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SUSTAINABLE AGRICULTURE AND THE STRUCTURE OF NORTH DAKOTA AGRICULTURE

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The authors accept responsibility for any remaining errors or omissions.

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Highlights

This is a summary of an investigation into the effects of sustainable agriculture on the structure of North Dakota agriculture. Farmers were divided into three types (conventional, mixed-type, and sustainable) on the basis of a seven-point index the participants in the Northwest Area Foundation Sustainable Agriculture Initiative defined (Bird and Hassebrook, 1990). Of the 495 North Dakota farmers surveyed in March and April of 1990, 71 were members of the Northern Plains Sustainable Agriculture Society (NPSAS), and 424 were from a panel of farmers surveyed by Leistritz et al. (1989).

This report describes the differences among farm types as they relate to the following structural characteristics of agriculture: farm size, farm diversification, labor, part-time farming, and land tenure. Analysis of the results led to the following conclusions:

- *Sustainable farms had lower gross sales per farm than conventional farms.*
- *Sustainable farms were more diversified than conventional and mixed-type farms. Conventional farms were more specialized in wheat and barley production, while sustainable farms were more specialized in oat production.*
- *Mixed-type and sustainable farmers relied less on such off-farm inputs as chemicals, fertilizers, and hired labor than did conventional farmers.*
- *The per-acre family labor requirements among farm types did not differ significantly. However, more family labor was observed for sustainable farms on a per-acre basis.*
- *The conventional farmers had less off-farm employment than did either the mixed-type or sustainable farmers; however, this difference was not significant.*
- *A larger percentage of sustainable farmers were full owners; however, this difference was not statistically significant.*
- *Sustainable farmers were younger than conventional farmers.*

North Dakota farmers did not differ in the size of sustainable and conventional farms. However, the sustainable operators relied less on off-farm inputs such as fertilizers, chemicals, and hired labor. The sustainable farmers had more diversified combination/crop livestock farms.

While transition from conventional to sustainable agriculture may not change the number of farms in North Dakota, it may change the farm type. The farms could become more diversified, which would require enhanced management skills to produce alternative crops on one farm with one manager. North Dakota's sustainable agriculture may have less need for hired labor, fertilizer, and chemical dealers. Chemical and fertilizer dealers in the state could lose business unless they incorporate alternative products. The younger farm managers could lead the transition to sustainable agriculture.

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The structure of agriculture determines who controls it. Those who describe the structure of agriculture own the resources needed to produce food and fiber and decide how those resources are to be used and what constraints are imposed on those who manage the use of these resources. Industrialization of the economy, including the food and fiber system, is a major force shifting the structure of many sectors away from the small owner-operated business. Many are concerned that agricultural output is becoming concentrated into the hands of fewer, larger farms.

The purpose of this report is to consider the following issues: Does the size of the farm operation differ between conventional and sustainable farmers? How do these two types of farmers differ in their need for labor and in their employment off the farm? How do they compare in land tenure and level of diversification? What are the implications of sustainable farming on the structure of agriculture?

In 1988, the Northwest Area Foundation requested research proposals to determine the socioeconomic and agronomic impact of low-input sustainable agriculture (LISA) practices. Five states (Iowa, Minnesota, Montana, North Dakota, and Oregon) received funding from the Foundation to participate in the research. This report presents a comparison of structural characteristics of farms categorized as sustainable (using the Northwest Area Foundation Sustainable Agriculture Initiative guidelines) versus conventional.

North Dakota is particularly suited for a study of sustainable agriculture since the state relies heavily on agriculture. Of North Dakota's 53 counties, 43 depend on agriculture[1], and nearly 10 percent of the total state personal income comes from farm sources[2]. Adopting alternative practices may change the state's agricultural production and income and may affect the state's economic condition.

North Dakota's agriculture industry is based primarily on the production of beef, wheat, barley, and sunflower. Cash receipts from marketing these farm products in 1988 were $651 million, $666 million, $233 million, and $168 million, respectively, accounting for over 70

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[1]Agriculturally dependent counties are those where 20 percent or more of the total labor and proprietor income was produced from farming/ranching (Bender et al., 1985; Ross and Green, 1985).

[2]Based on Bureau of Economic Analysis data for 1980 through 1989.

percent of the state's farm marketing cash receipts (excluding government payments) in 1988 (Bureau of the Census, 1989).

Farm Structure and Sustainable Agriculture

Changes in the structure of agriculture include changes in farm size, farm diversification, labor, part-time farming, and land tenure. The structure of agriculture tends toward larger, more specialized farms, less on-farm labor per acre, more part-time farming, and less full ownership of the farm. Sustainable farming would appear to challenge each of these changes. The discussion to follow examines the relation between current trends in agriculture and sustainable farming with respect to farm size, farm diversification, labor, part-time farming and land tenure.

Farm Size

Agriculture in the United States is moving toward a more bimodal distribution in farm size (Jensen, 1987). This trend can be seen in North Dakota. The 1987 Census of Agriculture reported that from 1982 to 1987 the number of farms in North Dakota with less than 50 acres (9.3 percent) increased along with the number of farms over 2,000 acres (8.2 percent). The number of farms between 50 and 2,000 acres decreased. The net effect is that larger farms increasingly dominate total agricultural output. Sonka and Heady (1974) indicated that under similar production levels, income generated in the rural community from agriculture is significantly lower in a structure where larger farms dominate.

Some researchers argue that a move toward sustainable agriculture will reverse this trend. Crosson and Ekey (1988) found that sustainable farms required more management time and skill than conventional farms. Without any change in the structure of agriculture, more sustainable farms would imply smaller farms. Based on these findings, sustainable farms would be smaller in size than conventional farms.

Farm Diversification

Crop specialization has increased as farm size has increased. One reason for specialization might be the importance of volume discounts to lower costs and of volume premiums to increase revenues. Krause and Kyle (1970) found that input prices varied as much as 25 percent among different-sized grain producers, with the largest producers having the advantage. They also stated that the largest producers received about five cents more per bushel when they sold their corn.

New technology increases agricultural specialization; that is, it reduces diversification in agriculture. New technology requires a major capital investment and encourages specialization in the production of the commodities with that investment (Babb, 1979).

Income risk affects the degree of specialization. Farmers diversify to protect their income against price volatility or

disasters. They specialize to achieve technology and size economies as risk is reduced. Because agricultural programs such as deficiency payments, disaster payments, all-risk crop insurance, and storage programs directly reduce risk, they also encourage more specialization.

Sustainable farms may be better suited to a more diversified production scheme and may need more diversification to meet its demands. Farms that are smaller and depend less on off-farm inputs can be more diversified. A more diverse crop-livestock operation is better suited to adopting sustainable practices than are conventional farms (Alternative Agriculture, 1989). Low-input farming requires more on-farm diversification to replace off-farm inputs. These factors suggest that conventional farms will be more specialized than sustainable farms.

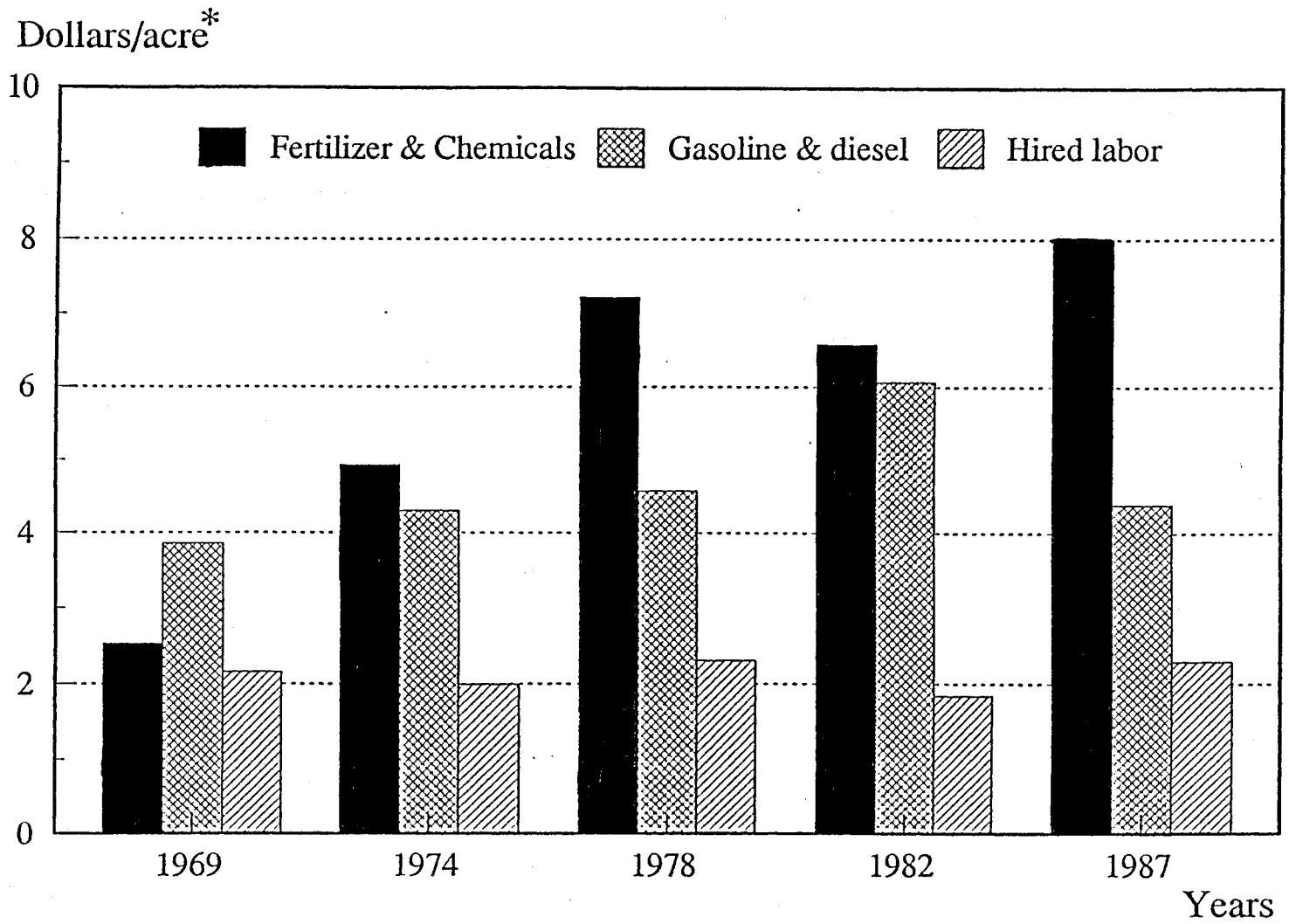
Labor

The amount of labor required to produce an acre of wheat has decreased steadily since the 1800s. In 1830, about 55 hours of field labor was required to raise an acre of wheat; in 1990 only one to two hours of field labor was required to raise an acre of wheat (Promersberger and Lucken, 1990). The biggest substitute for labor throughout this period was mechanization. Gasoline and diesel engines, large, powerful tractors, and field implements reduced labor requirements.

Agricultural output results from labor, land, and capital inputs. In less developed economies, agriculture depends more on labor and land and less on capital (Heady and Ball, 1965). However, as the economy develops and becomes more specialized, agriculture depends more on capital inputs. Throughout the 1970s and 1980s, capital and technology were substituted for labor (Johnson and Nelson, 1984), partially because of the overall increase in farm size. This substitution was predominantly in chemicals, fertilizers, and machinery. For every $1/acre paid to hired labor in 1969, North Dakota farmers used $1.17/acre for fertilizer and chemicals. By 1987, fertilizer and chemical expenses rose to $3.47/acre for every $1/acre of hired labor (Figure 1 and Appendix Table 1).

A move toward sustainable agriculture involves switching from purchased fertilizer and chemical inputs to on-farm inputs. Without chemicals and fertilizers, weed control requires more labor inputs, both from management and tillage standpoints (Poincelot, 1986). A move toward sustainable farming would increase demand for labor.

Sustainable farmers need more management expertise to handle crop rotations and livestock enterprises, to reduce potential pest problems and to maximize complementarity among enterprises. Conventional farmers need not be as concerned with nitrogen use during a given year because they can rely on the application of nitrogen before planting the next crop. Farm management may become more complex and demanding if farmers produce their own nitrogen, control weeds without chemical inputs, or produce livestock without antibiotics, hormones, and steroid growth implants. A shift from high-input farming (i.e.,



*All costs deflated to 1987 dollars.

Figure 1. Comparison of Typically Purchased Inputs in Dollars per Acre by North Dakota Producers, 1969-1987

SOURCE: 1987 Census of Agriculture; 1989 Economic Report to the President.

chemical and energy intensive farming) to low-input farming suggests sustainable farms will have increased labor requirements.

Part-time farming

Farmers can use off-farm employment to increase their income (Leistritz et al., 1987). According to Carlin and Ghelfi (1979), the shift toward more off-farm work is one of the most dramatic shifts taking place in U.S. agriculture. In North Dakota, the number of farm operators working off the farm more than 200 days per year increased 10 percent from 4,814 farmers in 1982 to 5,295 farmers in 1987 (Bureau of the Census, 1989).

Carlin and Ghelfi (1979) stated that small farmers tended to seek off-farm employment, especially younger farm operators. If sustainable farms are smaller and sustainable farmers are younger, then an anticipated greater percentage of sustainable farmers will work off the farm. However, the demand for greater labor on the farm may dampen such a trend.

Land Tenure

Trends in land tenure have involved a shift from full ownership and tenancy toward part ownership. Since 1935, the number of part owners nearly tripled in proportion to the number of farms, and the proportion of land part owners operate nearly doubled (Hottel and Harrington, 1979). Barry and Baker (1977) suggested that a farmer's location in his or her life cycle can influence debt use and resource control and that full ownership rises and tenancy declines with age. Use of debt capital to gain control of farm land can influence tenure. Differences in a farmer's life cycle likely would be reflected in the tenure and leverage of the farmers. If sustainable farmers are younger, they may be less likely to own their land.

Methods

A survey of 495 North Dakota farm and ranch operators was conducted in March and April of 1990. Their names were obtained from two sources: 1) a panel of 424 farmers previously selected at random and surveyed by Leistritz et al. (1989) and 2) names from the membership list of the Northern Plains Sustainable Agricultural Society (NPSAS).

The panel was selected because they were expected to be fairly representative of conventional farmers. Because the panel sample included only a small number of sustainable farmers, the 71 members of the NPSAS were added to the sample. Since this group comprises the only association of farmers with the explicit goal of sustainability, the likelihood of meaningful comparisons between sustainable and conventional farmers was enhanced.

The recommendation of the Northwest Area Foundation's Sustainable Agriculture Initiative was adopted to differentiate among farm types (Bird and Hassebrook, 1990). This approach involves constructing an index based on a farmer's self-identification,

practices, attitudes, and farm group membership. Each dimension would be scored to reflect the degree to which a farm operation relies on internal resources versus off-farm inputs. For a discussion of the index and methodology used to place respondents in either the conventional, mixed-type, or sustainable categories see Dahl et al. (1991), Jacobsen et al. (1991), and Stearns et al. (1991).

Results

Farm Size

Although sustainable farmers owned, rented, and operated fewer acres than did the conventional farmers, the differences were not significant (Table 1). Reported differences may decrease in the future. When respondents were asked about their expected farm size five years in the future, sustainable farmers were the only farm type who planned to increase the number of acres they operated.

An alternative measure of farm size is gross sales. Gross farm sales differed significantly among the farm types. Nearly a third (32 percent) of conventional farms had $100,000 or more in sales compared to 10 percent of sustainable farms. Thus, while conventional farms were not significantly larger in acreage, they were larger in value of farm products produced.

Farm Diversification

Respondents listed all crops raised in 1989 and the number of acres of each to compare the percentage of producers raising various crops. The percentage of farmers raising a particular crop provides insight into the differences in cropping patterns by farm type, while a particular enterprise (as a percentage of each farm's crop and livestock production) indicates the specialization of that enterprise by farm type.

Overall, the sustainable farms tended to be more diversified than were conventional farms with an average of six enterprises per farm compared to the conventional farms with an average of 4.4 enterprises per farm (Table 2). Conventional and sustainable farms differed significantly in barley, oats, spring wheat, and all wheat in percentage of a farm's total acres. Oats was the only crop in which the sustainable farmers had a greater percentage in their rotation. Thus, sustainable farms will be less specialized in barley and spring wheat production but more specialized in oats production.

Sustainable farmers traded possible advantages of specialization for advantages of diversification and income security. Sustainable farmers may not be able to specialize to the point of conventional farmers because they must control weeds and build soil nutrients through crop rotation practices.

Sustainable farmers desire to decrease their reliance on off-farm inputs may have resulted in their becoming more diversified. Sustainable farmers' ability to rely less on purchased inputs is evident in their reduction in purchased inputs (Table 3). Sustainable farmers spent 14 times less on fertilizer per farm and 653 times less on chemicals per farm than did conventional farmers. Without these

TABLE 1. LAND OWNERSHIP AND SIZE COMPARISONS AMONG CONVENTIONAL, MIXED-TYPE, AND SUSTAINABLE NORTH DAKOTA FARMS, 1989

Item	Conventional	Mixed-type	Sustainable	F	Chi²
Respondents	176	51	28		
	----------mean acres---------				
Owned	905	782	668	0.61	
Rented	1095	853	569	1.73	
Operated	1965	1572	1171	.17	
Size in future	1761	1409	1235	.13	
Certified organic	0	226	821	.44	
Respondents	187	54	29		
Acres operated	----------percent----------				
Less than 500 acres	7	11	24		
500 to 1,000 acres	22	28	31		
1,001 to 1,500 acres	27	31	28		
1,501 to 2,000 acres	13	9	3		
Over 2,000 acres	30	20	14		3.97
Total	99	99	100		
Respondents	187	54	29		
Value farm sales	----------percent----------				
Less than $20,000	27	43	38		
$20,000 to $50,000	13	24	31		
$50,001 to $75,000	14	11	7		
$75,001 to $100,000	13	7	14		
Sales over $100,000	32	15	10		20.05**
Total	99	100	100		

**Significant difference at P≤.01.

external inputs, sustainable farmers may need more on-farm diversification.

Labor

Several measures of on-farm labor were used to compare labor by farm type. Respondents listed all of the people living in their households and estimated the amount of time each household member worked on the farm per week in the summer and the winter. The number of hours worked per week did not differ significantly among farm types because of the large variation within each type (Table 4). When adjusted for farm size, conventional and mixed-type farmers reported more labor per week from household members than did sustainable farmers.

The dollar amount of hired labor used per farm was calculated from respondents' answers to questions about their 1040, Schedule F, tax forms. Sustainable and mixed-type farmers spent significantly less on hired labor than did conventional farmers on a per-farm basis (Table 4). Both sustainable and mixed-type farmers spent less per

TABLE 2. CROP AND LIVESTOCK DIFFERENCES BY FARM TYPE, 1989

	Conventional	Mixed-type	Sustainable	F
	per/farm			
Respondents	187	54	29	
Number of enterprises[a,b]	4.4	4.6	6.0	9.04**

Enterprise	Conventional Percent Farms with Enterprise	Conventional Percent of Farm's Total Acres	Mixed-type Percent Farms with Enterprise	Mixed-type Percent of Farm's Total Acres	Sustainable Percent Farms with Enterprise	Sustainable Percent of Farm's Total Acres	F
	percent						
Alfalfa	21	7	39	15	38	9	4.11*
Edible beans	10	18	0	0	17	16	0.15
Buckwheat	4	9	0	0	45	12	0.39
Barley[a]	70	14	59	8	31	6	8.00**
Corn	34	10	35	5	28	11	1.44
Flax	12	6	9	6	38	14	3.45*
Millet	6	5	6	6	48	12	1.58
Oats[a]	37	7	72	9	69	10	3.32*
Peas	0	0	0	0	3	6	--
Rye	<1	2	6	5	21	8	1.58
Soybeans	14	18	2	6	10	10	0.79
Sugar beets	6	26	0	0	0	0	--
Sunflowers	34	14	17	16	28	16	0.17
Durum wheat[b]	26	30	9	31	31	13	4.23*
Spring wheat[a,c]	81	29	76	19	72	19	9.69**
Winter wheat	2	8	2	12	7	7	0.24
White wheat	0	0	0	0	7	22	--
All wheat[a,c]	97	32	83	21	86	21	13.73**
Fallow[b]	95	11	83	8	90	15	5.36**
CRP	26	4	28	4	14	3	0.17
Hay and Pasture[b,c]	72	20	94	40	86	18	13.99**
Wasteland	60	3	45	2	72	4	0.65
Amaranth	0	0	0	0	3	6	--
Safflower	0	0	0	0	3	5	--
Canola	<1	4	0	0	0	0	--
Clover	0	0	0	0	7	22	--
Potatoes	<1	14	0	0	0	0	--
Sorghum/sudan	3	3	9	4	10	5	--
Grass seed	1	14	2	4	0	0	--
Lentils	0	0	0	0	3	12	--
Garbanzo	0	0	0	0	3	3	--
	head			head		head	
Beef	51	98	76	72	48	54	1.66
Swine	10	194	15	192	7	250	0.07
Sheep	5	183	11	39	10	64	0.46
Poultry	<1	50,000	7	464	3	6000	0.17
Horses	3	5	9	31	0	0	3.03

[a]Significant difference in percent of operated land in that enterprise between conventional and sustainable (P≤.05).
[b]Significant difference in percent of operated land in that enterprise between mixed-type and sustainable (P≤.05).
[c]Significant difference in percent of operated land in that enterprise between mixed-type and conventional (P≤.05).
*Significant difference at P≤.05.
**Significant difference at P≤.01.

acre on hired labor than conventional farmers, and the difference between mixed-type and conventional farmers was statistically significant.

While farm types differed in the amount of hired labor and not in family labor, the two groups may not be mutually exclusive. A farmer may

TABLE 3. DIFFERENCE IN AMOUNT OF PURCHASED INPUTS PER FARM BY FARM TYPE, 1989

Purchased inputs	Conventional	Mixed-type	Sustainable	F
Respondents	170	49	25	
	----------dollars/farm----------			
Fertilizer[a,c]	10,467	2,175	729	10.70**
Chemicals[a,c]	7,837	1,602	12	11.62**
	----------dollars/acre----------			
Fertilizer[a,b]	9.67	2.87	1.10	5.06**
Chemicals[a,b]	6.35	1.77	0.01	15.15**

[a]Significant difference between conventional and sustainable (P≤.05).
[b]Significant difference between mixed and sustainable (P≤.05).
[c]Significant difference between mixed and conventional (P≤.05).
**Significant difference at P≤.01.

TABLE 4. LABOR BY SEASON AND FARM TYPE, 1989

Item	Conventional	Mixed-type	Sustainable	F
Respondents	171	46	26	
Family labor	----------hours/week----------			
Summer	119	121	117	0.03
Winter	56	69	51	1.06
Family labor	----------hours/acre----------			
Year around	7.6	12.8	11.4	2.76
	----------dollars/farm----------			
Hired labor[a,b]	5,650	655	734	7.37**
	----------dollars/acre----------			
Hired labor[b]	3.55	0.40	0.70	6.62**

[a]Significant difference between conventional and sustainable (P≤.05).
[b]Significant difference between mixed and conventional (P≤.05).
**Significant difference at P≤.01.

pay family members, who would be counted as hired labor for tax purposes. Since hired labor was the only measure of labor that differed significantly by farm type, a transition from conventional to sustainable agriculture may decrease hired labor, both on a per-farm and a per-acre basis. A transition from conventional to sustainable farming may not increase labor requirements in agriculture. This finding is contrary to other research literature.

Part-time Farming

Respondents were asked if they or their spouses had off-farm employment in 1989. The sustainable farmers had a greater percentage of off-farm employment (Table 5). All but 22 percent of the sustainable farmers had the respondent, the spouse, or both working off the farm, while 45 percent of mixed-type farmers and 42 percent of conventional farmers had no off-farm employment.

TABLE 5. COMPARISON OF OFF-FARM EMPLOYMENT BY FARM TYPE, 1989

Item	Conventional[a]	Mixed-type[a]	Sustainable[a]	Chi²
	----------percent----------			
Only respondent	12 (20)	14 (6)	26 (6)	
Only spouse off-farm	32 (55)	25 (11)	26 (6)	
No off-farm employment	42 (72)	45 (20)	22 (5)	
Both have off-farm employment	14 (24)	16 (7)	26 (6)	
Total	100 (171)	100 (44)	100 (23)	8.12

[a]Percentages do not include unmarried respondents.
Note: The numbers in parentheses represent the total Ns used for calculating each percent.

Respondents were asked about the number of days they worked at least four hours per day off the farm. If farm operators worked off the farm more than 200 days per year, they were considered part-time farmers. Farm types did not differ in the percentage of part-time farmers nor the percentage of part-time farmers by land tenure across farm types (Table 6). These results provide a double check on screening efforts because all respondents were asked before the survey if they considered farming as their primary occupation.

Land Tenure

Sustainable farm operators have not been established as long as the conventional farmers. The length of time respondents had farmed differed significantly by farm type. The sustainable operators had farmed an average of 17 years compared with an average of 24 years for both the conventional farmers and the mixed-type farmers (Table 7). This shorter tenure for sustainable farmers was associated with their ages, as these farmers were significantly younger than the other types of farmers (Table 7).

These differences suggest differences in the stage of the farmer's life cycle among the farm groups. Operator age may be related to the financial condition of the farm. To explore this possibility, debt-to-asset ratios were calculated. For sustainable and mixed-type

TABLE 6. PERCENT OF RESPONDENTS AND SPOUSES WORKING OFF THE FARM, FULL-TIME, BY FARM TYPE, 1989[a]

Item	Conventional	Mixed-type	Sustainable	Chi²
	----------percent----------			
Respondent	3 (187)	7 (54)	0 (29)	4.03
Spouse	14 (187)	13 (54)	10 (29)	0.39
By tenure Respondent				
Full owner	7 (29)	14 (14)	0 (7)	1.41
Part owner	<1 (143)	6 (34)	0 (17)	5.14
Tenant	15 (13)	0 (6)	0 (4)	1.69
Spouse				
Full owner	14 (29)	7 (14)	14 (7)	0.44
Part owner	15 (143)	18 (34)	0 (17)	3.21
Tenant	15 (13)	0 (6)	25 (4)	1.47

[a]Full time means at least four hours per day for more than 199 days per year.
Note: The numbers in parentheses represent the total Ns used for calculating each percent.

farms, the ratios were 30 and 33 percent, respectively (Appendix Table 2). The debt-to-asset ratio of conventional farms was equal to the mixed-type farms. Thus, neither the amount of leverage by farm type nor percentage ownership of assets associated with the farm differed among farm types. So the age difference between conventional and sustainable farms was not affecting the financial condition among the farm types, and outside influence in farm management decisions may be equal across farm types.

TABLE 7. COMPARISON OF OPERATOR AGE AND TIME FARM HAS BEEN IN FAMILY, 1989

Item	Conventional	Mixed-type	Sustainable	F
Respondents	186	54	28	
	----------mean----------			
Years farm in family	61	62	55	0.78
Years farmed[a,b]	24	24	17	4.68*
Respondent age (years)[a,b]	49	48	41	5.94**

[a]Significant difference between conventional and sustainable (P≤.05).
[b]Significant difference between mixed and sustainable (P≤.05).
*Significant difference at P≤.05.
**Significant difference at P≤.01.

The percentage of sustainable farmers who were full owners exceeded the percentage of conventional farmers who were full owners; however, this difference was not significant (Figure 2 and Appendix Table 3). Twenty-five percent of sustainable farmers were full owners compared to 16 percent of the older conventional farmers. The main reason for this difference may be the three-year investment required to bring land into certified organic production. This period represents a high initial cost to the producer. During the certification period, the producer cannot take advantage of organic premiums, and production is likely to be lower. Without ownership of the land or a long-term rental agreement, sustainable farms may find the risk too great. Ownership of land gives the owner control and allows the owner to make decisions concerning production.

Sustainable farm practices may be interpreted as risky simply because they are different. As such, implementing sustainable farm practices for farm owners who are not full owners may be more difficult. A farm with a high debt load may be under financial pressure from the banking institution with a vested interest in the farm. The bank or level of indebtedness may influence the management of the farm. Alternatively, the farm operator, as a tenant, may be subject to the land owner's discretion regarding farm management.

Conclusions and Implications

Farm size did not differ significantly among farm types. However, farms in each group varied. Differences within the groups were generally greater than differences among groups. Therefore, while the distribution among the farm types differed, the average sizes did not differ significantly. A trend away from conventional toward sustainable agriculture is not likely to change family farm size.

Sustainable farmers were more diversified than were their conventional counterparts. The conventional farmers had a larger percentage of their farm acreage in barley and wheat than did the sustainable farmers, revealing a greater specialization in the production of these crops. Sustainable farmers specialized more in the production of oats than conventional farmers. Sustainable farmers were less specialized in the production of durum wheat, hay and pasture than mixed-type farmers; however, the sustainable farmers exceeded mixed-type farms in the average percentage of the farm in fallow.

Sustainable farmers were involved in a greater number of enterprises per farm than were conventional and mixed-type farmers. Because of this diversity, sustainable farmers need management skills that will allow profitable management of a variety of enterprises. A transition toward a sustainable agricultural structure may have a mixed effect on the diversification of North Dakota farms. A greater percentage of fallow in crop rotations may have the potential to decrease overall output because less cropland is in production. Because sustainable farms were less specialized in the production of barley and wheat, the per-acre output of these crops could decline, while oats production could increase.

Sustainable and mixed-type farmers purchased fewer off-farm inputs (fertilizers and chemicals) than did conventional farmers.

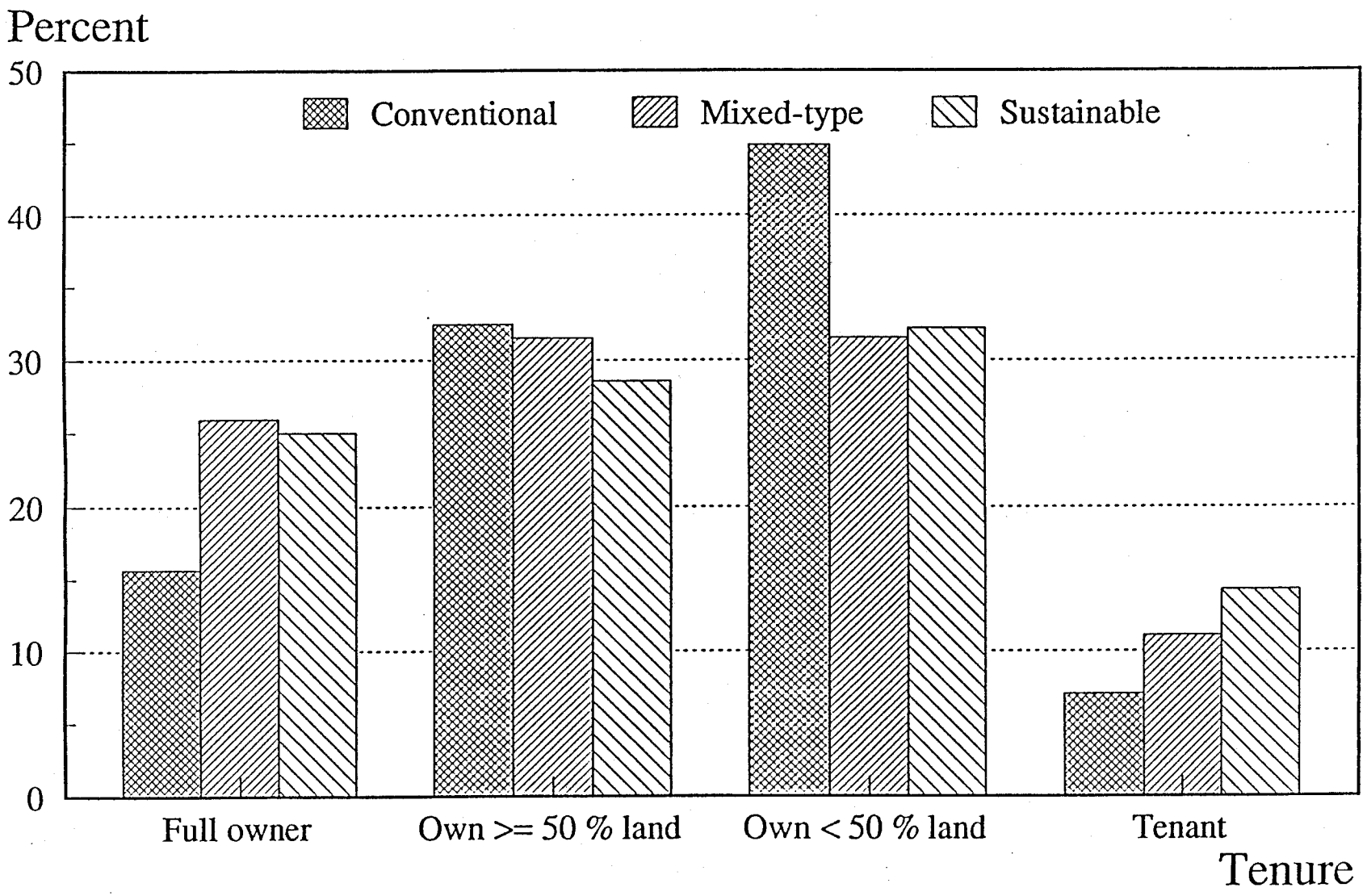


Figure 2. Land Tenure by Farm Type, 1989

Sustainable and mixed-type farmers relied less on these inputs than did conventional farmers. A shift toward sustainable agriculture may reduce the number of chemical and fertilizer input suppliers needed in a community.

Sustainable farms have been hypothesized to substitute labor for technology and capital. However, neither the number of family labor hours per week nor the number of family members employed full time differed significantly. The amount of labor the mixed-type and conventional farmers hired did differ significantly. Conventional farmers relied on hired labor more than did mixed-type farmers.

Sustainable and mixed-type farmers were more likely to have off-farm employment than were conventional farmers, although these differences did not vary significantly. Even though the national trend is toward increased off-farm employment, these opportunities may not exist for more isolated areas of North Dakota. Policies that can improve access to off-farm employment could improve the farm family's standard of living regardless of farm type.

Mixed-type and sustainable farmers had a greater percentage of full owners; however, this difference was not significant. Debt-to-asset ratios across farm types were approximately equal.

Many regional and geographic differences across North Dakota may explain the absence of more significant differences among farm types. Two farms may be classified as sustainable but have dissimilar farming systems because of differences in length of growing season, rainfall, soil type, and topography. For example, a sustainable farm in the Red River Valley may have a two-year legume-wheat rotation; the same type of farmer in western North Dakota may find the legume uses too much moisture in the rotation. This heterogeneity among farms and the large variation within farm types makes it difficult for statistical differences to emerge.

Further, 1989 data are a snapshot in time for variables such as net farm income and expenses. The type of year (i.e., precipitation, growing degree days) and prices affect these variables. Therefore, conclusions about effects of sustainability on the structure of agriculture are difficult. However, the fact that few differences are significant also may suggest that sustainable farmers might not differ in practice from conventional farmers as much as popular images of each farm type suggest.

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Appendix

APPENDIX TABLE 1. FERTILIZER, CHEMICAL, GAS, DIESEL, AND HIRED LABOR PER ACRE FROM 1969 TO 1987[a]

	1987	1982	1978	1974	1969
	dollars/acre				
Fert.& Chem.	8.00	6.59	7.22	4.93	2.53
Gas & Diesel	4.38	6.06	4.56	4.30	3.86
Hired labor	2.30	1.84	2.31	1.99	2.16

[a]All prices converted to 1987 dollars using index of prices paid by farmers, Economic Report of the President, 1989, Table b99.

SOURCE: 1987 Census of Agriculture.

APPENDIX TABLE 2. FINANCIAL CHARACTERISTICS BY FARM TYPE, 1989

	Conventional	Mixed-type	Sustainable
Respondents	181	46	24
	dollars/farm		
Assets	487,961	317,448	365,575
Debts	159,956	104,211	107,925
Equity	326,907	145,373	257,650
Debt/asset	.33	.33	.30

APPENDIX TABLE 3. LAND TENURE BY FARM TYPE, 1989*

	Conventional	Mixed-type	Sustainable
Respondents	185	54	28
	percent		
Full ownership	15.68	25.93	25.00
Own ≥ 50% farmland	32.43	31.48	28.57
Own < 50% farmland	44.86	31.48	32.14
Tenant	7.03	11.11	14.29

*Chi^2 = 7.508, not significant at P≤.05.