An Economic Analysis of the 3- and 4-Year Crop Rotations of the Wilke Project

Introduction – Policy and Economic Context. The economics of the 3- and 4-year rotations were analyzed. Explanations about the makeup of those rotations are found in the body of this report. The analysis strove to develop information useful to area producers as they made comparisons with the Wilke project results and their own practices. Additionally, the management of the financial risks in agriculture is a major challenge for all producers. Conclusions are drawn about the risks introduced by these cropping rotations.

The project began 3 years after the 1996 farm bill which was popularly called "Freedom to Farm." The 1996 bill released farmers from many of the acreage restrictions present in earlier farm bills, hence the “freedom” to farm name. Non-cereal grain crops could be grown on wheat and barley acreage without penalty from the government program. The freedom of cropping choices in “Freedom to Farm” turned loose a desire among many producers to explore alternative crops and production systems. The intent of “Freedom to Farm” also implied that producers would need to bear more of the financial risks associated with their farming operations.

The 4 years of the project were years in which prices for the commodities grown were at historical lows 3 of the 4 years and in the 4th year, prices were low, although not historically low. Wheat prices remained at or below the government loan rates for much of the marketing years of 1998–2000. As a reference, the loan rates set as part of the 1996 Farm Bill were considered to be so low that prices could not conceivably fall to those levels during the 7-year life of the farm bill. Another anomaly was that the prices of almost all commodities were low during the same time frame. One economic reason for bringing non-cereal grains into the rotation is for risk management. That is, the assumption being that if one crop’s prices are low, there is a reasonable chance others will be profitable, therefore spreading the financial price risk across several commodities. Since prices of all commodities were low during this 4-year period, there were no price risk management benefits from the non-cereal grain crops.

Markets were not well developed for all of the crops grown during the project. Well-developed markets are available for wheat, barley, corn, peas, and the oil seed crops, canola, mustard, and flax. For the other crops, finding markets was often problematic. Marketing challenges for the other crops included having only one buyer without well-established quality standards. The price quoted was often not the price received as quality issues downgraded the prices. An additional cost/risk was the need to spend significant time finding the niche markets, processing the crop into a form acceptable by those markets, or not being able to find a market at all. Our analysis does not reflect these costs.

The paradox is that well-developed markets and marketing channels usually mean highly competitive “commodity” markets, often where prices are driven by global competition. In competitive markets, being a low-cost producer is a key to profitability. Developed marketing channels for oilseeds often means securing a contract for that production and the opportunities for contracts are limited to 2 or 3 firms. Niche markets hold the possibility of higher prices, but bring additional risks and costs first to find the niche and then develop the required relationships. Unless the producer can develop a retail market directly, the production is still sold to a middle person, and there may be only 1 or 2 of those. It is not unusual to see a niche market, especially one that requires a middle person, to disappear quickly or have wide fluctuations in process from one year to the next.

Producers need to pursue niche markets and possibilities for value added to their production. The Wilke project shows how important it is to remember that there are additional risks involved. The producer needs to have the financial, management, and time resources to pursue and meet the requirements of niche markets. The economic axiom that without risk there is no reward seems to be most applicable here. It is also true that higher risks also bring the potential of larger losses. Clearly knowing the risk capacity of the farm is even more critical in the area of alternative crops, niche markets, and value added pursuits.

<u>Costing Method and Cost Assumptions</u>. The key to the economic feasibility of the direct seed, intensive crop rotations explored in this project, is ultimately the difference between the revenues and the costs to produce those revenues. The most difficult part of the economic analysis of a project of this type is developing and assigning the costs of generating that revenue. The key to realistic comparisons of the economics of the systems is how close are our estimates of the production costs to what would actually be experienced if these cropping patterns using direct seed were used across the entire farm. The experimental design of the project used plot sizes large enough that normal farm equipment could be used. This resulted in plots on cooperators' farms of about 25 acres each, and due to the need of replication on the Wilke farm, about 10 acres each there. The challenge then becomes to take information from far less than farm size and translate it into information usable for comparison with whole farm information. Ultimately, the decision about the findings depends on how each producer uses the information to compare with his or her own operation and the accuracy of his or her cost information.

The economic analysis was neither intuitive nor straightforward. The old joke about economists needing 2 arms to make any decision, depending on the assumptions or potential conditions, is very true here. Yield, inputs used per acre, and input costs were straightforward to record and collect. Yet, a *usable* analysis of the economics of the crop rotations must include an allocation of equipment costs and labor, items for which cooperator data was not easily broken out for the plots.

Assumptions were needed about equipment usage as if the rotations were being used across the entire farm. The information needed to build the equipment use assumptions was collected from seven different farm operations with various land ownership and leasing patterns, very different equipment complements, and record systems.

Crop enterprise budgets are widely used to compare the costs and profitability of crop production within an agronomic growing area. The budgets are developed by estimating the costs of the equipment operations, fixed costs, land costs, return to management, etc., through an economic "engineering" process. The background information for that process is developed through the interview of a panel of producers who are brought together to discuss their operations, costs, equipment, and other aspects of their farm operations. The enterprise budget developer then creates a "representative" farm and develops operational costs around that farm size and the typical operations of that farm as shaped by the information provided by the panelists. The analysis used for this report modifies that process as identified below.

Rather than develop a “typical farm,” an analysis was engineered for each individual cooperator using specific yields, prices, input, and input costs derived from each individual plot. The equipment costs were engineered using cooperators' information to build equipment use assumptions. Information was provided by each cooperator on his or her equipment usage, maintenance experience, and field operations. We asked about equipment speed, breakdown experience, time down for small, in-field repairs, and other items influencing use efficiency of equipment. Additionally, information was provided about purchase price or present value of equipment if known. Area equipment and input dealers were surveyed on equipment values, fuel and maintenance cost estimates, such as typical time between overhauls of the engine on a particular model tractor, etc. One cooperator had very detailed records on all equipment costs and maintenance, and that information was used to shape our equipment maintenance assumptions. Since most of the direct seed drills were relatively new, maintenance costs were low. Discussions were held with longer-time direct seed operators and with equipment dealers to build a reasonable assumption about drill maintenance costs.

The actual calculation of the equipment costs was developed using a University of Idaho software program. The program, *Machine Cost* by LeRoy Stodick and Robert Smathers, Department of Agricultural Economics, University of Idaho, March 1994, uses industry standards and engineering information for the built-in equipment operation and cost parameters. Individual information can be substituted for the industry based parameters built into the program to generate equipment cost information more specific to an individual operation.

To create the equipment use assumptions we made another very large leap. The analysis assumes that the crop rotations in the plots were used across the entire farm. From this assumption, we would assign usage for the direct seed drill, spray rigs, fertilizer equipment if separate from the drill, and develop an annual hourly use for the tractors and combines. This is most critical in developing a cost estimate for the direct seed operations.

Assuming the application of the rotation across the entire farm is a very large assumption and likely far removed from reality as most farmers would make this transition in stages. The whole farm assumption seemed the only way to develop any reasonable estimate for the per acre costs of production.

One of the key cost items in the transition to direct seeding is the cost of the direct seed drill which, almost in every case, is much higher in price than the conventional drills they replace. It is also true that most direct seed drills take high horsepower tractors. The direct seeding costs per acre can vary dramatically depending on the number of acres a direct seed drill is used to seed annually, assuming the annual depreciation/replacement costs are allocated across the acres seeded in that year. The inverse is that each year's crop needs to pay for that portion of the equipment used that year. Normal practice has been to replace equipment when there was a good crop or price year. The authors believe that there will be fewer very good years in agriculture so capital replacement must be a regular part of the farm business plan.

Developing a way to reasonably allocate a cost for the direct seeding operation would make a difference on the final outcome of the economic analysis. A poorly utilized direct seed drill would cost significantly more on a per acre basis than all of the field operations it replaces in crop-fallow system; in fact, a highly utilized drill might still cost more than the field operations it replaces.

It was beyond the scope of this study to address the transition costs to direct seed which can be significant both in terms of learning how to manage the new production practices, weed management, marketing skills, and equipment costs. An added cost during the transition comes from utilizing 2 very different kinds of equipment complements, each at less than the optimal amount. This is less a problem cost wise for conventional equipment, much of which has been depreciated out and has little resale value, especially as the transition to direct seeding accelerates. The key issue is the underutilization of the new direct seed drill which can cost from $50,000 to close to $100,000, depending on size, air carts, etc.

The development of the equipment costs for this project assumes that the transition has been made to direct seed. We did not consider the cost of maintaining surplus equipment or a dual equipment complement, an item that any farmer making the transition should consider, especially if he or she is still making payments on conventional tillage implements that are not used in direct seed operations. Another possible cost not considered was the possible rapid depreciation in value of certain direct seed drills as new, better models are introduced that meet area conditions.

The focus of the economic analysis are the variable costs including *all* equipment costs. Variable production costs are those costs which change depending on whether a crop is planted or not and what crop is planted. The analysis does not consider net rent or return on the land investment, returns to management, and other findings involving inclusion of fixed costs, returns on investment, or borrowed capital costs (interest on replacement costs for equipment being the exception). These are costs which vary widely from farm to farm depending on location, debt, production, and other variables. Our sample size was too small to make any generalizations about these costs, and an individual farm situation could have skewed the finding. The need for confidentiality on debt would have been impossible to keep given this small sample size. To put these omissions in perspective, interest on operating capital and overhead would likely run another $8 to $17 an acre. Net land rent, a proxy for an expected return on land investment, would run from $15 to $40 an acre, depending on the productivity of the land in question. (WSU crop enterprise budgets, various years).

To use all equipment costs as variable costs, all equipment costs, fixed and variable, were translated into a variable, per hour of use basis. We assumed that a piece of equipment had a finite life in hours of use before overhaul was required. The cost of each of those hours are consumed as a variable cost including allocating annual maintenance and depreciation/replacement, and interest costs to each of those hours used. Key information we gathered from each cooperator were the number of hours each tractor and combine were used, purchase prices, or if fully depreciated out, a replacement cost was found by calling several equipment dealers in the area. These prices were updated annually. Maintenance costs, interest rates, equipment speed, width, and fuel and oil prices were gathered. All of this information was used to modify the engineered parameters in the *Machine Cost* program.

The exception to this was harvest trucking costs. The truck fleet being used by most cooperators was fully depreciated out (i.e., older trucks), had low mileage use each year, and maintenance costs were difficult to obtain. Since the trucking costs for most crops would not be different than the harvest trucking costs, i.e., field to elevator or farm storage, in the area, a trucking cost was derived from enterprise budgets previously published by WSU. Table 9 shows the results for 1 year of the 4-year rotation on the Wilke farm and is typical of what was developed for each cooperator each year. This information was provided to each cooperator each year.

Table 9. Wilke Farm 1998 4-Year Rotation.

Crop	Sp Wheat		Millet		Sp Barley		Safflower	Average
	Alpowa		Colorado Red		Meltan		McKay Seed	
Variable Input Costs								
Seed	$ 11.00		$ 2.80		$ 9.10		$ 15.20	$ 9.53
Fert.	$ 31.70		$ 16.00		$ 19.87		$ 8.00	$ 18.89
Herbicide	$ 10.05		$ -		$ 10.70		$ -	$ 5.19
Insecticide								$ -
Fuel/Lube	$ 2.99		$ 2.43		$ 2.99		$ 2.43	$ 2.71
Total Variable Input Costs	$ 55.74		$ 21.23		$ 42.66		$ 25.63	$ 36.32
								$ -
*Labor	$ 4.41		$ 3.77		$ 4.41		$ 3.77	$ 4.09
								$ -
**Trucking	$ 4.88		$ 4.88		$ 4.88		$ 4.88	$ 4.88
								$ -
Equipment Costs (tractor, drill, harrow, sprayer, combine)								$ -
Replacement Cost	$ 18.49		$ 17.49		$ 18.53		$ 17.49	$ 18.00
Repairs/Maintenance	$ 8.01		$ 7.65		$ 8.01		$ 7.65	$ 7.83
Total Equip. Costs	$ 26.50		$ 25.14		$ 26.54		$ 25.14	$ 25.83
								$ -
Taxes/Housing	$ 3.20		$ 3.10		$ 3.20		$ 3.10	$ 3.15
								$ -
Yield	31.22 bu		596 #		1.44T		593#	$ -
Price	$2.67		$ 0.08		84/T		$0.08	$ 0.71
Revenue/acre	$ 83.36		$ 47.68		$ 120.96		$ 47.44	$ 74.86
								$ -
Revenue less variable input costs	$27.67		$26.45		$78.30		$21.81	$ 38.56
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	-$11.37		-$10.44		$39.27		-$15.08	$ 0.60
List of Operations:	Herb Spray	Harvest	Seed/Fert.		Herb Spray	Harvest	Herb Spray	Trucking
	Seed/Fert.	Trucking	Trucking		Seed/Fert.	Trucking	Seed/Fert.	
	Herb Spray		Harvest		Herb Spray		Harvest	

*Estimate developed from previous Wilke farm data.

Price Assumptions. A key source of area farmers' incomes during these low-price years were government payments. Most government payments have been decoupled from production. That is, the payment has no relationship to the amount produced in a given year nor does it relate to the price received that year. The exception being LDP's (Loan Deficiency Payments) which are tied not only to prices and the government loan rate, but also to a farmer's production. Our revenue data does not take into account government payments except for LDP's as noted below.

Establishing the price received can be elusive especially when cooperators market over the year and co-mingle the grain from the plots with the rest of their production (yields are measured for each plot, at harvest, in the field using either a weigh wagon or large portable scales). As a result, our cereal grain price information is based on the local price at harvest plus the LDP if applicable which is in effect the county loan rate. For non-cereal grain crops for which there was no established market, the price was the actual price received. These included millet and sunflowers. Oil seed crops were priced at the contract price plus LDP if one was available and applicable.

Results. This was a systems research project. That is, our goal was to view each rotation in whole as a system. The hope being that the combined nature of the crops in the rotation would lead to synergism that would allow reduced weeds, diseases, risk management, and increases in yields of cereals grains following non-cereal crops due to disease repression. The profitability of the combined "whole" is what we were interested in. We present that summary next, but also make comparisons among individual crops.

Table 10 shows the average for each of the rotations for the 4 years of the project. In each year except 2000, the 3-year rotation did better than the 4-year rotation. In 2000, the difference was a cost issue as fertilizer and herbicide costs ran considerably higher in the 3-year rotation than in the 4-year rotation. Revenue in the 3-year rotation was higher, but the higher costs more than offset the revenue difference.

Table 10. Average of All 3- and 4-Year Rotations, 1998 - 2001

	1998		1999		2000		2001	
	Avg for 4 year Rotation	Avg for 3 year rotation	Avg for 4 year Rotation	Ave for 3 year rotation	Avg for 4 year Rotation	Avg for 3 year rotation	Avg for 4 year Rotation	Avg for 3 year rotation
Variable Input Costs								
Seed	$ 10.29	$ 11.00	$ 11.94	$ 13.59	$ 10.56	$ 11.97	$ 13.60	$ 16.26
Fertilizer	$ 21.46	$ 23.59	$ 14.68	$ 17.32	$ 15.29	$ 19.89	$ 22.25	$ 22.71
Herbicide	$ 9.41	$ 15.20	$ 14.16	$ 23.60	$ 16.23	$ 26.08	$ 19.73	$ 27.21
Insecticide			$ 1.41	$ 0.64	$ 1.38	$ 0.62		
Custom	$ 1.20	$ 2.00		$ 0.27	$ 3.23	$ 4.13	$ 1.25	$ 2.50
Fuel/Lube	$ 3.39	$ 2.34	$ 4.84	$ 5.33	$ 5.37	$ 4.50	$ 3.34	$ 3.54
Total Variable Input Costs	$ 45.75	$ 54.13	$ 46.62	$ 60.72	$ 52.05	$ 67.18	$ 60.17	$ 72.22
*Labor	$ 5.12	$ 3.77	$ 3.46	$ 3.06	$ 3.59	$ 3.49	$ 3.22	$ 2.94
**Trucking	$ 4.88	$ 4.88	$ 4.88	$ 4.88	$ 4.88	$ 4.88	$ 4.88	$ 4.88
Equipment Costs (Tractor, drill, harrow, sprayer, combine)								
Replacement Cost	$ 17.65	$ 13.61	$ 19.75	$ 16.36	$ 21.28	$ 17.62	$ 18.42	$ 18.91
Repairs/Maintenance	$ 6.20	$ 5.64	$ 7.51	$ 7.38	$ 4.12	$ 5.70	$ 7.86	$ 9.76
Total Equip Costs	$ 23.85	$ 19.25	$ 27.26	$ 23.74	$ 25.40	$ 23.31	$ 26.28	$ 28.66
Taxes/Housing	$ 2.69	$ 2.29	$ 3.02	$ 2.13	$ 2.96	$ 2.27	$ 2.84	$ 3.28
Revenue/acre	$ 89.05	$ 94.14	$ 84.00	$ 99.69	$ 98.44	$102.55	$ 66.57	$ 102.43
Revenue less variable input	$ 43.31	$ 39.98	$37.39	$39.28	$50.75	$ 35.37	$ 12.18	$ 30.22
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	**$ 6.76**	**$ 9.85**	**-$1.22**	**$5.25**	**$17.02**	**$5.03**	**-$23.91**	**-$9.54**

* Labor calculated at $10 per hour, primarily operating time for field equipment

**Trucking cost "engineered"/ estimated from area enterprise budgets.

In general, cereal grains performed better financially than the non-cereals in the rotations (Table 11). There were 2 individual year crops of non-cereal grains that performed well, Canola in 1998, when it was grown only by 1 cooperator, and buckwheat in 1999. It was grown only 1 year and had a very small niche market that was developed by that cooperator. These niches are available and require developing marketing skills beyond those used in commodity marketing. In general, producing crops for which there is no developed marketing channel is a riskier proposition, but this was one example of success. Our millet was an example in frustration, both in production and marketing.

Table 11. Net Results for Individual Crops, Average across Years.

CROP	# of Years In Project	Revenue less Variable Input Costs (Average)	Revenue less Variable Input Costs, Labor, Equipment & Harvest (Average)
Winter Wheat	4	$73.69	$53.55
Spring Wheat	4	$56.37	$20.28
Spring Barley	4	$44.44	$8.60
Canola	4	$42.81	$3.00
Millet	4	$6.12	($32.05)
Mustard	2	$22.27	($16.48)
Peas	2	($26.99)	($63.79)
Sunflower	2	$18.58	($18.99)
Safflower	1	$0.36	($29.40)
Buckwheat	1	$92.41	$50.30
Corn	1	($40.67)	($79.67)
Flax	1	$26.50	$6.35
Oats	1	$10.30	($35.36)

The 4-year rotation had more non-cereals in the rotation, which lowered the net returns for the rotation. Warm season grasses, whether millet or corn, did not perform well and as the 4-year rotation included a warm season grass, which brought down the average for the rotation. One hypothesis of the rotations was that following 2 years out of cereals, there should be a rise in the production of the following cereal grain due to disease depression. This phenomenon did not appear in the data with the exception of wheat following sunflowers and the increase was not enough to offset the financial loss from the sunflowers so a net loss was realized. One observation based on the conditions present during this project is that the dominance of cereal grains in eastern Washington is not the result of irrational economic decisions.

In the absence of any measurable economic benefits to wheat and barley following 2 years out of cereals production, the information in Table 10 suggests that at most, 1 year out of 3 should be in a non-cereal crop. This, of course, would change if the profitability of the non-cereals were to improve. An unpublished report on oil seed production south of our project area, but in a similar rainfall zone, where yields were considerably better than ours and prices higher, indicate that even with higher yields and higher oil seed prices, only one of the 15 producers participating had raised an oil seed crop profitably (Hinman et. al, 2003).

There was wide variety in yields within years and across years. In 1998, spring wheat yields varied across cooperators between 31 and 50 bushels an acre (Tables 12A-12B). Spring barley yields varied from 1.36 tons per acre to 1.94 tons per acre. Millet yields varied between 400 and 800 lbs. per acre. Canola ranged in yield from 840 lbs. per acre in 2001, to 1570 lbs. per acre in 1998 (Tables 13 through 15). The 1998 canola crop price was $0.11 per pound and had the largest net over variable costs of any of the individual crops in any year. The average over the 4 years though was only $3 per acre, best of any of the other oil seed crops, but still well below the cereal grains. Since each faced roughly the same price in a given year (something that held true for the years in question, but might not in years with more price variation), the cooperators generated very different revenues from similar crops. The issue then for each producer is the net between the costs and those revenues.

The same was true for all years with a spread in input costs, primarily fertilizer and herbicides, between producers. The fertilizer differences reflect different application rates depending on yield expectations. Yield expectations are higher with a higher rainfall average, lower in traditionally dryer areas. The prices individual farmers are able to negotiate for inputs depends on the amount they purchase and whether they have their own application equipment. The spread in herbicide costs was primarily caused by timing issues, spraying too early and needing to spray again, or having to use extra sprays to compensate for the lack of effective weed control in a preceding crop for which there had been no registered herbicide. Until weed populations are stabilized, an assumption that will happen over time with direct seed and using different rotations, it is difficult to make firm conclusions about the economics of the system. As identified in the main project report, weed population changes were noted, but we had not experienced any stability in those populations nor were there clear conclusions that could be drawn about weed control, a significant cost of production.

Table 12A. 1998 Crops, Average Costs and Revenues, and Range of Costs and Revenues.

Variable Input Costs	Spring Wheat	Range of Input Cost	Spring Barley	Range of Input Cost	Canola	Winter Wheat
Seed	$ 10.37	$9.1-11.00	$ 8.57	$7.7-9.10	$ 25.65	$ 10.40
Fert.	$ 28.54	20.93-31.70	$ 22.86	19.87-31.70	$ 20.93	$ 28.84
Herbicide	$ 10.59	10.05-11.72	$ 13.53	10.70-22.70	$ 5.05	$ 31.43
Insecticide						
Custom	$ 3.00	$ 12.00	$ 0.72	$ 2.88		
Fuel/Lube	$ 3.38	1.97-5.59	$ 2.48	1.97-2.99	$ 3.18	$ 1.76
Total Variable Input Costs	$ 55.90		$ 48.18		$ 54.81	$ 72.43
*Labor	$ 4.79	$3.28-7.69	$ 3.84	$3.28-4.41	$ 4.66	$ 3.37
**Trucking	$ 4.88		$ 4.88		$ 4.88	$ 4.88
Equipment Costs (tractor, drill, harrow, sprayer, combine)						
Replacement Cost	$ 15.75	10.46-21.96	$ 14.73	10.46-18.53	$ 17.39	$ 10.63
Repairs/Maintenance	$ 6.67	3.15-8.02	$ 5.70	3.15-8.01	$ 3.71	$ 3.37
Total Equip. Costs	$ 22.41		$ 20.42		$ 21.10	$ 14.00
Taxes/Housing	$ 2.48	1.44-3.11	$ 2.40	1.44-3.2	$ 2.22	$ 1.70
Yield	35.78 bu	31-49.72	1.54 T	1.36-1.94T	1570#	60.6 bu
Price	$ 2.67	2.60-2.7	84.25/T	84-85 T	$ 0.11	$ 2.77
Revenue/acre	$ 95.60		$ 130.12		$ 172.70	$ 167.87
Revenue less variable input costs	$39.71		$81.94		$117.89	$95.44
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	$4.61		$50.36		$85.03	$71.49

*Labor calculated at $10 per hour primarily operating time for field equipment.
**Trucking cost "engineered"/estimated from area enterprise budgets.

Table 12B. 1998 Crops, Average Costs and Revenues, and Range of Costs and Revenues (continued).

Variable Input Costs	Millet	Range of Input Cost	Mustard	Range of Input Cost	Safflower	Range of Input Cost	Oats
Seed	$ 4.53	1.75-9.04	$ 14.38	12.5-16.25	$ 13.38	11.55-15.20	$ 8.54
Fert.	$ 18.55	13-26.65	$ 27.38	14.75-40	$ 11.26	8-14.52	$ 29.85
Herbicide	$ 5.05	4.50-10.64	$ 10.33	9.16-11.50	$ 2.72	$ 5.44	$ 11.72
Insecticide							
Custom	$ 3.84	$ 11.50					
Fuel/Lube	$ 3.09	2.43-3.87	$ 3.70	2.71-4.68	$ 2.01	1.58-2.43	$ 5.59
Total Variable Input Costs	$ 34.72		$ 55.79		$ 29.37		$ 55.70
*Labor	$ 5.25	3.77-7.62	$ 5.33	4.09-6.57	$ 3.42	3.06-3.77	$ 7.69
**Trucking	$ 4.88	$ 4.88	$ 4.88		$ 4.88	$ 4.88	$ 4.88
Equipment Costs (tractor, drill, harrow, sprayer, combine)							
Replacement Cost	$ 18.38	16.98-20.66	$ 18.97	17.99-19.95	$ 13.75	10.01-17.49	$ 21.96
Repairs/Maintenance	$ 5.81	3.61-7.65	$ 7.55	7.26-7.83	$ 5.40	3.15-7.65	$ 8.02
Total Equip Costs	$ 24.19		$ 26.52		$ 19.15		$ 29.98
Taxes/Housing	$ 2.88	2.18-3.35	$ 3.00	2.85-3.15	$ 2.37	1.63-3.10	$ 3.11
Yield	598.7#	400-800#	531.5#	513-550#	346.5#	100-593#	1650#
Price	$ 0.07	.07-.08	$ 0.125	0.125	$ 0.11	.081-.12	$ 0.04
Revenue/acre	$ 43.89		$ 66.44		$ 29.72		$ 66.00
Revenue less variable input costs	$9.18		$10.58		$0.36		$10.30
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	-$28.02		-$29.06		-$29.40		-$35.36

*Labor calculated at $10 per hour primarily operating time for field equipment.

**Trucking cost "engineered"/estimated from area enterprise budgets.

There were only 3 times in the rotations that non-cereal grains showed a positive return above our version of variable costs during the Canola in 1998 (grown all 4 years), flax in 2000 (only year), and buckwheat in 1999 (1 year only). The individual years for each crop are shown in Tables 12A&B above and Tables 13A&B, 14A&B, 15A&B below. The across-year average for crops is shown in Table 11 above. Spring wheat had positive returns above variable costs in each of the years and averaged $20.28 above variable costs. Barley was positive all years except 2001 when exceptionally high herbicide costs were experienced on the Wilke Farm because of spray timing issues. The 4-year average was $8.60 above variable costs. Winter wheat (re-cropped) showed positive returns each year it appeared in the rotation, averaging the highest of any individual crop at $53.55 an acre above variable costs.

While land costs, returns to management, fixed costs except for equipment were not calculated, using information from other studies cited earlier, no practical combination of crops in a 4-year or 3-year rotation would have showed returns adequate to fully cover all costs. The average for the 3- and 4-year rotations as shown in Table 10, show negative returns in 2001 for both rotations, and in 1999 for the 4-year rotation. Across the 4 years, revenues per acre would have to have increased on average some $40 to $50 an acre to cover total farm costs.

On average, across the project, this would mean wheat prices in the $4 to $4.25 a bushel range or some combination of increased yields and prices. Non-cereal grain yields in general were disappointing. Lack of rain and heat during key periods was primarily responsible. Whether this is a short-time phenomenon or longer-term pattern is not known. The spring rains are critical to the success of any spring crop, but especially the non-cereal grain crops. The yields experienced during the project are below area expectations and those experienced and recorded in other studies in the area. The Hinman et al., 2003 oilseeds study, with both higher yields and higher prices, does not provide much more optimism though for the oilseeds in the rotation.

Table 13A. 1999 Crops, Average Costs and Revenues, and Range of Costs and Revenues.

Variable Input Costs	Spg Wheat	Range of Input Cost	Spg Barley	Range of Input Cost	Canola	Range of Input Cost	Winter Wheat
Seed	$ 9.13	8.66-9.8	$ 9.40	6.30-10.95	$ 31.05	25-40.91	$ 8.65
Fert.	$ 15.09	10.75-20.13	$ 16.31	14.88-19.16	$ 20.94	18.29-25.37	$ 20.12
Herbicide	$ 20.15	7.18-36.34	$ 27.35	9.36-36.34	$ 15.76	5.94-23.97	$ 15.84
Insecticide					$ 6.92	3.81-16.95	
Custom					$ 0.53	$ 1.58	
Fuel/Lube	$ 4.70	3.49-6.46	$ 5.37	3.2-6.46	$ 5.49	4.93-6.46	$ 4.15
Total Variable Input Costs	$ 49.07		$ 52.36		$ 80.68		$ 48.76
*Labor	$ 2.98	2.18-3.91	$ 3.49	2.65-3.91	$ 3.17	2.46-3.91	$ 2.34
**Trucking	$ 4.88	$ 4.88	$ 4.88	$ 4.88	$ 4.88	$ 4.88	$ 4.88
Equipment Costs (tractor, drill, harrow, sprayer, combine)							
Replacement Cost	$ 16.56	12.5-19.22	$ 19.66	19.22-20.55	$ 22.89	15.51-33.94	$ 13.11
Repairs/Maintenance	$ 7.13	3.55-8.69	$ 7.25	4.56-8.6	$ 9.11	6.99-11.73	$ 3.92
Total Equip. Costs	$ 23.69		$ 26.92		$ 32.00		$ 17.03
Taxes/Housing	$ 2.42	1.15-3.04	$ 2.87	2.54-3.04	$ 3.15	1.31-5.11	$ 1.23
Yield	35.95 bu	29.8-48.5 bu	1.38 T	1.21-1.72T	1020.67	1000-1051	54 bu
Price	$ 2.79		70.53 T		.07/#		$ 2.77
Revenue/acre	$ 100.08		$ 97.75		$ 74.30		$ 149.58
Revenue less variable input costs	$51.02		$40.46		-$6.21		$100.82
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	$17.05		$2.30		-$49.58		$75.34

*Labor calculated at $10 per hour primarily operating time for field equipment.

**Trucking cost "engineered"/estimated from area enterprise budgets.

Table 13B. 1999 Crops, Average Costs and Revenues, and Range of Costs and Revenues (continued).

Variable Input Costs	Millet	Range of Input Cost	Mustard	Buckwheat
Seed	$ 5.25	4.00-7.88	$ 16.25	$ 8.00
Fert.	$ 12.81	8.52-19.16	$ 8.52	$ 10.75
Herbicide	$ 9.30	4.68-12.03	$ 11.20	$ 4.68
Insecticide				
Custom				
Fuel/Lube	$ 4.67	3.2-5.77	$ 5.77	$ 5.03
Total Variable Input Costs	$ 32.16		$ 41.74	$ 28.46
*Labor	$ 3.75	2.87-4.83	$ 3.56	$ 4.83
**Trucking	$ 4.88	$ 4.88	$ 4.88	$ 4.88
Equipment Costs (tractor, drill, harrow, sprayer, combine)				
Replacement Cost	$ 18.80	17.84-19.98	$ 18.57	$ 19.98
Repairs/Maintenance	$ 7.22	4.65-9.12	$ 7.88	$ 9.12
Total Equip. Costs	$ 26.01		$ 26.45	$ 29.10
Taxes/Housing	$ 2.95	2.57-3.30	$ 2.97	$ 3.30
Yield	872#	486-1080#	757#	1051#
Price	$ 0.06		.1/#	.115/#
Revenue/acre	$ 47.96		$ 75.70	$ 120.87
Revenue less variable input costs	$15.81		$33.96	$92.41
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	-$21.80		-$3.90	$50.30

*Labor calculated at $10 per hour primarily operating time for field equipment.
**Trucking cost "engineered"/estimated from area enterprise budgets.

Table 14A. 2000 Crops, Average Costs and Revenues, and Range of Costs and Revenues.

Variable Input Costs	Spring Wheat	Range of Input Cost	Spg Barley	Range of Input Cost	Canola	Winter Wheat	Range of Input Cost
Seed	$ 8.69	8.17-10.00	$ 9.40	7.44-12.00	$ 13.38	$ 9.48	8.43-10.00
Fert.	$ 21.07	17.86-23.97	$ 21.74	17.86-28.95	$ 20.02	$ 19.84	18.37-22.78
Herbicide	$ 17.61	7.40-44.88	$ 25.58	8.45-44.88	$ 19.65	$ 27.37	11.79-35.16
Insecticide					$ 8.46		
Custom	$ 0.75	$ 3.00	$ 1.00	$ 3.00	$ 15.75	$ 9.33	$ 14.00
Fuel/Lube	$ 6.96	3.30-8.39	$ 4.98	3.30-7.76	$ 3.30	$ 1.93	1.42-2.96
Total Variable Input Costs	$ 55.28		$ 62.69		$ 80.56	$ 67.95	
*Labor	$ 4.35	4.21-4.45	$ 4.19	3.92-4.45	$ 4.45	$ 2.00	1.21-3.57
**Trucking	$ 4.88		$ 4.88		$ 4.88	$ 4.88	
Equipment Costs (tractor, drill, harrow, sprayer, combine)							
Replacement Cost	$ 25.20	23.11-26.24	$ 21.18	15.24-25.19	$ 23.11	$ 12.11	11.18-13.97
Repairs/Maintenance	$ 4.05	2.30-7.49	$ 5.59	4.09-7.49	$ 4.09	$ 4.20	3.85-4.90
Total Equip. Costs	$ 29.24		$ 26.77			$ 16.31	
Taxes/Housing	$ 3.64	3.35-3.76	$ 3.08	2.20-3.68	$ 3.35	$ 1.90	1.82-2.07
Yield	49.59 bu	45-53 bu	1.74 T	1.4-2.36 T	1528#	51.19 bu	46-54.17 bu
Price	$ 2.84		73.33/T		$ 0.075	$ 2.84	
Revenue/acre	$ 140.82		$ 127.60		$ 114.60	$ 145.39	
Revenue less variable input costs	$85.54		$ 64.90		$34.35	$77.43	
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	$43.44		$5.98		-$5.53	$52.34	

*Labor calculated at $10 per hour primarily operating time for field equipment.

**Trucking cost "engineered"/estimated from area enterprise budgets.

Table 14B. 2000 Crops, Average Costs and Revenues, and Range of Costs and Revenue (continued).

Variable Input Costs	Millet	Range of Input Cost	Peas	Sunflowers	Range of Input Cost	Flax
Seed	$ 4.09	2.40-7.00	$ 30.00	$ 25.00	$ 25.00	$ 3.97
Fert.	$ 11.51	6.97-13.99	$ 8.38	$ 10.75	7.50-13.99	$ 23.00
Herbicide	$ 9.42	5.28-12.96	$ 18.22	$ 30.46	6.76-30.46	$ 23.01
Insecticide			$ 3.68	$ 4.05	$ 8.10	
Custom	$ 1.00	$ 3.00	$ 7.75	$ 1.50	$ 3.00	
Fuel/Lube	$ 5.51	3.07-7.76	$ 7.76	$ 7.52	6.11-8.92	$ 3.20
Total Variable Input Costs	$ 31.53		$ 75.79	$ 67.42		$ 53.18
*Labor	$ 3.77	3.02-4.21	$ 4.21	$ 4.19	3.21-5.16	$ 3.81
**Trucking	$ 4.88		$ 4.88	$ 4.88		$ 4.88
Equipment Costs (tractor, drill, harrow, sprayer, combine)						
Replacement Cost	$ 22.33	18.79-25.24	$ 25.19	$ 26.59	19.60-33.57	$ 14.92
Repairs/Maintenance	$ 4.38	1.65-7.49	$ 7.49	$ 6.04	1.86-10.21	$ 5.23
Total Equip. Costs	$ 26.70		$ 32.68	$ 36.62		$ 20.15
Taxes/Housing	$ 2.64	1.65-3.33	$ 1.65	$ 3.98	2.93-5.03	$ 2.17
Yield	508 #	174-850 #	791.64#	1076 #	1000-1152	960#
Price	$ 0.06	0.06	.055/#	.06/#	.04-.08***	.083/#
Revenue/acre	$ 32.15		$ 43.54	$ 63.03		$ 79.68
Revenue less variable input costs	-$1.04		-$32.25	-$2.42		$ 26.50
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	-$38.43		-$64.93	-$38.56		$ 6.35

*Labor calculated at $10 per hour primarily operating time for field equipment.
**Trucking cost "engineered"/ estimated from area enterprise budgets.
*** $0.04 is an estimate as sunflowers were used for hog feed when no market was available.

Table 15A. 2001 Crops, Average Costs and Revenues, and Range of Costs and Revenue.

Variable Input Costs	Spring Wheat	Range of Input Cost	Spring Barley	Canola	Range of Input Cost	Winter Wheat	Range of Input Cost
Seed	$ 10.75	8.51-16.00	$ 11.00	$ 17.68	16.55-18.80	$ 10.54	8.13-11.87
Fert.	$ 25.29	23.50-28.51	$ 28.21	$ 23.84	23.06-24.61	$ 30.57	19.61-39.02
Herbicide	$ 24.72	12.00-32.48	$ 39.60	$ 14.56	7.43-21.69	$ 29.25	7.63-42.00
Insecticide							
Custom	$ 1.50	$ 7.50	$ 7.50			$ 3.75	0-7.50
Fuel/Lube	$ 2.98	2.39-3.75	$ 2.39	$ 4.21	3.75-4.67	$ 2.98	2.39-3.75
Total Variable Input Costs	$ 65.18		$ 88.70	$ 60.28		$ 77.08	
*Labor	$ 2.86	2.15-4.04	$ 2.15	$ 4.53	3.25-5.81	$ 2.83	2.15-3.77
**Trucking	$ 4.88		$ 4.88	$ 4.88		$ 4.88	
Equipment Costs (tractor, drill, harrow, sprayer, combine)							
Replacement Cost	$ 17.32	14.95-18.99	$ 18.01	$ 22.21	18.81-25.61	$ 18.27	18.01-18.81
Repairs/Maintenance	$ 9.69	2.68-13.35	$ 6.98	$ 7.94	3.68-12.20	$ 7.16	2.47-12.20
Total Equip. Costs	$ 27.01		$ 24.99	$ 30.15		$ 25.43	
Taxes/Housing	$ 2.74	2.26-3.35	$ 3.06	$ 3.57	3.35-3.79	$ 3.02	2.6-3.35
Yield	37.89	30.94-56	1.02 T	840.00	755-925#	38.99 BU	32.77-46.5
Price	$ 3.34	3.23-3.45	82/T	$ 0.110	.1-.11	$ 3.29	3.25-3.30
Revenue/acre	$ 126.42		$ 83.64	$ 85.50		$ 128.15	
Revenue less variable input costs	$61.25		-$5.06	$25.21		$51.07	
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	$23.75		-40.14	-$17.92		$15.02	

*Labor calculated at $10 per hour primarily operating time for field equipment.

**Trucking cost "engineered"/estimated from area enterprise budgets.

Table 15B. 2001 Crops, Average Costs and Revenues, and Range of Costs and Revenue (continued).

Variable Input Costs	Millet	Range of Input Cost	Peas	Range of Input Cost	Sun-flower		Corn
Seed	$ 2.75	2.50-3.00	$ 34.00	$ 34.00	$ 25.00		$ 20.00
Fert.	$ 21.48	18.35-24.61			$ 11.00		$ 25.00
Herbicide	$ 5.95	5.00-6.90	$ 16.40	$ 16.40	$ 28.00		$ 18.00
Insecticide							
Custom							
Fuel/Lube	$ 4.00	3.38-4.61	$ 5.17	$ 5.17	$ 2.67		$ 2.67
Total Variable Input Costs	$ 42.85		$ 55.57	$ 55.57	$ 66.67		$ 65.67
*Labor	$ 3.29	2.8-3.77	$ 3.59	$ 3.59	$ 2.55		$ 2.55
**Trucking	$ 4.88		$ 4.88	$ 4.88	$ 4.88		$ 4.88
Equipment Costs (tractor, drill, harrow, sprayer, combine)							
Replacement Cost	$ 19.36	18.26-20.45	$ 20.97	$ 20.97	$ 15.85		$ 15.85
Repairs/Maintenance	$ 5.12	2.47-7.76	$ 7.99	$ 7.99	$ 13.35		$ 13.35
Total Equip. Costs	$ 24.47		$ 28.96	$ 28.96	$ 29.20		$ 29.20
Taxes/Housing	$ 3.02	2.6-3.44	$ 34.00	$ 34.00	$ 2.37		$ 2.37
Yield	578 #	356-800 #	541.5 #	541-542	850 #		500#
Price	*.06		$0.0625		0.125		.05/LB
Revenue/acre	$ 34.68		$ 33.85		$ 106.25		$ 25.00
Revenue less variable input costs	$0.51		-$21.72		$ 39.58		-$40.67
Revenue less variable cost+ labor+ Equipment + Trucking (Harvest Haul)	-$35.40		-$62.65		$ 0.58		-$79.67

Lessons Learned and Observations

Risk Management. The results of this project indicate that the introduction of non-cereal grain crops increases the risks of both price and yield to the farm. The hoped-for price risk mitigation from diversifying the cropping base was not experienced during this project as all prices were depressed at the same time. Yield risk from lack of moisture and heat to the non-cereal grains appears to be greater than to the cereal grains that are adapted to this area. Wheat and barley continued to be the least-risk crops and while prices were very low, their returns over costs were still above all viable alternatives.

Benefits to Wheat following Alternatives. Again, with the exception of sunflowers, the project did not identify any measurable increases in yields in wheat following a non-cereal grain crop. The losses associated with the sunflowers took away any possible gain from the increased production of wheat following the sunflowers. Given the increased risk introduced to the farm from the non-cereal grain crops, other alternatives should be explored. One issue not explored was whether the farm would be better off with canola or chemical fallow in the 3-year rotation. Canola appears to have the highest probability of profitability of any of the alternative crops but it was not compared with the costs of a chemical fallow in the 3-year rotation. The expectation with chemical fallow is/was that weed population improvements could be made with chemical fallow. (This was being tested in 2000.) It should be noted that there are producers in the area who have produced canola profitably for years. It should also be noted that there is no certainty in prices. Using 3 cereals in a 4-year rotation also has merit although this study was not long enough to make a sound analysis of that option. The low price patterns experienced during the project hopefully will not repeat themselves.

Crops for Which There Are No Developed Marketing Channels. Growing crops for which there are no developed marketing channels introduces increased costs and much higher price risks to the farm. Farm managers should consider these alternatives only after carefully exploring the marketing possibilities and identifying a market. It would be wise to wade in rather than jump in with crops with no developed market channels. While niche markets offer the potential for higher returns to the farm, farms should carefully ascertain if the time to pursue these markets is available. A key factor will be whether there are available within the management team the skills necessary to negotiate price, quality, delivery, guaranteed payment on delivery, etc. There often are additional transportation costs for not well-developed markets as the delivery point may be several hundred miles away. Many of the costs associated with niche markets are non-cash costs, primarily time. Farming is no different from any other part of 21st century business and living; time is the commodity. Research on crops for which there are no marketing alternatives should be confined to small plot work.

Warm Season . The theory behind bringing a warm season grass into the rotation was that it would allow later planting and therefore give additional weed control options. The highly negative economics of the warm season grasses leads to the conclusion that it is impossible to imagine any set of benefits that would justify the economic drain on the resources of the farm that the warm season grasses represent at this time. An analysis of rainfall patterns in May and June, back over time is necessary to measure the odds of success of crops requiring those late spring rains.

Management Complexity. By introducing so many new items into the equation all at once, success in each area was made more difficult. This project introduced several items that increased the managerial complexity of the farm operation. The first was the new technology of direct seeding and while some of the cooperators had had some experience with direct seeding, it was relatively new for all.

Combining direct seedingwith annual cropping and new crops brings a whole host of new variables into the decision-making matrix. An analogy is that the traditional wheat, barley, fallow, or wheat fallow system was like keeping 3 balls in the air simultaneously. The new direct seed annual cropping system with so many new crops requires keeping many more balls in the air at the same time. It is possible, but requires more intensity and skills than the 3-ball system.

Direct Seed. Many of the questions through the life of the project have been around direct seeding issues. It can be done successfully as a number of farmers in the area are making direct seed work. There were so many variables introduced through the many crops and various rotations of the Wilke project, a clear conclusion about the profitability of direct seeding cannot be made from this data. The economic data from the cereal grain production suggests that direct seeding clearly is highly probable to be successful. An area for further research is how to bring the weeds under control in the system. The application of direct seed technology is likely to accelerate the restructuring of dryland agriculture as farmers who learn the direct seed techniques will seek additional acreage to fully utilize the direct seed drill so as to spread the cost of the drill and tractor over as many acres as possible.

Observations and Conclusions. Replacing winter wheat with a spring crop introduces increased risk into the farming operation. The economic success on the Wilke project with recrop winter wheat (as measured by highest returns over costs) would suggest that in the intermediate rainfall area, removing the fallow year is a strong option. The key issue is identifying the crop to use in place of fallow.

There are a new set of issues and problems to solve with direct seed/annual cropping. Equipment utilization is one of the keys to keep the costs of direct seeding competitive. Very few farms go from no direct seed to total direct seed the following year. It is necessary to have the financial reserves to carry the farm through the transition. Drawing from the Wilke experience, the transition will be more costly farming; costly in time, additional risks, additional costs of equipment, and possibly lower yields and increased input costs. These risks are manageable, but that must be thought through while maintaining financial reserves.

No attempt was made to place an economic value on the environmental benefits from the rotations.