Regional Center for Sustainable Dairy Farming

Final Report for LS94-063

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Project Information

Abstract:

The Regional Center for Sustainable Dairy Farming was initiated with Southern Region SARE funding in 1994. Objectives included a comprehensive comparison of two integrated systems of dairy production; one based on intensively managed pasture crops, the other based on row crops and conventional confinement housing and feeding. The comparison was organized to allow us to examine animal performance, health, seasonal reproduction, and non-point source water quality and soil conservation impacts of the two systems. Estimates of milk income, feed costs, labor, equipment, and investments were evaluated in the economic analysis. The project also included a strong outreach component which included demonstrations and dissemination of results to farmers, extension personnel, service industry personnel, students, and others.

The Dairy Educational Unit of NC State University's Lake Wheeler Road Field Laboratory was the primary location of the experimental portion of the project. In addition, the teaching herd at NC A&T State University and cooperating producers in the region (VA, NC, SC) have been resources for various demonstrations, pasture walks, field days and as advisors.

The experimental project used groups of Jersey and Holstein cows assigned at calving to either the pasture-based system or to the confinement-feeding system. Cows were paired based on parity, age and milk production and then randomly assigned to the confinement or pasture group. When the project started in 1995, we used 24 Holstein cows and 12 Jersey cows in each replicate but since then we used 18 Holsteins and 18 Jerseys in each treatment group replicate. A replicate consisted a group of either 36 spring calving (January - March) or 36 fall calving (August - October) cows on pasture and a comparable group housed and fed in confinement. We have now completed the project, with a total of four spring-calving replicates and three fall-calving replicates. The economic analysis includes three spring and three fall-calving replicates.

Cows were kept in their respective groups through lactation but were managed

together in other areas on the farm during dry periods. Healthy cows that rebred within the breeding season were kept in the same treatment group for the following lactation.

Cows in the confinement system were housed in a free-stall barn with access to an outside exercise lot. Rations included a blend of corn silage and alfalfa silage with various grains and by-product feeds fed as a total mixed ration. In contrast, cows in the pasture system were kept on pasture except for supplemental grain feeding and for milking. The pasture cows ration included ground corn, soybean meal, whole cottonseed, minerals and sometimes included cottonseed hulls. The pasture ration was fed in a covered feeding area before each milking. When pasture was limiting, higher levels of supplemental grain and by-products were fed in addition to hay or round-bale silage that had been harvested from the pasture system. The hay or round-bale silage was fed on pasture paddocks using a looped electric wire to keep the forage from being trampled and spoiled. During periods of extreme heat and humidity, pasture-based cows were allowed to stay in the shade of the covered feeding area for an extra hour or two after the mid-day milking.

The pasture area was approximately 74 acres which was divided into 37 two-acre paddocks with several combinations of cool season and warm season grasses and legumes. Most of the pastures were perennial species, supplemented with winter and summer annuals to allow for grazing throughout the year. Each paddock included a water source and was accessible from a 16' travel lane.

Data collected included: daily milk yields, compositional analyzes of feeds and forages including fresh pasture, bimonthly pasture availability amounts, routine recording of udder infections (mastitis) and other health problems, weights and body condition scores of cows twice a month, reproductive information, and monthly concentrations of fat, protein, and somatic cell count in milk.

Multiple 24-hour cow watches were conducted for the pasture group to obtain an estimate of the distribution of feces and urine on pastures and the proportion of nutrients deposited in feeding and milking areas in contrast to pasture areas.

Results showed that some factors favored the confinement feeding system while others to favored the pasture-based system and some factors were similar for both. Milk production was higher for confinement-fed cows in all seasonal breed group daily averages except for one. Differences ranged from 2.6 pounds more milk per day from one group of pastured Holsteins to 13.3 pounds less milk per day for two other groups of grazing Holsteins. Jersey cows on pasture also milked less than those in confinement and Jerseys milked less than Holsteins across all lactation groups.

Measures of animal health and milk quality are also important in evaluating systems of production. Our work has documented that the overall incidence of udder infections (mastitis) was nearly twice as high for cows fed in confinement compared to cows on pasture (44% vs. 25%). Subclinical udder health can also be an issue but somatic cell count scores were similar for pasture and confinement cows. There were highly significant breed differences in incidence of mastitis with Holsteins at 41.2% vs. Jerseys at 25.8%. Culling and death losses for mastitis were also higher for confinement cows and for Holsteins. Other indications of animal well being include incidences of lameness, metabolic diseases, and death. Most disease and health problems were not notably different between the two groups. During the first year of the project, we had several Holstein cows in the pasture system with lameness due to sharp gravel in the travel lanes. The incidences of foot rot, displaced abomasums, and culling due to feet and leg problems were low and did not differ between the two treatment groups.

No differences due to treatment were observed although the overall pregnancy rate in a 75-day breeding period was numerically in favor of cows on pasture (71.7% vs. 64.2%). However, there were obvious breeding efficiency advantages for Jersey cows over Holsteins in first service conception rate, conception to all services, proportion of cows inseminated and overall pregnancy rate. Overall 75-day pregnancy rate is a function of the other measures and was 78% for Jerseys compared to only 57.8% for Holsteins.

Body weight changes and body condition scores have shown that cows in the pasture system do not carry as much weight and condition through the lactation. This may have been due to the increased exercise from walking to and from pastures and during grazing.

An important issue in comparing the two systems was the deposition, collection, and recycling of nutrients. All of the feces and urine of the confinement cows had to be handled or processed in some way whether from the feeding, housing, and milking areas or from the bare exercise lot. This required special needs for handling, storage, and redistribution of nutrients to cropland or other uses. In contrast, our 24-hour cow watches have shown that 87% of urine events and 86% of manure events occur in or near paddocks where the nutrients are available for pasture use. This means that a pasture-based system has to design storage and handling facilities for only about 14% of manure plus milking facility wash water. In addition, water pollutant runoff data showed that runoff from the confinement drylot area contained more than 19 times the amount of sediment than runoff from the pasture area when adjusted for cow use. Similarly, total nitrogen and total phosphorus runoff levels for the drylot area were more than 12 times the amounts from the pasture area.

In the economic analysis, milk production and income over feed costs generally favored the confinement cows but adjustments for mastitis and culling for mastitis reduced that advantage measurably. Differences in labor were small but in favor of pastured cows, particularly when manure handling is considered. Investments in equipment to support cropping practices and manure management would also be less for pastured cows under most scenarios. Housing and feeding system investments can also be lower for pastured cows. In reality there is a wide variation in profitability of dairy farms and such variability is likely to be evident among pasture-based dairies as well. Under our milk and feed price structure, a computer simulation indicated that the potentially most profitable pasture system would include high stocking rates and substantial supplementation. Documented financial records do indicate that pasture-based dairy farms can be profitable.

A short-term milk sample study was performed using the Spring1998 calving group during the summer of 1998. Milk samples were obtained from each cow for four consecutive weeks and analyzed for fatty acid composition, including the fatty acid conjugated linoleic acid (CLA) which has been identified as a natural anticarcinogen. The pasture cows had a significantly higher concentration of CLA in their milk compared to the confinement cows and Holsteins had higher concentrations of CLA than Jerseys.

Observations from the teaching herd at NCA&T State University have shown an estimated reduction in feed costs by at least 25% from 1995 before the grazing management program was initiated. They also report much less time scraping and handling manure because cows are on the pasture much more of the time. Body condition of cows has remained acceptable and overall health problems have been low. However, milk production and reproduction in the herd are still less than optimal.

These results should help define alternative dairy production systems for the southeast. A farm-scale pasture-based system was dedicated in 1998 in eastern

North Carolina to further examine the potential of pasture-based systems in the region. Because the region is milk deficient for much of the year, this project should lead to a more competitive local supply of milk at reasonable prices for consumers. In addition, successful pasture-based dairy systems can enhance local communities in several ways including economic stability, green space, and a pleasant rural environment compatible with nearby residential areas.

The project investigators have been quite active in outreach efforts with participation in 6 field days (two hosted), two grazing schools for dairy producers and four for NRCS employees, and poster exhibits at three regional and one national sustainable agricultural conferences and at other conferences. Papers have been presented at several meetings and this project has served as a focal point for several formal and informal tours. With subsequent funding from the SARE Professional Development Program, the project investigators also initiated a dairy farm study tour of Ireland and Northern Ireland, from which multidisciplinary training sessions were developed and presented, including much of the data from this project. At least twenty dairy producers in the region have greatly increased use of pasture in their management systems including a few new dairy farms organized as pasture-based herds from the start. Discussion support groups are becoming more active among dairy graziers in the region. Currently, two new (one small and another large) pasture-based dairy herds are being planned in the region.

Project Objectives:

a. Compare and evaluate profitability of two integrated systems of dairy production; one based on intensively managed pasture crops, the other based on row crops and conventional confinement housing and feeding.

b. Evaluate the impact of the pasture-based system on animal performance and health compared to the conventional confinement system.
c. Examine the feasibility of seasonal milk production within pasture-based and conventional confinement systems.

d. Evaluate non-point source water quality and soil conservation impacts of land uses under the pasture-based and row crop forage systems.

e. Demonstrate and disseminate the results among farmers, extension personnel, service industry personnel, students, and others.

Introduction:

Literature Review

Studies of the impact of grazing on total farm profitability in the Southeast are lacking. Recent surveys of Northern dairy farms have shown potential for increased profits, but also indicated a need for definitive information which can be used to make fair evaluations of the value of pasture in production efficiency and sustainability (Combs, 1991; Emmick and Toomer, 1991; Parker et al., 1992).

Grazing offers potential advantages over conventional drylot systems. Well managed pasture provides high quality, highly digestible forage which competes well with conserved forage in dairy cattle rations (Donker et al., 1968; Davenport et al., 1977; Conrad et al., 1981; Peel et al., 1988; Rakes et al., 1992). Farmers who have experimented with grazing systems have reported workload reductions (Pillsbury and Burns, 1989). Less equipment and storage facilities are needed for pasture feeding compared to year-round confinement systems (Cockrell, 1990). However, Davenport et al. (1977) projected that land requirements for forage production would be about 44 percent higher when grazing replaced 83 percent of the corn silage in a ration.

Grazing may improve herd health. Goldberg et al. (1992) indicated that grazing may provide a cleaner environment but that controlled studies are needed to determine impact on mastitis and udder health. Lameness is a major cause of culling and correlates closely with confinement housing and feeding systems. Pasturing alleviates feet stress and facilitates normal hoof wear (Nocek 1985). Cows demonstrate more mounting activity on pasture, which is likely to lead to improved heat detection and reproductive performance (Davenport et al., 1977; Bendixen et al., 1986).

A four-year study in Ohio (Zartman, 1991) indicated that seasonal calving provided several advantages over year-round calving; synchronized breeding and calving, the ability to focus on fewer tasks at one time, concentrated but reduced overall need for veterinary service, interrupted calf disease cycles, improved labor management, and opportunities for family vacations. However, impact on cash flow, forage utilization, milk price incentives, and cow fertility must be considered (Washburn, 1991).

There are public concerns about water quality problems caused by soil erosion, pesticides, animal manure, and agricultural fertilizers. Furthermore, the 1985 Food Security Act requires farmers to have a conservation plan in order to participate in federal programs. Resulting changes in farming practices are likely to increase the cost of producing milk (Westphal, et al. 1989). In New York, Rayburn (1993), estimated that increased use of pastures over cropping could reduce soil loss by 27-33% while using less fuel and reducing the cost of production.

Water quality problems have been associated with conventional dairy farm operations including elevated levels of bacteria caused by excessive manure application and poorly managed pastures (Baxter-Potter and Gilliland, 1988; Doran et al., 1981) and nitrogen and phosphorus enrichment from cattle wastes (Schepers and Frances, 1982). Heavy use areas have more runoff and sediment compared to well-managed pastures (Warren, et al., 1986). Dairy farming was identified as a major source of non-point contamination of surface waters in an ongoing North Carolina study (Jennings et al., 1992; EPA, 1993). All dairy farms in North Carolina with 100 or more cows in a confined animal feeding operation were required to have a nutrient management plan and a certified waste applicator license by December 31, 1997.

Statement of Problem

Dairy farm numbers in the Carolinas and Virginia have declined by one-third during the last decade! Milk prices are determined at the national level and little can be done to improve farm prices in this region. Increased profitability and competitiveness will, therefore, depend on reducing the cost of producing milk. Stricter environmental regulations and growing public concerns over water quality have begun to impose additional costs on conventionally managed farms. There is a need for integrated research upon which to base extension recommendations for producers interested in alternative dairy production systems.

Significance

Results of this work at the Regional Center for Sustainable Dairy Farming may increase competitiveness and survival of dairy farms in the three-state area with implications for the total Southern Region. The resulting stability among dairy farmers will mean continued economic activity in rural communities and survival of local companies associated with the dairy industry.

Reduced energy use for pesticides, fertilizer, and field operations will occur if farmers shift from harvested forages and row crops to grazed forages. Improved water quality should result from reduced soil erosion, reduced use of farm chemicals and more effective use of manure. Pasture-based systems are expected to have a beneficial effect on animal health, which could improve milk quality and enhance the public image of dairy farms.

Research

Materials and methods:

Investigation of Sustainable Systems: Two herds of approximately 72 cows each were used each year to evaluate the performance of a pasture-based system compared to a traditional high-input confinement system using corn silage as the primary forage. Cows were assigned to the two feeding systems at random, within age and production level stratifications, to control for genetic effects. In order to investigate the feasibility of seasonal milk production, half of the cows within each feeding system were bred to calve from January through early March with the other half calving from August through early October. Table 1 includes a description of the four spring and three fall calving groups and subgroups. This allowed evaluation of the ability to maintain short calving periods under two distinct feeding systems and at two different seasons. The use of common facilities, labor and management removed these as factors affecting the relative profitability of each system.

The confinement system consisted of free-stall housing with all feed brought to the cows. Rations included a blend of corn silage and alfalfa silage with various grains and by-product feeds and were fed as a total mixed ration. Cows had access to a bare drylot for exercise. Rations were balanced using the DART ration program and adjusted throughout the year.

In contrast, cows in the pasture system were kept on pasture except for supplemental grain feeding and for milking. The pasture cows ration included ground corn, soybean meal, whole cottonseed, minerals and sometimes included cottonseed hulls. The pasture cows ration was balanced using the DART ration program and was adjusted as the pasture availability changed. The supplemental grain ration was fed in a covered feeding area before each milking. When pasture was limiting, higher levels of supplemental grain and by-products were fed in addition to hay or round-bale silage that had been harvested from the pasture system. The hay or round-bale silage was fed on pasture paddocks using a looped electric wire to keep the forage be being trampled and spoiled. In periods of extreme heat and humidity, pasture-based cows were allowed to stay in the covered feeding area for shade for an extra hour or two after milking.

Dairy farmers in the region typically have about one acre per cow available for hay and pasture and the pasture system was designed to maximize the feed available from an equivalent acreage. Several combinations of cool season and warm season grasses and legumes were used to allow for grazing throughout the year. Perennial species included orchardgrass and clover, endophyte-free fescue and clover, matua bromegrass, crabgrass and bermuda grass. Rye was used for late winter and early spring grazing while caucasian bluestem and a sorghum sudan hybrid was used for summer grazing. Although the precise acreages varied from year to year, on the average, 46 acres were in cool season perennial species, 10 acres were in warm season perennial species, and 20 acres each were planted to summer and winter annuals. No irrigation was used but limited quantities of dairy lagoon effluent were applied on a few of the paddocks, as a source of nutrients.

The pasture area was approximately 74 acres which was divided into 37 two-acre paddocks with access to water in each paddock (Figure 1). No shade was provided in any of the paddocks, with the exception of three paddocks where a line of tall trees provided shade in the afternoon hours. Flexible polywire and tread-in posts were used to subdivide paddocks as needed. Paddocks were accessible from a 16’ travel lane. The width of the lanes allowed harvesting and mowing equipment easy access to the paddocks. Lanes were constructed with 3-6 inches of crush and run gravel with Geo-textile cloth placed under the gravel layer in high traffic areas. However, some rocks in the crush and run gravel were sharp and caused some problems for the cows during the first season of the project.

Field records were kept on: crop type, field operations, and inputs used; soil fertility changes, chemical, and nutrient transfer within the two forage systems. Manure distribution was measured under the two feeding systems. Pasture availability, composition, and use were measured every two to three weeks. Hay and silage yields and composition were measured at harvest. Daily weather records (rainfall and soil and air temperature) were available.

Individual animal and group data collected included daily milk yields, compositional analyses of feeds and forages including fresh pasture, bimonthly pasture availability amounts, routine recording of udder infections (mastitis) and other health problems, weights and body condition scores of cows twice a month, reproductive information, and monthly concentrations of fat, protein, and somatic cell count in milk.

The economic evaluation was based on the production data generated by the study, supplemented with information form other sources. Milk revenue was calculated from the milk production data and feed cost information was based on the type and quantity of feeds in the rations. Income over feed costs was calculated for all lactation groups. Adjustments were made in milk production for losses during cases of clinical mastitis. Some information on labor efficiency was collected and additional information was obtained from other sources. A computer model was used to simulate the effects of different stocking rates, different concentrate feeding systems, levels of concentrate feeding, and season of calving on the profitability of grazing.

Water quality monitoring consisted of automated storm water sampling at two sites on the NCSU dairy farm:
Site A. Intensive grazing watershed drainage (15.4 acres)
Site B. High-density drylot watershed drainage (2.8 acres)

Samples were collected from June 1995 until October 1998. The intensive grazing watershed drainage area was predominately alfalfa pasture the first two years of sampling. During the next two years the area was planted with Red River crabgrass for warm season grazing and rye for winter grazing. The pasture area had sandy loam soils and an average slope of 3.9%. The high-density drylot watershed drainage area had sandy loam soil at one end and a mixture of manure and soil at the other. There was no vegetation on the drylot with the exception of spiny amaranth during the late summer. The drylot area had a slope of about 3.2%. Flow-activated and proportioned sampling devices were used to monitor watershed runoff rates. The runoff data from each storm event included total runoff volume, total nitrogen, and total phosphorus. Pollutant loading rates were calculated by multiplying the runoff volume by the corresponding pollutant concentrations and dividing them by the watershed area. Adjustments were then made to account for the number of cows using each area. Grazing paddock records were examined and it was calculated that there was a daily average of 8 cows on the pasture during the sampling period. There was a daily average of 35 cows on the drylot area during the sampling period.

Nutrient distribution was monitored by use of several 24-hour cow watches to determine relative proportions of time in various locating and associated distribution of urine and fecal events. Pasture cows were constantly observed 5 times for 24 hours and 1 time for 12 hours within a 12- month period. Cows had access to about 54% of the paddock during the first grazing period (12 h) and had access to the entire paddock during the second grazing period (8 h). Data included: (1) all feces and urine events from eight cows, observed while in the pasture, feed area, milking parlor or in transit; and (2) all urine and feces events on pasture for all 36 cows each grazing period. After each grazing day, urine (marked with color coded flags) and feces were surveyed using Topcon Total Station Laser Transit System. Data were transformed using Tripod Data Systems Forsight Software for mapping and analysis using ArcView software.

Analyses of data among the two forage systems, two calving seasons and two breeds of cows, included use of the GLM procedure (SAS, 1990), for analysis of variance with systems replicated across time. The economic analyses included actual and estimated costs for various factors that can affect relative profitability.

Education and Outreach

1. The Regional Center for Sustainable Dairy Farming will host two multi-state field days to disseminate results, discuss on-going studies and obtain farmer input. Participation at additional field days in North Carolina, Virginia and South Carolina will provide other opportunities to share results.

2. The financial results from the project will be extended to permit farmers who are considering changing to grazing and seasonal calving regimens to evaluate the implications for their particular farm situations.

3. A survey of grazing management practices among cooperating farmers and NCA&TSU will provide additional data for use in educational programs. These will include: estimates of pasture availability, nutrient composition, and use; DHI records of herd performance; records on total feed consumption; and labor and equipment use specifically related to pasture-based feeding.

4. Producers with specific interests in applying results of studies will be provided assistance in adapting sustainable practices to their farms. Each of these farmers will be encouraged to host field days and serve as leaders for local discussion groups and extension training programs for other farmers.

5. Every effort will be made to disseminate results to producer through various channels, including mass media, publications, videotapes, farm demonstrations, workshops, and conferences.

Research results and discussion:

Progress on Objectives a, b, and c.

Results to date have shown tendencies for some factors to favor the confinement feeding system and others to favor the pasture-based system.

Milk production was almost always higher for confinement-fed cows except for Holsteins calving in Spring 1997. Lactation curves for all the groups of cows are shown on Figures 1-7 and adjusted lactation group averages for 6 of the 7 groups are shown in Table 2. There were marked differences in the levels of milk production under the two feeding systems. The confinement fed Jersey cows produced more milk than the grazing Jersey cows in all lactation groups, Table 2. The size of the adjusted difference ranged from a 4.7 lb. per cow per day disadvantage for the spring 1996 pastured Jerseys to a 9.4 lb. disadvantage for the fall 1997 pastured Jerseys compared to the respective confinement fed contemporaries. For the Holstein cows the confinement cows out-produced the grazing cows in five of the six lactation groups. In those five lactation groups the smallest difference in daily milk production for the grazing Holsteins was 4.2 lb. lower, on average, for the fall 1995 calving cows. For the spring 1995 calving group of Holsteins the comparable difference was 13.3 lb. per cow per day, which was the greatest difference. In the spring 1997 groups the grazing cows out-produced the confinement cows by 2.6 lb. This difference may be have occurred, in part or entirely, because of the younger average age of the cows in the confinement group. Due to culling circumstances beyond our control and unrelated to the project, all but one of the Spring 1997 confinement Holsteins were in their first lactations while the Spring 1997 pasture Holsteins had an average parity of 2.4 (Table 1). This parity difference carried over to Spring 1998 where parity of confinement Holsteins was 1.7 vs 3.0 for the Spring 1998 pasture Holsteins. This situation occurred because of unusually high cow turnover caused by factors unrelated to the basic management of the cows on the project. In Figures 6 and 8, the lactation curves for the Spring 97 and Spring 98 replicates are shown. During the first part of these lactations, the pasture Holsteins had higher production than the confinement Holsteins. This may be due to differences in parity as well as our increased experience with managing a pasture-based herd along with the flush of spring growth that occurred. Lactation curves shown in various figures also indicate a tendency for lower persistency in later lactation among pastured cows in many cases.

Data on udder health are included in Table 3. The incidence of clinical mastitis was significantly greater ($P < .05$) for cows kept in confinement compared to pasture cows (44% vs. 25%). There was also a greater ($P < .05$) incidence among Holstein cows than Jersey cows (41.2% vs. 25.8%) but the interaction of breed and feeding system was not significant. Note also that a total of 17 confinement cows died or were culled because of mastitis compared to only two from among the pastured cows. Even though clinical mastitis was higher, there was not any measurable effect of feeding system or breed on subclinical udder problems as measured by somatic cell count scores. These scores are from monthly DHIA tests and not from daily milk samples within feeding system groups.

There are also differences in body condition scores among treatment groups (Figures 9-15). Cows on the pasture system tended to have lower body condition scores throughout the lactation perhaps due to the increased walking to and from pastures. This did not apparently affect animal health or reproduction but may be related to the lower milk yield observed in pastured cows. Figure 9 shows the BCS for the Spring 1995 replicate. The severe drop in the BCS for the grazing cows can be explained by our inexperience in managing a pasture-based cow herd and the cows themselves were not familiar with grazing.

One of our objectives was to examine the feasibility of seasonal reproduction. Both grazing and confinement cows had a 75-day period in which to be detected in estrus and inseminated. Cows were checked after calving by a veterinarian to ensure reproductive soundness and those with a corpus luteum were synchronized with prostaglandin F2a to enhance estrous detection. A testosterone-treated heifer was also used to increase mounting behavior when cows were in estrus. Reproductive data for the seasonal calving groups are shown in Table 4. There were no significant differences for any reproductive measures between pasture and confinement cows although the overall 75-day pregnancy rate numerically favored cows on pasture by about 5 percentage points. There was not a significant effect of season on reproductive parameters. However, there was a definite effect of breed with Jersey cows having higher ($P < .05$) conception rates, estrous detection rates, and pregnancy rates than Holsteins. With only about 58% of Holsteins successfully becoming pregnant in 75 days, it would be difficult to maintain a seasonal herd. However, 78% of Jersey cows conceived within the 75-day breeding period which would be sufficient to maintain seasonal calving without excessive culling.

Other indications of animal well being include incidences of lameness, metabolic diseases, and death. Most disease and health problems were not remarkable between the two groups. During the first year of the project, we had several Holstein cows in the pasture system with lameness due to sharp gravel in the travel lanes. The cows were able to form “trails” within the lanes that were free of the sharp gravel, and so lameness was no longer a problem with the pasture cows. Also, one pasture cow died of alfalfa bloat in 1995 and a few others had to be treated for bloat. Changes in management practices of cows grazing alfalfa and heavy clover pastures prevented such problems. We briefly included a commercial product in the concentrate ration to prevent bloat but discontinued its use because of cost. The incidences of foot rot, displaced abomasums, and culling due to feet and leg problems were low and did not differ between the two groups. Based on farmer testimonies, we expected more of these ailments among confinement cows but perhaps the relatively younger age masked any such effect, at least among Holsteins.

Day to day pasture management was a challenge because of highly variable and sometimes extreme weather conditions. A second factor was the number of pasture species and their different growth patterns. Overall, the quality of the various species offered to grazing cows was good to excellent (Figure 16). Pasture walks were conducted each week by farm personnel, technicians, and one or more of the investigators. Discussions of pasture growth rates and a rotation schedule for the week was established. The walks were used as training opportunities for students and visiting professors and agricultural advisors. Dairy unit personnel had the flexibility to adjust rotation schedules based on available forage and cow responses.

The teaching herd at NC A&T State University has sought to convert its dairy to a system forage-based milk production with more use of controlled grazing and possible use of seasonal calving. Feed costs have been reduced substantially for summer months for heifers, dry cows, and lactating cows. No silage was fed from March 31 through October 23, 1997. Milk production improved from 1995 to 1996 and slipped back to 13,419 lbs. rolling herd average in 1997. Daily milk averages for the major grazing period (April -October) were 49 pounds in 1995, 58 pounds in 1996, and 48 pounds in 1997. Some of the decline in 1997 was attributed to dryer weather and loss of alfalfa in some of the grazing paddocks. Physical condition of the cows has generally improved and dry cows and heifers are used to graze behind the milking cows. One cow died of bloat on alfalfa and one yearling heifer, diagnosed as a chronic bloater was sold. Laminitis has been minimal in the herd and only one older cow (13 years) was culled this year. Time and cost for managing dry cows has been reduced by about 50% and the amount of time spent scraping and handling manure has been reduced 50 to 60% due to cows being on pasture day and night. Routine pasture walks are done by the herdsman to determine adjustments in pasture rotations. Pasture renovations have included use of summer and winter annuals, some of which have been overseeded on thinning alfalfa stands. Fescue and clover paddocks were used extensively.

During the summer of 1998, a short term milk sampling study was performed using the Spring 1998 pasture and confinement groups. The objective of the study was to compare the fatty acid content of the milk between the grazing and confinement groups and the two breeds. One of the more noteworthy fatty acids that was examined was conjugated linoleic acid (CLA). CLA is a fatty acid found primarily in dairy products and has been found to be an anticarcinogen in animal models. (Ip and Scimeca, 1994). Research has shown that Holstein cows consuming cool-season pasture produced higher levels of CLA in their milk compared to TMR fed cows.

(Kelly et al, 1998). Milk samples were obtained from each cow from the a.m. and p.m. milkings each week for four consecutive weeks. Milk samples were analyzed for fatty acid composition. Pasture cows produced a significantly higher concentration of CLA that the confinement cows. (.36 vs .66 percent of total fatty acids). Holsteins were also significantly higher than the Jerseys in the amount of CLA produced (.56 vs. .47 percent of total fatty acids). Treatment by breed interaction was not significant.

Participation Summary

Educational & Outreach Activities

PARTICIPATION SUMMARY:

Education/outreach description:

Education and Outreach

The project has included a diverse advisory group with members from VA and SC as well as NC. Advisory meetings were held in May 1994, March 1995, November 1996, and November 1997. Outreach activities have included hosting field days at the NCSU site in 1995 and 1997 and participation and presenting information from the project at other field days in the region including Mid-Atlantic Dairy Grazing field days in 1995 and 1997 in Virginia, the Holstein and Jersey field days in 1997 in North Carolina, and the Tom Trantham SARE field day in South Carolina in 1997. Two dairy grazing schools have been conducted in 1996 and 1997 and the dairy project was used as a laboratory for part of four Natural Resources Conservation Service sponsored Grassland Ecology Schools coordinated by project investigator Jim Green. Project investigators have also presented information and participated in two Sustainable Agriculture Conferences sponsored by the Carolina Farm Stewardship Association. The dairy project has also hosted several tour groups including a watershed educational tour in 1996, “Ag in the Classroom” in 1997, a Farm Bureau sponsored learning opportunity for classroom teachers, served as part of a tour for farmers and others attending the dedication of NCSU’s Animal & Poultry Waste Management Center in August 1997, a SARE regional training group in October 1997, the Southern Region SARE Administrative Council in November 1997, and a group of farmers and extension agents touring alternative manure management systems in December 1997 and March, 1998. Posters from the project have been presented at the Animal & Poultry Waste Management Field Day in August 1997, the 12th and 13th Annual Sustainable Agriculture Conference in Hendersonville, NC and Clemson, SC in November 1997 and November, 1998, respectively, and the “Nutrients in the Neuse River” conference in December 1997. The poster was also presented at the “Ten Years of SARE” SARE conference in Austin, Texas in 1998 and also as part of the professional development program workshop and Southern Agricultural Workers Group meetings in Jekyl Island, Georgia in January, 1999.

A concept paper on the project and opportunities for pasture-based dairy systems was presented at Tufts University in 1995 and published in 1996. A paper was also presented at the 1997 meeting of the Southern Branch of the American Dairy Science Association. Three papers were presented at the 1998 meeting of the American Dairy Science Association. Another paper was presented at the 1999 meeting of the American Dairy Science Association. Data on reproduction and mastitis were presented at an international conference on “Reproduction in the High Producing Dairy Cow” held in Galway, Ireland, September, 1999. Results were also shared at the 1999 annual meeting of the American Jersey Cattle Association in Minneapolis, MN.

Several articles from field days and interviews have been published in the popular press in the past four years. One thesis using data from the project was completed in 1997 and another in 1999 and a special project examining nitrogen and phosphorus balance of confinement and grazing systems was completed in 1995. A third thesis project is in preparation and will be completed in early 2000. Additional publications will be forthcoming from these theses.

Momentum from this project led to state funding for a farm-scale pasture-based dairy system that began at the Center for Environmental Farming Systems in December 1997. The new dairy at the Center for Environmental Farming Systems offers great opportunities for future studies and outreach. A PDP-sponsored agent training conference was held there in 1998 to teach more about sustainable animal production systems.

Funding was obtained for two surveys to examine the extent of pasture use on dairy farms in Virginia and North Carolina. Two separate allocations have also been received from the NC Dairy Foundation for a graduate student assistantship to allow continuation of the study and to begin an economic development project on opportunities to retain and expand dairying in NC.

Farmer members of the advisory group from three states participated in a panel discussion on use of grazing at the NC Dairy Conference in February 1998 and were active in the subsequent PDP study tour and training in 1998 and 1999. In the fall of 1997, one of the cooperating dairy farmers and some of the project investigators initiated the idea of a dairy farm study tour to Ireland and Northern Ireland. The intention was to strengthen a multi-state, multidisciplinary team and to study the detailed management of dairy systems with generations of experience in managing pastures for milk production. Funding was obtained from the SARE Professional Development Program in 1998. In September of 1998, 5 dairy farmers from 5 states, 4 extension agents from three states, 3 NCSU faculty, 2 Virginia Tech faculty, and one director of the NC Soil and Water Quality Division of Department of Environment and Natural Resources participated in an intensive 10-day study tour of dairy farms and research stations in Ireland and Northern Ireland. The grant obtained from SARE also featured training sessions to be held to share the information from the SARE study and from the Irish trip. Training sessions were conducted in South Carolina, North Carolina, and Virginia in the summer of 1999. Presenters and persons attending included dairy farmers, extension agents, NRCS personnel, university faculty, veterinarians and other dairy industry personnel. States represented by 122 participants included: South Carolina, North Carolina, Virginia, Kentucky, Tennessee, Georgia, Alabama, West Virginia, Texas, New York, Pennsylvania, Maryland, Arkansas, Wisconsin, Ohio, and Iowa.

The Regional Center for Sustainable Dairy Farming has served as a focal point for increased dialogue on alternative systems in the region and producer interest in the project has grown. At least twenty dairy producers in the three states have made major increases in the use of pasture in recent years and others are considering pasture use. Some information and perspectives from the project have also been shared on Internet lists such as Graze-L and Dairy-L.

The Southern Region SARE group has supported the project with publicity and understanding of its complexity. Some members of review panels and perhaps some on the Administrative Council may not realize how critical it is for systems research to have a relatively long term for investigation. However, this project did receive a no-cost extension which was very helpful in collecting and summarizing meaningful data.

Cooperative Efforts:

Faculty, producers, and extension personnel from North Carolina, Virginia, and South Carolina have been involved in this project at various levels. Dr. Jean Bertrand of Clemson, Drs. Carl Polan and Paul Petersen of Virginia Tech along with several NCSU faculty participated in the Field Day at NCSU in 1997. Drs. Bertrand and Tom Jenkins of Clemson also cooperated with Sharon White, Jim Green, and Steve Washburn at NCSU, and Mahogany Wade, an undergraduate student at NCA&TSU on the study on conjugated linoleic acids in 1998. Jerry Swisher of Virginia Cooperative Extension organized the Mid-Atlantic Dairy Grazing Field Days in 1995 and 1997 and involved several faculty from NCSU and Virginia Tech. Faculty and staff at NC A&T State University have participated in various events in the region. The farmer cooperators in the three states have been active in hosting pasture walks and in participation in panel discussions and advisory meetings. The dairy survey on pasture use involves several field and campus faculty from NCSU and Virginia Tech. Monitoring of sediment and nutrient runoff and manure distribution have involved several faculty and students from Biological and Agricultural Engineering, Forestry, and Soil Science. Other agencies have been involved in various field days and tours including NRCS, North Carolina Department of Agriculture and other representatives of state government. Nonprofit organizations have been kept aware of the project through various events and meetings of the Sustainable Agriculture Work Group (SAWG) in NC. Some funding for extensive water monitoring associated with this and related projects has been obtained through EPA-319 monies. This project has involved over 60 people from 7 departments at NCSU, three other universities and several farmers and extension personnel from three states. The project coordinator is also serving as a technical advisor to another SARE project: “The Hometown Creamery Revival” in Virginia.

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Project Outcomes

Project outcomes:

Attitudes toward pasture-based systems are becoming more favorable in the region. There is a very real possibility that results of this project and related outgrowths should help some dairy producers to compete more effectively in the region. This in turn should provide a more stable rural economy as well as benefiting consumers in the region by providing a fresh, local supply of milk.

The Regional Center for Sustainable Dairy Farming has served as a focal point for increased dialogue on alternative systems in the region and producer interest in the project has grown. At least twenty dairy producers in the three states have made major increases in the use of pasture in recent years and others are considering pasture use. Discussion support groups are becoming more active among dairy graziers in the region. At least three new pasture-based dairies have started in the region since the project began and several more are being planned or considered.

Economic Analysis

There were marked differences in the levels of milk production under the two feeding systems. The combined effect of the Jersey and Holstein milk production differences was such that the value of milk produced was greater for the confinement cows.

Although an incomplete measure, income over feed cost (IOFC) is a commonly used proxy for profitability. Average daily milk income was calculated using North Carolina average milk prices as reported by USDA, adjusted for butterfat test. Milk production was adjusted for milk discarded as a result of treatment for mastitis to arrive at the volume of milk available for sale. The pastured groups had lower incidences of mastitis but these adjustments to production were relatively small and only partially reduced the original production differences. As a consequence, the confinement groups generated more adjusted milk income than the pastured groups in all six lactation groups reported in Table 2.

Feed costs were estimated from the ration formulations. Rations for all groups were developed using the PCDART ration-balancing program. The confinement groups were fed a total mixed ration that included corn silage, alfalfa haylage, whole cottonseed, ground corn and soybean meal as the primary ingredients. Grazing was the primary source of forage for the pastured group. Hay or "baleage" made from seasonal surpluses of grass was fed when there was insufficient pasture to provide adequate nutrients in the diet. Concentrate rations for the pastured cows included whole cottonseed, ground corn and molasses. Concentrates feeding levels varied between 8 and 40 lb./head/day for the Holsteins, depending on the availability and quality of pasture, stage of lactation and body condition. The higher levels of concentrate feeding included whole cottonseed and cottonseed hulls as a fiber source. All rations were supplemented with trace minerals and vitamins.

Ingredient costs were calculated using prices comparable to prices paid by farmers at the time the ration was formulated. Forage costs were based on NCSU forage enterprise budgets. Corn silage was charged at $25/ton, alfalfa silage at $35/ton, pasture at $10/ton, and hays at $68 to $86 per ton depending on type. These cost estimates are on an as fed basis and were considered to be adequate to cover the full cost of production and harvesting these crops, including operating expenses, labor, and annual charges on capital investments in machinery and equipment. These costs do not include a charge for mixing and feeding the various grain and TMR rations.

Feed costs were lower for the pastured groups for all six lactation groups but in five of the six lactation groups this cost reduction was not large enough to overcome the lower milk income, Table 5. Income over feed costs varied between 22 cents per cow per day below the confinement group for the spring 1995 pastured group to a high of 83 cents in favor of the confinement group for the Spring 1996 calving cows. For the one lactation group where the pastured cows outperformed confinement cows the income over feed cost was 94 cents per cow per day higher.

The relative performance of the different breeds is of interest. The pastured Holsteins and Jerseys grazed together as a single group and they were fed the supplementary grain ration as a single group also, because there was no practical means to separate them. The confinement groups were fed together for the first three lactation groups because of limitations imposed by the facilities. Feed costs were partitioned between the breeds based on projected dry matter intake in order to estimate feed costs and income over feed costs. The estimated income over feed costs were highly variable for both breeds for both the pastured and confinement feeding systems, and there was no consistent pattern. Spring vs fall calving did not seem to be a factor.

Other Economic Considerations

Income over feed costs does not tell the whole story and several other factors affect the relative profitability of pastured and confinement systems. These include herd health, reproductive performance, labor efficiency, investment costs, stocking rate, waste storage and handling costs, quality of life, and environmental considerations.

The data presented in this report show that a lower incidence of mastitis was a significant health advantage for the pastured cows. Significantly more of the confinement Holsteins than the pastured Holsteins were culled for mastitis, 12 compared to one over the six lactation groups. One major cost of mastitis is lost milk income, and this was factored into the income over feed cost calculations. Cow turnover also represents a cost to the farm business. Based on USDA reports during the period of this project, dairy replacements were valued at $1075 per head and cull cows were valued at 32 cents per pound, net of sales costs. Therefore, a cull cow weighing 1300 pounds sold for beef has a salvage value of $416, which is $659 less than the cost of a replacement. Therefore, the additional 11 cows culled from the confinement Holsteins incurred a cost of $7,249. This represents $.352 per hundredweight of the milk sold from the confinement Holsteins during the six lactations, or $.237 per confinement Holstein cow per day. This added cost of culling has the effect of substantially reducing the income over feed cost advantage to the confinement cows reported in Table 5.

There is wide variation in labor efficiency on confinement dairies, based on data from several university farm business records programs. Part of this variation is likely to be caused by differences in facility design, age and layout. The NCSU dairy unit is not representative of a commercial farming operation and, therefore, is not ideal for evaluating labor efficiency. However, various aspects of the labor required for the pastured and confinement groups were studied. It should be noted that both the pastured and the confinement groups were managed as seasonal calving herds and this is the basis for comparison.

The time involved in the daily routine of feeding, milking and moving cows was measured. The various groups were milked consecutively so it was not possible to measure milking and clean-up times separately. However, it was judged that these times would be quite similar for both groups even though the lower milk production levels for the pastured cows should result in a slightly shorter milking time. Cow cleanliness is another factor that could cause some differences in milking times between two systems but did not seem to be a factor here. It took slightly less time, approximately 15 minutes per day, to bring the pastured cows in from the pasture for feeding and milking, move temporary fences, and feed grain than it did to move confinement cows, milk, and prepare and feed a total mixed ration twice daily. The supplementary grain mix for the pastured cows was milled and mixed on the farm, which took approximately 25 minutes per day, on average. Preparation of the grain and supplements for inclusion in the confinement TMR took about 20 minutes per day. In total, the advantage to the pasture system represents 100 hours during a 10 month lactation.

No measurable differences were noted in the time spent on heat detection, breeding, or herd health. This is not surprising because the groups had access to the same facility. One might expect a slight difference in favor of the pastured cows because their herd health was slightly better.

There are a number of different activities associated with forage production and management under the two systems. These activities were evaluated using the labor assumptions contained in the NCSU forage crop budget guidelines. A typical confinement ration contained 12 lb. of alfalfa silage and 56 lb. of corn silage, as fed. After allowing for waste, it was assumed that 7 acres of alfalfa and 20 acres of corn would be required to feed each group of cows, or 14 and 40 respectively per year. The estimated time required to produce these crops is 236 hours per year.

The pasture acreage for the pastured cows included 46 acres of cool season perennials, 10 acres of a warm season perennial (bermuda grass), 20 acres of a winter annual (rye) and 20 acres of a summer annual. The total adds to more than 76 acres because of double cropping. The estimated annual labor requirement for pasture establishment and maintenance is 80 hours. Approximately 40 tons of dry matter were harvested annually as hay or haylage, with an estimated labor requirement of 63 hours. However, these figures do not include the time required for managing the rotational grazing. It takes an estimated 45 minutes per day for pasture walks and setting up paddocks for the following day, on average, during the 10-month grazing period, or approximately 225 hours per year. Feeding hay or baleage out on the paddocks during the winter months and in drought periods added another 50 to 60 hours per year. The total labor required for all these activities is approximately 420 hours per year.

One area that should yield significant labor savings is manure management. As reported elsewhere, over 85 percent of the feces and urine events took place on pasture and, therefore, incurred no storage or handling costs. The type of manure handling system that was in place at this facility was designed for a confinement operation, namely, a flush system with solid separator, lagoons and an irrigation system. The waste from both groups of cows was handled jointly because they used the same feeding and milking facilities. The estimated time spent operating the system was 2 hours 15 minutes a day, or 675 hours for a 10-month lactation, excluding the time spent irrigating the waste. This system is not appropriate for a grazing dairy but it seems clear that a waste system can be designed for a seasonal pasture based dairy that would require significantly less labor and investment per cow.

On balance, this assessment suggests that the overall difference in labor efficiency between the pasture-based and confinement systems would favor the pasture system but the difference would be relatively small. In a farm setting, labor efficiency differences are likely to depend on site-specific factors.

Lower levels of investment are often cited as advantages of grazing systems. Machinery investments are likely to be lower on grazing farms that rely on pasture as their sole forage crop because of reduced cropping activity and less manure to handle. Based on typical equipment needs for a representative Middle Atlantic dairy farm and 1998-99 prices for new equipment, an investment of $183,000 would be required for corn silage production and harvesting equipment whereas a pasture based dairy equipped with hay making equipment would require an investment of $103,000, a 44% reduction.

There are likely to be significantly lower investments in housing and manure storage and handling facilities for a pasture-based dairy if pastures are the sole forage crops. However, existing confinement farms that convert to grazing will not realize these benefits because they have already made the investment in facilities. Also, some new investments may be needed when a grazing system is introduced.

For this project, new investments required to establish the pastured system included the lanes, fencing and water. The total length of the cow lanes to serve the 72 acre area is 5,400 feet at an estimated materials cost of $14,000, $2.59/linear foot, excluding labor and grading cost. Fencing cost included 11,540 feet of 6-wire perimeter fence ($.50/linear foot), 10,400 feet of 2-wire lane fencing ($.32/linear foot), and 12,800 feet of one-strand internal fencing for dividing paddocks ($.30/linear foot). The total materials cost was estimated at $14,000. Approximately one mile of 1.5 inch water line was needed to serve the paddocks, with connectors, at a materials cost of $6,200 ($1.25/linear foot). All materials costs were based on NC cost share prices.

Total materials cost for lanes, fencing and water were estimated at $33,400. If these materials costs were depreciated over 10 years, with no salvage value, the annual charge would be $3,340. Interest on investment at 8 percent would be $1,336 per year. At one cow to the acre, the combined depreciation and interest cost would be $65/cow/year. However, these costs are likely to vary widely from farm to farm, depending on layout and how the work is to be done.

It should be noted that the largest investments on a dairy farm are in land and cattle, and it is not clear what happens to these under pastured systems vis-à-vis confinement systems. Typical estimates for perennial pasture dry matter production are in the 3 to 4.5 ton per acre per year range, depending on species, type of harvesting and intensity of pasture management. Comparable corn silage production estimates are in the 5 to 6 ton range, so less acreage may be needed to support a cow's forage needs under row cropping. King investigated the effects of stocking rate, feeding systems and calving season on profitability using the data from this project. A computer simulation model, UDDER, was used to determine the optimum dairy farm design and management strategies for a grazing dairy herd. Gross margin per cow and per hectare was maximized when high levels of high energy concentrates were fed to the herd. Season of calving had only a minor effect when this concentrate feeding strategy was used.

In this simulation, increases in stocking rate were predicted to increase pasture utilization, milk production, and gross margin per hectare. Gross margin per hectare was maximized when pasture utilization rates were very high, i.e., between 80% and 90% of annual pasture accumulation. The stocking rates required to achieve high pasture utilization rates and high profits depended upon the concentrate feeding system used.

King's results challenge many popularly held opinions about pasture-based milk production systems. Specifically, the no or very low concentrate feeding levels that are representative of New Zealand were not the most profitable systems under the milk price and cost structure that is representative of the Mid-Atlantic region of the United States. The most profitable practices were not the lowest input or the lowest total investment. It must be noted, however, that pasture damage can occur at high stocking rates and metabolic problems can occur at high levels of grain feeding. Also, the combination of high stocking rates and high levels of grain feeding may create environmental concerns and nutrient management problems. It would be desirable to evaluate these results with field trials.

In summary, the economic evaluation performed here is necessarily incomplete, given the design of the field project and the limitations imposed by the facilities. The income over feed cost estimates presented here show a disadvantage to the pastured cows. However, herd health measures favored the pastured cows and the economic impact were relatively small. There are indications that other non-feed costs could be significantly lower for pastured systems on commercially sized farms. Investment in equipment needed for forage production and harvesting was estimated to be 44 percent lower. The indications were that labor efficiency differences are likely to be small, with the exception of the waste handling aspects of the farm operation. Savings in facility investments are also substantial for a new operation but would not be realized for existing operations that convert to pasture based systems. These factors may partially or completely offset the disadvantage in income over feed costs.

Economic Implications

What then can we recommend to farmers who have an expressed interest in pasture-based dairy farming systems? It seems fair to conclude that the advantages of pasture-based systems will be specific to a farmer and a farm. Therefore, there is no substitute for a specific plan that takes account of the particular characteristics of a site and an individual. The planning process should begin with an assessment of the resources that are available including the human resources. For an existing dairy farm the assessment should also include the current financial status of the business, an evaluation of past performance and projections of where the business is currently headed. The second step is to identify problems and opportunities. Diagnose the root causes of the major problems facing the business, then identify and evaluate possible solutions that can be put into practice. Grazing may be one option but it is unlikely to be the only option to consider.

If grazing is an option, someone must design the system, including land base, cow numbers, stocking rates, pasture types, paddock layout and fencing, water supply, lanes, grain and supplementary forage feeding, and cow comfort. A farmer may need help fitting all these pieces together. One concern of our study was the initial lack of knowledge of pasture and grazing management among the farm workers. For any system that requires management skill, there will be a learning curve and optimal efficiency of the system will likely take a few years. All of these factors affect cow performance and farm production, which, in turn, affect financial performance.

Another issue is the possibility of seasonal milk production. We did not evaluate a seasonal system in direct comparison to a year around calving and milking system. Our data did show that maintaining a strict breeding system could be difficult, particularly with Holsteins. However, seasonal herds could have advantages for managing groups of cows similarly without having to do every job on the dairy farm every day.

The particular farm circumstances will affect the new investment required. However, each situation probably fits into one of four basic grazing scenarios:

1. There is a confinement facility that is in good working order. The money invested in this existing facility is a sunk cost, meaning the owner is stuck with it regardless of what happens. However, a new grazing system will require some new investment. Therefore, a new grazing system must generate a large enough margin to recoup this new investment and still leave a greater profit compared to the confinement operation. This added margin could be obtained by increasing the margin per cow, adding cows, or a combination of both.

(a) If you plan to add a supplementary grazing system then the herd size will be limited to the current size by the facility. Therefore, the added margin must be generated by the same number of cows. This limit on cow numbers may be related to parlor capacity, housing, or manure storage capacity. Also, converting land to grazing will likely affect the total forage production capacity of the farm, so the types and amounts of feed the farm will produce under the new system must be estimated. This may affect the herd ration and cost.

(b). If the farm is converted to an intensively managed rotational grazing system then the number of cows it can carry is determined either by the availability and quality of land for grazing by the milking herd or by the capacity of the parlor. Cow housing ceases to be a limitation. There may be surplus equipment that can be sold and the proceeds may help finance the new investment needed for the grazing program.

2. If an existing confinement facility needs major repairs or remodeling before it can continue in use then the cost of the repairs or remodeling must be recouped if the herd will still be kept in confinement. Differences in profitability between continued confinement and a pasture based system will be affected by differences in the amount of new investment required, differences in herd size and differences in the operating margin for the two systems. For a confinement herd, the limit on cow numbers may be the capacity the dairy facility or the availability of land for feed production. For a pastured herd the limit on herd size may be the availability of land for grazing or the capacity of the milking parlor. The availability of credit and cash flow may be things to consider if a large new investment will be needed.

3. A new dairy farmer with an existing farm but no dairy facility has all his or her options open. The profitability of different systems is an important consideration. A pasture-based dairy would be preferred if it is likely to be more profitable than a new confinement operation. The comparison must be based on the best possible system for each type of dairy. The investments will be large for any new system, so projected cash flow is important and must be looked at too.

4. For someone not in dairy farming and who has no farm at present but who wishes to start dairy farming, all options are open, including the location, size, type and layout of the farm. This person could choose to locate anywhere in the country. Renting or buying are both options. In this situation, a new pastured based dairy must be shown to be more profitable than a new confinement operation, including the farm investment. The comparison must be based on the best possible system for each type of dairy, given that the choice is not limited in any way but is driven by expected costs and returns. Cash flow considerations are important and must be

considered in addition to the question of profitability.

Economic Conclusions

Grazing enthusiasts stress several advantages over confinement systems, including higher profits, labor savings, reduced levels of investment, smaller quantities of manure to store and handle, increased quality of life, and environmental benefits from reduced reliance on row crops. The income over feed cost estimates presented here show a disadvantage to the pastured cows. Herd health measures favored the pastured cows and there are indications that other non-feed costs are significantly lower for the pastured cows. These factors may partially or completely offset the disadvantage in income over feed costs.

It must be stressed, however, that we see a wide variation in profitability for any type of dairy farming system and we would expect to see comparable variation among grazing farms. Documented financial data from a few grazing farms do indicate that pastured systems can be profitable.

Farmers who are contemplating a switch to grazing should realize that the profitability of such a move depends on their particular circumstances. These circumstances affect the economic framework within which the decision must be made. Decisions whether or not to start grazing will be specific to individual farm situations and there is no substitute for careful planning. Planning should begin with family goals and an assessment of the farm resources and the existing financial situation. Developing a farming plan comes next, followed by financial projections of profitability and cash flow feasibility. This provides the best information for evaluating the financial consequences of changing to a pasture based system at the present time. Grazing is not a panacea, but it seems clear that it has potential in the right setting.

Progress on Objective d:

Storm water runoff was monitored at the Lake Wheeler Field Research Laboratory since the summer of 1995 to evaluate water quality differences of pasture-based conventional feedlot dairy farm management systems. Storm runoff samples were collected from a 15.4 acre pasture area and from a 2.8 acre drylot exercise area. The pollutant runoff data for the pasture and drylot area for sediment, total nitrogen and total phosphorus are shown in Table 6. These data were adjusted for the number of cows each area supported during the data collection. Because of the concentration of sediment and nutrients leaving the bare exercise lot, that area has been modified to include rotational vegetative loafing paddocks, a concrete settling basin, and a level spreader to reduce and dissipate sediment and nutrients before they enter the stream.

In addition to the water monitoring, we have conducted 24-hour cow watches for cows on the pasture system to determine relative distribution of feces and urine.

An important issue in comparing the two systems is the deposition, collection, and recycling of nutrients. All of the feces and urine of the cows has to be handled or processed in some way whether from the feeding, housing, and milking areas or from the exercise lot. This requires special needs for handling, storage, and redistribution of nutrients to cropland or other uses.

During the 24-hour cow watches, distribution of urine and feces areas within a grazing paddock were mapped. Figure 17 (all observation periods) and Figures 18 (July 1997) and 19 (February 1998) show the spatial distribution from the observation periods. The paddock was about 2 acres in size and was divided in half for the first 12 hours. The spots marked “urine 1” represent the urine events that occurred during the first grazing period. The spots marked “urine 2” represent the urine events that occurred during the second grazing period. The spots marked “manure” are the manure depositions for the entire period. Using literature sources feces and urine spots were estimated at .12 m2 and .36 m2, respectively (Petersen, 1956; Wilkinson, 1973). Feces and urine from the five 24-hr observations and one 12-hour observation covered 10% of the total area of the paddock. The front 54% of the paddock was used exclusively for 60% of the total grazing period and contained approximately 62% of the urine and 69% of the feces. Within 6 m of the portable waterer, concentrations of feces and urine were greater (1.5X and 2.5X respectively) than concentrations 6 to 75 m from the waterer, primarily due to 2 summer afternoons when cattle clustered near the waterer.

Figure 18 shows the spatial distribution from the observation period in July 1997. That particular day was warm and there was a tendency for a disproportionate amount of nutrients to be deposited near the waterer. If the waterer was moved for the second 12-hour grazing period the nutrients would have been more evenly distributed. Figure 19 shows the spatial distribution from one observation period in February 1998. In contrast to the map from July 1997, there is no concentration of nutrients around the waterer. These data suggest that manure on pasture was relatively evenly distributed over multiple grazing periods.

It should be noted that during the cow watches observers were careful not to unduly disturb the cows. When the cows were taken out of the paddock, they were allowed a few minutes to rise and void themselves in the paddock instead of the lanes or feeding area. The manner in which cows are handled can greatly affect the distribution of the manure. The manure events were highly correlated with the amount of time spent in each of the areas (R2=.99, P< .05). Therefore the time spent in the paddocks should be maximized to minimize the amount of manure that must be collected and handled.

These data show that 86% of urine events and 85% of feces events occurred in or near paddocks where nutrients are readily available for pasture use (Table 7). This means that a pasture-based system has to design storage and handling facilities for only about 15% of total manure production plus milking facility wash water. This would allow farmers to invest less money into manure handling systems. In addition, these systems would be much simpler to operate than the current conventional systems. Collectively, the costs of nutrient management will likely strongly favor the pasture system over the confinement system.

Progress on Objective e.

The outreach activities of this project have been a strong component. These activities are all included in Section G of this report below.

Recommendations:

Areas needing additional study

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Information Products

- Center for Environmental Farming Systems (Conference/Presentation Material)
- Enhancement of Communities with Pasturebased Dairy Producation Systems (Conference/Presentation Material)
- Proceedings of Dairy Field Day November 1 1995 Lake Wheeler Road Dairy Educational Unit (Conference Proceeding)
- Projected Nutrient Cycles of Two Different Dairy Farm Systems (Conference Proceeding)
- Regional Center for Sustainable Dairy Farming 1995 Report for North Carolina A and T State University (Bulletin)