping and continuous cropping systems are more sensitive to wheat prices than the fallow system. This greater sensitivity to wheat prices is seen by steeper slopes of the return line for recropping and continuous cropping systems. Higher wheat prices favor the intensive cropping systems more than the fallow system because higher wheat prices increase the opportunity cost of allowing the land to lie idle for a year under the fallow system. Returns under the fallow, recropping, and continuous cropping systems are equal at a higher wheat price in the West ($4.17), and the equivalent return price progressively declines as one moves to eastern areas of the state ($2.82 in EC).

Price of Nitrogen Fertilizer

Nitrogen is a major cost input that differs between production on fallow and nonfallow land. Depending on the yield level, small quantities of nitrogen fertilizer is required on fallow. This is due to accumulation of available nitrogen (nitrate-nitrogen) during the fallow year. Effects of nitrogen fertilizer prices on return to land are shown in Figure 4. Returns under recropping or continuous cropping are more sensitive to nitrogen prices. If nitrogen prices increase faster than prices of other farm inputs, the fallow system will be favored. In the West area where fallow is a relatively profitable

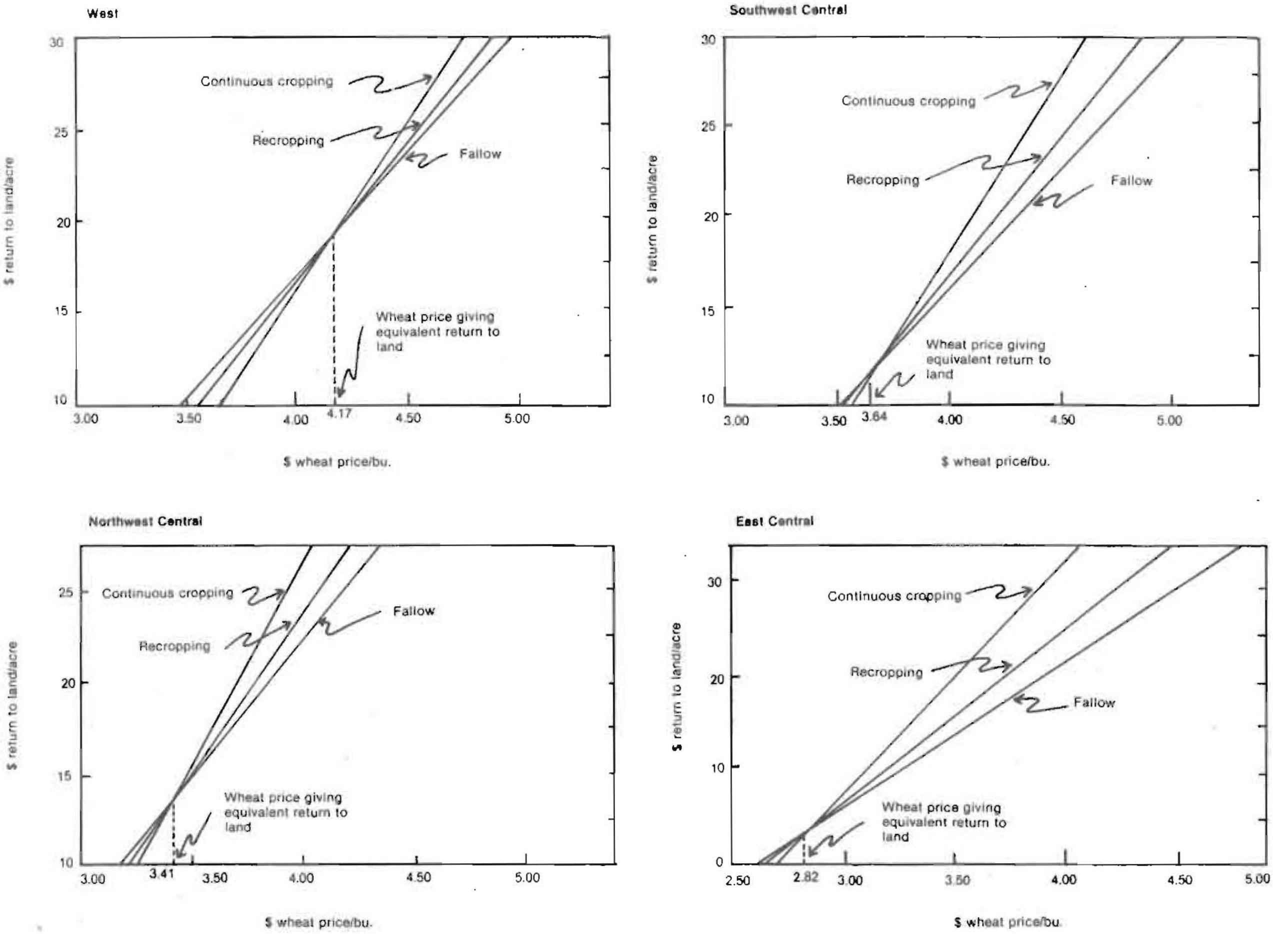

Figure 3. Effect of Wheat Prices on Return to Land Per Acre Under Three Cropping Systems for Four Farming Areas of North Dakota, 1980 Costs and Yields.

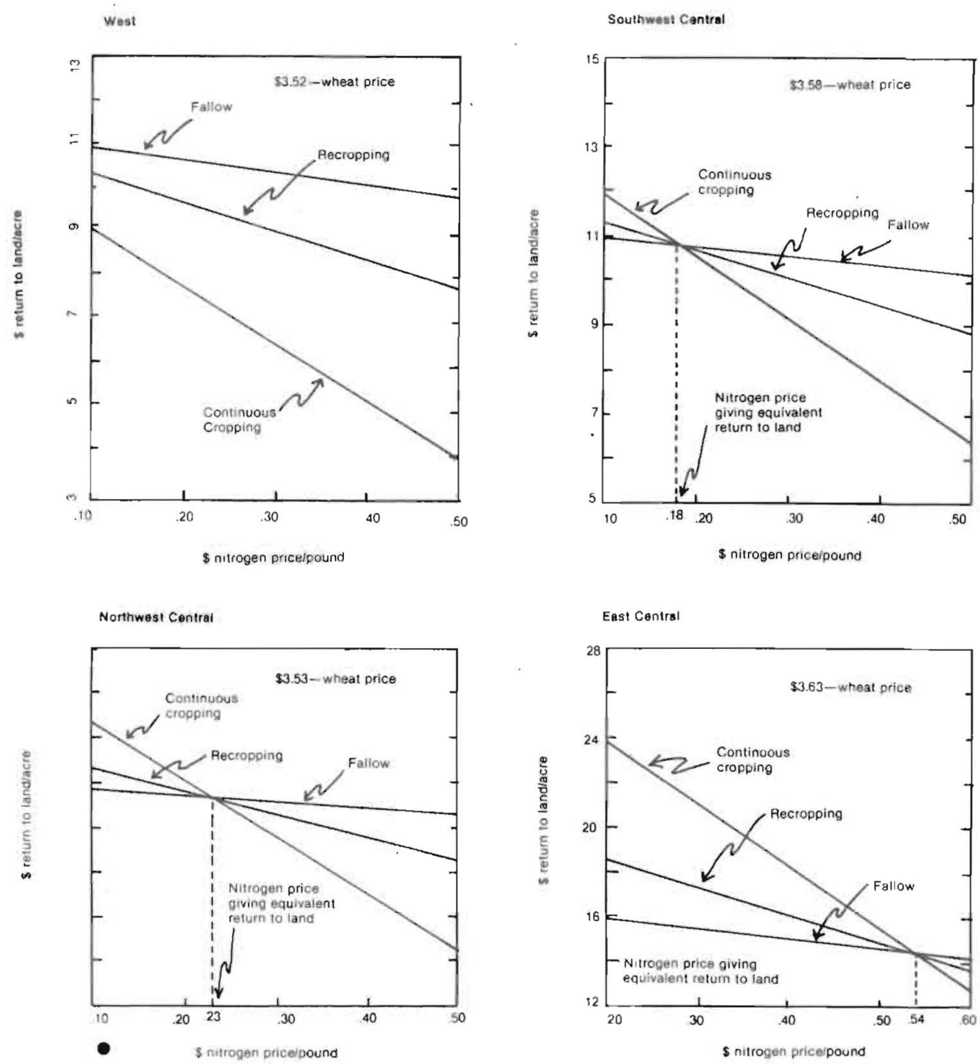

Figure 4. Effect of Nitrogen Prices on Return to Land Per Acre Under Three Cropping Systems for Four Farming Areas, North Dakota, 1980 Costs and Yields

practice at 1980 target wheat price and production costs, even a very low nitrogen price would not make an intensive cropping system competitive with fallow. In the SWC and NWC areas, the more intensive cropping systems compete with the fallow system when nitrogen prices are less than \$.18 and \$.23 per pound in their respective areas. In the EC area where intensive cropping systems are more profitable, the fallow system could compete only at a very high nitrogen price (greater than \$.54/pound).

Income Variability

An important advantage of the fallow system is the reduced variability in yields. Variability in yields can be measured statistically by the standard deviation (S) and the coefficient of variation (C.V.). The mean yield plus or minus the S gives the range in yields which have occurred two-thirds of the time, while the C.V. measures the range in yields as a percent of the mean yield. County average wheat yield data (1950-77) were used to measure variability in yields on fallow and nonfallow (Table 1). Absolute varability (S) in yields is greater for wheat on fallow than nonfallow. However, the relative variability (C.V.) is less for wheat on fallow. Among areas, the variability in yields on both fallow and nonfallow increased from east to west. Yield variability for a farm will tend to be greater than indicated by the county data (1). This is because yield affecting factors like hail, diseases, and insect damages often affect only a portion of the county.

Return and variability of return for the three cropping systems at 1980 costs and yields are presented in Table 2[3]. Two wheat price levels were used: (1) 1980 area target wheat price and (2) target price plus 20 percent.

Risk is increased in going from the fallow system to more intensive cropping systems. At the higher wheat price, farmers in the West and SWC areas selecting the more intensive cropping systems would face a substantial increase in income variabilty to achieve a small increase in returns. At the lower wheat price, farmers in the NWC and EC areas can increase returns through intensive cropping systems but must give up some income stability.

Table 1. Average Wheat Yield (1950-1977) and Measures of Variability for Four Farming Areas, North Dakota

	Average yield (bu./planted acre)	Standard deviation (bu./planted acre)	Coefficient of variation (∅)
West			
Fallow	19.23	6.71	34.89
Nonfallow	13.74	5.68	41.34
Southwest Central			
Fallow	18.98	6.79	35.77
Nonfallow	13.50	5.69	42.15
Northwest Central			
Fallow	21.93	7.13	32.51
Nonfallow	15.55	6.25	40.19
East Central			
Fallow	23.26	7.59	32.63
Nonfallow	17.93	6.71	37.42

Table 2. Return to Land Per Acre and Deviation in Return Under Three Cropping Systems for Four Farming Areas, North Dakota

$ Wheat price/ bu.	$ return to land/acre 1980 budget			Deviation in $ return/acre		
	F	R	C	F	R	C
West						
3.52	10.55	9.51	7.41	10.13	12.49	17.21
4.22	19.70	19.78	19.95	12.48	15.38	21.19
Southwest Central						
3.58	10.65	10.53	10.30	10.42	12.77	17.47
4.30	19.87	21.11	23.59	12.87	15.77	21.57
Northwest Central						
3.53	15.26	15.53	16.07	10.76	13.49	18.93
4.24	25.77	27.61	31.27	13.30	16.65	23.37
East Central						
3.63	15.80	18.43	23.70	11.77	14.78	20.80
4.36	27.41	32.41	42.41	14.54	18.26	25.70

F = Fallow system R = Recropping system C = Continuous cropping system

Conclusions

Low yields, low crop prices, and high nitrogen prices favor the fallow system. The trend of increasing wheat yields on fallow and nonfallow results in summer fallow becoming somewhat less economically desirable each year.

At 1980 production costs and target price levels, wheat on fallow gave higher returns to land in the West and Southwest Central areas, while in the Northwest Central and East Central areas, the more intensive cropping systems gave the highest returns to land. For more intensive cropping systems to give the same return to land as the fallow system, the price of wheat needs to be higher in the west than in the east. An increase in nitrogen prices (in relation to other farm input prices) give the fallow system an economic advantage.

Variability in income is less under the fallow system. Among areas, income variability increases from east to west. Western North Dakota is already a high risk production area. Variability in income is a major factor limiting a large shift from the fallow to the more intensive cropping systems. However, in the East Central and to a lesser extent in the Northwest Central areas, there are economic incentives to reduce the use of summer fallow.

The price of grain and cost of nitrogen fertilizer, as well as trends in yields on fallowed and nonfallowed land, will influence the future role of summer fallow in North Dakota agriculture.

[1]For further discussion of summer fallow, see 1, 4, 5, 6, and 7.

[2]Refer to Appendix A for formulas and production costs used in the analysis.

[3]Variability in income was based only on absolute variability in yields

(S). Other factors affecting income variability such as variability in prices were not included in the calculation.

[4]Since fallow and recropping systems represent two acres and three acres of land, their costs, yields, and returns are divided by 2 and 3 respectively to compare the systems on an acre basis. Due to lack of information about yields on recropped versus previously cropped land, the yield estimated for nonfallow (mostly recropping in the western area) was used for both recropping and continuous cropping.

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Appendix A. Formulas and Values Used in Calculations

A.1. Formulas Used to Calculate[4]:

(a) Equivalent return yield:

$$Y_f^* = \frac{2\pi_f + C_f - V_fY_f}{P - V_f}$$

$$Y_c^* = \frac{\pi_c + C_c - V_cY_c}{P - V_c}$$

(b) Wheat price at specified return to land:

$$P = \frac{2\pi_f + C_f}{Y_f}$$

$$P = \frac{\pi_c + C_c}{Y_c}$$

$$P = \frac{3\pi_r + (C_f + C_c)}{Y_f + Y_c}$$

(c) Return to land at specified nitrogen fertilizer price and wheat price:

$$\pi_f = \frac{Y_fP - C_f^* - N_fP_n}{2}$$

$$\pi_c = Y_cP - C_c^* - N_cP_n$$

$$\pi_r = \frac{Y_fP - C_f^* - N_fP_n + Y_cP - C_c^* - N_cP_n}{3}$$

(d) Income variability:

$$D_f = \frac{d_fP - V_f^*d_f}{2}$$

$$D_c = d_cP - V^{c*}d_c$$

$$D_r = \frac{(d_f + d_c)P - (V_f^*d_f + V^*_cd_c)}{3}$$

Where:

π_f = return to land per acre on fallow system
π_c = return to land per acre on continuous cropping system
$_r$ = return to land per acre on recropping system
Y_f^* = equivalent return yield on fallow
Y_c^* = equivalent return yield on nonfallow
P = price of wheat per bushel
V_f = cost associated with one bushel change in yield on fallow
V_c = cost associated with one bushel change in yield on nonfallow
Y_f = wheat yield on fallow for which costs were developed
Y_c = wheat yield on nonfallow for which costs were developed
C_f = total cost per acre excluding land cost on fallow (includes costs for fallow year)
C_c = total cost per acre excluding land cost on nonfallow
C_f^* = total cost per acre excluding land and nitrogen fertilizer on fallow
C_c^* = total cost per acre excluding land and nitrogen fertilizer on nonfallow
N_f = amount of nitrogen fertilizer applied per acre on fallow
N_c = amount of nitrogen fertilizer applied per acre on nonfallow
P_n = price of nitrogen fertilizer per pound
D_c = deviation in per acre return to land—continuous cropping system
D_f = deviation in per acre return to land—fallow system
D_r = deviation in per acre return to land—recropping system
d_c = standard deviation in yield on nonfallow
d_f = standard deviation in yield on fallow
V_c^* = cost per bushel of unplanned change in yield on nonfallow
V_f^* = cost per bushel of unplanned change in yield on fallow

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TABLE 4. GRAIN DRYER CAPACITY BY FARM SIZE GROUPS, NORTH DAKOTA, 1978

Farm Size Group	Dryer Capacity in Bushels Per Hour Per Farm	Dryer Capacity in Bushels Per Hour Per 1,000 Acres
1-639 Acres	22.9	69.0
640-959 Acres	23.2	29.4
960-1,499 Acres	71.3	60.5
1,500 Acres and More	159.4	72.0

Analysis of available dryer capacity from a per acre perspective indicated that the 1-639 acre farm size group averaged 69 bushels per hour per thousand acres. This is comparable to the average available dryer capacity of 61 bushels per hour per thousand acres for the 960-1,499 acre size group and 72 bushels per hour per thousand acres for the 1,500 and more acre size group. However, the 640-959 acre size group averaged only 29 bushels per hour per thousand acres of available dryer capacity (Table 4). The large amount of dryer capacity per acre in the 1-639 acre size group is due to the smaller amount of cropland owned by each dryer owner in this group and the minimum capacity of grain drying units.

Summary

Many North Dakota farmers are installing and using grain drying facilities. Even in the excellent harvest year of 1978, nearly 1.3 billion hundredweight of sunflower was dried—more than 41 per cent of the sunflower crop. Farmers also dried 76 per cent of their shelled corn and 42 per cent of their mustard crops. Although less than 10 per cent of the wheat and barley crops was dried, farmers dried millions of bushels of crops in 1978.

North Dakota's on-farm drying facilities handled almost all of this load. Ninety-two per cent of North Dakota's on-farm dryer capacity had been acquired since 1971, almost all fueled by LP gas. Most of this dryer capacity was in the eastern and north central portions of the state where sunflower and corn production is concentrated.

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A.2. Values Used in Calculations

Items	Units	Area: West	NWC	SWC	EC
Average Annual Precipitation (1950-1977)	Inches	15.65	16.50	16.74	18.08
Wheat Planted on Nonfallow Land (In Hundreds), 1979 County Average	Acres	253	883	885	967
Average Percent of Acres Harvested (1950-1977)					
Fallow	Percent	95.34	97.81	96.47	96.91
Nonfallow		91.62	95.00	94.87	96.03
1980 Normalized Wheat Yields					
Fallow	Bu./Planted	26.14	29.62	25.62	31.81
Nonfallow	Acre	17.91	21.41	18.46	25.63
Cost of Production Except Land[a]					
Fallow	$/Acre	70.91	74.04	70.42	83.88
Nonfallow		55.63	59.51	55.79	69.34
Cost of Production Except Land and Nitrogen[a]					
Fallow	$/Acre	69.57	72.68	69.47	81.81
Nonfallow		52.67	54.47	52.85	63.72
Nitrogen Used					
Fallow	Lbs./Acre	5.83	5.92	4.12	9.01
Nonfallow		12.89	25.31	13.63	27.60
Cost Associated With Change In Yield[b]					
Fallow	$/Bushel	1.55	1.56	1.56	1.58
Nonfallow		1.54	1.43	1.50	1.47
Cost Associated With Unplanned Change in Yield[c]					
Fallow	$/Bushel	.50	.51	.51	.53
Nonfallow		.49	.50	.51	.53

[a]No charge was made for management, risk, or general farm overhead.
[b]Fertilizer and handling cost only.
[c]Handling cost only.