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UTAH SCIENCE

UTAH STATE UNIVERSITY

AGRICULTURAL EXPERIMENT STATION

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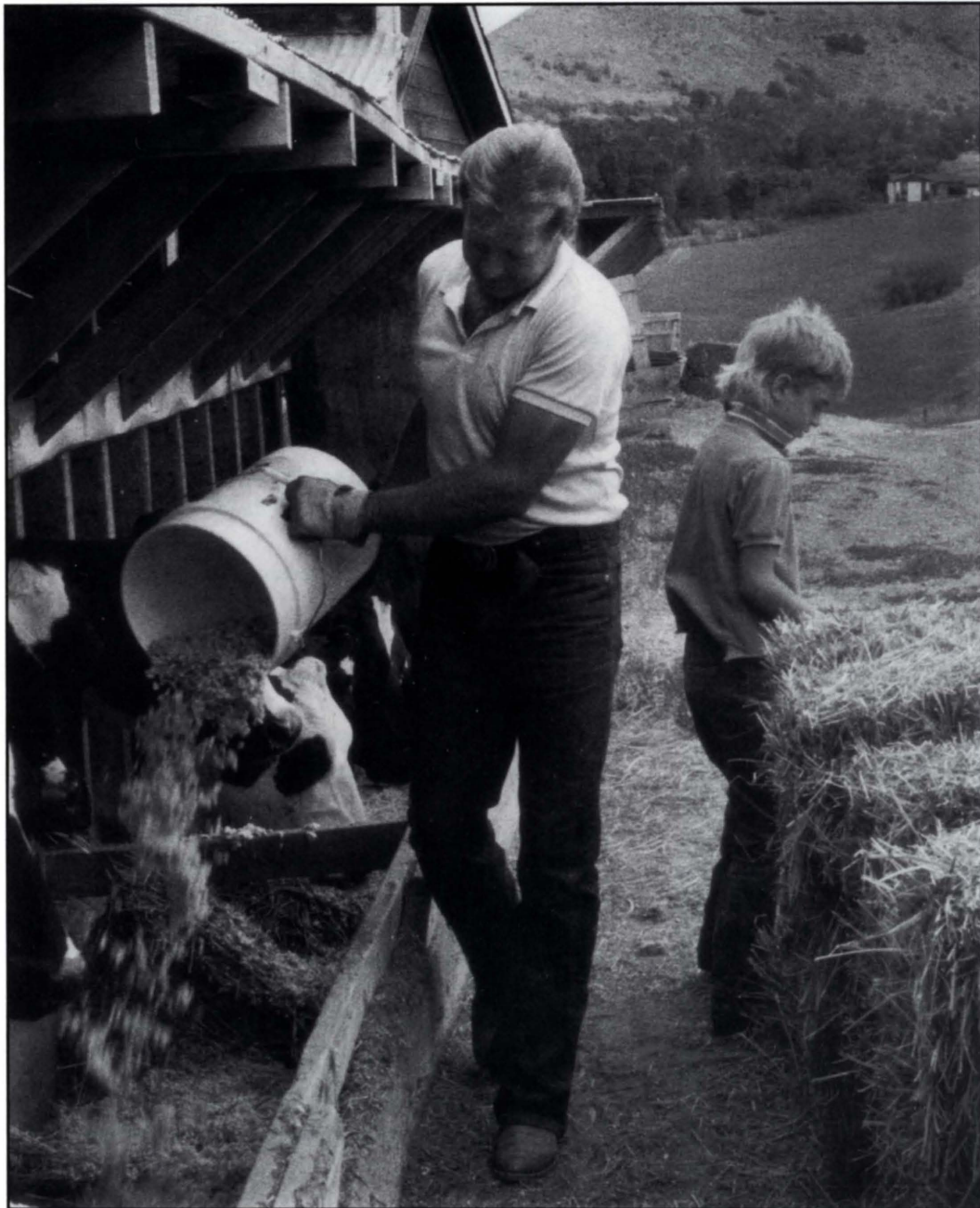
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Farm Work and Family:

MAJOR SOURCES OF SATISFACTION FOR FARM FAMILIES

N. ACKERMAN, G. JENSON AND D. BAILEY



The recent farm financial crisis affected all segments of agriculture. The dairy industry in Utah was severely affected because the crisis followed a rapid expansion in cow numbers and milk production that occurred between 1979 and 1983 (Utah Department of Agriculture 1987). The dairy industry is an important component of the state's agricultural economy. In 1985, for example, 25 percent of all agricultural sales in Utah were related to dairy products, second only to cattle as a source of income (Utah Department of Agriculture 1987).

Bailey, Jenson and Ackerman (1988) previously documented the financial condition of Utah dairy farms. It is important to learn how both potential and actual financial problems affect the quality of life of husbands and wives on these dairy farms. What adjustments will be required of these families if they leave farming? How has the financial crisis affected these families?

The quality of life and the factors which contribute to it may be measured objectively or subjectively. Objective measures—such as family income, debt-asset ratios and acres farmed—are useful but do not measure a person's perceptions. Subjective measures, such as satisfaction with income, with financial security and with farming as an occupation, reflect a person's expectations or goals as well as the actual situation. Subjective measures provide more information about the quality of life of a respondent and can help identify potential problems, often before they can be measured objectively.

This survey examined the quality of life of husbands and wives who lived on dairy farms in the five major milk-producing counties in Utah. We then

simulated how the quality of life might change if these families left farming. Subjective life quality was assessed by measuring satisfaction involving a number of areas: the individual, the family, leisure time and activities, the financial situation, the house, the community and the national government.

Previous Surveys

Two types of surveys have studied subjective life quality. The first type involved U.S. adults; the second was limited to rural and farm populations.

The Survey Research Center of the University of Michigan looked at how people perceived the quality of life (Campbell *et al.* 1976, Andrews and Withey 1976). Results of both studies indicated that a person's overall life satisfaction involved a variety of domains or areas of one's life. The four domains that contributed most to perceived overall life quality were satisfaction with (1) self, (2) family life, (3) the amount of fun, and (4) a money index based on satisfaction with family income and level of consumption (Andrews and Withey 1976). The remaining domains involved health, job, goods and services, house or apartment, family activities, time to do things, spare time activities and an index of satisfaction with national government. These 12 domains explained satisfaction with the quality of life as well as information about income, sex, race, age, family life cycle stage and education was included.

The results of both studies indicated that people derived the most satisfaction from the personal and intimate aspects of their lives. For example, re-

spondents were most satisfied with their marriages, second most satisfied with their family life, and least satisfied with savings and investments (Campbell *et al.* 1976).

Income was also important to perceived well-being. Strumpel (1975) found that satisfaction with income and past increases in income were strongly related to a sense of well-being, regardless of income level.

Other research concerning the quality of life focused on rural and farm populations. Marans *et al.* (1980) analyzed information from three national surveys and one Michigan survey conducted between 1971 and 1975. They divided samples into five groups based on population density (large and small urban areas, small towns and large and small rural areas). Their major findings included the following: (1) people in small rural areas tended to express more satisfaction with the quality of life than residents of large urban areas, (2) rural residents were among the most satisfied with leisure activities, (3) farmers expressed more job satisfaction than those employed in other occupations, (4) rural residents were among the most positive in their overall assessment of their homes, (5) residents of rural areas and small towns were just as likely as people in urban areas to positively evaluate their marriages and children, and (6) rural Americans tended to be older, predominantly white, and have lower incomes and education levels, and were more likely to be unemployed than residents of urban areas.

Molnar (1985) studied how objective and subjective characteristics of an individual and the farm business were related to a farm operator's sense of

Wives expressed less satisfaction with their personal accomplishments than husbands.

well-being. One major factor associated with well-being seemed to be the financial status of the farm family. Commitment to farming as a way of life was also important, regardless of farm size.

Campbell (1981) concluded that satisfaction with life tends to be associated with the prestige of occupations, with the notable exception of farmers, who are among the most satisfied with their lives. Farmers gave high ratings to the challenges and working conditions associated with farming but perceived that their work offered less than average sociability and poor financial rewards. The Quality of Life Project (Institute for Survey Research 1971) compared men's satisfaction with their jobs. On a 7-point scale ranging from completely satisfied (7) to completely dissatisfied (1), farmers, farm managers and laborers had average job satisfaction scores of 6.04, the highest of any occupational group.

The Survey

This study involved dairy farm couples in the five Utah counties with the highest milk production in the state (Cache, Box Elder, Weber, Wasatch, Morgan and Utah counties). Randomly selected respondents were sent a letter and were then called to schedule an interview. Two-person interview teams conducted separate, simultaneous interviews with the husband and wife in each dairy farm household in 1986. A total of 116 couples were interviewed. The response rate was 72 percent.

The measures of quality of life used in this study were developed and tested by Andrews and Withey (1976) and

included a question concerning the overall quality of life and 12 single questions found to best explain satisfaction with areas of life. Questions were modified to specify off-farm work and satisfaction with farm work. Their 7-point scale ranged from delighted (7) to terrible (1).

The Respondents

The average age of husbands in the survey was 51.0, with a range of 24 to 81 years (Table 1), close to the 50.5 average age of farm operators reported in the 1982 U.S. Census of Agriculture (U.S. Congress 1984). The mean age of wives was 48.7 years, with a range from 23 to 82 years. Most husbands had graduated from high school and many wives had attended vocational school or college. All respondents were married; more than 90 percent of husbands and wives were in their first marriage, while 8.9 percent of husbands and 4 percent of wives were remarried. The average length of the current marriage was 27.9 years. The number of children under 19 years old living at home was 1.64 for an average dairy farm household of 3.64 persons, larger than the average of 3.20 persons per household in the state (Utah State University 1980).

Slightly more than 60 percent of husbands and wives were not employed off the farm. In families with off-farm employment, husbands were more likely to hold full-time (35+ hours per week) jobs than wives. Net farm income was low in 1985; 26.4 percent had a net loss, and an additional 36.4 percent netted less than \$10,000. When off-farm income was included, only

Table 1. Characteristics of the dairy farm families.

Description	Husband		Wife	
	Percent	Mean	Percent	Mean
Age, in years		51.0		48.7
Education:				
9-11 years	13.4		6.2	
High school graduate	36.7		42.5	
Vocational or some college	31.4		43.5	
College graduate, or more	18.5		7.8	
Marital status:				
First marriage	91.1		96.0	
Remarried	8.9		4.0	
Length of current marriage (yrs.)		27.9		
No. of children at home (< 19 yrs.)		1.6		
Grew up on a farm	94.3		46.7	
Current farm in family				
2+ generations	77.0			
Off-farm employment:				
None	61.3		72.0	
Part-time	11.6		12.4	
Full-time	27.1		15.6	
Off-farm incomes (excludes not employed)		\$17,047		\$6,880
Farm income (1985) net				
Loss	26.4			
Less than \$10,000	36.5			
\$10,000 - \$19,000	14.7			
\$20,000 or more	22.4			
Family income (1985) net				
Less than \$10,000	20.2			
\$10,000 - \$19,000	28.5			
\$20,000 - \$29,000	20.9			
\$30,000 or more	30.4			
Debt/asset ratio		.33		
USDA herd buyout bid submitted	25.2			
USDA herd buyout bid accepted	17.3			

T*he importance of farm work to husbands may make it more difficult for them to adjust if they discontinue farming.*

20.2 percent had a net family income of less than \$10,000 and 30.4 percent of dairy farm families had incomes of \$30,000 or more. The mean debt/asset ratio of .33 was higher than the .29 debt/asset ratio for all U.S. dairy farms (U.S. Department of Agriculture 1985), but is still considered a "safe" level of farm debt.

Seventy-seven percent of farms had been in the family for two or more generations and 94.3 percent of husbands and nearly one-half of the wives had grown up on farms. The possibility that the family would leave farming was partially measured by participation in the USDA Dairy Termination Program, popularly referred to as the "whole herd buyout." In this sample, 25.2 percent of the farmers submitted bids, more than two-thirds of which were accepted, thus leading to herd liquidation, a shift to other types of agriculture or a decision to quit farming.

Husband-Wife Comparisons

Paired t-tests revealed a number of significant differences in the satisfaction level of husbands and wives. Both husbands' and wives' responses to the question concerning overall satisfaction with life were slightly above the midpoint between "mostly satisfied" and "happy" (Fig. 1).

Husband and wife pairs expressed similar levels of satisfaction with their families. Mean scores slightly exceeded "happy" for family life, and were between "mostly satisfied" and "happy" for family activities.

When asked "How do you feel about yourself — what you are accomplishing and how you handle problems?" wives

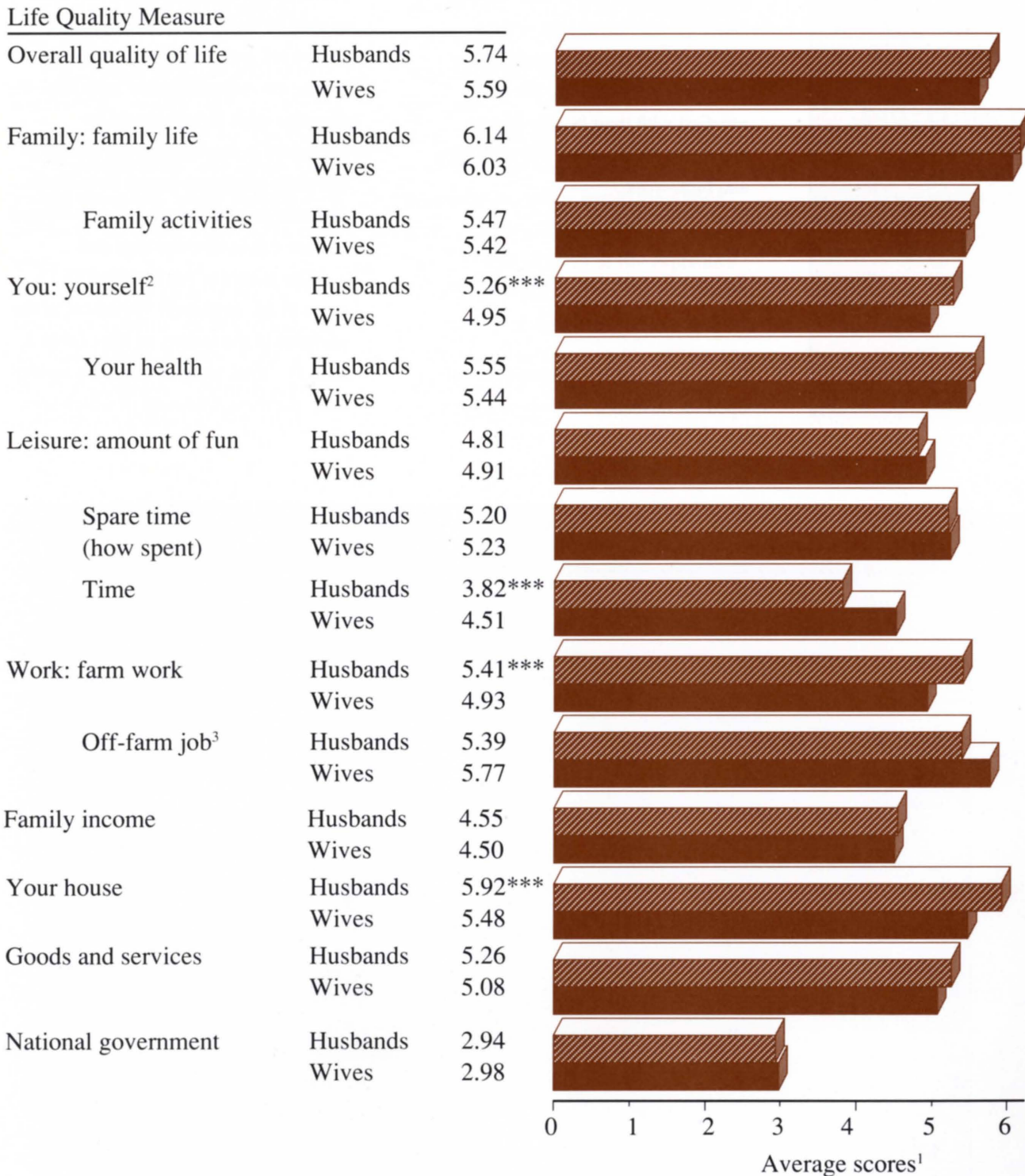
expressed less satisfaction than their husbands. Husbands and wives both expressed similar satisfaction with health.

When asked "How do you feel about the amount of time you have for doing things you want to do?", the husbands' lower average score (3.82 vs 4.51) may reflect the long hours associated with dairy farming, especially during the summer. Perhaps it also reflects the fact that many of the wives in the sample are beyond the age when young children place heavy demands on their time. Husbands and wives expressed similar satisfaction with the amount of fun and enjoyment in their lives and with the use of spare time ("mostly satisfied").

Wives expressed much less satisfaction with farm work (4.93) than husbands (5.41). Wives were more satisfied with off-farm jobs (5.77), while husbands appeared to be about equally satisfied with farm work and off-farm jobs (5.39). Off-farm job satisfaction was computed only when both spouses were employed off-farm, a small proportion of the total sample. Perhaps those who were dissatisfied with off-farm employment no longer worked off the farm; their opinions were not recorded.

Husbands and wives expressed similar levels of satisfaction with family income. Wives were significantly less satisfied with their houses than their husbands. Husbands and wives were both "mostly satisfied" with goods and services in the local area. Couples' low satisfaction with "the way our national government is operating" may reflect the worsening financial conditions in the dairy industry since 1979. In summary, husbands and wives

Figure 1. Average life quality scores of husbands and wives.



¹7=delighted, 6=happy, 5=mostly satisfied, 4=mixed, 3=mostly dissatisfied, 2=unhappy, 1=terrible.

²*** indicates significant difference between the average score of husband-wife pairs at the .001 level.

³The average scores include only couples who both had off-farm jobs.

Husbands and wives expressed similar levels of satisfaction with family income.

were both dissatisfied with the national government and had mixed feelings about the amount of leisure time available and family income. They were happy with family life and satisfied with their health, family activities, their houses, off-farm jobs and farm work.

Factors Explaining the Quality of Life

Separate regression equations developed for husbands and wives related

satisfaction with 13 various areas of life to overall satisfaction with life. Farmers expressed high job satisfaction, and farm work was a major factor in husbands' overall satisfaction with life. To simulate what factors would be important in maintaining the quality of life if the family no longer farmed, the satisfaction with farm work was deleted and the regression was repeated.

The equation that included all 13 areas of life explained 59 percent of the variance in the quality of life (Table 2, Col. 1). Four areas of life were significant, the most important of which was

Table 2. Areas that contribute to the quality of life of husbands.

Farming	Col. 1	Col. 2	Left farming (simulated)
	Beta ^{1,2}	Beta ^{1,2}	
How husbands feel about...			How husbands feel about...
Farm work	.36***	—	Farm work (deleted)
Yourself	.28***	.36***	Yourself
Your health	.21**	.27***	Your health
Spare time: how spent	.17*	.24**	Spare time: how spent
Time available	.07	.14	Goods and services
National government	.06	.08	Family life
Goods and services	.06	-.06	Off-farm job
Family income	.05	.05	Family activities
Amount of fun	-.03	.04	National government
Your house	.02	.04	Amount of fun
Off-farm job	-.02	.02	Family income
Family life	-.02	.01	Your house
Family activities	.01	.00	Time available
R-square ³	59%	52%	R-square ³

¹ The higher the beta, the greater the contribution to overall life quality.

² * = statistically significant at the .05 level, ** = .01 level, *** = .001 level.

³ R-square is the percentage that these areas contributed to the perceived quality of life.

satisfaction with farm work; the others were feelings about self, health and spare time.

The 13 areas of life explained 62 percent of the variance in life quality of the wives (Table 3, Col. 1). The five most important areas were family life, feelings about self, family income, amount of fun in one's life and farm work.

Because more areas of life were significant to wives' quality of life, they may find it easier to adapt to change than their husbands. Family life, the most important factor for the wives,

was not as dominant as farm work, the most important factor for the husbands. The second most important factor for both husbands and wives was satisfaction with self.

Results changed when the equations were modified to determine how husbands and wives would view their quality of life if their families no longer farmed. The 12 areas of life explained 52 percent of the variation in husbands' perceptions of the quality of life (Table 2, Col. 2). Satisfaction with self, health and spare time continued to be statistically significant.

The elimination of farm work had a less dramatic effect on wives' perception of quality of life. The 12 areas of life explained 60 percent of the variation in life quality (Table 2, Col. 2). The most important areas were still family life, self satisfaction, family income and available time.

Discussion and Conclusions

Husbands and wives in dairy farm households differed in some of the areas of life which provided the most satisfac-

Table 3. Areas that contribute to the quality of life of wives.

Farming	Col. 1	Col.2	Left farming (simulated)
	Beta ^{1,2}	Beta ^{1,2}	
How wives feel about...			How wives feel about...
Family life	.30***	.28***	Family life
Yourself	.22**	.23**	Yourself
Family income	.21**	.21**	Family income
Amount of fun	.19*	.17*	Time available
Time available	.15	.16	Amount of fun
Farm work	.15*	—	Farm work (deleted)
Family activities	-.13	.13	Spare-time: how spent
National government	-.12	.11	Your health
Spare time: how spent	.15	-.11	National government
Your health	.08	-.10	Family activities
Your house	.08	.06	Your house
Off-farm job	.06	.03	Off-farm job
Goods and services	-.00	-.03	Goods and services
R-square ³	62%	60%	R-square ³

¹ The higher the beta, the greater the contribution to overall life quality.

² * = statistically significant at the .05 level, ** = .01 level, *** = .001 level.

³ R-square is the percentage that these areas contributed to the perceived quality of life.

tion and which were associated with the quality of life. The most important area associated with husbands' quality of life was satisfaction with farm work; only three additional areas were significant—satisfaction with self, health and spare time. The most important area for wives was satisfaction with family life; satisfaction with self, family income and amount of fun were also significant.

The importance of farm work in husbands' quality of life illustrates the difficult adjustments faced by farmers who must discontinue farming. Many may be likely to experience self doubt and stress-related ailments. Assistance in developing stress-management skills would be useful, as would counseling to help maintain a good self-concept despite the financial problems. Personal counseling could be blended with farm financial counseling to assist both the farm couple and the dairy farm operation.

Farmers experiencing financial difficulties should maintain a balance of activities and rely on friends and support groups to keep financial problems in perspective and, if necessary, help make the transition to a non-farm lifestyle.

Wives may also suffer due to reduced income, decreased self esteem and marital problems. During periods of financial stress, families should try to continue to do those things that provide satisfaction. Good husband-wife communication is extremely important, and it is important to separate financial problems from self worth.

The strengths of successful farm families are reflected in the areas of life that husbands and wives said were most important in the quality of life.

Maintaining the quality of life during periods of financial stress could do much to ease the emotional stress that farm families are likely to experience.

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MIGRATION IN NONMETROPOLITAN UTAH

W.F. STINNER AND I. AL-MASARWEH

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By the mid-1980s, annual rates of net migration declined, regardless of the predominant type of employment.

The nonmetropolitan turnaround of the 1970s had apparently run its course by the mid-1980s in Utah, the West and the nation (Stinner and Al-Masarweh 1987). Although all counties in Utah experienced a loss in net migration in the 1980s, the rate of decline was higher in nonmetropolitan counties. Even many of the "turnaround counties," i.e., counties that experienced a net migration loss prior to 1970 and a net migration gain during the 1970s, registered net migration losses between 1980 and 1986.

This article concerns some of the factors associated with net migration patterns in nonmetropolitan counties in Utah during both the turnaround (1970-1980) and the post-turnaround (1980-86) periods. Our objectives are to determine: (1) how various characteristics of counties were related to net migration during these periods, and (2) whether different relationships characterized these periods. Recent findings concerning population change across all U.S. counties indicate that demographic changes are related to county characteristics (see Elo and Beale 1988).

We studied characteristics related to isolation (whether adjacent to a metropolitan area, the urban-rural status of counties not adjacent to a metropolitan area, and presence of an interstate highway), labor force structure and level of living (percentage unemployed and median family income). Estimated net migration was determined from estimates prepared by the Utah Population Estimates Committee (see Barber *et al.* 1983, 1985; Barber and Taylor 1986; Watanabe *et al.* 1982, 1983). The data concerning county characteristics, except location and presence of an interstate highway, were derived from

the 1970 and 1980 censuses. Only Weber, Davis, Salt Lake, Tooele and Utah counties are considered metropolitan counties; the remaining 24 counties are nonmetropolitan.

Reversal in Migration

The reversal in migration was clearly evident in the more isolated metropolitan counties during 1970-80 (see Table 1). Nonadjacent counties experienced higher annual rates of net migration gains (1.51, based on net migrants per 100 average population) than nonmetropolitan counties adjacent to metropolitan areas (1.27). The nonmetropolitan turnaround in Utah and other areas was not just the result of the continued suburbanization of outlying areas. Nevertheless, the annual rate of net migration gain was higher in remote counties with some urban development than in totally remote rural counties (1.79 vs. 1.35, respectively). The fact that the annual rate of net migration in remote rural counties was slightly higher than in counties adjacent to metropolitan areas indicated the widespread nature of the turnaround.

In the 1980s, nonadjacent counties registered annual losses in net migration while adjacent nonmetropolitan counties experienced gains. However, the annual losses in the most isolated rural counties was smaller (-0.35) than in the nonadjacent counties with some urban development (-1.17).

The migration patterns during 1980-83 generally differed from those during 1983-86. Annual rates of net migration gain between 1980 and 1983 were low, but were higher in nonadjacent counties (.77) than in adjacent counties (.62). Nonadjacent counties registered greater

Table 1. Annual net migration rates* by metropolitan isolation and location of interstate highway: 1970-1986.

	Time periods			
	1970-80	1980-86	1980-83	1983-86
Metropolitan isolation				
Adjacent	1.27	0.00	0.62	-0.58
Nonadjacent	1.51	-0.64	0.77	-1.89
Urban	1.79	-1.17	-0.27	-1.94
Rural	1.35	-0.35	1.34	-1.87
Interstate highway				
Yes	1.79	0.01	0.78	-0.65
No	1.13	-0.85	0.68	-2.24

*The formula used to calculate annual net migration rates is

$$\frac{N}{K(1/2)(P_2 + P_1)} (100)$$

where: N is the total number of net migrants; P₁ and P₂ are total populations at the beginning and end of the specific time interval for the particular unit; and K is the length of the time interval.

annual rates of net migration during 1983-86 (-1.89 vs. -.58). Only in the mid-1980s was there a reversal of the differences that characterized these two types of counties during 1970-80. In the early 1980s the totally rural nonadjacent counties experienced net migration gains (1.34) while the urban counties experienced net migration losses (-.27). By the mid-1980s both rural and urban nonadjacent counties experienced similar high net migration losses (-1.87 and -1.94, respectively).

Annual rates of net migration were higher in nonmetropolitan counties with an interstate highway than in nonmetro-

politan counties without an interstate highway during 1970-80. Between 1980 and 1986 counties without an interstate highway experienced losses in annual rates of net migration while counties with an interstate highway experienced slight gains. From 1980-83 both types of counties still experienced annual rates of net migration gain similar to that which occurred during the 1970s. Nevertheless, the difference in net migration between these two types of counties declined considerably, and both types of counties subsequently experienced annual rates of net migration loss; the annual loss in the counties without an interstate highway was more

than triple that in counties with an interstate highway.

In the 1970s nonmetropolitan counties with substantial economic activity in mining, construction, nonlocal service (employment in wholesale trade, financial institutions, trucking and warehousing), and tourism (employment in eating and drinking establishments, hotels and other personal services, excluding private households, and entertainment and recreational services) were characterized by high annual rates of net migration gain (Table 2). The higher the level of government employment, the higher the annual rate of net migration.

During the early 1980s, people may have returned to a more familiar environment seeking the support of family and friends.

The net migration gains in counties with considerable employment in agriculture and manufacturing were lower than in counties with low and medium levels of such employment. Nonmetropolitan counties with high levels of employment in nonlocal service, construction, mining, tourism and government had the highest rates of net migration gain, from 2.20 in counties with high nonlocal service employment to 1.44 in counties with high government employment. The lowest annual rates of net migration gain occurred in counties with high employment in agriculture and manufacturing (0.92 and 0.60, respectively). In summary, net migration in the 1970s increased across counties with varying industrial bases, although the rate of net migration varied.

Only counties with high nonlocal service employment registered net migration gains in the 1980s, and even in these counties the rate of net migration gain was less than one-sixth of that in the 1970s. Counties with high mining, government employment and construction employment were especially prone to net migration losses. Nonmetropolitan counties with high employment in agriculture, manufacturing and tourism experienced the lowest rates of loss.

The rate of net migration gain or loss varied between periods according to characteristics of the labor force (Table 2). Counties with high employment in agriculture, manufacturing, nonlocal service and tourism still experienced gains in the early 1980s, while counties with high employment in mining, construction and government were already experiencing losses. The annual rates of net migration gain in counties with

high employment in agriculture and manufacturing were higher than in the 1970s. The opposite was true in counties with high employment in nonlocal service and tourism.

By the mid-1980s, annual rates of net migration declined, regardless of the type of predominant employment. The higher the level of employment in agriculture and mining, the greater the rate of loss. Conversely, the higher the level of employment in construction, nonlocal service and tourism, the lower the rate of loss. Manufacturing counties experienced lower rates of loss than counties with the lowest share of manufacturing labor force; however, the rate of net migration increased in counties with moderate levels of employment in manufacturing.

Annual rates of loss were similar in counties at all levels of government employment. The highest annual loss from 1983 to 1986 occurred in nonmetropolitan counties with high levels of employment in mining (2.95), agriculture (-2.14), government (-2.19) and manufacturing (-1.64). The lowest rates of loss during this period were in counties with high employment in nonlocal service and tourism (-0.20 and -.58, respectively).

In the 1970s, the highest annual rates of net migration gain occurred in nonmetropolitan counties with the *lowest* median family income (Table 3). Annual rates of gain were also slightly higher in counties with high unemployment in the 1970s than in counties with low unemployment.

The gains continued in nonmetropolitan counties with high unemployment and those with low family income in the early 1980s, but both types of counties experienced losses in the mid-

Table 2. Annual net migration rates* by labor force structure: 1970-1986.

Labor force structure %	Time periods			
	1970-80	1980-86	1980-83	1983-86
% Agriculture				
Low	1.58	-.57	-.30	-.80
Medium	1.81	-.66	.38	-1.59
High	0.92	-.13	2.09	-2.14
% Mining				
Low	1.69	.46	.73	.21
Medium	0.74	-.06	1.85	-1.79
High	1.87	-1.76	-.40	-2.95
% Construction				
Low	0.90	-.45	.99	-1.74
Medium	1.52	-.09	1.56	-1.61
High	1.89	-.82	-.38	-1.19
% Manufacturing				
Low	1.34	-1.99	-.10	-3.68
Medium	2.51	1.40	1.41	1.43
High	0.60	-.34	1.06	-1.64
% Nonlocal services				
Low	0.82	-.72	1.34	-2.62
Medium	1.29	-1.05	-.23	-1.71
High	2.20	.40	1.06	-.20
% Tourism				
Low	1.15	-.93	1.04	-2.72
Medium	1.31	-.22	.94	-1.23
High	1.84	-.21	.20	-.58
% Government				
Low	0.96	-.52	1.17	-2.03
Medium	1.91	.39	1.17	-.31
High	1.44	-1.24	-.16	-2.19

* For formula see Table 1.

By the mid-1980's even nonmetropolitan areas with high standards of living experienced net migration losses.

1980s. Nevertheless, annual rates of loss between 1983 and 1986 in these counties were only about one-half of those experienced by nonmetropolitan counties with low unemployment and high family income.

Net Migration and Standard of Living

We previously compared changes in population growth and net migration patterns in the 1970s and the 1980s. This report examined relationships between various indicators and annual rates of net migration between 1970 and 1986.

Our findings indicate that the turnaround that characterized the 1970s affected all nonmetropolitan counties in Utah. Annual gains in both nonadjacent urban and the remote rural counties exceeded those in nonmetropolitan counties adjacent to metropolitan areas. By the mid-1980s, however, each type of county experienced losses; the rates of loss were substantially greater in the more remote counties.

The presence of an interstate highway in a county was also related to migration. Annual rates of net migration gain in the 1970s were lower in counties lacking an interstate highway. By the mid-1980s both types of counties registered losses, although the rate of loss was higher in the isolated counties. Thus, isolation did not impede gains in net migration in the 1970s but did not prevent losses in migration in the mid-1980s.

In the early 1980s, counties with high levels of employment in construction and tourism tended to experience smaller gains in net migration, and

counties with high employment in mining, nonlocal services and government experienced losses in net migration. These gains were reversed and losses increased in the mid-1980s, except in counties with high levels of employment in agriculture and manufacturing, which experienced increases in net migration in the early 1980s and losses in the mid-1980s.

Nonmetropolitan counties with the lowest standards of living benefitted from the turnaround during the 1970s. In the early 1980s, the gain in annual rates of net migration in counties with the highest unemployment rates was nearly four times that in counties with the lowest levels of unemployment; counties with the lowest income levels registered gains while counties with the highest income levels experienced losses. By the mid-1980s, counties with the lowest standards of living also experienced losses in net migration, although the rates of decline were lower than in counties with the highest standards of living.

The relationship between net migration and standard of living may reflect the fact that these pockets of economic dislocation attracted returnees from areas in which economic conditions were similar or worse. Perhaps the gains in net migration registered during the early 1980s may have represented returnees seeking the support of family and friends and a more familiar environment.

In general, migration research shows that returning migrants are likely to be seeking assistance (DaVanzo and Morrison 1981). During times of economic contraction return migration would be expected to increase, especially in those counties which had

Table 3. Annual net migration rates* by level of living indicators: 1970-86.

Indicator	1970-80	1980-86	1980-83	1983-86
Percent unemployed				
Low	1.23	-.37	.64	-1.33
Medium	1.74	-1.45	-.45	2.29
High	1.28	.73	2.34	-.71
Median family income				
Low	1.74	.36	1.79	-.91
Medium	1.33	-.33	1.32	-1.83
High	1.24	-1.40	-.94	-1.79

* For formula see Table 1.

previously witnessed high rates of outmigration. In some locations, elderly immigrants may have been attracted by the amenities of an area rather than employment. Elo and Beale (1988), for example, note that nonmetropolitan retirement counties were the major exception to the general patterns of sharp nonmetropolitan population declines during the 1980s and, in fact, attracted large numbers of immigrants and grew more rapidly than the nation as a whole.

In summary, by the mid-1980s in nonmetropolitan Utah widespread net migration loss had replaced the extensive net migration gains evident during the turnaround of the 1970s. Even nonmetropolitan areas which were not isolated and which had high standards of living were experiencing net migration loss. Net migration loss was also occurring in counties with varying economic bases; differences were matters of degree, not direction. Analyses of the post-1986 period are necessary to determine the degree to

which revival occurred, where it has been concentrated and its correlates.

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FORAGE PRODUCTION BY COOL-SEASON PLANTS

N. J. CHATTERTON, P.A. HARRISON,
J.H. BENNETT, W.R. THORNLEY AND
K.H. ASAY

Livestock production on rangelands of the western United States is often limited by the amount and seasonal distribution of forage. Forage production, in turn, depends on ambient temperatures and available soil moisture. Hot temperatures and lack of moisture during much of the summer frequently arrest the growth of grass, particularly on desert ranges.

Plants have evolved various strategies to increase their water use efficiency, e.g., hairy or waxy leaf surfaces that reduce water loss from leaves,

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thereby reducing transpiration. Even so, during much of the summer there is not enough moisture for optimum plant growth. Because irrigation is not economically feasible on rangelands, developing plants better able to grow during the fall and spring, when moisture is usually plentiful, holds considerable promise for increasing forage production on rangelands.

Scientists in the Forage and Range Research Laboratory of the USDA-Agricultural Research Service, in cooperation with the Utah Agricultural Experi-

ment Station, are studying the physiology and biochemistry of forage plants to help plant geneticists and breeders select and develop varieties and hybrids that produce more forage under cool temperatures.

Cool-Season vs. Warm Season Grasses

Plants in the grass family are generally classified as either warm-season plants (those of tropical origin) such as corn

and bermudagrass, or as cool-season plants (those of temperate origin). Cool-season grasses include many grasses native to northern Utah, such as bluebunch wheatgrass and Great Basin wildrye, as well as many introduced species, such as crested wheatgrass, orchardgrass, tall fescue and timothy.

Warm-season and cool-season grasses differ in the kinds and amounts of nonstructural carbohydrates that they synthesize and store in their vegetative tissues (Chatterton *et al.* 1989). In general, warm-season grasses store starch for a short-term carbohydrate supply. Thus, on sunny warm days when leaf photosynthesis rates exceed the translocation of photosynthates to other parts of the plant, warm-season grasses form starch grains in their leaf chloroplasts (where photosynthesis occurs). During warm nights, the plant breaks down accumulated starch and sucrose is then translocated from leaves to other parts of the plant.

In contrast, cool-season grasses accumulate only small amounts of starch in their leaves. They synthesize fructan (Pollock and Chatterton 1988), a series of carbohydrate polymers similar to starch that are composed primarily of fructose molecules. Starch and fructan also have different synthesis storage sites. Leaf starch is synthesized and deposited in chloroplasts while fructan is synthesized in leaf vacuoles (cavities within leaf cells that contain water), where they temporarily accumulate as carbohydrate reserves.

During the night, environmental and physiological conditions must be favorable for warm-season plants to break down and translocate starch. If evening temperatures are too cool, starch synthesized during the previous

warm day may not be completely translocated and large amounts remain in the chloroplasts. If this occurs over a number of days, so much leaf starch accumulates that it interrupts the normal metabolic processes in the chloroplast, thus reducing or inhibiting photosynthesis (Chatterton *et al.* 1972). Starch accumulation can eventually cause leaves to become chlorotic and die. Such leaves may appear to have been damaged by frost.

If the rates of carbohydrate synthesis exceed those of translocation in cool-season grasses, most of the excess carbohydrate is deposited in the vacuole as fructan, not as starch (Chatterton *et al.* 1989). Accumulated fructan in the vacuole does not significantly impair photosynthesis.

Fructan Metabolism

The enzymes involved in the biosynthesis and breakdown of vacuolar fructan are less sensitive to cool temperatures than those associated with chloroplast starch metabolism (Pollock 1986). This means that photosynthesis can continue in cool-season plants when temperatures are too cold for significant carbohydrate metabolism and growth in warm-season plants. Bennett *et al.* (1986) have shown that photosynthesis in cold-adapted crested wheatgrass leaves can occur when temperatures are near freezing (Fig. 1). This ability, coupled with fructan biosynthesis in the vacuoles, permits plants to be physiologically active during cold temperatures. Some plants can even grow

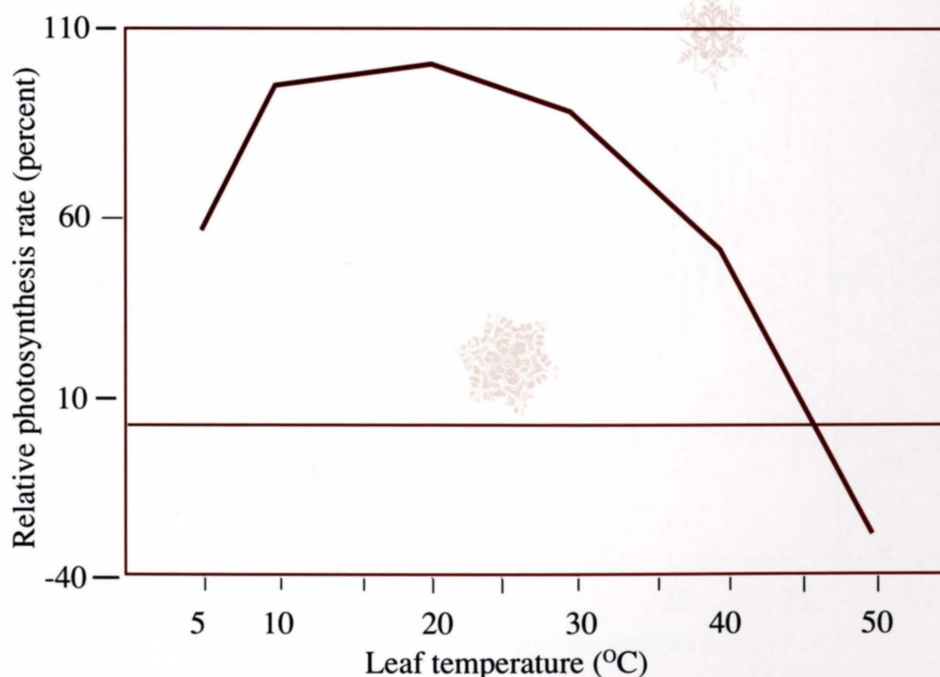


Figure 1. A photosynthesis-temperature response curve for intact crested wheatgrass leaves. Note the broad temperature optimum near 20° C and the relatively high rates of photosynthesis at 5° C.

Carbohydrate metabolism involves an extremely complex series of relatively small carbohydrate molecules.

under wet snow when temperatures are only slightly above freezing.

Fructan accumulates in leaf vacuoles when carbohydrate translocation out of the leaf is limited. This accumulated fructan provides a reduced carbon source for sucrose synthesis, the major soluble carbohydrate used in plant growth. Sucrose may also be a cryoprotectant in some plants. Fructan breakdown provides a carbohydrate substrate during late winter-early spring when ambient temperatures are 5° to 15° C and rapid growth is initiated (Figs. 2 and 3).

There is little change in the total amount of reserve carbohydrates in crested wheatgrass leaves during the winter (Chatterton *et al.* 1988); in contrast, many other perennial plants such as alfalfa utilize large amounts of

carbohydrates in their roots for respiration and maintenance during winter.

Crested wheatgrass can maintain green photosynthesizing leaves throughout the winter, thus reducing the need for large carbohydrate reserves. It derives most of the carbon for early spring regrowth from current photosynthates (Richards and Caldwell 1985).

Some researchers have suggested that fructan prevents damage to leaf tissues during freezing weather (Pollock 1986). However, we found that crested wheatgrass contains relatively low levels of fructan during the coldest part of the winter (Fig. 2). Leaf fructan levels are highest in the fall and early spring when ambient temperatures range from 5° to 15° C. The decrease in fructan with the onset of the coldest weather coincides with an increase in

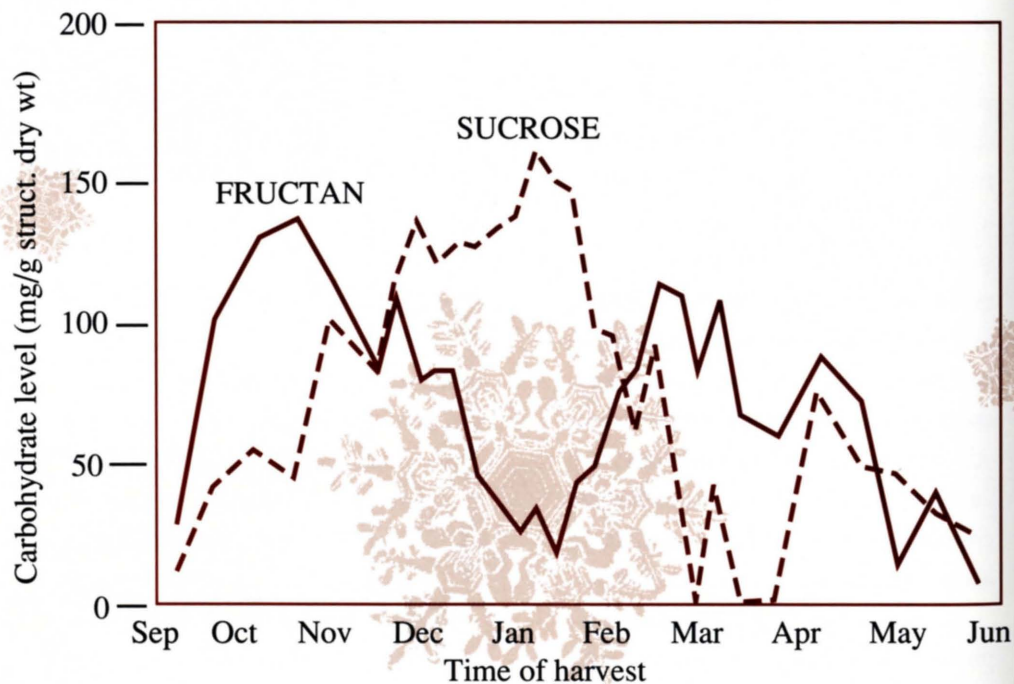


Figure 2. Fructan and sucrose concentrations in leaves of crested wheatgrass grown under field conditions at Logan, Utah, from September 1986 to June 1987. Fructan concentrations were lowest in mid-winter when sucrose concentrations are highest.

leaf sucrose concentrations. These relationships are consistent with the hypothesis that fructan reserves are metabolized into sucrose, which may be the functional cryoprotectant.

Cool Temperature Growth

Carbohydrate profiles of a wide range of grasses and broadleaf plants, which are capable of at least limited growth during cold weather, indicate that a class of sucrosal carbohydrates including fructan serve both as a reserve sink and as a substrate for growth during cold weather. Unlike starch, this class of carbohydrates is highly soluble in water and has unique structures that permit rapid changes in their size with a minimum expenditure of energy.

Sucrose (glucose plus fructose, a disaccharide), the most common free sugar in plants, is the precursor/substrate for the synthesis of these carbohydrates. For example, fructan synthesis involves the attachment of an additional fructose molecule to either the glucose or the fructose subunits of sucrose to form trisaccharides (molecules made up of three simple sugars). If a molecule of galactose instead of fructose is attached to the fructose subunits of sucrose, either planteose or lynchnose is formed. When galactose is attached to the glucose molecule of sucrose, unbelliferos, raffinose or loliose is formed. If an additional glucose molecule is attached to sucrose, gentianose is formed.

Raffinose, the second most common free sugar found in plants, is a trisaccharide and the smallest of an important series of oligomers, the largest of which contains seven or eight galactose units

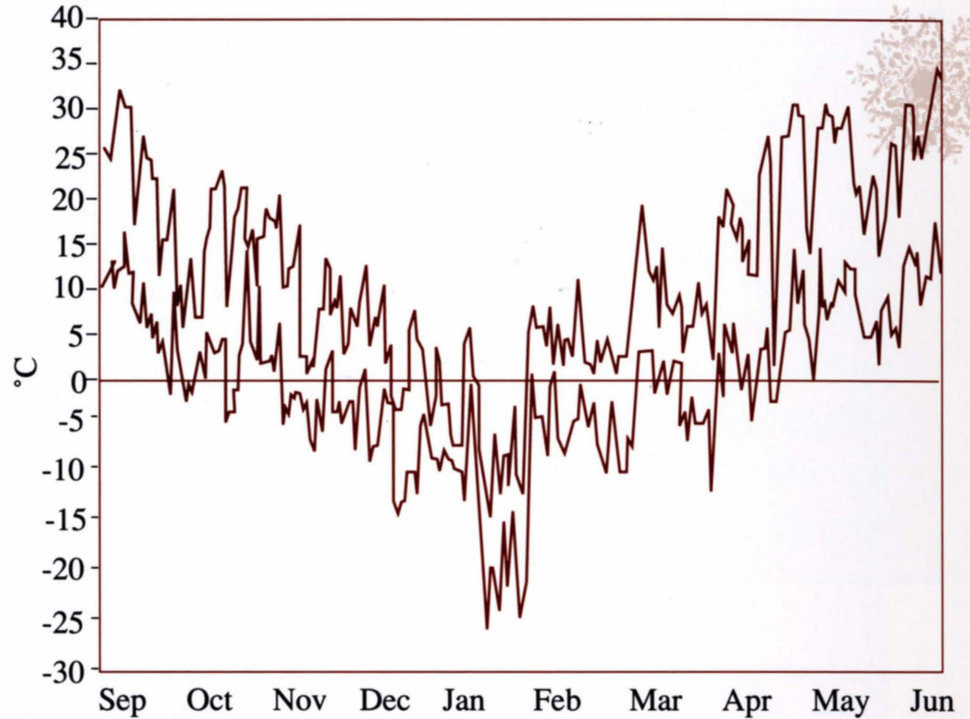


Figure 3. Daily temperature patterns (maximum and minimum) from September 1986 to June 1987 at Logan, Utah.

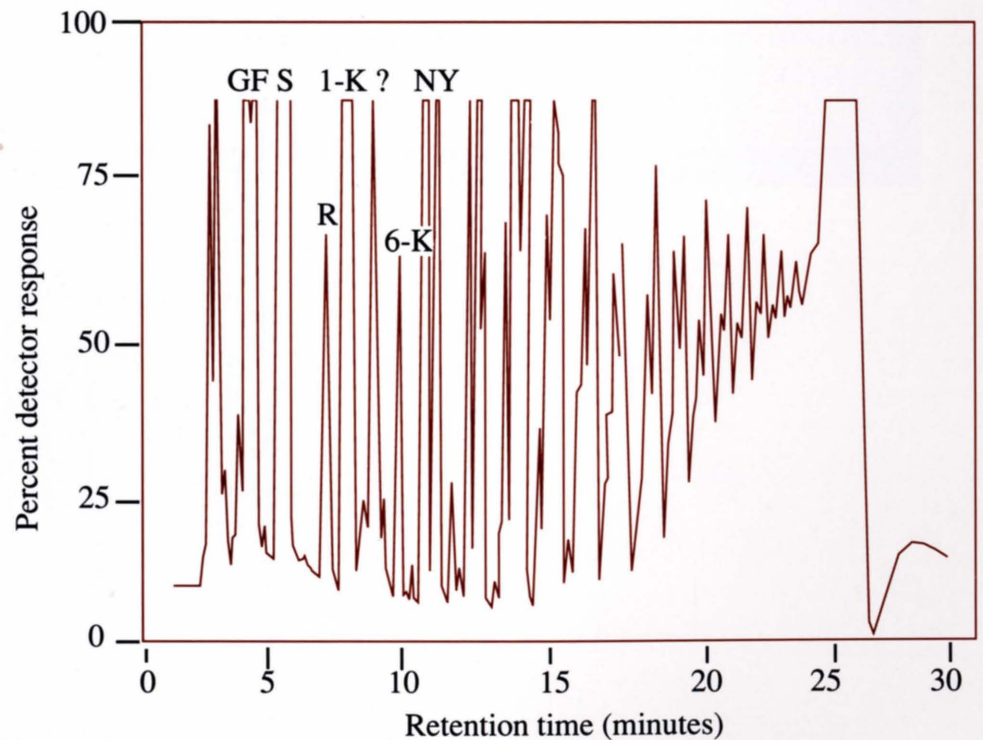


Figure 4. Water soluble carbohydrate profile of leaf extracts from crested wheatgrass (anion exchange separation using dionex pulsed amperometric detection).

Some crested wheatgrass germ-plasm yields 1.4 times as much biomass as plants adapted to warmer temperatures.

per molecule. Raffinose and stachyose (a tetrasaccharide in the raffinose series) form sugar-protein glass-like complexes in woody plants that help plants tolerate repeated freezing and thawing (Hirsh 1987). These glass-like complexes prevent intracellular damage from ice crystals. These sugars are also commonly found in grasses and forbs able to grow under cool temperatures and may be important factors in cool temperature tolerance and cool temperature growth. Table 1 lists the predominant trisaccharides found in 10 such species.

Carbohydrate metabolism, at least in temperate plant species, involves an extremely complex series of relatively small carbohydrate molecules, in addition to the larger starch and fructan polymers. We hypothesize that these energy-rich products of photosynthesis and intermediary metabolism may

regulate growth, as well as increase cold temperature tolerance. Figure 4 shows the carbohydrates in crested wheatgrass leaves. Each peak represents a different saccharide. Figure 5 shows the simplest fructan series from Jerusalem artichoke tubers (*Helianthus tuberosus*). Jerusalem artichokes contain a series of simple linear fructan polymers, each of which differs from an adjacent molecule by a single fructose unit. The more commonly recognized glucose, fructose and sucrose are minor components in the complex array of polymeric carbohydrates found in grass leaf tissues.

Future Research

The USDA's Forage and Range Research Laboratory in Logan has a plant breeding program designed to

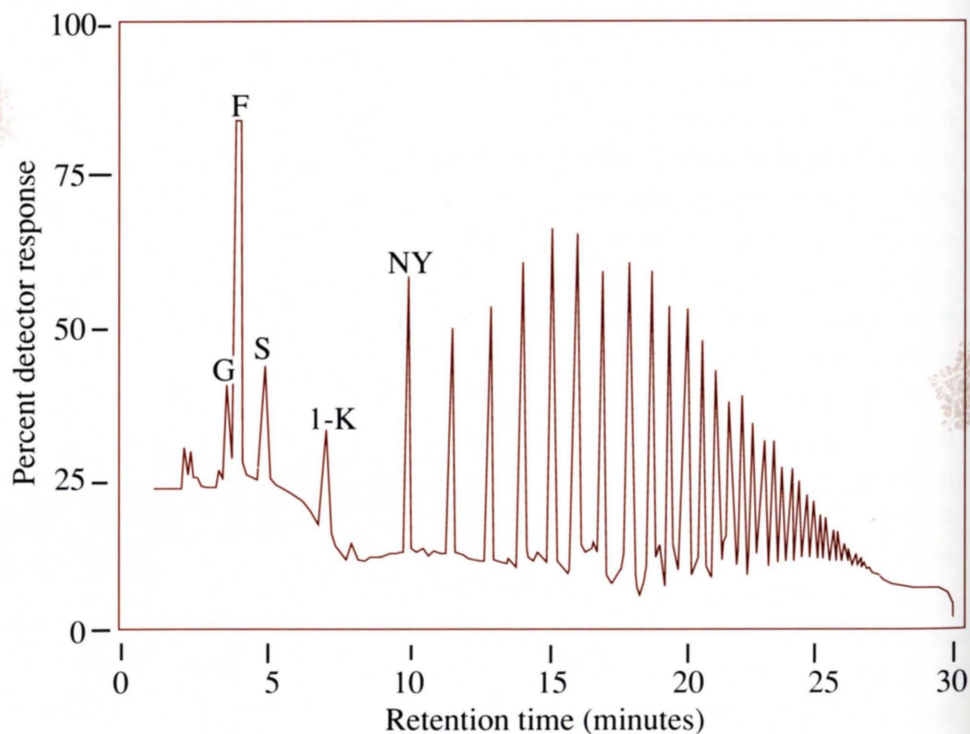


Figure 5. Water soluble carbohydrate profile of an extract from tubers of *Helianthus tuberosus* (Jerusalem artichoke).

Table 1. Predominant trisaccharides in the leaves of cool-season species in which significant amounts of late-fall and early-spring growth occurs even when temperatures are cold.

Species	Family	Predominant trisaccharides
Allium cepa (onion)	Liliaceae	Raffinose and 1-kestose
Thinopyrum intermedium (intermediate wheatgrass)	Gramineae	Raffinose and 1-kestose
Conium maculatum (poison hemlock)	Umbelliferae	Umbelliferose
Daucus carota (carrot)	Umbelliferae	Umbelliferose, raffinose and 1-kestose
Erodium cicutarium (storksbill)	Geraniaceae	Raffinose
Rorippa nasturtium (watercress)	Cruciferae	Raffinose and 1-kestose
Malva neglecta (cheeses)	Malvaceae	Raffinose and 1-kestose
Lactuca serriola (prickly lettuce)	Compositae	Raffinose and 1-kestose
Taraxacum officinale (dandelion)	Compositae	1-kestose and raffinose
Swertia radiata (swertia)	Gentianaceae	Gentianose

Table 2. Yields (g/plant) of Hycrest plants selected for high and low growth under cool temperatures in controlled environments and under field conditions.

Plant type	Yields (g/plant)*
Low growth	
Chamber	550
Field	468
Mean	509**
High growth	
Chamber	675
Field	711
Mean	693**

*Average yields during 1987 and 1988.

**Significantly different at the $P < 0.001$ level.

develop crested wheatgrass cultivars able to grow early in the spring and late in the fall. The desired characteristics can be selected from the pool of germplasm already assembled. The cool-tolerant crested wheatgrass germplasm yields 1.4 times as much biomass as plants adapted to warmer temperatures (Table 2). We hypothesize that these larger yields are the result of greater photosynthetic activity and growth during late winter and early spring. Although temperatures are cool at that time, there is adequate soil moisture for growth. We hope to improve the ability of crested wheatgrass to grow under these conditions. The yields of other important forage species may also increase by improving their ability to grow during cool weather.

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Jesse H. Bennett is a plant physiologist whose research interests include photosynthesis, metabolism and

mineral nutrition interactions in improved plant hybrids, genotype-specific protein patterns and enzyme induction in efficient and inefficient plants.

N. Jerry Chatterton is research leader. His research concerns the biochemistry and biosynthesis of fructans in forage plants.

Phillip A. Harrison, plant physiologist, studies the biochemistry and enzymology of storage carbohydrates in cold-tolerant grasses and high-fructan plants.

W. Robert Thornley, plant biochemist, studies the enzyme activity of temperature-preconditioned tissues from cold season forage plants.



Research in Brief

Fall 1989

NO YIELD REDUCTION IN FORAGE CROPS IRRIGATED WITH SALINE WASTE WATER

Since 1977, saline waste water from an electric plant at Huntington, Utah, has been used to irrigate crops. The arrangement benefits the power company (which saves several million dollars annually by not having to dispose of water in evaporation ponds) and provides Experiment Station researchers with a unique laboratory to study the effects of salinity.

The saline water hasn't yet reduced the yields of forages such as alfalfa but it has reduced the yields of other crops such as barley and wheat, especially at high irrigation levels, says soil physicist John Hanks. The reduction in yield is probably due to boron toxicity, not salinity.

A specially designed sprinkler system is used to apply varying amounts of irrigation water.

Even if forage yields eventually decrease somewhat, evapotranspiration apparently isn't reduced, Hanks says, which means that it should be possible to dispose of saline water in this manner for many more years.

REFERENCE

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NEW USES FOR DAIRY PRODUCTS

It makes nutritional and aesthetic sense to use milk proteins to "lighten up" some meat products.

Consumers prefer light-colored veal and poultry rolls to those made from darker meats. Sodium and calcium caseinates available from New Zealand are now widely used as whiteners but nonfat dry milk and whey protein concentrates might be acceptable—and less expensive—substitutes, says meat scientist Daren Cornforth.


It should work. Other researchers have found milk caseinates lighten meat color when injected as a brine or when tumbled with chunks of meat. Cornforth will try both methods and test the acceptability and characteristics of the final products.

Using milk proteins as whitening agents might also mean meat from older calves would be acceptable as veal.

In other meat products, milk proteins are now used as emulsifiers to bind water and fat, and improve texture.

"Meats research at USU is moving into processing areas where more jobs are available and where more research is needed," Cornforth says.

Cornforth's research is supported by the National Dairy Products Research Board.



Research in Brief

RESEARCH HELPS GROWERS CONTROL THE APPLE MAGGOT

Six years ago, the apple maggot was “discovered” as an agricultural pest in the state, even though it has apparently resided here for some time.

The discovery was unwelcome news for many Utah growers. In other states, apple maggot larvae bore into and ruin apples. Not in Utah, however.

In spite of its name, the apple maggot found in Utah prefers cherries to apples. Nonetheless, Utah growers who wanted to ship apples to other states (some already infested with apple-loving strains of the insect) had to spray to control cherry-loving apple maggots.

According to interstate marketing regulations, Utah growers within a half mile of any location where apple maggots had been caught must follow a strict (and expensive) pesticide-treatment program,

one that threatened to upset integrated pest management.

But a potential entomological nightmare was avoided, thanks to USU researchers.

Growers still must spray to meet interstate marketing requirements, but researchers helped them do so in a manner that cut costs and avoids upsetting the ecological balance.

A major portion of the research involved the most effective traps and trapping techniques for the apple maggot, key elements in the effort to learn the life cycle of the insect.

Once it was apparent that the pest was too widespread to eradicate, researchers determined how temperature affected emergence (pupae overwinter in the soil) and when flies reach reproductive

Research in Brief

maturity. This information made it possible to apply pesticides when they were most effective and to coordinate control of the apple maggot and the codling moth.

Researchers also determined which pesticides had the fewest detrimental effects on predators of mites. Mites are important pests in orchards.

"This meant that one less spraying (to control codling moths) was needed if growers followed the spraying program needed to meet the quarantine requirements," says entomologist William Brindley, coordinator of the research program.

Growers avoided some of the pesticide applications that would have escalated costs and exacerbated other insect-control problems.

The apple maggot "has a tremendous range of hosts, but there are only a few major hosts in Utah, primarily cherries and hawthorns," Brindley says.

Even though the larvae of the apple maggot in Utah can develop in apples, females prefer to deposit their eggs in other hosts. Apple maggot larvae have never been found in apples from managed orchards.

"The discovery of the apple maggot in Utah might not have been such a major issue if it weren't for the quarantine on Utah apples imposed by California," Brindley says.

Monitoring programs must continue in order to detect any changes in the ovipositional preferences of the insect.

"At present, only a small proportion of females will accept apples, but should infestations start in apple, apple-adapted strains could multiply rapidly," the researchers say in a report prepared for the Utah State Department of Agriculture.

Biological controls were studied, and some parasites of apple maggots were identified, none of which appears to be a viable control option.

The current apple maggot management program includes cleaning abandoned orchards and hawthorn stands.

USU entomologists say that apple maggot pupae can live in the ground for more than a year, which means that flies should be controlled as they emerge or pupae should be destroyed in the ground.

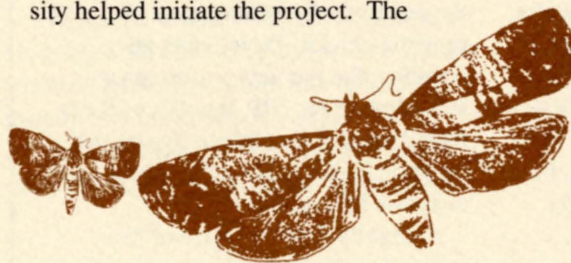
No chemical soil treatments have been satisfactory against apple maggot pupae. Control now involves plowing and packing infested sites, burning residue or spraying when flies emerge.

To accurately track infestations, researchers also studied how to distinguish between larvae of the apple maggot strains that infest different hosts, and between larvae of the apple maggot and larvae of the western cherry fruit fly.

Major contributors to the project were USU entomologists Don Davis, Vince Jones, Wilford Hanson, Frank Messina and Nabil Youssef. Entomologist Clive Jorgensen with Brigham Young University helped initiate the project. The

project also involved the USU Cooperative Extension Service, the Utah State Department of Agriculture, and the Utah Horticultural Association.

Much of the Experiment Station research was supported by the Utah State Department of Agriculture.



SHEDDING NEW LIGHT ON LIVESTOCK PERFORMANCES

Researchers plan to shed more light on livestock production.

The light is near infrared, and the result could be leaner beef, better management of dairy herds and improved poultry rations.

Several USU researchers are determining whether near infrared light, which is now widely used to assess forage quality, can be a quick and inexpensive way to monitor total animal performance, including an on-the-hoof evaluation of carcass quality.

The procedure involves recording the intensity of near infrared light after it is reflected from or interacts with material of known chemical composition. Computers then compare these results with the intensity of near infrared light from other samples, thus making it possible to determine the composition of a sample without repeating the chemical analyses.

Dave Clark, an animal scientist with USU and the USDA Agricultural Research Service, is seeing whether NIR (Near Infrared Reflectance) readings accurately monitor changes in the body composition (fat, protein and moisture) of dairy cows that receive bovine somatotropin, a hormone which increases the efficiency of milk production.

The entire carcass, including the hide, will be ground in a huge (3,000-pound capacity) grinder. Chemical analyses of these composite samples will then be compared to NIR readings taken at several body locations.

By placing a probe against the skin, NIR is now used to measure fat levels in humans. If this technique is accurate for cattle, it could be a rapid and accurate method of determining the condition of dairy cows.

NIR could also be put to work in beef feedlots. In a study similar to that involving dairy cows, animal scientist Randy Wiedmeier is determining the areas of fat loss when beef cattle lose weight. If fat is removed from lean meat rather than from the digestive tract, putting cattle on diets may be a way to produce leaner meat. NIR readings could monitor these changes and assess the effects of various rations on fat deposition.

Poultry scientist Dean Bell is analyzing rations with NIR and will compare the results to the performance of growing chicks. Developing an equation that predicts performance according to the NIR analysis of feeds would make it possible to bypass the traditional chemical methods now used to assess feed quality.

A slightly different form of near infrared analysis may improve reproductive management in dairy herds. Clark and dairy scientist Dave Marcinkowski use infrared light and a fiber optic probe to monitor changes in vaginal tissue during pregnancy and the estrous cycle. Results may improve heat detection and the ability to determine the stage of pregnancy.

"So far, results are fairly promising," Clark says.

Clark says the analysis of near infrared light holds considerable promise for animal agriculture, and many applications have not yet been identified.

"The chemical analysis of feeds often doesn't clearly relate to animal performance. Near infrared analysis may make it possible for the animals to tell us what happens," Clark says.

GENETIC ENGINEERING TO IMPROVE LIVESTOCK PRO

In the Middle Ages, alchemists unsuccessfully tried to transform lead into gold.

Several centuries and a biological revolution later, molecular biologists have upped the ante with their ability to genetically engineer living organisms.

USU researchers are relying on mice to bring these benefits to the barnyard.

Many genes have the potential of making livestock healthier and more productive, says USU molecular biologist John Morrey. Unfortunately, many of these combinations look better on paper than they would in livestock.

For example, pigs have been genetically altered to produce more growth hormone, thus yielding more muscle and less fat. However, the complicating effects of growth hormone meant that the pigs were "grossly inadequate" for the market and prone to metabolic disorders, Morrey says.

Morrey and animal scientist Thomas Bunch plan to "bridge the gap between molecular biologists and animal scientists" by modifying gene transfer techniques for commercial livestock production.

It would be prohibitively expensive to use livestock in many studies involving gene manipulation. Mice (which produce 20 or more eggs and have a 21-day gestation period) are much less expensive subjects than livestock, and are a more economical model. Results are applicable to livestock, however.

In spite of the high-tech underpinnings of gene transfer, the actual transfer process places a premium on manual dexterity and patience.

TECHNIQUES

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Some of their research now concerns the genes associated with a human virus. To transfer the genes, fertilized eggs (each about the size of a pin point) from superovulated mice are collected at the right state of development, microsurgically injected with a portion of the viral DNA, and transferred to other mice. The resulting transgenic mice integrate the foreign gene into their chromosomes; this gene is inherited from generation to generation.

About 1,000 eggs must be injected to obtain one transgenic mouse that has properly incorporated the transferred genes. Odds of obtaining progeny with the right genes and the right traits are even lower because an animal with the desired genetic material may not properly express the trait.

"Even though the added DNA is present in every cell, that doesn't mean the trait will be expressed in every cell of the body," Morrey says. The DNA sequences that activate the gene in the proper tissue, "tissue-specific promoters," which are somewhat analogous to a starter in a car, must also be identified and transferred, Morrey says.

Morrey and Bunch plan to study genes that increase resistance to livestock viral diseases such as parainfluenza and infectious bovine rhinotracheitis. Increased resistance might result from genes that either inhibit virus replication, prevent the virus from entering cells, or that produce an enzyme that breaks apart viral RNA.

Researchers elsewhere have already engineered transgenic chickens with a 10,000-fold increased resistance to avian leukosis.

Transgenic livestock offer nearly limitless possibilities for improvement, Morrey says, including changing them to become "pharmaceutical factories." For example, animals have already been engineered to secrete a compound necessary for blood clotting. Genetic engineering techniques could result in cows that produce milk containing larger amounts of the drug.

Researchers have also transferred genes that increase growth rates in fish. Australian researchers have identified a gene that controls the reproductive rate in sheep and other genes that control the synthesis of a biochemical required to produce good-quality wool.

Transgenic animals will be invaluable in studying a host of biological processes such as cholesterol metabolism, nutrition and disease resistance, Morrey says.

"For the first time, scientists can study these processes in mammals. In the future,

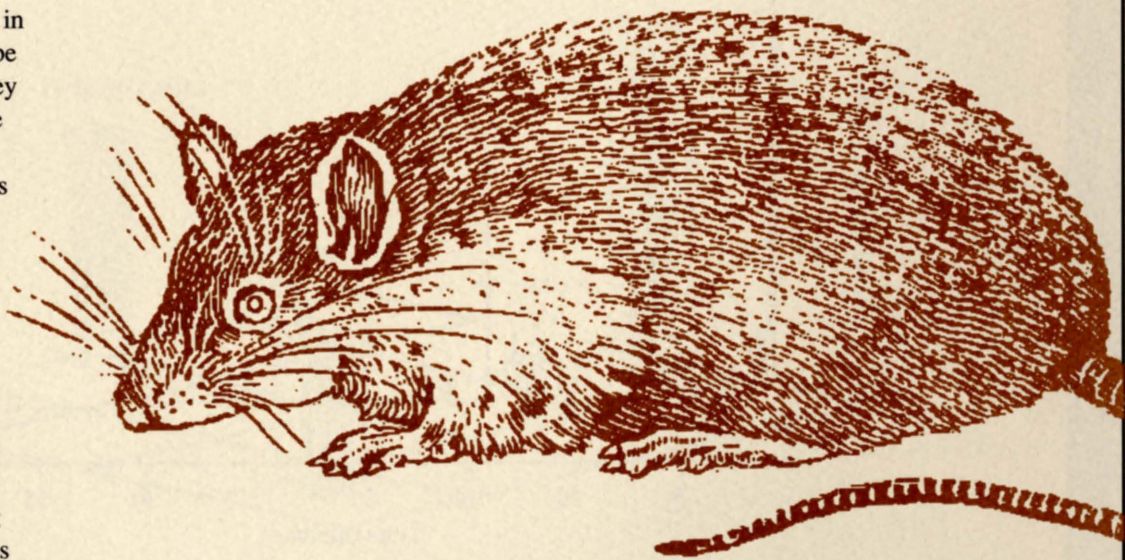
transgenic animals may become as useful in biochemical research as test tubes," Morrey says.

The danger that these animals will go on a "reproductive rampage" is no greater than, for example, that pigs or any other animal would start reproducing wildly. "Such an event is not likely to go unnoticed," Morrey quips.

And the risk that these genes would "infect" other species is no greater than the possibility that humans will suddenly acquire the ability to lay eggs when chickens are bred for increased egg production.

In some respects, transferring individual genes is simply "highly specific crossbreeding," Morrey says. Conventional crossbreeding involves the transfer of millions of genes in addition to those controlling the desired trait.

Genetic engineering techniques make the transfer more precise—and productive.



CHEMICAL FINGERPRINTS HAVE MANY USES

Chemical "fingerprints" of living things from honeybees to sagebrush may prove to be as important to ranchers and farmers as conventional fingerprints are to the F.B.I.

USU scientists combine analytical pyrolysis with computer programs used to recognize patterns to produce chemical fingerprints of substances as diverse as honeybees, sagebrush plants, and leafy spurge, a weed.

The chemical fingerprint indicates the sample's DNA or genetic material. The fingerprints can distinguish among closely related materials.

Chemist Grant Gill Smith and students Julie Robinson, Doug Stevenson and Ron Valcarce say the fingerprints they study are useful in honeybee management, rangeland improvements, and weed control.

Pyrolysis ("heat-breaking") involves the cleavage of a chemical into smaller molecules at high temperatures in the absence of oxygen. There are several pyrolysis procedures. The USU researchers use Curie-point pyrolysis in which samples placed on wires of metal alloys are heated electromagnetically.

A gas chromatograph or mass spectrometer coupled with the pyrolysis unit produces a "pyrogram," a tracing or graph of the chemicals from the sample (Figure 1 and 2). The peaks or bars of the pyrogram correspond to different chemicals.

Because it's impossible to visually compare many programs, each of which is slightly different, a sophisticated computer program sifts, sorts, simplifies and compares patterns. Various computer programs may be used, all of

which create a numerical "fingerprint" of each sample, for comparison with other samples.

The USU researchers have used the fingerprinting process to distinguish among African, Africanized and European honeybees, and to identify a hybrid between European and Africanized honeybees. The Africanized or "killer" bees have been moving north from Brazil since the mid-1950s and are a serious concern for U.S. beekeepers. The ability to identify the bees will help track the movement of the aggressive bees and aid in designing control programs.

Differences in the palatability of sagebrush plants are correlated with

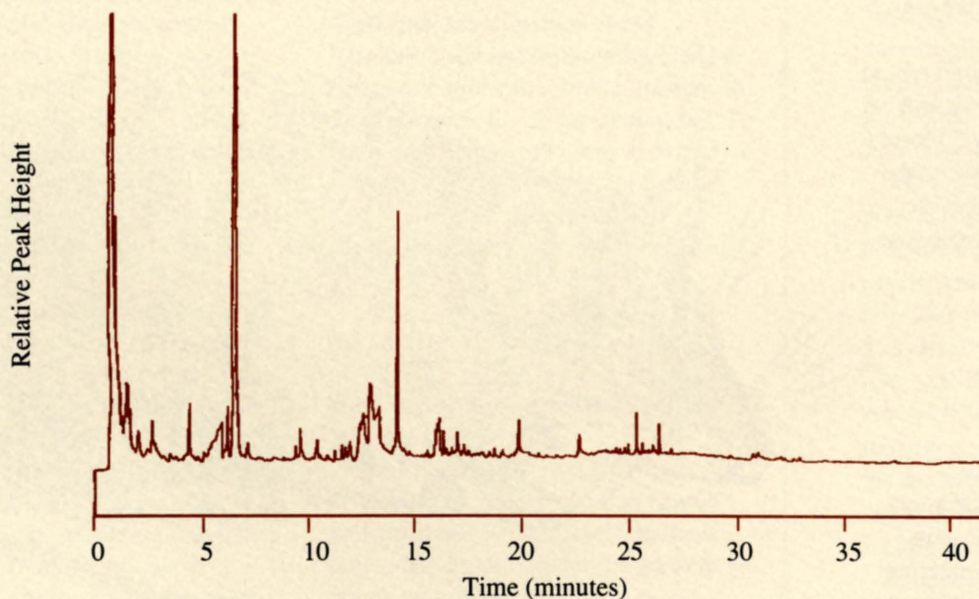


Figure 1. Representative pyrogram from pyrolysis-gas chromatography of *Euphorbia esula*.

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chemical differences, which can be identified by the fingerprinting technique. This means that sheep do not have to be used to verify the sagebrush's desirability or undesirability. The ability to identify different varieties of sagebrush can help range managers, who can plant tasty sagebrush to provide forage for game and livestock and plant unpalatable sagebrush along highways to discourage animals.

Leafy spurge, a weed which has spread throughout much of Canada and the Northern United States, is a serious

problem in range management. Taxonomists disagree whether the leafy spurge population consists of a complex of species, subspecies or hybrids. Chemical fingerprints can help resolve this issue and clarify the biochemical differences in populations, information which will help scientists devise biological control strategies, perhaps using insect herbivores, such as the Leafy Spurge Winged Hawk Moth. Biochemical differences might mean that insects are more useful on some populations.

The chemical fingerprints should have widespread application. The USU scientists are using the fingerprinting technique to study accessions of shadscale (a range plant), seeds of winter wheat varieties, and to distinguish between seeds of quackgrass and a new grass hybrid.

Samples used in the experiments were provided by scientists at USU, Brigham Young University, and by USDA-ARS laboratories in Logan, Provo and Baton Rouge, LA.

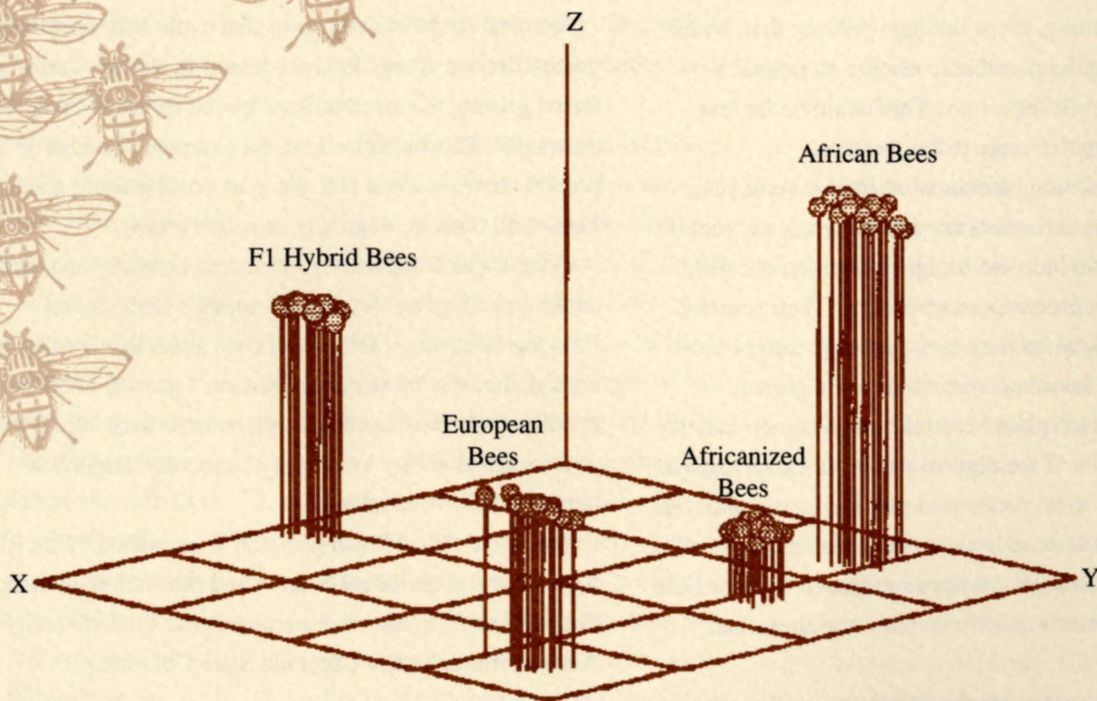


Figure 2. Plot of the first three principal components, which account for 98.5 percent of the differences in the samples of the bees.

NEW INSIGHTS ON GRAZING BEHAVIOR COULD IMPROVE RANGE PRODUCTIVITY

The younger twigs on blackbrush look tastier, but goats avoid them in favor of older (and less nutritious) twigs.

Neither goats nor blackbrush are important commodities on western rangelands, but both could play prominent roles in making rangelands more productive.

There's considerable interest in using goats as "biological manipulators" to improve range quality, either to increase the amount and quality of desirable forages (e.g., bitterbrush) or by eliminating or reducing the incidence of plants with little forage value (e.g., oakbrush), says range scientist Fred Provenza.

Blackbrush, a shrub found in the transition zone between cold and hot deserts in a band across southern Utah, northern Arizona, Nevada and California, is a potential winter forage for cattle. It is also being studied for the factors that influence foraging behavior.

Coupled with the results of studies concerning the role of inheritance and learning, these findings indicate that, within certain limits, it may be possible to change an animal's foraging behavior to fit the range. That could be far less costly than changing the range to fit livestock.

The research involving blackbrush started several years ago when USU range scientists tried to use goats as "mobile pruning machines" to increase forage production because browsed blackbrush produces more forage. Their research took a different tack when they found goats preferred older growth to the more luxuriant current season's growth.

Goats may avoid the plant because certain compounds are toxic, erode the walls of the digestive tract, or cause nausea. The culprit appears to be condensed tannins, compounds that cause the astringent taste in banana peels, tea and many other foods. Nutritional deficiencies apparently aren't responsible because current season's growth is more nutritious than older foliage.

Goats that haven't eaten blackbrush before will eat the current season's growth or feed containing condensed tan-

nins—once. They won't eat it again, however. "This tells us that it's not the flavor but the consequences associated with consumption of current season's growth that is important," Provenza says.

Provenza thinks goats may be able to detect variations in the structure of condensed tannins in different plants. For example, goats strongly prefer food laced with tannins from bitterbrush to food containing blackbrush tannins. Additional feeding trials will determine if the structure of condensed tannins changes as foliage matures, thereby enhancing the consumption of older blackbrush twigs.

Although researchers have not examined livestock preferences for blackbrush, ranchers say cattle familiar with the shrub tend to eat it while cattle that haven't encountered the shrub tend to avoid it, behavior consistent with recent findings concerning the importance of learning on foraging behavior.

"Several studies have shown that cattle and sheep learn to graze different areas. In cross-fostering studies, lambs preferred grazing the areas utilized by the foster mother," Provenza said. This indicates that, for example, it might be possible to train cattle and sheep to avoid grazing streambanks and other ecologically sensitive areas.

Genetics also apparently influences consumption, and could make it possible to breed animals with certain foraging behavior. "One set of twin goats in a feeding trial ate significantly more current season's growth of blackbrush, which indicates that some animals may inherit the physiological ability to detoxify condensed tannins in blackbrush," Provenza says.

Provenza's blackbrush research is supported by the Utah Agricultural Experiment Station and the National Science Foundation. It involves researchers with the University of Alaska-Fairbanks and Colorado State University.

OUR STAKE IN IMPROVING
AGRICULTURAL TECHNOLOGY
IN
DEVELOPING COUNTRIES

J. C. ANDERSEN

When he received his Nobel Prize for economics, Theodore W. Schultz (1980) noted that because most of humanity is poor, knowledge of the economics pertaining to the poor entails knowledge of most of the economics that is really important. Because most of the world's poor earn their living from agriculture, the economics of agriculture in developing countries is nearly synonymous with the economics of poverty.

Schultz noted that "poor people are no less concerned about improving their lot and that of their children than are rich people." In other words, people in developing countries work very hard to utilize the resources available to them, but may not know how to optimally utilize these resources.

Schultz said that most low-income countries have the physical resources

to produce enough food to improve the welfare of the poor. The limits to production are not energy or cropland but human education and understanding.

Two centuries ago, a period (due to the work of Thomas Malthus and others) when economics became known as the "dismal science" for the gloomy predictions of starvation and poverty, English laborers' weekly wages were less than the price of half a bushel of wheat. During the 1960s the weekly wage of an agricultural worker in India was somewhat less than the price of two bushels of wheat, which may indicate that impoverished residents of developing countries may be faring better than the residents of England two centuries ago. Furthermore, recent developments in India show that rapid progress is possible. India was an exporter of wheat in

1986, although the weather subsequently reduced grain production in that region.

Some observers think Malthus (1826) was correct in his prediction that population grows geometrically and food supply grows arithmetically, and that starvation will eventually result. However, that dismal forecast is unlikely to materialize, as Schultz noted when he said that our social and economic history shows that "we didn't breed like lemmings headed toward destruction."

However, it will not be easy to balance population with the capacity to produce food, a process which requires education, training, and economic development. Ultimately, the quality of life must change because (1) family planning reflects personal, social, and religious values, and (2) in less developed societies, children are

Development occurs only when a country produces adequate food so workers can be released to produce other goods.

often regarded as assets in working the land to produce food, i.e., the larger the family, the more food that can be produced.

American agriculture has a stake in agricultural development in less developed countries. This paper briefly examines some of the major factors affecting economic development and the trends that are likely to affect agricultural exports.

Factors Affecting Agricultural Development

What determines the difference between poverty and plenty? A review of the history of development in developed countries clearly indicates that the proportion of the workforce engaged in agriculture is an important factor. Development occurs only when a country can produce adequate food and release workers to produce other goods. Thus, increased productivity in agriculture means that fewer people and resources are required; other industries and jobs must be available to absorb the workers no longer needed in agriculture.

Education is a key factor in economic development. A number of underdeveloped countries stress the importance of education, but the educational systems in many emphasize the classics—poetry, language, and similar topics. A system of education conducive to development should emphasize agriculture and other topics needed by fundamental industries and should foster entrepreneurial skills.

Marketing systems also warrant attention. The lack of markets in many areas means peasants have little or no

incentive to increase agricultural production beyond subsistence levels. For example, even though pineapples can be grown in the interior of Guyana (northeast of Brazil) the lack of marketing facilities in that region obviously precludes the establishment of pineapple plantations.

Agricultural development is also inhibited by economic policies that establish low food prices. In many countries, the prices of basic agricultural commodities are deliberately kept low to placate consumers. Consumers often control government, and such a “low-price” policy destroys incentives for farmers to produce. (In some respects, we may have established a low-price policy for food in the United States, but this is largely due to the productivity of American farmers.)

Obviously, natural resources shape agricultural development. In the United States where land and other resources except labor are plentiful, agriculture uses minimal amounts of labor and huge amounts of capital and other inputs. In Israel, water is limited and is carefully husbanded in agriculture, while other resources such as capital and labor are used liberally. In Japan, land is scarce and production per hectare is high. Fertilizer, labor and other resources are applied liberally.

Farmers value security and dependability, which often explains why traditional techniques that are likely to provide enough for subsistence are sometimes preferred to new techniques, which may greatly increase yields under optimal conditions but may not be as dependable under adverse conditions. For example, in Bangladesh less productive varieties of rice with stems 12 feet long and a floating head are still

Table 1. Potential increase in food production from adoption of conventional techniques (Chou *et al.* 1977).

	Increase by factor of
Increased agricultural land harvested	2.5
Multicropping	1.5
Cultural practices:	
Fertilizer	1.5
Irrigation	1.5
High-yielding varieties	2.0
Other inputs	1.2
Total potential increase*	20.0

*Present food production is multiplied by each following figure to arrive at multiplicative total of 20.

grown in large part because over one-half of the country is subject to flooding every year. The rice head of the older variety will float in a flooded field and the plant will survive and still produce some rice. Most of the plant's energy is allocated to straw, which is used for thatched roofs. Many peasants doubt the dependability of polders (dikes) and water pumps. The dikes often failed (sometimes because peasants removed the riprap of bricks and other material used to reinforce them), thus flooding and killing the short-stem, high-producing varieties of rice. The old varieties were almost certain to yield enough for peasants to subsist when fields flooded.

Farmers also need economic incentives to produce. In Senegal, the lack of incentives has hampered the success of some large projects because workers do not have a stake in the crops, which are poorly tended and yield poorly in spite of machinery and other inputs. On small plots owned by farmers, yields are improving even though these endeavors receive much less financial support.

These and numerous other examples clearly demonstrate that there are adequate physical resources to produce an abundance of food, and that technology is available for the optimal use of these physical resources. Agricultural development often fails simply because people do not manage and combine resources and technology in a manner to produce enough food.

This is shown in Table 1, which is based on work by Sylvan Wittwer (former Director of the Michigan Agricultural Experiment Station) and his associates. They found that food production in the world could potentially increase 20 times if currently available technologies were adopted. This figure may initially be disconcerting to American farmers who anticipate that their exports will increase to meet the world's demand for food. However, it is unrealistic to expect food production to increase by 20 times. Nonetheless, these projections indicate the vast potential to increase food production.

For the reasons noted above, new varieties and improved technology have

received only limited application in spite of their widespread availability. As a result, many countries remain quite dependent on imports, but they lack the resources to pay for sorely needed foodstuffs.

World Grain Production and Trade

Grain imports by developing countries are essential in meeting nutritional needs. World grain production and consumption and year-end stocks as a percentage of annual world consumption are shown in Figure 1. Consumption sometimes outpaces production. In 1984, stocks on hand increased when production started to outstrip consumption by a fairly substantial margin (stocks were still a small percentage of world consumption, however). The maximum carryover (1985-1987) was 25 percent of annual production. Note that the U.S. storage is a substantial percentage of the world total. Carry over stocks for 1988 decreased due to

Encouraging economic growth in developing countries should improve export markets for American grains.

adverse weather and government crop reduction programs, and prices rose dramatically.

Total food production increased more rapidly in developing countries even though population growth in these countries resulted in the lowest per capita growth (Fig. 2). Centrally planned countries experienced the highest increase in per capita production but this increase was largely confined to the developed countries in this category.

In 1981, 70 percent of the wheat grown in the United States was exported. Wheat exports decreased to about 40 percent of domestic production and subsequently increased to more than 50 percent. Climatic conditions favored wheat production in many parts of the world until 1987. In 1988, stocks of grain experienced the largest

decrease in history because of the drought in the United States, government grain policy, poor climatic conditions in other regions and increased demand. Exports from competing exporting countries also increased as recent adverse climatic conditions in several parts of the world caused prices to skyrocket.

Trends In Agricultural Production

World agricultural production has increased by about 20 percent in less than a decade and per capita food production has increased by nearly 5 percent during this period. In the developed countries, total food production and per capita food production increased somewhat more than average.

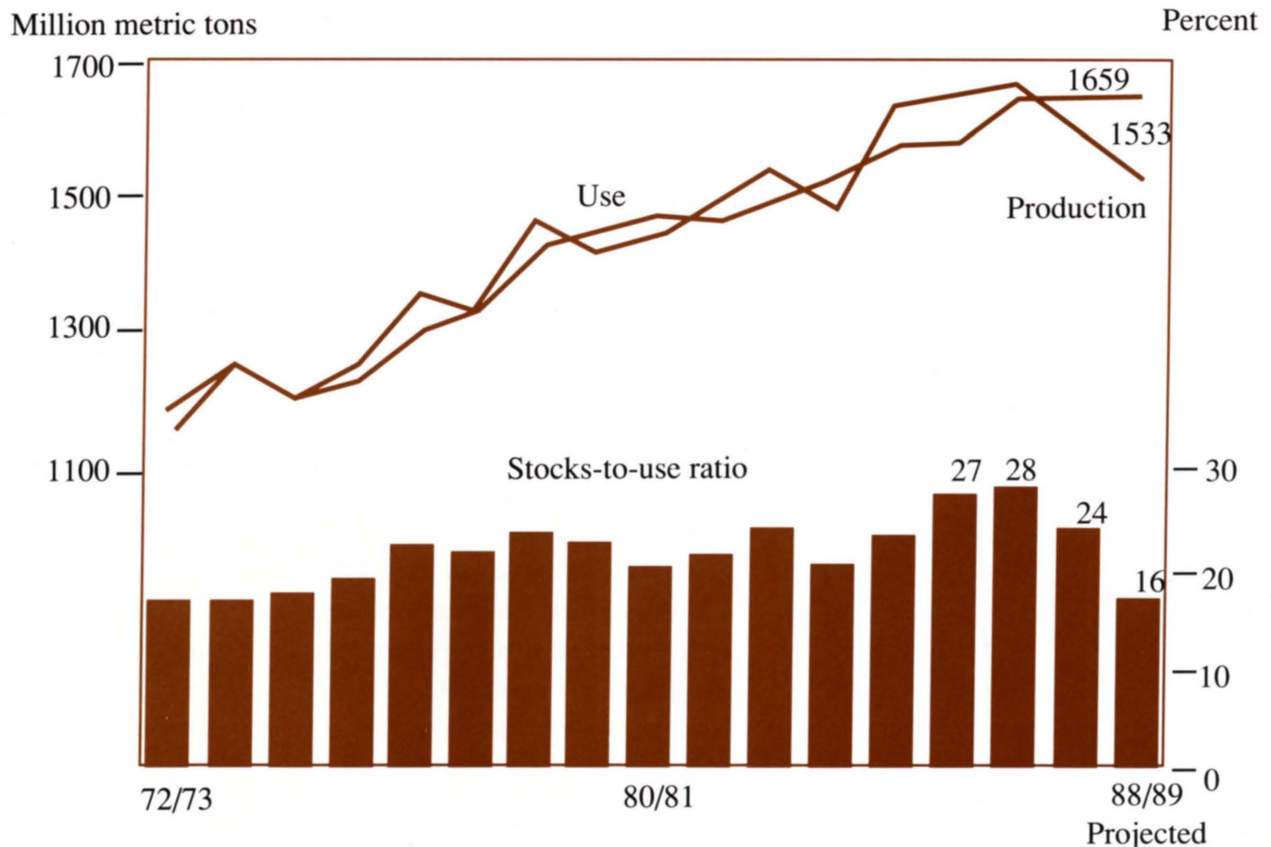


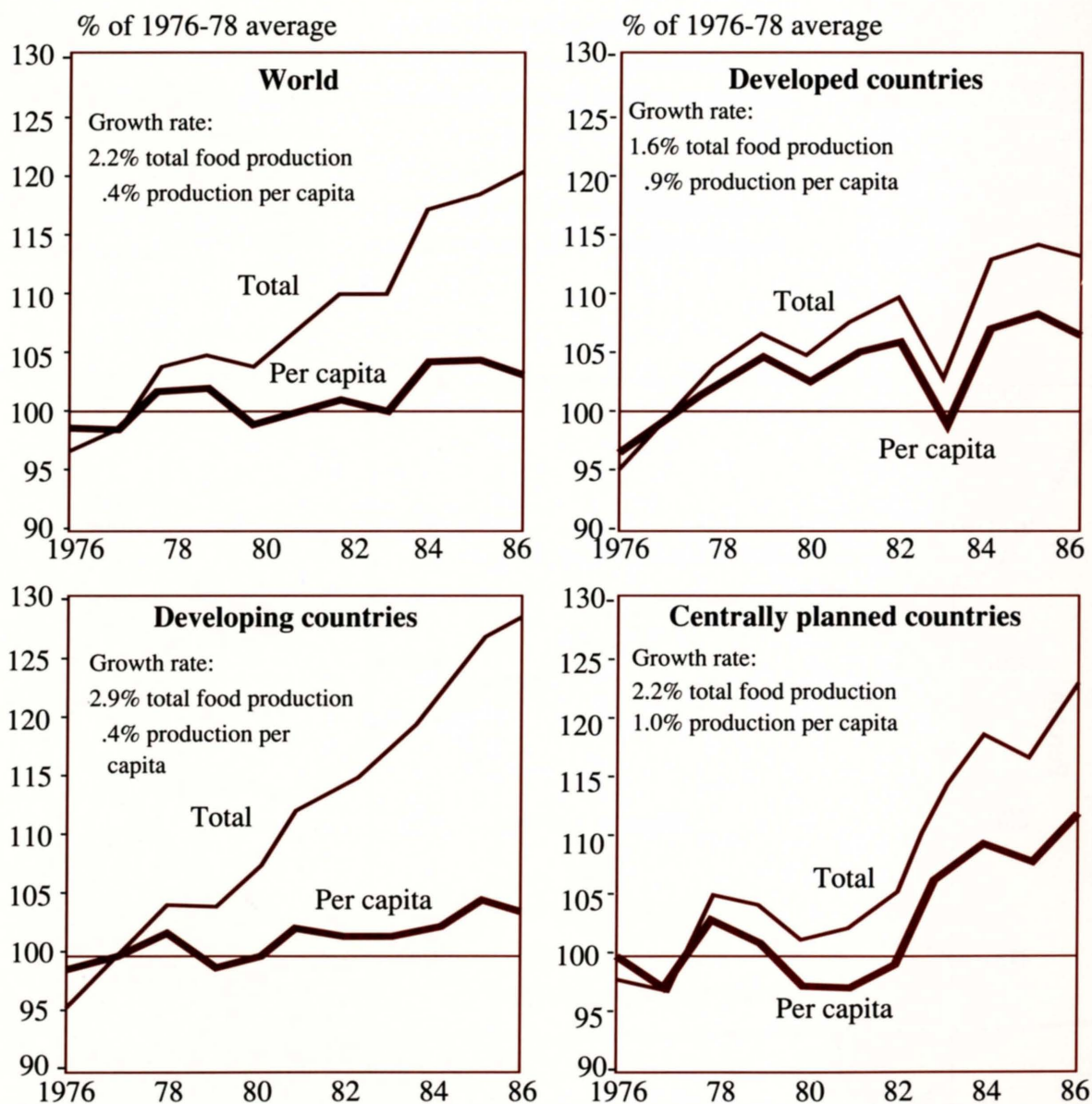
Figure 1. World grain production, consumption, and ending stocks (Source: Donald 1988).

In developing countries, food production increased more than 20 percent but the per capita increases in food production were much smaller. In centrally planned countries during the 1980s, food production per capita increased dramatically. Much of the increase occurred in China and was largely due to that country's low rate of population growth.

Vocke (1988a) and Mellor (1989) note that trade increases substantially with the higher income of developing countries and very little with the poorest countries (see Fig. 3). The increase is largely in feed grains (Vocke 1988b, see Fig. 4). Thus these higher income developing countries are becoming less self-sufficient and more dependent on grain imports (Vocke

1988c, see Fig. 5). Perhaps of even greater importance to Utah producers is the increase in foreign demand for forages that is expected to accompany these rising incomes.

Industrialization has not advanced and incomes have not increased in the low-income countries, which lack the purchasing power to be major participants in world trade (Fig. 5). Diets in



Compound annual growth rates computed for 1976-86

Figure 2. Changes in world food production (Source: U.S. Department of Agriculture, 1988).

Developing countries may have to increase their exports to raise needed foreign currency.

middle-income countries are improving and include more animal and non-cereal products. As demand for feed grains outpaces domestic production, these countries tend to become less self-sufficient and increase imports. The newly industrialized countries have been growth markets for our grains (and grains from other exporting countries) for two decades. These markets will continue to expand if these countries can reduce debt. The reduction in debt will be facilitated if these countries can increase exports of currency generating goods to developed countries.

The poorest countries must improve food production and distribution if they are to meet the nutritional requirements

of their citizens. Lack of income to purchase food, whether imported or domestically produced, is probably a greater limitation than the availability of food *per se* (Tweeten 1978). Food supplied by other countries should be viewed as a source of emergency relief rather than as a long-term remedy.

Trends in agricultural production indicate that enough food is produced. The major problems appear to be associated with the distribution of food and the ability of developing countries to pay for food and other needed imports. Solutions to these problems often require that developing countries increase their exports to the developed countries in order to raise needed foreign currency.

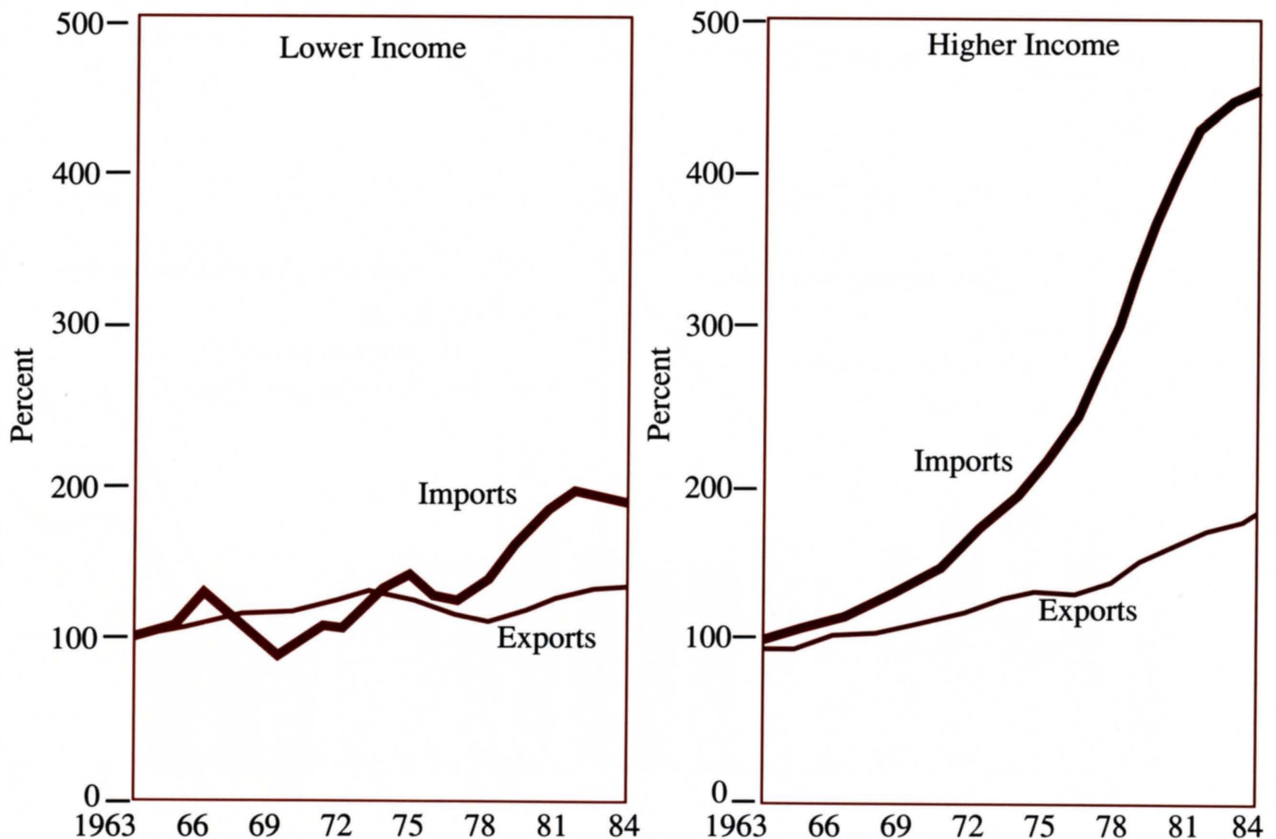


Figure 3. Agricultural trade in less developed countries (Source: Vocke 1988a).

Policy Recommendations

The above information is the basis for the following observations on policies and programs (see also Tweeten 1978):

1. We need not be overly concerned that technical agricultural aid to developing countries will increase competition for markets. Our resources are best suited to producing grains (especially feed grains); as consumers in developing countries demand higher quality diets, demand for imported feed grains will increase.

2. Programs to increase productivity in agriculture in developing countries should be linked with entrepreneurial activity so industries can absorb labor released from agriculture.

3. It may be in the self-interest of the United States to implement programs to relieve or restructure the debts of some countries in order to enhance their ability to import agricultural commodities.

4. Food aid will continue to be necessary, especially for the poorest countries. Effective aid programs require an adequate commodity reserve program. The United States will probably continue to provide a large share of this aid. Some stored grain might be considered "emergency reserves" rather than "surpluses."

5. We should remove trade barriers on imports, especially from developing countries that must earn foreign currency from their exports in order to

import our commodities. Most of the commodities they export do not compete with our products.

6. The United States should continue a strong domestic program of agricultural and nutritional research, which is essential for the adaptation of new technology in developing countries to generate economic development. For similar reasons, Utah must continue to develop technologies and products that will make agriculture in the state competitive with agriculture in California, Colorado and other states. States that do not invest in new technology will lose markets to competitors.

7. Some of our foreign agricultural aid seems to be misdirected. For example, we continue to pay a disproportional

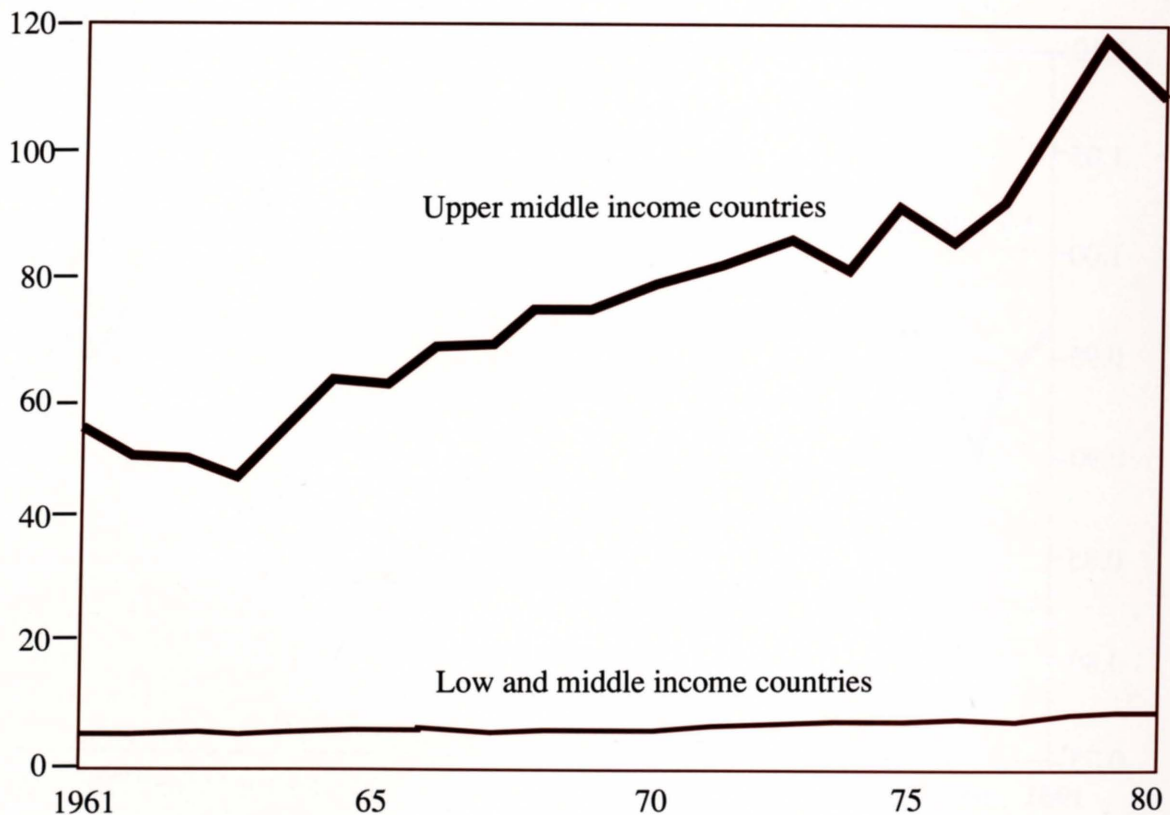


Figure 4. Per capita feed use of coarse grains in the less developed countries (Source: Vocke 1988 b).

About 10 percent of the world's total food production enters the international market.

tionate share of the cost of military protection for developed countries. Other policies seemingly seek to dump unwanted surpluses. However, policies that foster economic development in the developing world are in our best interest because they encourage the development of viable markets for U.S. agricultural products.

We could better foster development in many countries if we devoted more resources to developing their human capital and institutions rather than donating food or physical resources (land development, equipment, seeds, fertilizer, etc.). Donated food may destroy economic incentives for local producers.

Our aid to these countries should provide:

1. **Incentives to produce.** This requires markets, which depend on roads, entrepreneurs, communication systems, government policies that do not destroy incentives by taxes and price regulations, and access to domestic and foreign customers.

2. **Readily available technology.** Clearly, production systems must be adapted to fit the needs of other countries. This requires considerable in-country research and demonstrations to tailor technology to local conditions.

3. **Inducements for producers to accept new technology.** New ideas must be presented in a form acceptable

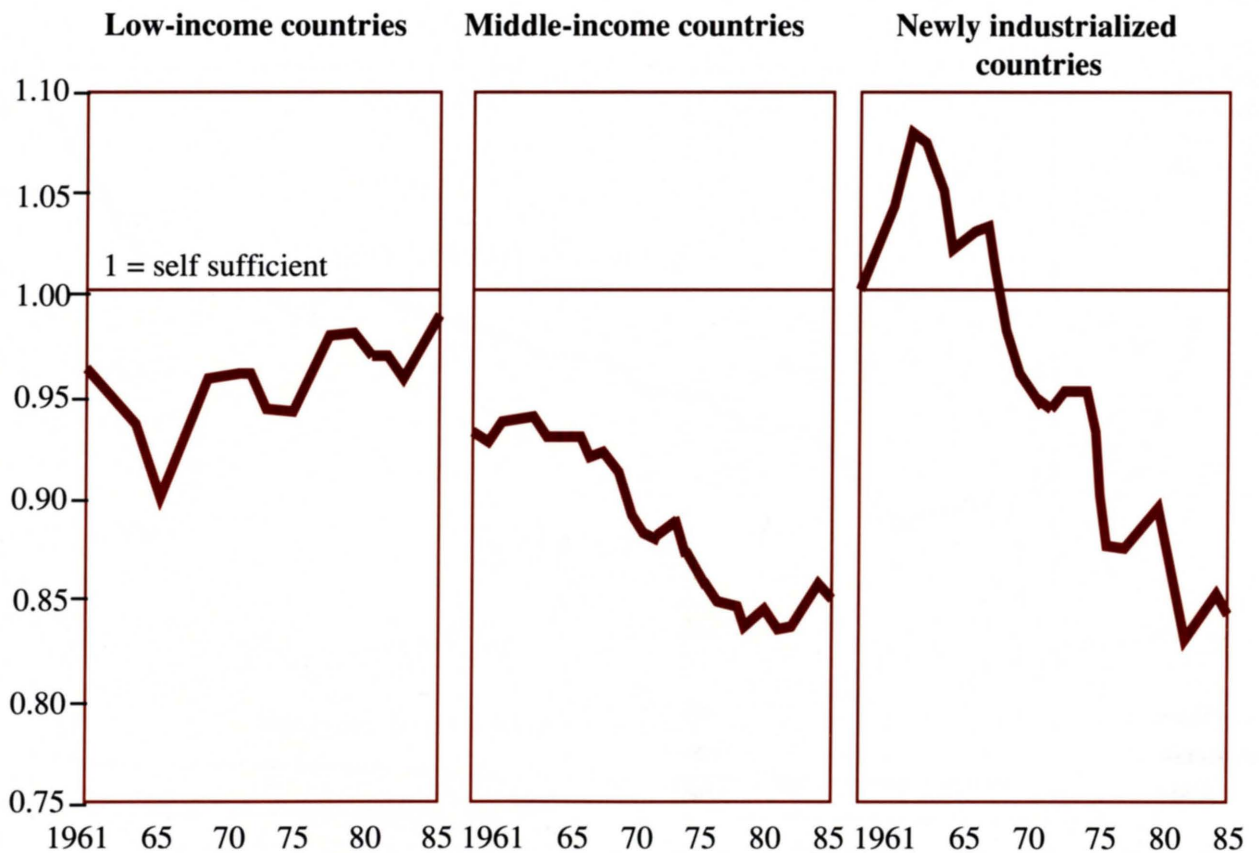


Figure 5. Proportion of grain provided by domestic production (Source: Vocke 1988c).

to intended users and should encourage activity that will increase the general level of productivity.

The costs of agricultural production in developing countries must be reduced so resources not required in agriculture can be utilized in other enterprises. This will raise the general income level in these countries so they become better customers for our goods and services.

The world has the potential to feed the hungry. American farmers will have some role in this endeavor, but the major responsibility must be borne by the farmers in the developing countries. These farmers need our assistance in applying new technology.

Only about 10 percent of the total food produced or consumed in the world enters the international market. Ninety percent is grown and consumed domestically. The proportion of basic food items grown for domestic consumption will probably increase as more countries try to achieve self-sufficiency. Items that can enrich diets will play an increasingly important role in international trade.

The United States has an interest in the economic well-being of developing countries for humanitarian reasons and because these countries become better customers as they increase their standards of living.

During the next several years, world production is likely to increase and the proportion of at least some U.S. crops that can be exported may decline. Programs that encourage economic growth in developing countries are the best hope for improved export markets for some grains and forages raised by American farmers.

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WHY DID BISON FAIL WEST

OF THE ROCKIES?

P. J. URNESS

In some ways, this is a rhetorical question: Buffalo did *not* fail but were less abundant and were more scattered than on the Great Plains at the time of European contact. The following brief review examines why this occurred, and also discusses the relationship between forage and bison populations in the Great Basin and possibly in the Columbia Plateau.

Our perceptions about bison in the Far West are colored by conditions in the 18th century and in the 3-4 decades following Lewis and Clark's expedition (1803-06). Archeological evidence indicates that bison seldom were the dominant item in Native American middens and that Native Americans switched from the staples of fish, birds, small mammals, and plant foods to bison and other ungulates on an opportunistic basis. Rock art in Utah (Castleton 1974, 1979) depicted bison at only 19 of 193 sites. In contrast, bighorn sheep were represented at 134 sites, deer at 59, elk at 7, and antelope at 6. However, most

rock art occurs in the Colorado Plateau country, not in the Great Basin.

In any case, it is apparent that bison were more numerous prior to the arrival of western man, and were quite abundant in some locales even during the peak years of the fur-trapper era of the 1820s and 1830s (Rawley 1985). However, some historians suggest that buffalo populations had been declining for a long time prior to 1800 for unknown reasons (Butler 1978), although acquisition of the horse (perhaps as late as the early 1700s in the Northwest) probably had precipitated considerable changes shortly before the Lewis and Clark expedition (Christman 1971, Van Vuren 1987).

Status at the End of the 18th Century

The Escalante-Dominguez expedition of 1776 through central and southern Utah encountered a few bison near the Green River and received Indian reports of other bison around the Great

Salt Lake, but these Indians also reported that intertribal conflicts apparently prevented them from hunting there (Bolton 1950). Lewis and Clark (1893) reported few wild ungulates or much evidence of their use by Indians along the lower Snake and Columbia River Plains from the Bitterroot Mountains to the Pacific, even though Indians possessed horses. Farther south, William Ashley and Jedediah Smith reported in 1825 that bison were abundant around the Great Salt Lake (Dale 1941). Peter Skene Ogden's brigades of Hudson Bay Company fur trappers reported that bison were abundant in the Cache and Ogden valleys in northern Utah in 1825, and scattered to abundant in northwestern Utah and southern Idaho in 1826-29 (Miller 1952, Rich 1950, Williams 1971). Osborne Russell saw bison by the "thousands" in various locations in the upper Snake River country including Jackson Hole in 1835 (Haines 1955). Apparently no bison remained in Cache Valley when

Bison could do very well in the grasslands and sagebrush grass steppe throughout the Far West.

he visited in 1840; Simmonds (1988) states that the last bison in Cache Valley were seen in 1833. It is unlikely that bison survived anywhere west of the Rockies after the end of the fur-trapper era, about 1850 (Roe 1970).

Why So Few Bison in the Columbia Plateau?

The relative abundance of bison in the upper Snake River Plains and parts of the northeastern Great Basin during the period of European exploration is undisputed (Haines 1967, Kingston 1932, Butler 1971, 1978, Harper 1986). There is much less agreement about conditions in the Columbia Plateau region. Despite frequent statements by early explorers to the effect that the grasslands west of the northern Rockies were as good or better than those to the east (Daubenmire 1985, Kingston 1932, Lewis and Clark 1893) there are no authenticated records that western man sighted bison in this region. Archeological evidence, however, indicates that modern bison (*Bison bison*) were present continuously before 2000 years BP (before present) until historic contact, but that numbers diminished in the late prehistoric period (Butler 1978, Schroedl 1973). Osborne (1953) suggested that bison were fairly common until just before the period of European exploration. He also dismissed the view that there were only small invader bands of bison. Indeed, bison, deer, elk, antelope, and bighorn sheep remains are found in middens throughout the Columbia Plateau, although they seldom make up a high percentage of mammalian material.

Others argue that this region was essentially devoid of significant numbers of large herbivores since retreat of the Pleistocene glaciers (Mack and Thompson 1982, Daubenmire 1970, Young *et al.* 1976). This is offered as an explanation for the failure of the dominant caespitose grasses of the Columbia Plateau, the *Agropyron spicatum* Province, to acquire the herbivory tolerance characteristic of the Great Plains species of the *Bouteloua gracilis* Province. Indeed, Daubenmire (1985) suggested that bison failed to permanently colonize anywhere west of the Rockies and that large populations in the upper Snake River Plains had to be restored by incursions through South Pass because bison herds were periodically decimated during severe winters. Livestock losses in the Columbia Plateau during the severe winters of 1860-61 and 1880-81 lend some credence to this view (Meinig 1968); however, the fact that severe winters are rather infrequent and the recognized hardiness of bison are not consistent with this explanation.

Mack and Thompson (1982) speculated that the "failure" of bison to occupy the Palouse Prairie grasslands was due to the poor forage quality of Plateau grasses, which was too low to sustain lactation of bison cows and early growth of calves. Johnson (1951) offered a similar explanation for why densities of bison in the tall-grass prairies east of the Mississippi River were lower than in the short-grass prairies to the west. However, neither offer any substantive proof of these putative deficiencies in forage quality, and Mack and Thompson (1982) ignore the obvious contradictory evidence. Lewis and Clark remarked (mid-April

1806) upon the quality of the dry grasses and their ability to winter their horses in fat condition (Meinig 1968). The astonishing growth of the cattle industry from about 1855 to 1885, which was due to yearlong grazing with no supplementation, is proof that the quality of forage in the Columbia Plateau was more than adequate in all seasons (Meinig 1968, Galbraith and Anderson 1971, Kingston 1923). Moreover, an elk herd at the Hanford Reserve near Richland, Washington, (in the heart of the hot, dry Columbia Basin and on degraded grassland) is, without supplementation, reproducing at near the biological potential for the species (McCorquodale *et al.* 1986). The limited research concerning the nutritional requirements of bison suggests that they do not require forage of as high a quality as cattle (Peden *et al.* 1974); it is unlikely, therefore, that forage quality limited bison populations west of the Rockies, as Daubenmire (1985) indicated for at least the peripheral belts around the mountains surrounding the Columbia Plateau and Van Vuren (1986) indicated for southcentral Utah.

Van Vuren (1987) rejected the four explanations commonly proposed for low bison densities: (1) inaccessibility of the area coupled with Indian-caused mortality, (2) low forage quality, (3) lack of synchrony between forage plant phenology and bison reproductive cycle, and (4) severe winters that periodically killed all colonizing bison. His alternative hypothesis involved low forage quantity and isolated habitats that limited recolonization when local populations were wiped out. According to Janis (1976), wild horse numbers were more limited by the low quantity

of forage than were ruminants. If so, why did wild horses prosper in the Columbia Plateau when they were reintroduced if forage supplies were inadequate for bison? The lack of forage might explain why horses became extinct between 10,000 and 7,000 years BP (Butler 1976) and the bison did not, albeit densities were lower than on the Great Plains.

This seemingly contradictory evidence is confusing but does not preclude the possibility that aboriginal hunting may have been a dominant influence on the bison population. The physical barriers to rapid immigration to the Columbia Plateau (Kingston 1932), despite Haines' (1967) view to the contrary, combined with unrestricted hunting that resulted in exploitation that exceeded sustainable recruitment in a species like bison (with low biotic potential contrasted to deer) appear to be compelling reasons for the "failure" of bison west of the Rockies. Archeological analysis of Indian middens throughout the region show that ungulates were an alternative prey whenever opportunities allowed (use probably increased when Indians obtained horses around 1700) but that Indians were sustained by other food staples of fish, fowl, small mammals, and other invertebrate and plant foods (Kay 1988). Such prey-switching by other predators (e.g., wolves, lynx) has allowed them to suppress or exterminate ungulate populations in other areas (Bergerud 1971, 1983). This appears to have repeatedly characterized the relationship between Indians and bison (and other ungulates) west of the Rockies over long periods and contributed to the population drain caused by other predators (e.g. wolves).

Prospects for Future Production

If excessive exploitation rather than forage quality and quantity restricted bison populations, the potentials for bison production west of the Continental Divide are quite high. There is increased interest in bison in the northeastern Great Basin and upper Snake River Plains. More rangeland will probably be devoted to bison production and some of the land entered in the Conservation Reserve Program may also be used for this purpose.

Attractive features of bison production are the relatively low overhead due to minimal winter feeding as well as the present differential price favoring bison meat over beef. A private herd (more than 500 bison) exists on sagebrush-grass and meadow grassland on the Deseret Ranch in northeastern Utah. Unlike beef cattle, these hardy animals do not receive any supplemental hay during the winter. The little data concerning the nutritional requirements of bison are for habitats east of the Rockies (Peden *et al.* 1974, Rice *et al.* 1971, Hawley *et al.* 1981a, 1981b, Richmond *et al.* 1977, Schaefer *et al.* 1978). I have started research to resolve some of the questions concerning the relative efficiencies of bison and cattle on Far West ranges.

Another herd (almost 500 animals) on Antelope Island in the Great Salt Lake occupies a degraded semi-arid range in the sagebrush-grass steppe of the northeastern Great Basin. The animals appear small but are reproducing well. These bison have been on the island since the late 1800s even though the area was severely overgrazed by livestock until 2 years ago. The fact

Aboriginal hunting may have been a dominant influence on the bison population.

that bison can thrive under these conditions is inconsistent with the hypothesis that poor quality forage or a lack of forage limited bison colonization west of the Rockies. Moreover, these bison survived the 1983-84 winter (a one-in-a-100 years episode), contrary to the theory that periodic deep-snow winters caused extensive mortality. Another free-ranging herd (300-400 bison) in the Henry Mountains of southern Utah occupies a high-elevation habitat of sagebrush-grass, juniper-pinyon and spruce-aspen on the Colorado Plateau (Van Vuren 1982). Increases in herd size are limited by hunting governed by a cooperative agreement. Herd size would increase if permitted.

I believe that bison could do very well in the grasslands and sagebrush-grass steppe throughout the Far West if there is a moderate level of exploitation. The evidence noted above indicated that exploitation was intensive historically or in prehistory, and probably explains why bison did not thrive west of the Rockies.

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PERCIEVED RISKS ASSOCIATED WITH CATTLE PRODUCTION AND MARKETING

D.L. SNYDER



Webster's dictionary (1983) defines risk as the "possibility of loss or injury" or "the chance of loss." Risks are present any time that an outcome is uncertain. According to these definitions, agriculture involves risk because virtually all major management decisions related to production and marketing involve uncertainty. Planting and harvesting decisions are at the mercy of frosts, rain and other factors, and marketing involves changes in demand, supply and prices. Real and perceived risks must be known to develop appropriate production and marketing plans.

In 1982 and 1988, surveys were conducted to determine how cattle producers in Utah perceived the risks involved in (1) production and marketing systems and (2) selling options. The production and marketing alternatives were (1) selling all calves in the fall, (2) holding calves through the winter and selling them the next spring as yearlings, (3) holding cattle until the following fall and selling them as "long yearlings", (4) selling some calves in the fall and selling the remainder as

yearlings and long yearlings and (5) purchasing and backgrounding calves. The selling options were (1) in-state auctions, (2) out-of-state auctions, (3) direct cash sales, (4) forward cash contracts, (5) hedges on commodity markets, (6) commodity market options and (7) video auctions¹.

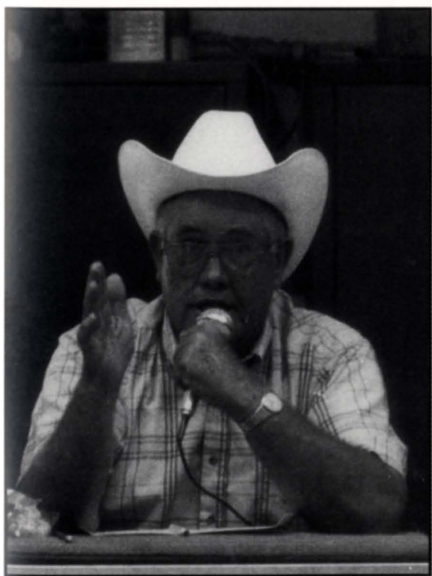
The producers were also asked about the size and type of operations, current production and marketing practices and types of market information utilized. In 1982, the survey was sent to more than 1,300 producers around the state; 30 percent responded. In 1988, a similar survey was sent to those who completed the first survey and 200 producers randomly selected from the original list of producers. Producers from all parts of the state completed the surveys.

There were very few changes in the size and type of operation during the 6 years between the two surveys, but producers had diversified their opera-

tions, e.g., an increase in the percentage of producers involved in cow/calf and stocker operations. There were also shifts in the marketing alternatives and methods of sale. In 1988, more producers sold yearling calves and fewer relied on "long yearling" systems. In addition, more producers utilized in-state auctions, and there was a dramatic increase in the use of video auctions. The diversification in marketing tactics was indicated by the fact that 50 percent of the producers in the 1988 survey and 40 percent in the 1982 survey employed a combination of selling methods.

Because financial institutions play a key role in agricultural enterprises from year to year, their perceptions of the risks inherent in agriculture may influence the production and marketing systems adopted by producers. For this reason, a survey similar to that sent to producers was sent to credit institutions in Utah in 1982. One hundred twenty of the 200 surveys were returned. In a similar survey conducted in 1988, slightly more than 100 (85%) of the 120 original respondents participated.

¹The use of video auctions in marketing cattle is a relatively new concept. Video auctions were not included in the 1982 survey but were included in the 1988 survey.



Cattle producers could use other production and marketing strategies to reduce risks.

Survey results indicated that substantial changes had occurred in the financial sector. Fewer lending institutions offered cattle loans and most of those that did were located along the Wasatch Front. In addition, only one bank reported that a major portion of its business involved cattle producers; however, the average bank had more clients and a larger loan volume than in 1982. These results reflect the consolidation that had occurred in the financial sector. Most lenders could identify the primary production and marketing strategies of their clients but were not able to identify their clients' secondary strategies.

Producers' Perceptions of Risk

Cattle producers confront various types of risks—including price changes and production risks (e.g., fertility, injury, sickness, drought, etc.). In most agricultural enterprises, price and production risks both contribute to income risk. While respondents were not asked to identify the type of risk they associated with the various production and marketing alternatives, their responses indicated that they associated risk with price risk. Respondents were asked to rank alternatives from 1 (the least risky alternative) to 6 (the riskiest alternative)². Responses were averaged for each alternative.

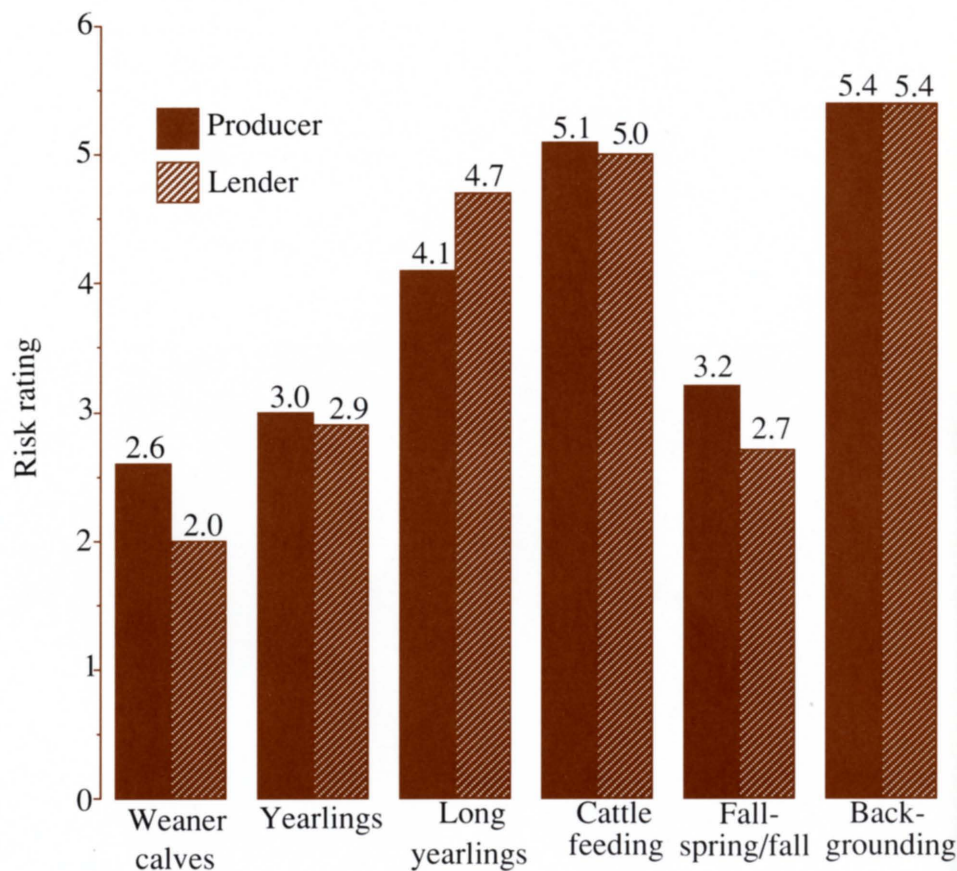


Figure 1. Risk ratings (marketing alternatives).

This average was the risk rating (RR) that was used to compare the risk associated with various alternatives.

Producers' perceptions of risk did not change substantially during the 6 years between the surveys. They perceived that selling all calves in the fall was the least risky production/marketing alternative (RR = 2.63) and that purchasing and backgrounding calves was the riskiest alternative (RR = 5.35). The risk ratings of the remaining alternatives are shown in Figure 1.

²For selling methods, the ranking was 1 (the least risky alternative) to 7 (the riskiest alternative). There was a greater range for selling methods because more categories were included.

Lenders' Perceptions

Lenders perceived the sale of weaner calves in the fall as the least risky alternative (RR = 1.97) and purchasing and backgrounding of calves as the riskiest alternative (RR = 5.38), which was consistent with producers' views. Lenders' perceptions of the risk associated with marketing alternatives are also shown in Figure 1. Direct cash sales (RR = 2.44) and in-state auctions (RR = 2.51) were considered the least risky methods of sale (Fig. 2).

Perceived risk was analyzed by type of operation and marketing method. Cow/calf operators gave cattle feeding a much higher risk rating than produc-

ers who fed cattle. Producers who fed cattle thought that in-state auctions were the riskiest selling method. The larger the operation, the less the risk that producers associated with marketing strategies that involved selling at several times during the year (i.e., fall, spring, and the following fall).

Lenders ranked selling methods in much the same order as the producers. In-state auctions (RR = 2.78), direct cash sales (RR = 2.81) and forward cash contracts (RR = 2.85) were viewed as the least risky methods of sale, followed by out-of-state auctions (RR = 4.21), video auctions (RR = 4.46), hedging (RR = 5.0) and commodity options (RR = 5.63). Lenders' assessment of risk varied with the loan volume. The larger the average loan volume, the less risk that they associated with hedging, although it was not perceived as involving the least risk.

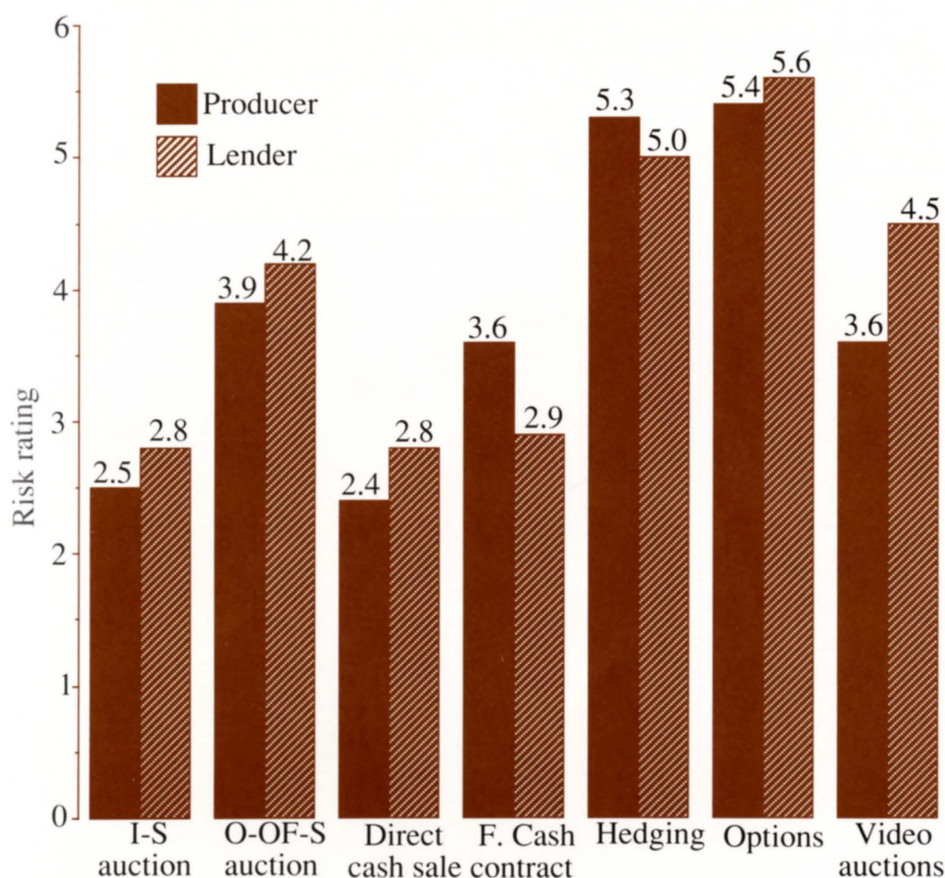


Figure 2. Risk ratings (methods of sale).

Summary and Implications

The majority of producers were cow/calf operators, which reflected the importance of grazing in Utah. Producers had diversified their operations since 1982 and thought that those production and marketing alternatives that reduced the time animals were held (i.e., fall sale of weaner calves or a combination of fall and spring sales) involved less risk; those alternatives that extended ownership (i.e., sales as long yearlings) were perceived as involving more risk. Lenders had similar opinions.

Producers viewed sale methods that provided relatively close outlets and immediate payment (i.e., in-state auctions and direct cash sales) as

Results indicate that producers may need to communicate better with lenders.

involving less risk. Methods that involved deferred payment and that were farther away (i.e., out-of-state auctions and commodity hedging and options) were viewed as involving more risk. The views of lenders were similar to those of producers.

Most actions were characteristic of risk averse individuals, who would be expected to diversify, utilize production and marketing strategies that minimize the duration of ownership, and adopt "localized" selling strategies. Producers in Utah have tended to diversify their production and marketing options. In general, they have adopted strategies that are more "local" and involve "immediate" returns. These may be indicative of a healthy aversion to risk in an industry has been buffeted by considerable change in markets.

Results of this study also identified some areas of concern. First, Utah cattle producers (and lenders) are reluctant to adopt production and marketing strategies that supposedly reduce producer risk (i.e., forward cash contracting and commodity options and hedging). This indicates that these alternatives either do not effectively reduce risks for producers or that educational programs have not clearly revealed the true benefits and costs of these strategies. Additional research should address the real and perceived risks faced by cattle producers and how to effectively reduce those risks. Educational programs for producers and lenders should help them accurately understand the risks associated with agricultural markets.

Second, results indicated that lenders generally knew their clients' primary production and marketing strategies. However, few lenders could

identify producers' secondary strategies, an indication that producers may need to communicate better with lenders. If risks are inversely related to the amount of information, then providing evidence of production and operation diversity may help producers garner additional financial support.

A healthy, viable cattle industry in Utah requires that producers understand the risks they confront and the options that are available to reduce those risks.

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THE ECONOMIC FEASIBILITY OF DIVERTING HIGH-PROTEIN GRADE A MILK TO MANUFACTURING PLANTS

R.A. CHRISTENSEN AND S.W. LEI

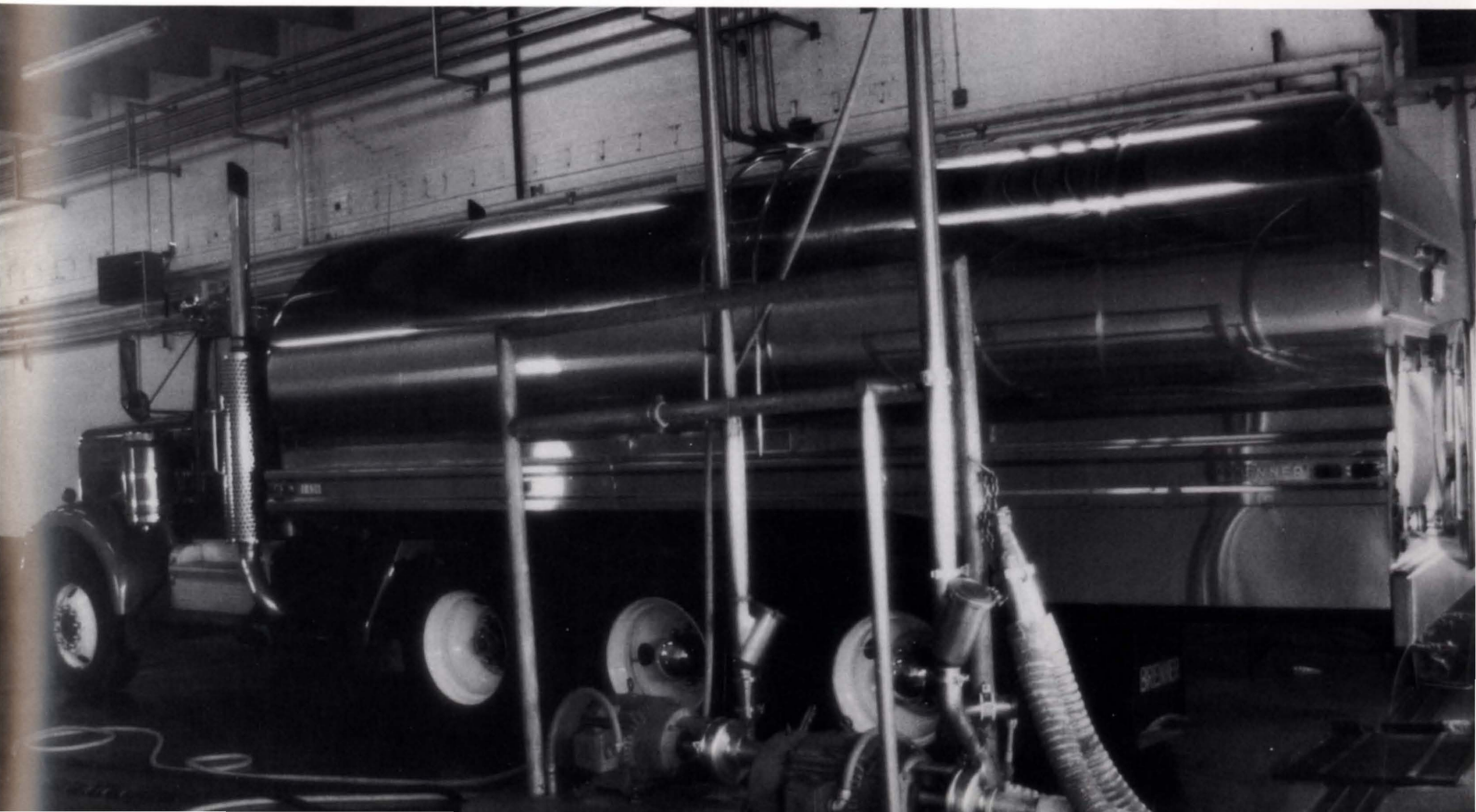
In April 1988, the U.S. Department of Agriculture began using protein in addition to fat and differential prices to compute prices paid to producers for Grade A milk in the Great Basin Order, which covers Utah and surrounding states. This was the first time multiple component pricing had been used in the Federal milk order system. Protein is now also used to establish milk prices paid by handlers, except for milk used in fluid milk products, which will continue to be priced on a fat and skim milk basis.

This new pricing plan is expected to change the price individual producers receive for milk and the cost individual handlers pay for milk. It could become a model for multiple component pricing in other Federal milk orders.

Because handlers are not required to pay for protein used in fluid milk products, producer marketing organizations may attempt to recover the costs associated with high-protein milk by diverting it to manufacturing plants that base product yields and handler payments on

protein. This study evaluated the economic feasibility of such a policy.

We used TRUCKSTOPS, a commercial computerized linear programming truck routing system, to simulate the costs of assembling and distributing milk. The simulation involved assembling 5.5 million pounds of milk (102 truckloads) from 582 dairy farms in the Great Basin area and distributing this milk to 12 fluid milk and manufacturing plants. Half of the milk went to fluid milk plants and half to manufacturing plants. Fluid milk



It is not economically feasible to divert high-protein Grade A milk to manufacturing plants.

plants were located in Denver, Colorado; Las Vegas and Logandale, Nevada; Ogden and Salt Lake City, Utah; and Pocatello, Idaho. Manufacturing plants were located in Beaver, Ogden and Smithfield, Utah; Idaho Falls and Twin Falls, Idaho; and Thayne, Wyoming. All manufacturing plants were assumed to be cheese plants. These data represented conditions in the Great Basin market during 1985.

In the first simulation, referred to as "normal" routing, milk assembled from dairy farms every 2 days was delivered to the nearest available fluid or manufacturing plant according to plant demand without regard to protein content. In the second simulation, referred to as "special" routing, milk from each dairy farm was classified according to protein content; high-protein milk was assigned to manufacturing plants and low-protein milk was assigned to fluid milk plants. In both cases, TRUCKSTOPS assigned stops to trucks, configured routes, and simulated assembly and distribution of milk to minimize total costs.¹

Miles

With normal routing, it would require a total of 13,655 miles of travel to assemble the 5.5 million pounds of milk from farms and deliver it to plants during each 2-day period (Table 1). Of the total, 11,550 would be "stem" miles

(travel between plants and supply areas) and 2,105 would be "stop" miles (travel between stops).

Total miles traveled would increase 52 percent to 20,747 miles if milk was assembled and delivered according to protein content. Total stem miles would increase 44 percent and travel between stops would increase 95 percent. Average miles traveled per truckload would increase from 134 to 203.

Time

It would take 28,850 minutes of driver time (17,439 minutes traveling and 11,411 minutes loading milk) to assemble and deliver the milk with normal routing (Table 2). Assembling milk by protein content would increase driver travel time 43 percent. Loading time would remain the same. Total travel and loading time would increase 26 percent. Average time required to assemble a truckload of milk would increase from 4.7 to 5.9 hours.

Cost

It would cost \$25,031 to assemble and deliver milk to plants every 2 days, based on normal routing and driver and truck costs of \$30.00 per hour and \$0.85 cents per mile (Table 3). Total costs would increase by 45 percent to \$36,298 if milk was assembled by protein content. Mileage costs would increase by 52 percent and time-related costs would increase by 29 percent. The average cost to assemble a truckload of milk would increase from \$245 to \$356. On a hundredweight (cwt.) basis, cost would increase from 45 to 66 cents.

¹For additional information on study procedures, see "Economic Feasibility of Assembling Grade A Milk by Protein Content," Research Bulletin 513, Utah Agricultural Experiment Station, Utah State University, Logan, UT 84322-4845.

Table 1. Miles required to assemble Grade A milk by normal routing and by protein content.*

Type of plant	Truck loads	Normal routing			Special routing		
		Stem	Stops	Total	Stem	Stops	Total
Miles							
Fluid milk	51	7,080	1,148	8,228	8,516	1,826	10,341
Manufacturing	<u>51</u>	<u>4,469</u>	<u>957</u>	<u>5,427</u>	<u>8,126</u>	<u>2,279</u>	<u>10,405</u>
Total	102	11,550	2,105	13,655	16,642	4,105	20,747

*Milk was collected every 2 days; based on costs and returns in 1985.

Table 2. Time required to assemble Grade A milk by normal routing and by protein content.*

Type of plant	Truck loads	Normal routing			Special routing		
		Stem	Stops	Total	Stem	Stops	Total
Fluid milk	51	10,329	5,597	15,926	12,892	5,597	18,489
Manufacturing	<u>51</u>	<u>7,110</u>	<u>5,814</u>	<u>12,924</u>	<u>12,027</u>	<u>5,814</u>	<u>17,841</u>
Total	102	17,439	11,411	28,850	24,919	11,411	36,330

*Milk was collected every 2 days; based on costs and returns in 1985.

Table 3. Cost of assembling Grade A milk by normal routing and by protein content.*

Type of plant	Truck loads	Normal routing			Special routing		
		Stem	Stops	Total	Stem	Stops	Total
Fluid milk	51	6,995	7,962	13,957	8,791	9,243	18,034
Manufacturing	<u>51</u>	<u>4,613</u>	<u>6,461</u>	<u>11,074</u>	<u>8,843</u>	<u>9,420</u>	<u>18,264</u>
Total	102	11,608	14,423	25,031	17,633	18,663	36,298

*Milk was collected every 2 days; based on costs and returns in 1985.

Costs of diverting high-protein Grade A milk would decrease net returns to producers.

Table 4. Average protein and fat content of milk assembled by normal routing and by protein content.

Type of plant	Truck loads	Normal routing	Special routing	Change	
				Amount	Percent
————— Pounds protein per cwt. —————					
Fluid milk	51	3.176	3.087	-.089	- 2.8
Manufacturing	<u>51</u>	<u>3.181</u>	<u>3.270</u>	<u>.089</u>	<u>2.8</u>
Total	102	3,179	3.179	.000	0.0
————— Pounds fat per cwt. —————					
Fluid milk	51	3.569	3.483	-.086	- 2.4
Manufacturing	<u>51</u>	<u>3.599</u>	<u>3.685</u>	<u>.086</u>	<u>2.4</u>
Total	102	3.584	3.584	.000	0.0

Change in Milk Composition

With normal routing, average protein per cwt. was 3.176 pounds in milk shipped to fluid milk plants, and 3.181 pounds in milk shipped to manufacturing plants (Table 4). These differences were not statistically significant.

Assembling milk on the basis of protein content would decrease protein in milk shipped to fluid milk plants by 2.8 percent to 3.087 pounds per cwt. and would increase protein in milk shipped to manufacturing plants by 2.8 percent to 3.270 pounds per cwt. The protein levels in these two types of milk were statistically different.

With normal routing, there were no significant differences in the average fat content of milk shipped to fluid milk plants (3.569 pounds/cwt.) or to manufacturing plants (3.599 pounds/cwt.). There were significant differences in fat content when milk was assembled according to protein content: Fat in milk

shipped to fluid milk plants decreased 2.4 percent (3.483 pounds/cwt.) and fat in milk shipped to manufacturing plants increased 2.4 percent (3.685 pounds/cwt.), which basically meant that fluid milk plants received milk containing less than 3.5 percent fat, while manufacturing plants received milk with more than 3.5 percent fat.

Cheese Yield

Average cheese production would be 267,796 pounds every 2 days when milk was assembled and delivered in a normal manner (Table 5). Cheese output would increase 2.6 percent to 274,816 pounds if high-protein milk was assembled and delivered to manufacturing plants.

The high-protein milk would also contain more fat, which would also help increase cheese production: Plants would be able to make 7,020 more pounds of cheese from the additional 2,382 pounds

Table 5. Cheese yield of milk assembled by normal routing and by protein content.

Type of assembly	Truck loads	Total pounds milk	Total pounds		Cheese yield, pounds
			Fat	Protein	
Normal	51	2,754,000	99,106	87,616	267,796
By protein content	<u>51</u>	<u>2,754,000</u>	<u>101,488</u>	<u>90,068</u>	<u>274,816</u>
Change			2,382	2,454	7,020

of fat and 2,454 pounds of protein that they received every 2 days. Cheese yields were calculated according to the formula: $Y = ((0.9F + 0.78P) - 0.1) * 1.09 / (1.0 - 0.37)$, where Y = cheese yield per cwt of milk, F = fat test, using the lower of the actual fat test and 1.37P, and P = protein test.

Net Extra Value

The additional cheese and fat in high-protein Grade A milk would be worth \$7,948 each 2-day period (cheese was valued at \$1.132 per pound and excess fat was worth \$1.663 per pound).

This additional income would not accrue to dairymen, however. Fluid milk plants would pay an average of \$3,963 less to producers for milk each 2-day period because of its lower fat content. This would be part of the cost of diverting high-protein milk to manufacturing plants.

In addition, it would cost \$11,267 more every 2 days to assemble and deliver high-protein Grade A milk to cheese plants. Thus, the costs of diverting high-protein Grade A milk to manufacturing plants would decrease net returns to producers by \$7,282 every 2 days (\$7,948 in

increased returns minus \$15,230 in additional costs).

The annual net loss would be \$1,329,000, an average loss of 26.4 cents per cwt. of milk delivered to manufacturing plants, or 13.2 cents per cwt. of milk delivered to all plants, including fluid milk plants. Thus, while diverting high-protein Grade A milk to manufacturing plants would increase cheese yields, it would not be economically feasible in the Great Basin area, or in other Federal orders where market conditions are similar.

These results can be applied in pricing milk. Producers should be paid for the net market value of their milk. The results of this study indicate that the costs of assembling and delivering high-protein milk may exceed the additional income. This is an important consideration in markets where a relatively high percentage of producer milk is used in fluid products because high-protein milk would probably have to be assembled separately and diverted to manufacturing plants to assure its use for manufacturing purposes.

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