Can We Identify Key Characteristics Associated with Grazing-Management Dairy Systems from Survey Data?

R. L. Parsons,¹ A. E. Luloff,² and G. D. Hanson²

¹Department of Community Development and Applied Economics,
University of Vermont, Burlington 05405

²Department of Agricultural Economics and Rural Sociology,
The Pennsylvania State University, University Park 16802

ABSTRACT

Discriminant analysis was used to identify farms using confinement and grazing-production systems from mail survey data of 2074 dairy farmers in Pennsylvania, Vermont, Virginia, and North Carolina. Survey respondents included 45.1% of the farms using confinement management; 13.5% of farms practicing intensive grazing, defined as moving cows to new pasture at least every 3 d; and 41.4% of farms using nonintensive grazing. Farmers using confinement management had significantly more cows, higher milk production, more crop acreage, higher debt, used automatic takeoff milking units (ATO), fed total mixed rations (TMR), and were more satisfied. In general, dairy farmers who grazed their milking cows had smaller herds, fewer acres, but had more acres per cow and made less use of technology. However, farmers practicing intensive grazing were significantly younger, more educated, less experienced, more likely to use computers, and farmed less acreage than other graziers or farmers on confinement farms. The discriminant function correctly classified 70% of the total sample when divided into confinement and overall grazing categories. However, the discriminant function correctly classified only 36% of intensive-grazing farms in comparison to confinement farms. Significant variables identified using ordinary least squares as being related to confinement management were milk per cow, acres of corn, use of ATO and TMR, debt greater than 40%, and residence in North Carolina. Significant variables associated with grazing management were acres of pasture, future use of pasture, education, and residence in Vermont. The analysis indicated that the discriminant function could correctly classify confinement and nonintensive-grazing management but was unable to reliably differentiate between confinement and intensive-grazing farms.

(**Key words:** grazing, confinement, factor analysis, discriminant analysis)

Abbreviation key: ATO = automatic takeoff milking units, OLS = ordinary least squares.

INTRODUCTION

Technological advances in milking systems, feeding methods, housing approaches, and biotechnology, coupled with restructured USDA marketing regulations and an increased focus on environmental concerns, have significantly changed production processes on US dairy farms. As a result, the US dairy industry is undergoing major structural changes that are effectively altering the profile of farm size, production technology, owner characteristics, and the accompanying infrastructure support needs of dairy farm businesses. Whereas the total numbers of dairy farms and dairy cows continue to decrease, there is a distinct trend toward larger farms, more cows per farm, and an accompanying greater reliance on mechanized, confinement feeding (Hallberg, 1993; Perez, 1997; Olsen, 2000). At the same time, a counter trend has emerged, one characterized by dairy farmers adopting cost minimization production systems that rely on intensive management of grazing systems (Fales et al., 1993; Parker et al., 1993; Jackson-Smith et al., 1997).

Since the mid-1980s, nominal milk prices have become more volatile, with record highs and lows, whereas average prices have been generally flat or slightly lower than prices 20 yr earlier. Meanwhile, the prices of most purchased inputs (e.g., labor, parts, equipment, and supplies) and taxes have been characterized by an upward trend (Greaser and Parsons, 1997-99; Knoblauch et al., 1999; Stafford et al., 2000). In the context of declining milk prices and increasing costs, maintaining farm-family living standards has been a challenge for the typical producer. In such a dynamic, technologically changing environment, many small- and mid-size dairy farmers find themselves needing to develop a significantly changed business strategy to ensure farm survival. Choices tend to include the following: increase

Received May 9, 2003.

Accepted February 23, 2004.

Corresponding author: R. L. Parsons; e-mail: bob.parsons@uvm.edu.

herd size, decrease milk-production costs; rely increasingly on off-farm income; reduce farm size by selling substantial assets and lowering farm debt; or the ultimate decision to abandon the business of dairy farming (Hanson et al., 1998b).

The most common motivation for increasing herd size is to capture the advantages of economies of scale and size hence improve overall farm profitability. In this approach, the operator tends to focus on dairy as the primary income source for the farm. Increasing herd size typically involves substantial new expenditures for facilities, purchase of additional dairy cows or bred heifers, and the acquisition of high-technology machinery and equipment. Because of the bulkiness of investments, such as milking facilities, housing, and additional labor, herd size often has to double or triple for an expansion project to result in a positive net cash flow. Such additional expenditures often threaten the stability of farm net worth by placing a large interest and principal repayment burden on the farm family (Ford and Shonkwiler, 1994; Hanson et al., 1998a).

Whereas many farmers have increased herd size to 100 to 500 cows (or more), other producers have concluded that this strategy, normally associated with high-debt leverage, was too risky to undertake. As an alternative to expansion, some producers have identified intensively managed rotational grazing as an innovative approach to reduce costs. Intensification of grazing technology fits the "reduced cost-structure" approach because it commonly does not require financing large additional investments. It is also appropriate to acknowledge that the principles of intensive grazing management are not recently invented but rather are merely being rediscovered (Voisin, 1959). In the simplest terms, one can suggest that rotational grazing changes farm reliance from capital-intensive machine-harvested forages to a cow-forage harvest system (Barnham et al., 1994; Murphy, 1994; Jackson-Smith et al., 1997).

However, the shift to intensive grazing of dairy cows is not necessarily easy to accomplish. Intensive grazing requires a new dimension of management that effectively evaluates the quality of a variety of standing forages, determines when to move cattle from one paddock to the next, assesses when to harvest grass mechanically when growth is exceeding grazing harvest, and balances the overall feed ration of cattle that spend most of their active time grazing.

The intensive grazing system described above differs from more traditional grazing that has been practiced on many dairy farms in the United States. Many farmers have used grazing to provide some forage for their dairy cows, but pastures were not managed to provide high-quality forage. Instead, management was highly

variable between farms, with pastures managed to primarily provide cheap forage in which milk-production quality was not the priority. This system is still widely used on many US dairy farms. The intensive grazing system and, to a lesser extent, traditional grazing (non-intensive) systems, require a different set of management skills than needed for mechanized harvest- and confinement-feeding systems (Murphy, 1994).

Moreover, because many farmers have developed a preference for the widely acknowledged efficiency advantages of mechanical devices and equipment, and because economies of size are associated with advances in machinery and manufactured inputs technologies, only a subgroup of farmers may in fact choose an intensive grazing system. Studies indicate that the principles of intensive, rotational pasture management are now in use on a growing, but limited, number of farms, about 8 to 16% (Gripp et al., 1993; Jackson-Smith et al., 1994; Parsons et al., 1998). One objective of this study was to determine the farmer characteristics, farmer attitudes, farm size, and farm-location characteristics associated with the use of grazing and the adoption of intensive grazing.

Given the shift away from mechanical feeding systems, as is now represented by intensive grazing, it is not surprising that many dairy researchers and extension specialists have been noncommittal toward grazing adoption (Hanson, 1995). If, as we believe, a growing dichotomy or even a tri-level structure has emerged representing diverging informational needs of confinement-feeding versus grazing systems, the new challenge for extension educators is how better to identify alternative producer groups within the greater population of dairy producers to better serve their educational outreach needs (Hanson, 1995; Parsons et al., 1998). More specifically, a key question is how can cooperative extension identify and direct education efforts toward groups that are most likely to adopt cost minimization grazing strategies versus those who plan to develop larger confinement operations and those farmers who are trying to use both strategies? The ancillary question of whether farmers who are adopting intensive-grazing management practices can be identified by demographic and other characteristics is examined herein.

MATERIALS AND METHODS

Survey Data Collection

This study is based on a 1999 mail survey of dairy farmers in Pennsylvania, Vermont, Virginia, and North Carolina. Comprehensive, statewide lists of dairy farmers shipping milk in Pennsylvania and Vermont were sampled randomly. For Virginia and North Carolina, the entire populations of milk shippers were surveyed.

Table 1. Farmer scores of satisfaction on a scale of 1 = dissatisfied to 5 = very satisfied for various survey categories and farm types.

Farmer satisfaction score category	Confinement ¹	Grazing ²	Grazing farms ³		Full sample
			Intensive	Nonintensive	
Corn silage yields	3.93 ^{a,b}	3.79 ^a	3.68 ^{d,b}	3.82 ^d	3.86
Corn silage costs	3.31 ^{a,b}	3.20 ^a	3.13 ^b	3.22	3.25
Hay yields ⁴	3.64 ^{a,b,c}	3.50 ^a	3.47 ^b	3.51 ^c	3.56
Hay production costs ⁴	3.35	3.31	3.31	3.31	3.33
Milk per cow	3.21 ^{a,b}	3.10 ^a	3.02 ^b	3.12	3.14
Purchased feed costs ⁴	2.06	2.03	2.06	2.03	2.04
Milking facilities ⁵	3.65 ^{a,b}	3.54 ^a	3.50 ^b	3.55	3.59
Cow housing ⁵	3.48 ^{a,b,c}	3.33 ^a	3.31 ^b	3.34 ^c	3.40
Capital replacement costs ⁴	2.65	2.62	2.64	2.61	2.63
Machinery repair costs ⁴	2.52 ^b	2.58	2.62 ^b	2.56	2.55
Time away from the farm ⁴	2.54	2.44	2.50	2.42	2.48
Stress level ⁴	2.53	2.51	2.57	2.50	2.52
Profit level ⁴	2.49 ^c	2.39	2.43	2.38 ^c	2.44
Financial progress ⁴	2.68	2.64	2.66	2.64	2.66

^aStatistically significant difference between confinement and grazing (all) farms at the $P < 0.05$ level.

^bStatistically significant difference between confinement and intensive grazing farms at the $P < 0.05$ level.

^cStatistically significant difference between confinement and nonintensive grazing farms at the $P < 0.05$ level.

^dStatistically significant difference between intensive and nonintensive grazing farms at the $P < 0.05$ level.

¹Confinement farms are those farms that indicated that they do not graze their milking cows.

²Grazing farms are those farms that indicated that they do graze their milking cows.

³All farms indicating they grazed their dairy cows were separated into two groups.

"Intensive" grazing farms are those farms that move their milking cows to fresh pasture at least every 3 d. "Nonintensive" grazing farms are those farms that keep their milking cows on the same pasture for more than 3 d before moving them to a new pasture.

⁴Nine variables indicated above were defined by factor analysis as a new composite variable: "financial factor."

⁵Two variables indicated above were defined by factor analysis as a new composite variable "facility factor."

The mail survey instrument focused on farm characteristics, production system, technology applications, future plans, producer demographics, and farmer satisfaction with yields, costs, facilities, and profitability. The survey was conducted following procedures recommended by Dillman (1978). An initial survey instrument, cover letter, and postage-paid return envelope were mailed to sampled farmers by first class postage. A postcard reminder was sent 10 d after the initial mailing to farmers who had not yet returned their survey. At 10 d subsequent to the date of the reminder-postcard, a second survey form was mailed to farmers that still had not returned the initial questionnaire form. For Virginia and North Carolina only, a third survey instrument was mailed to farmers who had not responded to either of the first 2 questionnaires.

All data were coded in Excel and analyzed with SPSS (Windows Release 11.0.1, SPSS, Inc, Chicago, IL). The initial analysis examined frequencies and then tested for statistical differences by state, dairy production system, and grazing intensity. Further analyses were completed with factor analysis and discriminant analysis, as described below.

Factor Analysis

Factor analysis was employed to examine and reduce information gathered from a battery of 16 items (Table 1) exploring farmer satisfaction in a smaller number of cases. The basic assumption of factor analysis is that underlying correlated factors can be used to explain a complex relationship among related variables. This "grouping" reduces the total number of variables and eliminates the "guess" procedure in determining which key variables belong in the analysis when there is limited theory available for guidance (Mulaik, 1972; Harman, 1976; Cattell, 1978). The reduced variables identified by the factor analysis were then used as independent variables in following statistical procedures.

Factor analysis requires close scrutiny of missing values in order to include appropriate data and to eliminate variables with many missing values. Vermont had many farms that did not raise corn silage, thereby eliminating the questions on corn-silage production costs and yields in the factor model. In addition, the questions that focused on satisfaction with hired labor costs and operator labor requirements were found to have many

Table 2. Characteristics of survey respondents by state.

Survey characteristics	PA (n = 874)	VT (n = 214)	VA (n = 702)	NC (n = 284)	Combined sample (n = 2074)
Cows per farm	65.3 ^{a,b,c}	99.3 ^{a,d,e}	114.9 ^{b,d,f}	148.5 ^{c,e,f}	97.0
Milk per cow (lb/yr)	17,476 ^b	17,650 ^d	18,192 ^{b,d,f}	17,378 ^f	17,720
Crop & pasture acreage (ac)	222.5 ^{a,b,c}	287.9 ^{a,d,e}	383.3 ^{b,d}	427.8 ^{c,e}	310.5
Corn (ac)	80.6 ^{a,b,c}	63.8 ^{a,d,e}	129.9 ^{b,d,f}	177.2 ^{c,e,f}	108.3
Hay (not pastured) (ac)	77.3 ^{a,b,c}	143.5 ^{a,d,e}	69.0 ^{b,d}	62.1 ^{c,e}	78.9
Hay/pasture (ac)	11.1 ^{a,b,c}	30.0 ^{a,e}	36.1 ^b	45.3 ^{c,e}	25.9
Permanent pasture (ac)	25.7 ^{a,b,c}	50.9 ^{a,d,e}	106.5 ^{b,d,f}	77.9 ^{c,e,f}	62.5
Other crops (ac)	28.0 ^{a,b,c}	4.2 ^{a,d,e}	43.5 ^{b,d,f}	66.0 ^{c,e,f}	36.1
Age (years)	45.1 ^{a,b,c}	49.1 ^a	48.3 ^{b,f}	50.7 ^{c,f}	49.0
Completed high school (%)	60.8 ^{a,b,c}	81.3 ^{a,e}	76.3 ^{b,f}	93.6 ^{c,e,f}	72.7
Debt greater than 40% (%)	22.5	21.8	20.1	16.4	20.8
More than 10 yr farm experience (%)	71.0 ^{a,b,c}	79.8 ^a	76.5 ^{b,f}	83.2 ^{c,f}	75.5
Off-farm income (%)	21.6 ^{a,b,c}	35.5 ^a	29.0 ^{b,f}	39.9 ^{c,f}	28.1

^aStatistically significant difference between Pennsylvania and Vermont at the $P < 0.05$ level.

^bStatistically significant difference between Pennsylvania and Virginia at the $P < 0.05$ level.

^cStatistically significant difference between Pennsylvania and North Carolina at the $P < 0.05$ level.

^dStatistically significant difference between Vermont and Virginia at the $P < 0.05$ level.

^eStatistically significant difference between Vermont and North Carolina at the $P < 0.05$ level.

^fStatistically significant difference between Virginia and North Carolina at the $P < 0.05$ level.

missing values. Farmers who had only family help tended not to respond to the question on satisfaction with hired labor costs. Moreover, nearly 30% of the surveys did not answer the question regarding their satisfaction with operator labor requirements. Thus, due to missing values as described above, satisfaction variables were reduced from the original 16 to 12 variables for the factor analysis.

Discriminant Analysis

This study explored the feasibility of identifying independent variables that can serve as predictors of 2 types of producers, confinement and grazing farms, and then identified additional predictors of differences of intensity among grazing farms. The hypothesis was that farmers using grazing methods could be differentiated from confinement producers on the basis of farm operator, farm, satisfaction, and location characteristics. To conduct this phase of the study, factor and discriminant analytic procedures were employed to identify dairy farms using confinement systems versus either intensive or nonintensive dairy-grazing production systems. *Intensive* grazing systems were defined as those farms moving milking cows to new areas of pasture at least every 3 d. *Nonintensive* grazing systems were those farms that kept milking cows on the same pasture for more than 3 d.

Discriminant analysis classifies individual observations into separate groups based on linear combinations of predictor (independent) variables that identify the variables that are important for both distinguishing

between groups and for predicting group membership for new cases whose group membership was undetermined. Basic assumptions of discriminant analysis must be met for the analysis to be valid. For example, each group must consist of independent samples from a multivariate normal population, group membership must be mutually and collectively exclusive, and the population covariance matrices must be equal (Lachenbruch, 1975; Goldstein and Dillon, 1978; Hand, 1981).

RESULTS AND DISCUSSION

Survey Results

The survey achieved an overall 64.2% response, ranging from 59.8 for Vermont to 70.1% for Virginia. Significant differences were found among the states surveyed for farm size, milk-production levels, operator age, operator education, and farm debt level (Table 2).

Pennsylvania, the nation's fourth largest dairy producer, has a much larger dairy farm population than the other states and is characterized by smaller herds and acreage (Pennsylvania Agricultural Statistics Service, 1998). Pennsylvania farmers were also younger, less formally educated, more likely to have a debt/asset ratio greater than 40%, had lower proportions with over 10 yr of experience, and relied less on off-farm income. Pennsylvania's statistics are influenced by Amish and Mennonite populations who have much smaller herds, less acreage, are younger than other farmers, and are less likely to have a spouse working off the farm. Education level is specifically influenced by the Amish generally not attending school beyond the eighth grade.

Table 3. Characteristics of dairy herds by confinement and grazing group.

Survey characteristics	Confinement ¹	Grazing ²	Grazing farms ³		Full sample
			Intensive	Nonintensive	
Production system (%)	45.1	54.9	13.5	41.4	
Location:					
Pennsylvania (%)	42.3	57.7	12.5	45.2	
Vermont (%)	30.3	69.7	30.3	39.4	
Virginia (%)	49.6	50.4	10.7	39.6	
North Carolina (%)	53.3	46.7	10.9	35.8	
Farmer Characteristics:					
Age (yr)	47.0 ^b	47.6	44.2 ^{d,b}	48.8 ^d	47.4
Post-high school education (%)	32.2 ^{a,b,c}	36.5 ^a	45.3 ^{d,b}	33.7 ^{c,d}	34.5
More than 10 yr farm exper (%)	76.9 ^b	74.3	67.7 ^{d,b}	76.4 ^d	75.4
Off-farm income (%)	28.0	28.0	31.2	27.1	28.1
Farm Characteristics:					
Cows per farm	123.8 ^{a,b,c}	75.0 ^a	77.1 ^b	74.3 ^c	97.0
Milk per cow (lbs/year)	18,660 ^{a,b,c}	16,940 ^a	16,670 ^b	17,030 ^c	17,720
Crop and pasture acreage (ac)	368.8 ^{a,b,c}	262.2 ^a	225.1 ^{d,b}	274.0 ^{c,d}	310.5
Corn (ac)	150.6 ^{a,b,c}	73.1 ^a	55.8 ^{d,b}	78.7 ^{c,d}	108.3
Hay (not pastured) (ac)	84.6 ^{a,b}	74.1 ^a	64.2 ^{d,b}	77.3 ^d	78.9
Hay/pasture (ac)	23.7	27.8	34.8	25.5	25.9
Permanent pasture (ac)	61.4	63.5	58.5	65.1	62.5
Other crops (ac)	49.5 ^{a,b,c}	24.9 ^a	14.3 ^b	28.3 ^c	36.1
Debt greater than 40% (%)	25.3 ^{a,c}	17.1 ^a	19.1	16.4 ^c	20.8
Use of milking parlor (%)	67.7 ^{a,b,c}	48.0 ^a	44.2 ^b	49.2 ^c	56.9
Use of automatic takeoffs (%)	54.4 ^{a,b,c}	29.7 ^a	25.5 ^b	31.1 ^c	40.9
Use of barn pipeline (%)	29.1 ^{a,b,c}	39.7 ^a	38.1 ^b	40.1 ^c	34.8
Use of TMR (%)	62.0 ^{a,b,c}	32.4 ^a	35.1 ^b	31.5 ^c	45.8
Use of DHIA (%)	69.1 ^{a,b,c}	51.8 ^a	55.4 ^b	50.7 ^c	59.7
Use of bST (%)	24.1 ^{a,b,c}	13.9 ^a	15.3 ^b	12.1 ^c	18.0
Use of personal computer (%)	35.1 ^{a,c}	28.5 ^a	37.1 ^d	25.6 ^{c,d}	31.5
Use of written farm plans (%)	27.0	25.3	31.2 ^d	23.3 ^d	26.0

^aStatistically significant difference between confinement and grazing (all) farms at the $P < 0.05$ level.

^bStatistically significant difference between confinement and intensive grazing farms at the $P < 0.05$ level.

^cStatistically significant difference between confinement and nonintensive grazing farms at the $P < 0.05$ level.

^dStatistically significant difference between Intensive and Non-intensive grazing farms at the $P < 0.05$ level.

¹Confinement farms are those farms that indicated that they do not graze their milking cows.

²Grazing farms are those farms that indicated that they do graze their milking cows.

³All farms indicating they grazed their dairy cows were separated into 2 groups. "Intensive" grazing farms are those farms that move their milking cows to fresh pasture at least every 3 d. "Nonintensive" grazing farms are those farms that keep their milking cows on the same pasture for more than 3 d before moving them to a new pasture.

Vermont, although of much smaller size than the other states, ranks 14th nationally in milk production. Vermont farmers managed larger herds and farmed more acreage than their Pennsylvania counterparts but were still considerably smaller in farm size and cow numbers than either Virginia or North Carolina dairy farms. Dairy farms in North Carolina and Virginia, although far fewer in number than in Pennsylvania or Vermont, were characterized by larger herds and acreage. North Carolina farmers were the oldest and most experienced, most likely to have completed high school, had the lowest debt/asset ratio, and had greater reliance on off-farm income. Virginia dairy farmers had the highest milk production per cow, had the largest number of acres of permanent pasture, and relied less on off-farm income than the other states except Penn-

sylvania. The Virginia data also potentially included a sizable population of farmers belonging to the Church of the Brethren and Mennonite groups.

Grazing vs. confinement systems. Nearly 55% of all dairy farms indicated that they grazed their milking cows. Responses to this question ranged from 46.7 for North Carolina to 69.7% for Vermont (Table 3). The farms that indicated that they grazed their milking cows had significantly smaller herds and produced less milk per cow. The farms that did not graze their milk cows (confinement systems) had significantly more acres of corn, hay, and other crops than the grazing farms. The distribution of acreage was different, with the grazing farms using only 0.97 acres of corn per cow as compared to 1.22 acres per cow for the confinement farms. The grazing farms had greater acreage per cow

of hay (including haylage), hay/pasture, and permanent pasture and overall had 3.49 acres per cow as compared to 2.97 for the confinement farms. These findings suggest that grazing systems are more land extensive (on a per cow basis) than confinement farms, but no comparison by farm type can be made on the total value of farmland because of varying farmland characteristics, locations, and soils.

There were only minimal differences in operator age and years of farming experience between graziers (farmers practicing grazing management) and confinement farms. Reliance on off-farm income was identical for both groups. Graziers were more likely to have completed high school and had significantly less debt. It has been suggested that constraints on available credit have influenced farmers to adopt grazing (Hanson et al., 1998a). These findings also support the perspective that use of credit is relatively more restrained among graziers versus confinement producers. Findings from this study indicate that graziers tend to fit the role of cost minimizers, maintaining production expenses at minimal levels, and not taking on substantial additional debt to finance more cows and the associated reinvestment in milking and housing facilities.

The responses identified the presence of several newer technologies on surveyed dairy farms. As expected, 6 of the 8 technology items were found to be in use on a significantly greater percentage of confinement than grazing farms. Milking parlors, automatic takeoffs (ATO), and TMR were most likely to be associated with larger dairy farms that were more characteristic of confinement herds. Compared to confinement farms, the smaller grazing herds were more likely to use a barn-pipeline milking system. The use of the DHIA and rbST (recombinant bovine somatotrophin) were likely associated to a greater extent with confinement managers, compared to graziers, as tools for increasing production per cow. Although only 25.6% of nonintensive graziers used personal computers, use of personal computers was similar between intensive grazing farms and confinement farms (37.1 and 35.1%, respectively) (Table 3). There was no statistical difference in usage of written farm plans between grazing and confinement farms, but intensive grazing farms had a higher percentage of farm plans than nonintensive grazing farms (31.2 vs. 23.3 %, $P < 0.05$) (Table 3).

State-by-state comparisons revealed few key differences between graziers and confinement producers (not shown), but graziers in each state milked fewer cows, produced less milk per cow, and farmed fewer acres than their within-state confinement counterparts. Corn silage acreage was lower for both graziers and confinement producers in Vermont, attributed to a shorter growing season than the other states. Also, both gra-

ziers and confinement farmers in Pennsylvania and North Carolina averaged nearly the same age, whereas nongraziers in Vermont were a bit younger, and the graziers in Virginia were significantly older than nongraziers. One measure of grazing intensity is the amount of time cows are kept on a particular pasture or paddock. The reported rotation interval was significantly shorter in Vermont than for the other states. When compared with North Carolina, Pennsylvania, and Virginia, Vermont farmers were least likely to keep their dairy cows on the same pasture for 30 d or more. Vermont farmers were most likely to obtain more than 50% of total forage from pasture, whereas the dairy cows that were grazing were also likely to receive supplemental protein and energy when grazing. These findings suggest that Vermont farmers more closely adhered to grazing practices recommended by Voison (1959) than graziers sampled from other states in the survey.

Intensive vs. nonintensive grazing farms. Intensive graziers that move milking cows to fresh pastures at least every 3 d made up 30.3% of Vermont's dairy farms but included only 10 to 13% of farms in the other states (Table 3). As compared to the nonintensive graziers, the intensive group was significantly younger, had less farm experience, less crop acreage, and fewer acres of corn. The nonintensive group was more likely to make greater use of milking technology, whereas the intensive group was more likely to use TMR, DHIA, rbST, and computers. The degree of dependence on grazing is also shown by the percentage of dairy forage requirements that was provided by grazing. For the nonintensive group, only 49.8% of the farms depended on pasture to provide more than 25% of daily forage needs, with only 12.3% obtaining more than 75%. However, for the intensive group, 81.9% depended on pasture to provide more than 25% of dairy forage needs with 32.4% obtaining more than 75%.

Farmer satisfaction. All farmers were asked to rate their level of satisfaction (on a scale of 1 = dissatisfied to 5 = very satisfied) on 16 variables regarding facility cost and stress (Table 1). Overall, farmers were most satisfied with corn silage yields, milking facilities, and hay yields. Farmers were most dissatisfied with purchased feed costs, profit level, and stress level. These categories were very similar across groups. Surprisingly, operators of confinement farms were more satisfied than their counterparts on several survey categories. Confinement farmers were significantly more satisfied with corn silage yields, corn silage costs, hay yields, milk per cow, milking facilities, and cow housing. Grazing management advocates have suggested that graziers enjoy the advantages of a less stressful lifestyle and greater profitability (Murphy, 1994; Jackson-Smith

et al., 1997). However, survey responses demonstrated no significant differences among subgroups in terms of producer satisfaction with time away from the farm, stress levels, and financial progress. Farmer satisfaction for profit levels was slightly higher for confinement than for nonintensive grazing herds, with intensive grazing responses being intermediate (Table 1). The only significant difference in level of satisfaction between intensive and nonintensive graziers was higher satisfaction for corn silage yields among nonintensive graziers (Table 1).

Factor Analysis

Factor analysis was utilized to reduce the 12 satisfaction variables to fewer common underlying variables. Exploratory analysis began with the correlation matrix because small correlations indicate a low likelihood of identifying common factors, whereas larger correlations indicate a greater likelihood of identifying underlying factors. More than 40% of the variables in the matrix had correlation coefficients greater than 0.3 (absolute value). All variables had one correlation coefficient of at least 0.54 except satisfaction with milk per cow (highest was 0.33) and purchased feed costs (highest was 0.42). These results indicate that there were underlying factors and were supported by the Bartlett test of sphericity which rejected the hypothesis that the correlation matrix was an identity matrix.

The initial factor analysis identified 3 groupings or factors with eigenvalues greater than one that accounted for 58% of the total variance within the correlation matrix. There were 11 variables with component loading values greater than 0.4 associated with factor one, 2 variables for factor 2, and 2 variables for factor 3. There was cross loading between the factors, with profit level and financial progress both associated with factors 1 and 2 and milk per cow associated with all 3 factors.

To reduce the cross loading and to identify clearly distinct groupings, the model was reestimated for a 2-factor solution. The second round identified 2 distinct factors with 9 variables with a component loading value greater than 0.40 for factor 1 and 2 variables for factor 2. The second round successfully eliminated cross loading for profit level and financial progress. The variable milk per cow was excluded from the final model because it failed to meet the 0.4 component loading criterion.

The 2 groupings were defined as new variables, including the “financial” factor (hay production costs, hay yields, purchased feed costs, capital replacement costs, machinery repair costs, time away from the farm, stress level, profit level, and financial progress) and the “facility” factor (milk facilities and cow housing). The alpha

of reliability for the 2 factor models was 0.82, indicating a reliable factor model. Thus, factor analysis reduced the data from responses to the 11 satisfaction variables to 2 variables. The factor scores associated with each observation were saved and used for the “financial” and “facility” independent variables in the next stage of this study.

Discriminant Analysis

The discriminant analysis followed a 2-step procedure. The objective of the first step was to examine the difference between confinement and all grazing dairy farms. Then the model was used to examine the intensive and nonintensive grazing groups with the confinement farms. The dependent variable used for the first discriminant analysis was membership in either grazing or nongrazing groups. This determination was based on the response to the survey question of whether farmers grazed their milking cows. Possible choices were yes = 0, or no = 1. The known sample membership was 46.8% of the farms practicing confinement management and 53.2% who grazed their milk cows. The independent (predictor) variables from the survey were classified into 4 sets: *farmer characteristics*, *farm characteristics*, measures of *farmer satisfaction*, and *state location*.

The *farmer characteristic* variables included operator age, education level, years farming, and prevalence of off-farm income. The *farm characteristic* variables included herd size, crop acreage, technology use, future business size, farm ownership, and debt levels. The size variables included cows per farm, milk per cow, acres of corn, acres of hay, and acres of pasture. The technology variables included the use of ATO, TMR, DHIA, rbST, and computers. Future business size included use of pasture, acres farmed, and cows milked. The *farmer satisfaction* variables included the “financial” and “facility” variables identified in the factor-analysis procedure of the survey questions on operator satisfaction described above. The *state location* variables included residence in North Carolina, Vermont, and Virginia, with Pennsylvania as the comparison group.

There were several high correlations, including acres of corn and number of cows (0.75) and operator age and years farming (0.68). Other relatively high correlations included number of cows and use of ATO (0.43), use of TMR and ATO (0.46), use of ATO and residence in Virginia (0.46), and number of cows milked in the future and acres farmed in the future (0.49). No other variables were correlated greater than 0.40 (absolute value). Regression diagnostics revealed no problems with multicollinearity in the data set.

The 4 sets of independent variables were examined individually and then added to the analysis in sequence to appraise the ability of each group of variables and the combined models to classify individual cases correctly (Table 4). Statistical measures from the discriminant analysis include the *Wilks' lambda*, eigenvalue, and canonical correlation. The *Wilks' lambda* (with a range of 0.0 to 1.0), the ratio of the within groups sum of squares to the total sum of squares, tests the hypothesis that the population means are equal. Eigenvalues, which are calculated as the ratio of the sum of squares of between groups to within groups, provide an estimate of the model's effectiveness. Relatively large eigenvalues are associated with more effective discriminant functions, whereas relatively smaller eigenvalues are associated with less effective functions. The canonical correlation measures the degree of association between the discriminant scores and the groups. With the group variable being grazing or confinement management, the canonical correlation is the Pearson correlation coefficient between the discriminant score and the group variable. Higher canonical correlation coefficients indicate better overall model fit.

Individually, the *farm characteristic* variables proved to be the best set of variables, correctly classifying 70.0% of the individual cases (Table 4). The *Wilks' lambda* was 0.798, and the function was significant at the 0.001 level, rejecting the hypothesis that the population means were equal. The eigenvalue was 0.252 and the canonical correlation was 0.449. The statistics indicated that the *farm characteristic* variables represented a reasonable model at predicting membership in overall grazing or confinement management groups.

The other individual models were relatively ineffective compared with the *farm characteristic* variables. The *Wilks' lambda* for the other 3 models ranged from 0.981 to 0.996, as compared to 0.798. The eigenvalues ranged from 0.004 to 0.019, and the canonical correlations ranged from 0.066 to 0.137. These models correctly classified no more than 56% of the overall cases, as compared to 70% for the *farm characteristic* model. Both the *farmer characteristics* and the *farmer satisfaction* models correctly classified more than 80% of the grazing farms but correctly classified fewer than 23% of the *confinement* farms (Table 4). The variables in these models appeared to be ineffective at distinguishing between grazing and *confinement* management. The *state location* variables correctly classified more than 50% of both groups; however, this is very ineffective when considering the dependent variable had a 47:53 outcome by chance. Based on the classification and statistical results, particularly the eigenvalues and the canonical correlations, the *farmer characteristic*, the *farmer*

satisfaction, and *state location* functions are much less effective at predicting group membership than the *farm characteristic* variables.

The 4 individual models were then combined one at a time to compare the change in model effectiveness as new variables were added. We began the analysis with the *farmer characteristics* and then added the *farm characteristic* variables, slightly increasing function effectiveness. The same pattern was produced with the addition of the *farmer satisfaction* and *state location* variables. The combined model correctly classified 71.3% of the individual cases, with correct classification of 75.6% of the farms using grazing management and 66.3% of the farms using *confinement* management. The model was statistically significant with a *Wilks' lambda* of 0.783, an eigenvalue of 0.276, and a canonical correlation of 0.465.

The combined discriminant function was an effective model, but adding the *farmer characteristic*, *farmer satisfaction*, and *state location* variables added little additional predictive power. Overall classification effectiveness increased by only 1.9 to 71.3% from the 70.0% for the *farm characteristic* variables. The *Wilks' lambda* for the combined model decreased from 0.798 to 0.783 for the *farm characteristic* model, the eigenvalue increased to 0.276, and the canonical correlation increased to 0.465. Thus, the discriminant analysis results indicate that the *farm characteristic* variables were most effective in predicting membership in the *confinement* and grazing groups. Adding the other 3 sets of variables added little predictive power to the function.

Each of the models was entered into the discriminant analysis in steps to assess its contribution toward predicting group membership (Table 5). The R^2 of the *farm characteristic* variables was 0.202, explaining 20.2% of the variation between the *confinement* and grazing group membership. The addition of the *farmer characteristic*, *farmer satisfaction*, and *state location* variables added little to overall model predictability. The R^2 increased only to 0.217, and the adjusted R^2 increased from 0.193 to 0.203. Only the *farmer satisfaction* model was insignificant compared to the full model. All full models were significant at the 0.05 levels.

Examination of the Intensive and Nonintensive Grazing Groups

The next part of the analysis examined the discriminant results of the *confinement* and the nonintensive graziers, those farms that kept their milking cows in pastures more than 3 d before moving them to new areas of fresh grass. No intensive grazing farms were included. Following the same discriminant function as

Table 4. Discriminant analysis results.

Model	Percent confinement classified correctly	Percent grazing classified correctly	Percent overall classified correctly	Wilks' Lambda	Chi- Square	Level of significance	Degrees of freedom	Eigen- value	Canonical correlation
Confinement vs. all grazing farms ¹									
Farmer ²	22.8	81.7	54.2	0.995	7.54	0.110	4	0.005	0.072
Farm ³	64.2	75.1	70.0	0.798	324.54	< 0.001	15	0.252	0.449
Satisfaction ⁴	17.8	83.3	52.7	0.996	6.38	0.041	2	0.004	0.066
State ⁵	51.7	59.8	56.0	0.981	27.63	< 0.001	3	0.019	0.137
Farmer-farm	65.7	75.6	71.0	0.790	339.43	< 0.001	19	0.266	0.458
Farmer-farm-satisfaction	65.8	76.2	71.3	0.789	340.10	< 0.001	21	0.267	0.459
Farmer-farm-satisfaction-state	66.3	75.6	71.3	0.783	350.64	< 0.001	24	0.276	0.465
Confinement vs. nonintensive grazing farms ⁶									
Farmer-farm-satisfaction-state	68.8	68.7	68.8	0.808	275.17	< 0.001	24	0.238	0.438
Confinement vs. intensive grazing farms ⁷									
Farmer-farm-satisfaction-state	95.0	35.7	81.0	0.763	234.60	< 0.001	24	0.311	0.487

¹Sample consists of 46.8% confinement and 53.2% grazing farms.

²Farmer variables included operator age, education level, years farming, and off-farm income.

³Farm variables included cows per farm, milk per cow, acres of corn, acres of hay, acres of pasture, use of ATO, TMR , DHIA, rbST, computers, future use of pasture, future acres farmed, and future cows milked.

⁴Farmer satisfaction variables included the grouped "financial" and "facility" factor variables identified in Table 3 and in the text on factor analysis.

⁵State variables included residence in North Carolina, Vermont, and Virginia with Pennsylvania as the comparison group.

⁶Sample consists of 51.7% confinement and 48.3% nonintensive grazing.

⁷Sample consists of 76.5% confinement and 23.5% intensive grazing.

Table 5. Regression results.

Model	R	R ²	Adjusted R ²	Standard error of the estimate	F value	Significance $P \leq$
Farm ¹	0.449	0.202	0.193	0.448	24.16	<0.001
Farm-farmer ²	0.458	0.210	0.200	0.447	20.03	<0.001
Farm-farmer-satisfaction ³	0.459	0.211	0.199	0.447	18.15	<0.001
Farm-farmer-satisfaction-state ⁴	0.465	0.217	0.203	0.446	16.42	<0.001

¹Farmer variables included operator age, education level, years farming, and off-farm income.

²Farm variables included cows per farm, milk per cow, acres of corn, acres of hay, acres of pasture, use of ATO, TMR, DHIA, rbST, computers, future use of pasture, future acres farmed, and future cows milked.

³Farmer satisfaction variables included the grouped "financial" and "facility" factor variables identified in Table 3 and in the text on factor analysis.

⁴State variables included residence in North Carolina, Vermont, and Virginia with Pennsylvania as the comparison group.

the initial analysis, the *farm characteristic* variables were most effective in predicting membership in the confinement and grazing groups. The combined discriminant function included *farmer*, *farmer characteristic*, *farmer satisfaction*, and *state location* variables. The model eigenvalue was 0.238, and the canonical correlation was 0.438. The model correctly classified 68.8% of the confinement farms and 68.7% of the nonintensive grazing farms. The results indicate that the model's ability to classify individual observations correctly when only nonintensive graziers were included was nearly identical to the above case when all farms that grazed their milking cows were included.

The third step of the analysis examined the discriminant function's ability to classify correctly observations from a sample consisting of confinement and intensive grazing farms, those farms that moved their milking cows to new grass at least every 3 d. No nonintensive grazing farms were included. The intensive group was considerably smaller, accounting for only 23.5% of the observations. The results proved to be considerably different, as the discriminant function correctly classified 81% of all observations. However, the model correctly classified 95% of confinement farms but only 35.7% of the intensive grazing farms, failing to identify any significant distinction between the 2 groups.

The discriminant function that included variables measuring the characteristics of the *farmer*, *farm*, *farmer satisfaction*, and *state* showed mixed results. The model was consistent in classifying confinement farms from any farm that grazed and between confinement farms and farms that practiced a grazing rotation more than 3 d on the same pasture. However, when the farms with a rotation period less than 3 d were compared directly with confinement, the model classified nearly all farms as confinement.

This analysis indicates that intensive grazing farms tend not to have common characteristics that enable

consistent classification. A reexamination of Table 3 provides some insight. There are 9 variables with a statistically significant difference between intensive and nonintensive, indicating some key differences between the 2 grazing groups. It does appear that the intensive group is younger, higher educated, and has lower milk production than the nonintensive graziers and the confinement farms. However, other variables are not nearly as distinct.

The conclusion from the discriminant analysis is that survey data of farm and farmer characteristics and farm attitudes do provide a reliable basis for classifying farms into *confinement* and general grazing groups. The analysis also does equally well in classifying dairy farms between confinement and nonintensive grazing groups, the latter representing about 75% of farms using pasture for lactating cows. However, there appear to be characteristics of farmers practicing intensive grazing that are indistinguishable from the confinement farms. There may be key characteristics of farmers in the intensive group, but these were not measured in the survey data. We can only speculate as to the reasons for the inability to distinguish characteristics of the intensive grazing farms. As surmised above, it may be that key characteristics are not the demographic and visible farm data easily collected in a mail survey. It is also possible that the production system in use is not related to the above data and is related to other factors that are difficult to identify and measure. There is also the possibility that factors such as age, education, attitudes, and satisfaction are nearly indistinguishable between successful intensive graziers and confinement farm operators.

Description of Model Coefficients and Variables

The standardized canonical discriminant function coefficients for each variable as the models were combined

Table 6. Discriminant analysis results: Standardized canonical discriminant function coefficients for each variable as models were combined into a general model classifying confinement versus all grazing farms.

Variable	Farm	Farm-farmer	Farm-farmer-satisfaction	Farm-farmer-satisfaction-state
Cows per farm	0.094	0.098	0.096	0.095
Milk per cow	0.317 ^a	0.297 ^a	0.292 ^a	0.310 ^a
Acres of corn	0.439 ^a	0.433 ^a	0.434 ^a	0.364 ^a
Acres of hay	-0.072	-0.058	-0.059	0.029
Acres of pasture	-0.242 ^a	-0.225 ^a	-0.223 ^a	-0.239 ^a
Use auto takeoffs	0.271 ^a	0.275 ^a	0.269 ^a	0.241 ^a
Use TMR	0.334 ^a	0.332 ^a	0.332 ^a	0.323 ^a
Use DHIA	0.036	0.079	0.081	0.067
Use bST	0.056	0.049	0.049	0.034
Use computer	-0.193 ^a	-0.121	-0.123	-0.112
Sole proprietorship	0.083	0.066	0.066	0.076
Debt	0.248 ^a	0.228 ^a	0.235 ^a	0.247 ^a
Future cows milked	-0.017	-0.016	-0.020	-0.011
Future acres farmed	-0.020	-0.023	-0.024	-0.009
Future use of pasture	-0.384 ^a	-0.355 ^a	-0.354 ^a	-0.366 ^a
Age		0.003	0.000	0.005
Education		-0.257 ^a	-0.243 ^a	-0.247 ^a
Years farming		0.000	0.001	-0.005
Off farm income		0.059	0.063	0.060
Satisfaction factor 1 ¹			0.028	0.047
Satisfaction factor 2 ¹			0.050	0.058
North Carolina				0.151 ^a
Vermont				-0.132 ^a
Virginia				0.052

^aSignificant variables ($P < 0.05$) as identified with ordinary least squares regression.

¹Combinations of variables defined in Table 3.

into the general model classifying confinement and all grazing farms are shown in Table 6. The coefficient for any specific variable is dependent on other variables in the function and changes value as other variables are added to or removed from the function. The signs of the standardized coefficients from the discriminant analysis are arbitrary in the analysis but maintain their inverse relationship with other coefficients. The 5 largest positive coefficients for the combined model, associated with confinement management, ranged from 0.364 to 0.241, and all were for farm characteristic variables. Each of the coefficients' values was slightly lower for the combined model than when examined without the additional variables from the other 3 models (Column 1); however, several coefficients show a slight increase in value as the additional models were added to the analysis. The 3 largest negative coefficients ranged from -0.239 to -0.366. Two coefficients were for variables in the *farm characteristic* model and one coefficient from the *farmer characteristic* model. Similar to the positive coefficients, the negative coefficients all decreased in absolute value with the addition of the other 3 models but also fluctuated as new variables were added to the analysis.

The significance of individual variables cannot be identified with discriminant analysis, so identical re-

gressions were conducted with ordinary least squares (OLS) to identify significant variables (Table 6). For the combined model, 10 variables were identified as statistically significant ($P < 0.05$). Six variables with positive coefficients, associated with confinement management, were milk per cow, acres of corn, use of ATO, use of TMR, greater than 40% debt/asset ratio, and North Carolina location. All but the North Carolina location variable were associated with the *farm characteristic* grouping. There were 4 significant variables with negative coefficients associated with grazing. Two variables, acres of pasture and future use of pasture, were associated with *farm characteristics*. Education was grouped with *farmer characteristics* and Vermont was grouped with *state location*. The individual significant variables remained very consistent as additional variables were added to the analysis. The only change occurred when education replaced computer use (both negative) as the *farmer characteristics* were added to the analysis.

The discriminant analysis and OLS results strongly suggest that the *farm characteristic* variables are the strongest indicators of predicting farmers' membership in the grazing or confinement management groups. Seven of the 10 significant variables were grouped with *farm characteristics*. The single largest significant coef-

ficient (future use of pasture) is associated with grazing, but the next 5 largest significant coefficients are associated with confinement management. Several of the significant variables, milk per cow, acres of corn, use of ATO, and use of TMR, are strongly associated with confinement management that allows for milking and feeding more cows. Use of TMR has been found to be a major factor in increasing milk production as consistent balanced rations are directed to groups with similar milk production levels. The finding that education was the only *farmer characteristic* contributing toward identifying grazing management tends to agree partially with theories that operator age, education, and farming experience are major determinants in the adoption of intensive grazing. Most technology adoption theories generally hypothesize that younger, more educated producers would be more likely to consider and adopt non-mainstream production practices, such as grazing. Age and years of experience were not found to be significant, whereas education was a significant factor. In addition, grazing proponents often associate a more satisfied lifestyle with grazing management. This analysis does not seem to support that hypothesis, as the *farmer satisfaction* variables were both insignificant and do not add any greater predictive effectiveness. The coefficients for *state location* were much smaller, with a negative sign for Vermont and positive signs for Virginia and North Carolina. Overall, the OLS identification of significant variables replicates the discriminant analysis in identifying *farm characteristic* variables as the most indicative predictors of membership in the grazing or confinement management group.

These statistical findings are similar to the general survey statistics which showed that farms practicing confinement management have larger herds, produce more milk per cow, have more corn acres, are more likely to use TMR and ATO, and are more likely to have a debt-asset ratio greater than 40%. Table 3 also shows similar results for the grazing farms that had more pasture acreage, whose operators were more likely to graduate from high school and were associated with residence in Vermont.

CONCLUSIONS

This study sought to identify the use of confinement, nonintensive grazing or intensive grazing production methodology from mail survey data of dairy farmers in North Carolina, Pennsylvania, Vermont, and Virginia. Factor analysis was used to summarize information from 12 questions on producer satisfaction. Two general factors were identified—one factor associated with financial satisfaction and a second factor associated with facility satisfaction.

Discriminant analysis was used in a series of variable sets—*farm characteristics*, *farmer characteristics*, *farmer satisfaction*, and *state location*. The *farm characteristic* variables proved to be the most effective set at explaining group membership, correctly classifying 70% of the confinement and combined grazing cases. Individually, the *farmer characteristic*, *farmer satisfaction*, and *state location* variable groups correctly classified only 52.7 to 56% of the cases. Adding the 9 variables included in the latter models to the *farm characteristic* variables improved predictive effectiveness only by 1.9 percentage units.

The full discriminant analysis was equally effective in correctly classifying nearly 69% of all observations between confinement farms and the nonintensive grazing group, those farms which kept milking cows on the same pasture for more than 3 d. However, when the sample included only the confinement farms and intensive grazing group, farms that moved milking cows to new pasture at least every 3 d, the discriminant function proved ineffective, classifying nearly all farms as confinement.

The results from this study indicate that demographic and survey data can be reliable in classifying general grazing groups. However, the same data were able only to classify correctly a few intensive grazing farms because of few statistical differences between those farms and confinement farms. From this study, one can conclude that major farmer, farm, and attitudinal variables failed to distinguish the difference between dairy farmers practicing intensive grazing compared with nonintensive grazing or confinement production systems. Although farms practicing intensive grazing may have measurable differences from farms using confinement systems, the data available in the current study could not reliably distinguish between those systems.

With the growing gap in technologies used by dairy farmers in differing systems, there is a greater need for understanding the associated production practices and educational demands of each group. This is even more important as state land grant research institutes and cooperative extension education programs are facing greater demands on shrinking resources. The ability to understand and associate producer needs with the characteristics of their production systems is of greater importance each year. This study and more refined studies can provide cooperative extension educators and researchers valuable insights for identifying and delivering educational programs that meet the needs of a varied clientele.

An obstacle identified in this study is the inability to characterize farmers in the intensive grazing group with greater precision. Although they seem to be differ-

ent, are they any different from top managers of confinement farms? The results from this study do not provide much guidance. However, we do identify differences between operators of confinement operations and the nonintensive grazing group that indicate a different set of characteristics. These findings do provide some additional information that will allow cooperative extension personnel to refine their programs for targeted audiences.

ACKNOWLEDGMENTS

The authors acknowledge the valuable contribution of Jonathan Winsten (Winrock International), Gordon Groover (Virginia Tech), and Geoff Benson (North Carolina State University) for their part in conducting the mail survey.

REFERENCES

- Barnham, B., J. P. Chavas, and R. Klemme. 1994. Low capital dairy strategies in Wisconsin: Lessons from a new approach to measuring profitability. Department of Agricultural Economics, University of Wisconsin-Madison, Madison, Wisconsin.
- Cattell, R. B. 1978. *The Scientific Use of Factor Analysis*. Plenum, New York, NY.
- Dillman, D. A. 1978. *Mail and Telephone Surveys: The Total Design Method*. Wiley and Sons, New York, NY.
- Fales, S. L., S. A. McMurry, and W. T. McSweeney. 1993. The role of pasture in northeastern dairy farming: Historical perspective, trends and research imperatives for the future. Pages 111–133 in *Agricultural Research in the Northeastern United States: Critical Review and Future Perspectives*. T. Sims and O. K. Hatley, eds. American Society of Agronomy, Madison, WI.
- Ford, S. A., and J. Shonkwiler. 1994. The effect of managerial ability on farm financial success. *Agric. Resource Econ. Rev.* 23-2:150–157.
- Goldstein, M., and W. R. Dillon. 1978. *Discrete Discriminant Analysis*. Wiley and Sons, New York, NY.
- Greaser, G., and R. L. Parsons. 1997–99. Pennsylvania dairy farm business analysis. Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, University Park.
- Gripp, S. I., A. Elbehri, R. D. Yonkers, S. A. Ford, and A. E. Luloff. 1993. Pennsylvania dairy profitability project. A. E. & R. S. 245. Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, University Park.
- Hallberg, M. C. 1993. The US agricultural and food system: A postwar historical perspective. Publication # 55. The Northeast Regional Center for Rural Development. The Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, University Park.
- Hand, D. J. 1981. *Discrimination and Classification*. Wiley and Sons, New York, NY.
- Hanson, G. D. 1995. Adoption of intensive grazing systems. *J. of Ext.* 33-4(August). (<http://www.joe.org/joe/1995august/rb3.html>).
- Hanson, G. D., L. Cunningham, S. Ford, L. D. Muller, and R. Parsons. 1998a. Increasing intensity of pasture use with dairy cattle: An economic analysis. *J. Prod. Agric.* 11:175–179.
- Hanson, G. D., L. Cunningham, M. Morehart, and R. L. Parsons. 1998b. Profitability of moderate intensive grazing of dairy cows in the northeast. *J. Dairy Sci.* 81:821–829.
- Harman, H. H. 1976. *Modern Factor Analysis*. 3rd ed. University of Chicago Press, Chicago, IL.
- Jackson-Smith, D., B. Barnham, M. Nevius, and R. Klemme. 1994. Status of Wisconsin farming, Department of Agricultural Economics, University of Wisconsin Cooperative Extension, and Agricultural Technology and Family Farm Institute (ATFFI).
- Jackson-Smith, D., B. Barnham, M. Nevius, and R. Klemme. 1997. Grazing in dairyland: The use and performance of management-intensive rotational grazing among Wisconsin dairy farms. Agricultural Technology and Farm Family Institute, Madison, WI.
- Knoblauch, W., L. Putnam, and J. Karszes. 1999. Dairy farm management business summary: New York State. Cornell University, New York. R.B. 2000–03.
- Lachenbruch, P. A. 1975. *Discriminant Analysis*. Hafner Press, New York, NY.
- Mulaik, S. A. 1972. *The foundations of factor analysis*. McGraw-Hill, New York, NY.
- Murphy, B. M. 1994. *Greener pastures on your side of the fence*. 3rd ed. Arriba Publishing, Colchester, VT.
- Olsen, K. E. 2000. Dairy farm numbers drop to 83,025. *Hoard's Dairyman* 145-18:699.
- Parker, W. J., L. D. Muller, S. L. Fales, and W. T. McSweeney. 1993. A survey of dairy farms in Pennsylvania using minimal or intensive pasture grazing systems. *Prof. Anim. Sci.* 9:159–165.
- Parsons, R. L., G. D. Hanson, A. E. Luloff, and J. R. Winsten. 1998. Extension outreach opportunities among segmented dairy producers. *J. Ext.* 36-4 (August). (<http://www.joe.org/joe/1998august/a2.html>).
- Pennsylvania Agricultural Statistics Service. 1960–98. Statistical summary and annual report. Pennsylvania Department of Agriculture, Harrisburg, PA.
- Perez, A. M. 1997. Changing structure of U.S. dairy farms. Economic Research Service, USDA. ERS-AER 690.
- Stafford, D., J. Block, and B. Zweigbaum. 2000. 1999 Dairy farm summary. Farm Credit of Western New York, ACA. Batavia, NY.
- Voisin A. 1959. *Grass Productivity*. Philosophical Library, Inc., New York, NY.