USDA Agricultural Research Service

PASTURE SYSTEMS AND WATERSHED MANAGEMENT RESEARCH UNIT RESEARCH SUMMARIES and FACT SHEETS

Improving Productivity, Sustainability, and Profitability of Grassland Agriculture

We conduct research to develop and transfer economically, environmentally, and socially sustainable management systems for northeastern grazing and cropping enterprises. We focus on providing the knowledge, capability, and tools to solve important problems that threaten the sustainability of agriculture.

Background. Forages and pastures on livestock farms lower feed costs, reduce veterinary expenses, and improve the health of livestock. Grassland agriculture (farming based on forages and grazing) allows new farmers to start up with less money, which could help rural communities. In a highly urbanized northeastern USA, grassland agriculture offers green space and pleasant landscapes. Forage crops can also be used to make products such as bioenergy (energy from plants), paper, and plastics.

An Ecological Approach to Pasture Research Improvements in pasture and forage management often have been made through traditional agronomic approaches. Applying ecological principles may improve pasture condition, productivity, and sustainability with fewer inputs. Managing complex mixtures of plants to take advantage of variability in land and climate may be one ecological approach to increase productivity of pastures. Farmers, however, lack information on how many and what types of forage plants to use when managing highly diverse pastures. Dependable information and technologies are also needed to monitor pastures, to restore damaged land, and to identify management practices that increase or maintain profits while protecting the productivity of pastures. New research information is needed on how to best manage grasslands for biofuels production.

Research Goals Our goal is to develop diverse, stable, and persistent forage and pasture lands that provide a permanent cover and protect the natural resource base for future generations. Research on forage-livestock systems seeks to improve the productivity, sustainability, and profitability of northeastern forage and grazing lands by managing and enhancing forage diversity. Research on integrated farming systems focuses on the farm management scale to develop pasture-based systems that are profitable and protect the environment.

Extending Results to Farmers and Advisors. To get our results out, we meet one-on-one with farmers, hold field days, and publish popular press articles. We work closely with the USDA NRCS Grazing Lands Technology Institute. We cooperate with farmers throughout the Northeast USA in our research and frequently conduct field experiments on farms. This puts research results directly into the hands of the farmer. Scientists on this project serve as technical advisors to farmer organizations. A major vehicle for technology transfer is the Northeast Pasture Research and Extension Consortium formed of representatives from private industry, producers, extension, and research.

Recent Pasture, Forage, and Biofuels Research Accomplishments

Economic Analysis of Planting Forage Mixtures for Grazing Dairy Cattle

We used a whole-farm model (Integrated Farming Systems Model, IFSM) to simulate the costs and returns of planting and establishing five types of pasture with stand lives of 3, 5, or 10 years. The five pasture types included four mixtures of forages (two, three, six, or nine species of grasses, legumes, and a forb) and an orchardgrass+N (134 lb/acre) pasture with a 10-yr stand life. The whole-farm economic returns of these five pasture types were estimated for a representative 100-cow dairy based on actual costs of establishment and pasture production from two published studies. Planting pastures to grass-legume or grass-legume-chicory mixtures increased net returns per cow compared with the orchardgrass+N pasture. The increase in net return ranged from $127/cow for the two-species mixture to $234/cow for the six-species mixture. Increasing stand life increased net returns from all mixtures but the increase of net return was greatest with the nine-species mixture. The greater forage yields of the mixture compared with orchardgrass+N reduced purchased feed inputs and in some instances increased the income from forage sold off the farm.

Key Findings: Planting grass-legume or grass-legume-chicory mixtures increase net returns per cow compared with an orchardgrass-nitrogen pasture.

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Planting grass-legume or grass-legume-chicory mixtures increased net returns per cow compared with an orchardgrass-nitrogen pasture

Options to Reduce Phosphorus Loss from Farming Systems

The United States Environmental Protection Agency estimates that there are 22,000 impaired surface waters (e.g., lakes, streams, reservoirs) in the country, with 11% of these impairments due to nutrients originating primarily from agriculture. Research on phosphorus management is focused on implementing alternative management practices to reduce the amount lost from farms. If these management strategies reduce the profitability of farms though, the practices are unlikely to be implemented. Thus, strategies to reduce phosphorus pollution from farms must be evaluated along with other environmental factors and the economics of the farm. Computer models provide a cost-effective and relatively rapid method of analyzing farm management scenarios. One model, the Integrated Farm System Model, simulates the major farm processes including crop growth, herd performance, economics, and nutrient flows. This farm model was expanded to include a component that predicts the effects of management on farm-level phosphorus loss. The model was used to illustrate manure handling and tillage effects on phosphorus loss from dairy farms along with other farm performance and economic considerations.

Key Findings: For a 100 cow dairy farm, a manure handling strategy that used a six-month storage and application by injection decreased total P loss by 19% compared to daily surface application but decreased annual farm net return by $57/cow. Compared to conventional tillage using a moldboard plow, use of conservation tillage and no-till systems reduced total P loss by 46% and 57%, respectively, with small increases in farm profitability. Reduced tillage increased soluble P loss, suggesting that conservation and no-till systems should be combined with systems such as manure injection to reduce all forms of P loss. The enhanced IFSM containing the soil P model provides a tool for whole-farm analysis of management effects on P loss along with other environmental and economic considerations.

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Management effects on phosphorus losses from farms can be estimated using the Integrated Farm System Model.

Accurately Measuring Forage Yield in Pastures

Our research shows that a dairy grazier can save up to $80 per acre or $48 per cow per year by accurately measuring and budgeting forage on pasture. How accurate must the grazier be? We ran some hypothetical scenarios about forage budgeting on the computer model DAFOSYM to estimate the costs of inaccurate forage budgeting. For one scenario, under or over estimating the amount of forage available on pasture by 10% caused a loss of $6 per cow per year. An error rate of 20% caused losses of $20 per cow per year.

In another scenario, underestimating forage production on pasture by 10 or 20% and not harvesting the excess as silage or hay resulted in up to $48 per cow per year less farm profit compared with the base farm. Annual profit was about $20 less per cow when either 20% more forage from pasture was allocated in the ration or if pasture yield was underestimated by 10%.

If the grazier overestimates the amount of forage in a paddock, then each paddock laid out is too small and the cows that graze there won't have enough feed for optimum performance. Some additional forage may be gained by harvest for winter feed or (if you sell instead of store it) some additional money. But that gain is offset by the money that must be spent on feed to either get animals through the winter or perhaps even to maintain decent performance. What if the grazier is too conservative in the estimate of forage? If the amount of forage in an area is underestimated, the grazier sets up paddocks that are too large and wastes some valuable feed.

Key Findings: Assuming a producer would spend about 1 hour per day measuring forage yield before and after moving cows, then the labor cost (at $8 per hour) for monitoring pasture yield would be $1440 (180 days x 1 hour/day x $8 per hour). Except for one instance in our study, the reduction in net return was less than $1000 per year for error levels of 10%. Thus, a 10% error rate in measuring pasture yield appears acceptable. As the error level increased above 10% the loss in profit was greater than the labor cost required to regularly monitor pasture yields. In addition to saving money on feeding, regular pasture monitoring keeps the grazier tuned to fluctuations in pasture condition.

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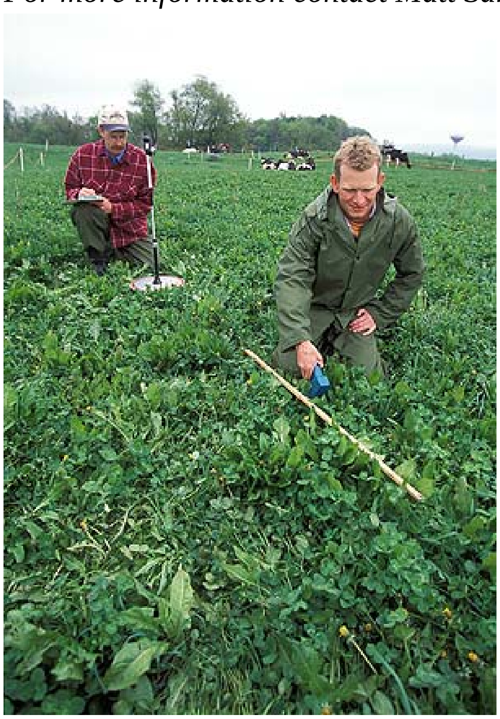

Producers who accurately measure and budget forage in pastures can cut costs significantly

Greenhouse Gas Emissions and Soil Carbon Sequestration of Dairy Forage, Biomass Production, and Grazing Systems

Adapting agricultural practices that eliminate tillage and increase plant biomass production has the potential to increase the sequestration (storage) of carbon as soil organic matter and lower atmospheric carbon dioxide concentrations. In addition to carbon dioxide, agricultural production also influences atmospheric concentrations of the greenhouse gases nitrous oxide and methane. Nitrous oxide is especially important because it is approximately 300 times more effective than carbon dioxide as a greenhouse gas, and it's emission from soils can be greatly influenced by the management of nitrogen fertilizers. We are monitoring soil organic matter changes and nitrous oxide and methane emissions with a dairy forage rotation (corn/soybean/alfalfa), biomass production for alternative fuel uses (switchgrass and reed canarygrass), and pasture.

Key Findings: Changes in soil organic matter occur slowly, and we do not expect to detect differences among the land uses until plots have been in place for at least five years. Nitrous oxide emissions are generally expected to increase as soil moisture increases. 2005 was a dry year, and nitrous oxide emissions were low with little difference among land uses. Greater rainfall in 2006 lead to greater nitrous oxide emissions from soil under corn, soybeans, alfalfa, and pasture, but emissions under switchgrass and reed canarygrass have remained low. Soils were a small sink for methane, except where it was emitted from freshly deposited cow dung. However, the consumption of methane by soil bacteria offset methane emitted from dung.

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Agriculture influences atmospheric carbon dioxide and the greenhouse gases nitrous oxide and methane. We are comparing different forage systems for the emissions of these gases.

Management to Reduce Ammonia Emissions from Dairy and Beef Farms

The effect of farms on the environment has become a major social concern in many regions, particularly those with high concentrations of animal production. A relatively new environmental concern is the volatilization of gases from animal facilities with the major emission being nitrogen in the form of ammonia. Ammonia emissions are of concern because ammonia in the atmosphere leads to the formation of small airborne particles with potential effects on human health. Atmospheric ammonia also contributes to over fertilization, acidification, and eutrophication of ecosystems. A number of management options can be used to improve nitrogen utilization in cattle production and thus reduce ammonia emission. Finding a cost-effective approach though, can be a challenge. All parts of the farm and their interactions must be considered when developing production practices to reduce emissions. This type of evaluation is best done through computer simulation. A processed-based model was developed to predict management effects on ammonia emissions from manure in the barn, during storage, following field application, and during grazing. This ammonia emission model was added to the Integrated Farm System Model forming a comprehensive tool for evaluating management effects on ammonia losses along with other aspects of farm performance and profit.

Key findings: Whole-farm simulations illustrated that the use of a free-stall barn, bottom-loaded slurry storage, and direct injection of manure into the soil reduced ammonia emissions by 35-50% compared to other commonly used dairy housing and manure handling systems in the northeastern US. The improvement in nitrogen utilization more than offset the increased cost in manure handling, providing a small increase in farm profit. The farm model provides a research and teaching tool for evaluating and comparing the economic and environmental sustainability of dairy and beef production systems.

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Management can be used to reduce Ammonia emissions in the barn, during manure storage, following field application and during grazing.

Soil Nutrient Levels on Grazing Farms in the Northeast

A common myth about pastures in the northeastern U.S. is that they are on low-fertility soils. Our research, however, indicates that soil fertility is very high on many intensively managed grazing operations. We compiled soil nutrient information on 215 pastures on 66 farms across the northeast that used intensive grazing management. Three-fourths of the pastures sampled had optimum to high levels of phosphorus and potassium in the top six inches of soil. The low, optimum, and high categories are based on agronomic criteria and are not necessarily environmental indicators. Increased levels of soil test phosphorus have been associated with an increased risk of phosphorus loss in surface water runoff; however, other risk factors such as landscape position and hydrologic connections must be considered as well. Paddocks farthest from the barn tended to have lower soil phosphorus levels; however, there was a large range in soil phosphorus regardless of distance from the barn. Soil potassium also tended to be lower in pastures farther from the barn. High soil potassium may result in high forage potassium concentrations, which can cause metabolic problems in cattle. Soil nutrient levels are only one indicator of the level of nutrient management on farms. Nearly 60% of the pastures sampled had a low soil pH (between 5.1 and 6.4) indicating that liming may be beneficial on these pastures. Organic matter content varied widely and averaged about 5%. Older research on pasture soil fertility focused mainly on pastures managed at a relatively low intensity. In recent years, many graziers have intensified their grazing management (increased stocking rates; rapid rotations, etc.). Because of the perceived benefits of improved nutrient cycling and lower soil erosion on grazing farms, some producers may place a low priority on nutrient management. Our results indicate that farms with more intensive grazing management often have greater soil fertility levels and that these producers need to implement appropriate nutrient management practices.

Summary of phosphorus, potassium, and pH in pasture soils (0 to 6-inch depth) across the northeast

Agronomic category	# of pastures (% of total)	Mean	Range	Location from barn	# of pastures	Mean	Range
			Phosphorus (ppm)				
Low	51 (24)	20	4-30	Near	51	76	4-288
Optimum	62 (29)	44	31-59	Intermediate	57	75	7-220
High	102 (47)	107	61-313	Far	63	61	13-208
			Potassium (ppm)				
Low	48 (22)	69	35-82	Near	51	198	38-386
Optimum	74 (34)	129	83-172	Intermediate	57	168	35-546
High	93 (43)	245	175-546	Far	63	165	39-507
			pH				
Low	127 (59)	5.96	5.1-6.4				
Optimum	82 (38)	6.77	6.5-7.4				
High	6 (3)	7.52	7.5-7.6				

Key Findings: 75% of pastures had optimum to high levels of P and K
60% of pastures had low soil pH
Pasture soils must be monitored regularly as part of a nutrient management plan

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Soil Sampling Strategies for Pasture and Forage Management

There is general concern that traditional soil sampling strategies, whereby discrete samples are mixed to provide one composite sample for analysis, may not provide sufficient insight into environmentally-important variation in soil test phosphorus (STP). This concern is especially relevant to pasture conditions where the major component of nutrient input comes from animal deposits of urine and manure. We sampled two pastures, an alfalfa field and a hay field on a 10 meter grid to characterize the spatial variability of STP. Patterns of phosphorus (P) distribution in the alfalfa and hay fields were relatively uniform and reflected manure spreading practices. In contrast, the two pastures showed the presence of "hot spots" at which STP is elevated at several random points, reflecting manure deposits by grazing animals. We then conducted simulated rainfall and runoff events to investigate the potential impact of such variability on P concentrations in runoff. High soil P conditions produced high concentrations of P in runoff. However, the P concentration in runoff declined rapidly over short distances as runoff flowed across areas of low soil P conditions. Therefore, the "average" conditions represented by composite soil sampling appear to provide a good representation of the overall potential for runoff P losses from pastures with hot spots.

Key Findings: The use of single composite samples for soil test phosphorus appears to be an appropriate indication of P concentration in runoff, because the compositing effect that masks "hot spots" during soil sampling also buffers against high concentrations of P being lost in runoff.

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Bolting-Resistant Chicory Varieties: Yield and Persistence

A challenge in managing chicory as a forage in pastures is dealing with "bolting" or rapid elongation of flower stalks in spring. Varieties with reduced bolting potential are available. We conducted a field-plot experiment at Rock Springs, PA during 1999 to 2001 to evaluate commercial forage cultivars and European root-type cultivars of chicory for yield, bolting, and persistence. 'Grasslands Puna', 'LaCerta', and 'Forage Feast' forage-type chicory, and 'Dagerrad', 'Halle', and 'Katrein' root-crop chicory cultivars were sown in field plots in May 1999. The cultivars did not differ in dry matter yield in 2000 (average of 6700 lb dry matter/ac). Grasslands Puna and LaCerta yielded more dry matter than other cultivars in 2001. Chicory cultivars differed in their persistence and degree of bolting. More than 80% of LaCerta chicory plants bolted during both years and LaCerta suffered an 89% loss of plants during 1999 to 2002. Less than 50% of Forage Feast and the root-type chicory plants bolted, but these cultivars did not produce as much dry matter and were less persistent than Puna. Puna maintained the highest plant density (12 plants ft^{-2}), but up to 90% of plants bolted.

Key Findings: Chicory cultivars with reduced bolting would be useful provided that persistence is not compromised.

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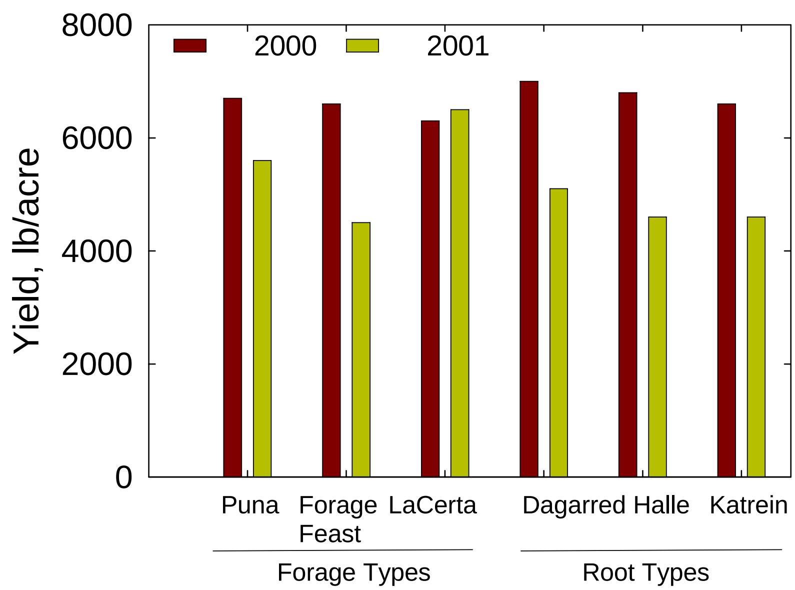

Chicory varieties differed in their degree of bolting, persistence, and yield. Puna was the most persistent but also had the most bolting.

Nutritive Value of Virginia Wildrye, a Cool-Season Grass Native to the Northeast USA

Virginia wildrye is a perennial cool-season grass native to the northeastern U.S. Greater interest in the use of native grasses has created a need for information on the suitability of locally adapted native plants for the northeast. In this research, we evaluated several northeastern populations of wildrye for their nutritive value as forage for cattle. The wildrye populations differed in nutritive value traits such as crude protein, fiber, and digestibility mainly because they also differed in their leaf-to-stem ratio. Wildrye populations with a higher leaf-to-stem ratio had higher forage nutritive value.

Key Finding: At similar maturity stages, wildrye was comparable to orchardgrass in terms of crude protein levels and digestibility; however, our previous research showed that wildrye had low forage yields and lacked persistence. These traits would require improvement to make Virginia wildrye a practical species for forage production.

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Virginia wildrye is a cool-season grass native to the northeast U.S. It has good forage quality, but its yield and persistence were much lower than traditional forage grasses such as orchardgrass

Switchgrass Evaluation under Grazing and Clipping

New cultivars of switchgrass have been released in recent years but information on their performance and nutritive value in the northeast U.S. is needed for producer recommendations. We determined the performance and nutritive value of switchgrass cultivars under grazing and clipping management. In 1999, Cave-in-Rock, Trailblazer, and Shawnee switchgrass were established in replicated plots at Rock Springs, PA and in replicated pastures on a farm in southeastern PA. In 2000 and 2001, two-cut and three-cut clipping treatments were imposed at Rock Springs. At the southeast PA farm, the switchgrass pastures were grazed three or four times per year during 2000 to 2004. Forage yield was determined before each grazing along with nutritive value. There were small and inconsistent differences among cultivars in yield and nutritive value. There was much more variation among years and management treatments than among switchgrass cultivars in forage yield and nutritive value.

Key Findings: The Trailblazer cultivar appeared to suffer from leaf diseases and lodging during wet years and yields decreased after three years. Cave-in-Rock and Shawnee are equally suited for Pennsylvania and similar areas in the northeast. Cutting or grazing switchgrass too often reduces stand persistence.

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Yields of three switchgrass cultivars under grazing in southeastern PA.

Cultivar	2000	2001	2002	2003	2004
			lb dry matter per acre		
Cave-in-Rock	5400	3500	7800	9400	3600
Shawnee	4600	3400	7700	9300	3300
Trailblazer	6400	4000	8300	5900	2800

Yields of three switchgrass cultivars under clipping at Rock Springs, PA

Cultivar	Two-cut	Three-cut
	lb dry matter per acre	
Cave-in-Rock	6200	7100
Shawnee	6000	7200
Trailblazer	5900	6900

Cave-in-Rock and Shawnee varieties of switchgrass are well suited for the northeast U.S.

Warm-Season Grasses for Wet Soils

Better information on plant growth and persistence is needed to make improved recommendations of native, warm-season grasses for use on wet soils. We evaluated 9 cultivars from five warm-season grass species for survival, vigor, and biomass production at four locations in Maryland, Pennsylvania, and New York. A relatively high rainfall year, except for the Maryland eastern shore, and the passage of several hurricanes through the northeast during the fall of 2004 ensured that ideal conditions existed for testing these grasses under wet conditions.

Key Findings: Red River prairie cordgrass had excellent survival and vigor at all locations but did not form as dense a stand as switchgrass or eastern gamagrass and, thus, had relatively low yield. Prairie cordgrass provides low quality forage but would be excellent for conservation plantings. Switchgrass had superior performance at all locations. Eastern gamagrass had high survival, yield and vigor at three sites but did relatively poorly at one location where water completely covered the plants on several occasions for 1-10 days at a time. Indiangrass and big bluestem cultivars had inferior performance at all locations.

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Relative rankings of warm-season grass cultivars averaged across four locations.

Cultivar	Survival (2006)	Vigor (2006)	Yield (2005)	Overall
	Relative ranking (1=best, 9=worst)			
Red River prairie cordgrass	1	1	4	2.0
Hightide switchgrass	2	3	1	2.0
NY tetraploid eastern gamagrass	4	2	2	3.0
Shelter switchgrass	3	4	3	3.3
Osage indiangrass	7	5	7	6.3
Niagara big bluestem	5.5	6	8	6.5
Suther big bluestem	5.5	8.5	6	6.7
Suther indiangrass	8	8.5	5	7.2
Bonilla big bluestem	9	7	9	8.3

† 1 = best, 9 = worst. ‡ Average rank for all three performance measures

Switchgrass and eastern gamagrass performed well on wet soils. Big bluestem and indiangrass are not adapted to wet soils.

Switchgrass and Big Bluestem Response to Spring Burning and Glyphosate Treatment

Spring burning or glyphosate (Round-Up) herbicide application may be useful in controlling cool-season weeds invading switchgrass and big bluestem. We burned or applied glyphosate to these grasses in April, early-May, and mid-May at Rock Springs, PA. Hay yield was measured in July and bioenergy feedstock yield measured in September along with seed yield. Glyphosate reduced yields of both warm-season grasses when applied later than April 21. Delaying glyphosate application until late May reduced hay yields by 80% and biomass feedstock yields by 30% in switchgrass. Late application of glyphosate to big bluestem reduced hay yields by 90% and biomass feedstock yields by 40%. A late burn reduced yields less than a late application of glyphosate. Seed yields responses were inconsistent, but indicate that late burning benefited seed yields, whereas late glyphosate reduced seed yields.

Key Findings: Switchgrass and big bluestem can be burned any time through the first week of May in central Pennsylvania. Glyphosate application, however, should be done before mid to late April if switchgrass or big bluestem are to be cut for hay in summer or by the first of May if the grasses are to be harvested in September or later.

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Summer and fall biomass yields of switchgrass burned or treated with glyphosate in two years.

	Switchgrass				Big Bluestem			
	Year 1		Year 2		Year 1		Year 2	
Treatment	July	Sept.	July	Sept.	July	Sept.	July	Sept.
Burned	Dry matter, lb/ac							
Mid-April	5100	8700	2500	4700	4400	6900	2300	3000
Early May	4200	8300	2200	5000	4300	5800	2300	3800
Late May	2900	7100	2400	5200	2600	6100	2200	5400
Glyphosate								
Mid-April	5100	8400	2900	5200	4500	6200	3200	3800
Early May	3500	8400	2700	4700	2800	6000	2400	3700
Late May	1200	5500	600	3700	700	3200	300	2200
Control†	4600	8100	2000	3300	4900	5800	2200	3100

† No burn or herbicide

Burning warm season grasses in the spring can be a useful tool for managing residue and weeds. HOWEVER, producers must be aware of local regulations regarding burning.

USDA Agricultural Research Service

PASTURE SYSTEMS AND WATERSHED MANAGEMENT RESEARCH UNIT FACT SHEET

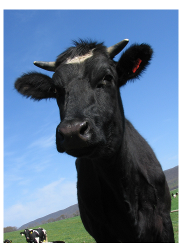
FORAGE AND GRAZING LANDS BIODIVERSITY PROJECT

Pasture Diversity and Management

The Forage and Grazing Lands Biodiversity Project is one of three major projects in the Pasture Systems and Watershed Management Research Unit at University Park, Pennsylvania. The mission of this unit is to conduct research leading to the development of land, water, plant, and animal management systems, which ensure the profitability and sustainability of northeastern farms while maintaining water quality.

Background

There are 120 million acres of pasture in the United States, along with 406 million acres of rangeland and 62 million acres of hay. These grazing and forage crops contribute to more than $80 billion in yearly farm sales. On the farm, pastures can lower feed and energy costs and improve livestock health. Regionally, permanent grasslands reduce soil erosion and nutrient losses, and provide open space for wildlife and bird habitat. Despite the importance of pastures, not much is known about their ecology. We have been studying the diversity and composition of pastures, and how that contributes to:

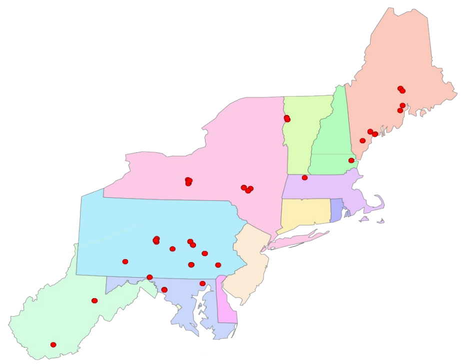


- Productivity of both plants and grazing animals.
- Stability of pasture production under stress (for example drought).
- Ability of pastures to recover after stress.

This fact sheet will focus on what we have learned about pasture diversity and pasture monitoring.

Regional Survey

From 1998 to 2005, we surveyed 44 farms from Maryland to Maine. All farms had grazing animals, usually dairy cows. In 2-8 pastures on each farm, we collected information on plant species number and total cover, bare ground, and number and cover of each species present. We made complete species for a 0.25 acre area (1000 m^2), and estimated species cover in ten smaller quadrats (11 ft^2, or 1 m^2) within the larger plot. We also collected soil test results, slope, elevation and aspect (for example, north- or south -facing) for each pasture, and annual precipitation and temperature for each farm.



Pasture Diversity and Composition

Northeastern pastures were very diverse. We found 310 species of plants. The average number of plant species in a pasture was 32, but we found anywhere from 9 to 73. Nearly half of the species identified were native. Most species were rare, but some were common and abundant. Many of these were forage species, such as orchardgrass, Kentucky bluegrass, tall fescue, timothy and red and white clovers. Other common species included quackgrass, English and common plantains, curly dock and dandelion.

Species Numbers

	Introduced	*Native*	*Total*
Broadleafs	95	103	**198**
Legumes	14	2	**16**
Grasses	37	21	**58**
Woody	14	24	**38**
All species	**160**	**150**	**310**

Prepared by the ARS Pasture Systems and Watershed Management Research Unit. For additional information contact Dr. Sarah Goslee (814-863-0887; Sarah.Goslee@ars.usda.gov; http://www.ars.usda.gov/naa/pswmru)

The average pasture:

- **has 32 species.**
- **has 6% bare ground.**
- **has 67% grass cover.**
- **has 21% legume cover.**
- **has 23% broadleaf cover.**

Pasture Condition Score

The NRCS has developed a pasture monitoring method called the **Pasture Condition Score**. It uses ten criteria, each ranked on a scale of 1 (major effort required) to 5 (no change needed):

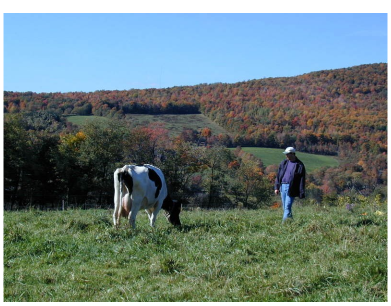
- Percent desirable plants: Plants that livestock will graze readily
- Plant cover: Important to forage production, soil and water protection
- Plant residue: Amount of standing dead, litter, and thatch
- Plant diversity: Number of different forage plants well represented
- Plant vigor: Indicates health of desirable species
- Legume content: Source of N, improves forage quality
- Uniformity of use: Indicates "spot" grazed, over grazed, avoided areas
- Livestock concentration areas: Indicates where livestock congregate and potentially damage pastures
- Erosion: Presence, severity of wind, water erosion
- Soil compaction: Indicator of impaired water infiltration capacity

The ten criteria are added, for a score ranging from 10 to 50. More information can be found in the "Guide to Pasture Condition Scoring", available at http://www.glti.nrcs.usda.gov/technical/publications/index.html.

Pasture Monitoring

As part of the regional survey, we recorded 182 pasture conditions scores. Only 1% of the pastures were very high-scoring, but most of the pastures needed only minor or moderate changes. None of the pastures we sampled scored in the lowest category. Pastures scored lowest in two areas, plant diversity and legume content. Manipulating plant diversity would improve the pasture condition score for many of these farms. The lowest-scoring pastures were rated poorly for plant cover, uniformity of use and soil compaction, and generally lower for all criteria. Changes in grazing management, to reduce under- and over-use, could improve the ratings of these pastures.

PCS	*Recommendation*	*Percent of pastures*
45-50	No change needed	**1%**
35-45	Minor changes	**45%**
25-35	Moderate change	**42%**
15-25	Needs immediate changes	**12%**
10-15	Major effort required	**0%**



Future Work

Now that we have a good idea on what is in pastures in the northeastern United States, we will be working to understand how those complex mixtures of planted and unplanted species contribute to pasture production and forage quality. Manipulating species diversity and content would improve the pasture condition score rankings of many pastures in the Northeast. We will be looking at benefits and drawbacks of forage mixtures containing grasses, legumes and broadleaf plants. The next step will be to identify effective methods for establishing and maintaining the most useful of these mixtures on a range of site types.

MANAGING INTENSIVELY GRAZED PASTURES

Improving Drought Tolerance

The Forage and Grazing Lands Biodiversity Project is one of three major projects in the Pasture Systems and Watershed Management Research Unit at University Park, Pennsylvania. The mission of this unit is to conduct research leading to the development of land, water, plant, and animal management systems, which ensure the profitability and sustainability of northeastern farms while maintaining water quality.

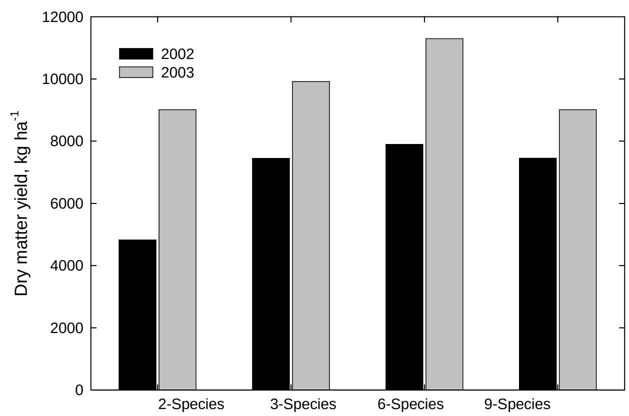
Background

Reduced forage production on pastures during periods of summer drought presents a significant risk to producers who are constantly searching for ways to reduce that risk. Considerable research suggests that increasing the number of species in pasture mixtures can increase and stabilize productivity under stressful conditions. Benefits from increased species diversity are often greatest under harsh environmental conditions and have been associated with several factors including:

- Improved utilization of scarce resources;
- Facilitation of the growth and survival of one or more species by a companion species;
- An increased probability of including the most productive species for a given environment

Important Findings

- Including more than two species in pasture mixtures increased yield under drought conditions but not when rainfall was adequate.
- Photosynthesis increased with increasing species number during the summer and fall when moisture was limited but not in the spring when drought stress was not present.
- Roots were distributed deeper in the soil profile with increasing species richness, thus improving access to deep soil moisture.
- Including species in pasture mixtures that exhibited specific desired attributes was more important in determining forage yield than was the actural number of species. All mixtures tended to lose species over time.

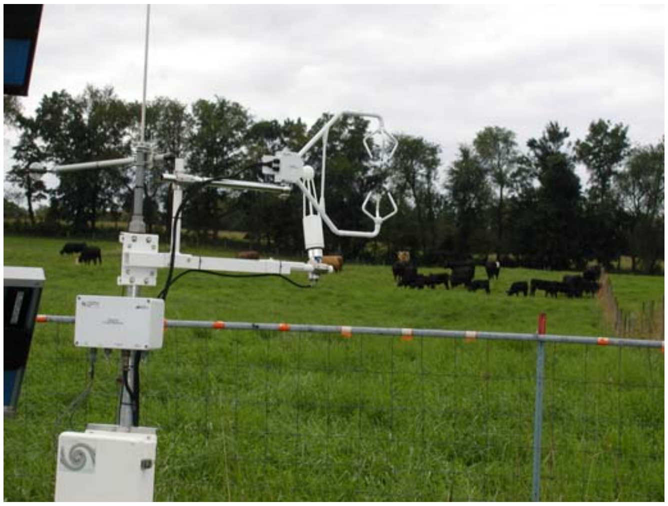


Practical Application of Results

Forage production during periods of summer drought can be increased by including additional species in the pasture mixture, especially if those species have desirable attributes such as improved water use efficiency or deep root systems. However, many relatively drought-tolerant species such as chicory or red clover are relatively short lived and will probably require periodic reestablishment for long-term realization of the benefits they can provide to pastures.

Prepared by the ARS Pasture Systems and Watershed Management Research Unit. For additional information contact Dr. Howard Skinner(814-863-8758); howard.skinner@ars.usda.gov; http://www.ars.usda.gov/naa/pswmru)

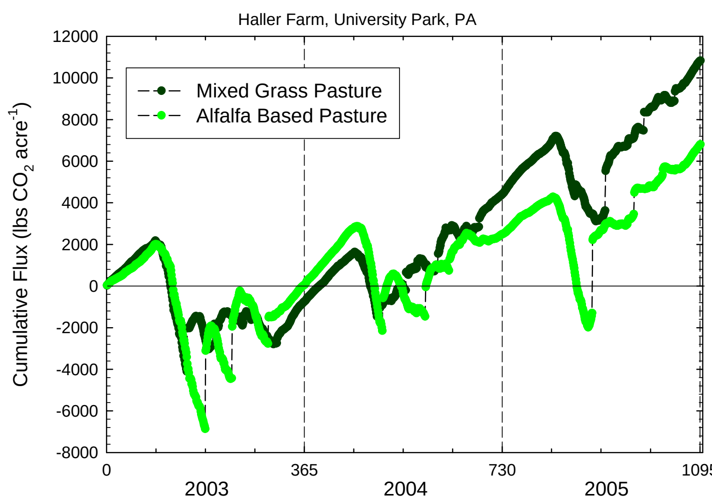
Carbon Sequestration in Mature Humid-Temperate Pastures



Background. Decades of plowing have depleted organic carbon stocks in many agricultural soils. Conversion of plowed fields to pasture has the potential to reverse this process, recapturing organic matter that was lost under more intensive cropping systems. Systems are being put into place to provide payments for practices that increase soil carbon. Pastures in the northeastern USA are highly productive and could act as significant sinks for carbon dioxide. However, such pastures have relatively high shoot relative to root growth, the majority of which is removed as hay or consumed by grazing animals. In addition, the ability of pastures to sequester carbon dioxide decreases over time as previously depleted stocks are replenished and the soil returns to equilibrium conditions.

Important Findings. We have monitored carbon dioxide (CO_2) gains and losses from two fields in Central Pennsylvania that have been managed as pastures for at least 40 years. Results are shown in the figure to the right.

- When biomass removal as hay or by grazing was taken into account, the pastures experienced a net loss to the atmosphere of about 1.4 ton CO_2 $acre^{-1}$ $year^{-1}$ (positive values represent loss to the atmosphere while negative values represent uptake by the pastures).
- Returning manure from the hay that was consumed off site would have partially replenished the lost carbon, but the pastures would have still experienced a net loss of CO_2.
- Heavy utilization of the biomass produced on these mature pastures prevented them from acting as carbon sinks.



Application of Results. Although good management practices following conversion to pastures can increase soil carbon sequestration, land managers must realize that limits exist to the amount of carbon that can be stored. Mature pastures and those that are heavily utilized, either by haying or grazing, can not be counted on to continuously accumulate soil carbon.

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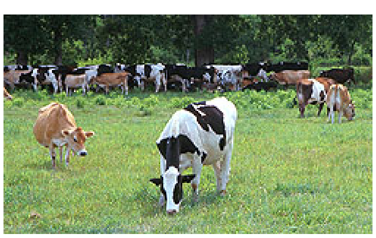
FORAGE AND GRAZING LANDS BIODIVERSITY RESEARCH

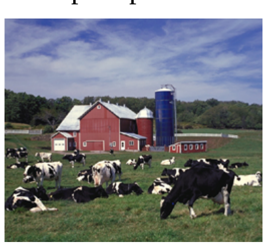
Biodiverse Forage Mixtures: Can They Improve Animal and Pasture Productivity?

The Forage and Grazing Lands Biodiversity Project is one of three major projects in the Pasture Systems and Watershed Management Research Unit at University Park, Pennsylvania. The mission of this unit is to conduct research leading to the development of land, water, plant, and animal management systems, which ensure the profitability and sustainability of northeastern farms while maintaining water quality.

Background

The role of plant species diversity or forage mixture complexity in pastures is not yet well characterized. Nonetheless, taking their cue from the plant diversity found in natural grassland communities, some producers in the Northeast often plant complex mixtures of grasses and legumes because they believe that maintaining a highly diverse botanical composition in pastures benefits plant persistence, yield stability, and pasture productivity. Most of the previous work on diversity effects on forage productivity has been in clipped experimental plots, with no actual grazing. Although clipped plots provide useful information that enables us to screen several treatments, little was known about the effects of forage mixture on animal productivity or the effect of animal grazing on botanical composition and productivity of complex pastures.





Prepared by the ARS Pasture Systems and Watershed Management Research Unit. For additional information contact Dr. Kathy Soder (814-865-3158; Kathy.Soder@ars.usda.gov; http://www.ars.usda.gov/naa/pswmru)

Productivity and Forage Mixtures

Our research has shown that planting a mixture of grasses, legumes, and chicory benefits forage production during drought years and reduces weed invasion for a few years after planting. Producers may have to re-establish the chicory and legume components relatively frequently to maintain these benefits. We found that all pastures became dominated by orchardgrass after two years of intensive grazing.

Pasture Intake and Grazing Behavior and Forage Mixtures

Pasture intake and grazing behavior (measured as grazing time, bites per minute, and grazing jaw movements) was not affected by botanical composition. This is surprising in view of previous literature describing grazing behavior. One possible explanation is that these lactating animals had a high intake drive, which may have made them less selective, particularly at the beginning of the grazing session. More research is needed (and is ongoing at our location) at the animal-plant level to better understand this complex relationship when animals make dietary choices, and how we can either work with or influence those choices through feeding management (i.e. grazing management, supplementation, pasture seeding, and whole-system management).

Milk Production and Composition and Forage Mixtures

Milk production per acre was similar for the more complex forage mixtures and was 86% higher for these mixtures than for the simple orchardgrass-white clover mixture during a drought year, and 34% higher during a wetter year. These differences in milk production per acre were due to differences in stocking densities rather than from daily milk production per cow, which was similar for all forage mixtures.

Forage mixture did not affect pasture dry matter intake (**DMI**). Milk conjugated linoleic acid (**CLA**) content was 188% higher than pre-trial levels (when cows were fed a total mixed ration in confinement). Cows grazing forage mixtures with chicory (3-, 6- and 9- species treatments below) had 17% higher CLA content than cows grazing a simple 2-species orchardgrass-white clover mixture.

Pasture and Animal Productivity with Four Forage Mixtures

	FORAGE MIXTURE			
	2 Species	**3 Species**	**6 Species**	**9 Species**
Pasture DMI, lb/cow/day[1]	32	30	30	28
Milk Yield, lb/cow/day[1]	77	78	77	77
Milk fat, %[1]	3.5	3.4	3.5	3.3
Milk CLA,g/100g of fatty acids [1]	0.87	1.02	0.99	1.04
Forage DM yield, lb/acre				
Year 1 (drought)	4,300	6,650	7,050	6,650
Year 2 (normal precipitation)	8,050	8,860	10,090	8,040
Pounds milk/acre				
Year 1 (drought)	3,469	6,228	6,684	6,775
Year 2 (normal precipitation)	5,961	7,920	8,769	7,376

[1]Data averaged across 2 years

The Bottom Line

Managing for a moderately complex (3 to 5 forage species) mixture of forages on pasture may result in greater carrying capacity of the pastures due to increased forage productivity and reduced weed competition, while maintaining animal productivity. Cows were able to select a high quality diet on any of the forage mixtures. Therefore, maintaining a vegetative dense pasture is key, regardless of species composition, to providing high-producing dairy cows with enough high-quality forage to maintain high levels of milk production and maintain or improve pasture productivity.

The Future

We do not yet have a good handle on diet selection by dairy cows grazing different forage mixtures. A better understanding of the interaction between grazed plant and grazing animal is needed to predict preference, intake, and productivity of grazing cows. Current research at our location focuses on structural and physical attributes of various forage species that affect grazing behavior such as bite mass (how much dry matter a cow consumes with each bite), grazing jaw movements, and bite rate (how fast they take bites). We will continue this research by using a combination of highly controlled small experimental boxes (pictured at right) and pasture-scale research to evaluate grazing patterns as well as productivity.

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FORAGE AND GRAZING LANDS BIODIVERSITY RESEARCH

Incorporating a Total Mixed Ration into Pasture-Based Dairy Systems: The Best of Both Worlds?

The Forage and Grazing Lands Biodiversity Project is one of three major projects in the Pasture Systems and Watershed Management Research Unit at University Park, Pennsylvania. The mission of this unit is to conduct research leading to the development of land, water, plant, and animal management systems, which ensure the profitability and sustainability of northeastern farms while maintaining water quality.

Background

Feeding dairy cows on pasture challenges nutritionists and producers due to changing pasture quality and availability which make dry matter intake (**DMI**) difficult to monitor and control. Milk yield per cow and milk fat and protein percentages in pasture-based systems are frequently lower than in confinement. Some producers are using a 'hybrid' approach- many dairy producers have the knowledge and equipment for total mixed ration (**TMR**) feeding systems and have incorporated a "partial" TMR (**pTMR**- partial since the pasture is not physically part of the mixed ration) into their summer grazing management.

Why Feed a pTMR with Pasture?

Increasing numbers of dairy producers in the northeastern and midwestern US are using or have expressed interest in using a pTMR with their grazing dairy cows to maintain or improve milk production and composition, particularly as herd size increases with the land base remaining constant. Few recommendations exist regarding the use of a pTMR. Therefore, we rely on basic ration balancing methods and practical experience for developing feeding recommendations.

Prepared by the ARS Pasture Systems and Watershed Management Research Unit. For additional information contact Dr. Kathy Soder (814-865-3158; Kathy.Soder@ars.usda.gov; http://www.ars.usda.gov/naa/pswmru)

A pTMR incorporated into a pasture-based diet provides the advantages of:

- A more **uniform ration** throughout the grazing season
- Improved monitoring of **DMI**
- **Less chance of rumen digestive problems** due to slug feeding of grain
- Potentially **higher milk yield** and components
- **Environmental benefits** due to better utilization of nutrients.

Formulating a pTMR

Balancing a ration for cows on pasture is the same as formulating a ration for confined cows. Pasture is simply an ingredient that is not mixed in the mixer wagon- rather, it is mixed in the rumen with the other pTMR ingredients. Since pasture quality can vary widely, ***Forage Testing*** of pasture as well as the pTMR is crucial in balancing the diet. While this may seem an obvious statement, in a case study conducted at our location that monitored pTMR use on 13 farms in PA and NY, we found that some producers and nutritionists are not fully aware of the nutritional quality of pasture. In our study, the most common change in the pTMR was to replace pasture for grass silage on a 1:1 DM basis since grass silage most closely matches pasture in terms of nutrient content of any pTMR ingredient.

The second most common change was to reduce the protein level in the pTMR, usually through reducing or eliminating soybean meal to compensate for the typically high degradable protein levels in well-managed pastures. Other changes may include the addition of other fiber (forage or non-forage) sources to compensate for low pasture fiber, particularly during the spring season. Other farms, however, were found to be overfeeding protein, particularly rumen degradable protein. Not only does this waste money, it causes greater nitrogen losses in urine.

Is Feeding Pasture Plus TMR Economical?

Research at our location, using a whole-farm simulation model, showed that utilizing a pasture plus pTMR was comparable economically to feeding a TMR in confinement, and both TMR systems increased net return per cow by an average of $260 annually when compared to pasture plus concentrate. In addition, the pasture plus pTMR provided environmental advantages in terms of lower phosphorus and potassium accumulation when compared to the confinement system.

How Much pTMR Should I Feed?

The amount of pTMR fed will depend on the cows' requirements, pasture quality and quantity, and land availability. While there are no set guidelines for minimum amount of forage to include in a pTMR, a minimum of 6-7 lb. of forage dry matter per cow is recommended to serve as:

- A source of **effective fiber** (to promote cud chewing)
- A **rumen buffer**
- A **carrier** for other components in the pTMR

As pasture quantity decreases, the amount of forage in the pTMR can be increased to meet this deficiency.

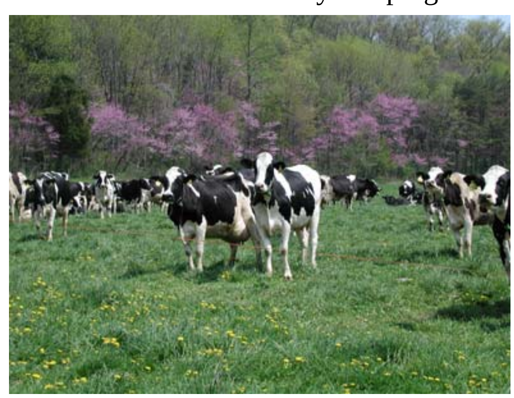
When to Feed a pTMR?

Timing of pTMR feeding in relation to milking and grazing may affect intake of both TMR and pasture. Feeding a pTMR before cows graze will encourage greater pTMR consumption but it may lower pasture intake. A pTMR may also provide better synchronization of nutrients in the rumen; energy and effective fiber in the pTMR (energy) and protein in the pasture. Alternatively, offering pTMR after an initial period of grazing may decrease pTMR intake and maximize pasture utilization.

Guidelines for Feeding a pTMR

While pTMR can be used to complement pasture and provide a balanced ration, pasture variables such as pasture DMI, quality and quantity, and selective grazing behavior still challenge nutritionists and producers. These management practices below can help to effectively incorporate a pTMR in a pasture-based system.

1. **Provide adequate feed bunk space**- Cows have a limited time to consume pTMR before returning to pasture. It is important to provide sufficient bunk space (25 to 30 inches/cow) so all cows have sufficient opportunity to consume the pTMR. This ensures that aggressive cows do not dominate the feed bunk by keeping more submissive cows from consuming their share of the pTMR.
2. **Including Corn Silage**- Corn silage in a pTMR can be an excellent supplemental forage as it adds rumen fermentable carbohydrates as a source of energy for the rumen microbes (to re-capture the abundant pasture protein) and also 'dilutes' the high protein in pasture. Corn silage also adds effective fiber that can complement high-quality pastures. Corn silage is a highly palatable feed, an excellent carrier for supplemental grains, and may allow for a reduction of concentrate fed.



3. **Flexibility**- Many farms in the case study were flexible in pTMR formulation, reacting quickly to perceived changes in pasture quality or quantity. Flexibility is key in utilizing a pTMR on pasture-based operations- flexibility in ingredients used in a pTMR to keep costs low, to meet nutrient demands, to maintain satisfactory milk production and milk components, and flexibility on the part of producers and nutritionists in reacting to changes in environment, pasture quality and quantity, feed prices, and animals.

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Integrated Farming Systems Research

Developing Profitable and Environmentally Sound Farming Systems for Animal Production

The Integrated Farming Systems Project is one of three major projects in the Pasture Systems and Watershed Management Research Unit at University Park, Pennsylvania. The mission of this unit is to conduct research leading to the development of land, water, plant, and animal management systems, which ensure the profitability and sustainability of northeastern grazing and cropping enterprises while maintaining the quality of ground and surface waters.

More Sustainable Farms are Needed. Dairy and beef farms are major contributors to the economy of the northeast region. Increasing production costs, static or declining product prices, and environmental issues though, are jeopardizing the long-term sustainability of these farms. More efficient, economical, and environmentally sound production practices are needed.

Integrated crop, pasture, and livestock farms form complex physical and biological systems. Only by studying the farm as a whole can improved practices be developed that maintain a reliable food supply, a strong agricultural economy, and a safer environment.

Our goal is to develop and apply software tools for comprehensive evaluation of the impacts and interactions of farm management on air and water quality while maintaining or improving farm profitability. Specific objectives are to:

- Quantify management effects on gaseous emissions from animal, feed, and manure sources on dairy farms.
- Quantify carbon sequestration potential of temperate grasslands.
- Validate and use farm and watershed scale models to assess the effects of conservation practices on farm management and our soil and water resources.

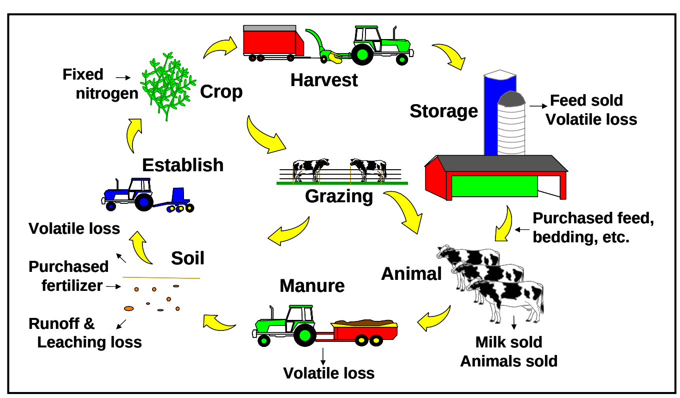
Prepared by the ARS Pasture Systems and Watershed Management Research Unit. For additional information contact Dr. Alan Rotz (814-865-2049; Al.Rotz@ars.usda.gov; http://ars.usda.gov/naa/pswmru).

Gaseous Emissions. We are developing process-based relationships that predict the formation, disassociation, and loss of gaseous compounds from animal, feed and manure sources on farms. These are being integrated into a model and software tool for estimating emissions from dairy farms as influenced by animal and manure management.

Carbon Sequestration. Carbon sequestration by forage crops is being determined by measuring the net carbon balance in grazed pastures, harvested grassland, and switchgrass fields managed for bioenergy production. We are developing a remote sensing tool that estimates carbon fluxes from small, rotationally-grazed pastures.

Watershed Evaluation. We are refining and validating models that assess the effects of conservation practices on water quality in watersheds. Models are used to determine optimal choices for the selection and placement of conservation practices and to determine model uncertainty associated with watershed environmental impact assessments.

Farming Systems. We are refining and using a farm simulation model to evaluate alternative strategies for dairy and beef production. Simulation is used to establish practices that are environmentally sound while maintaining or improving farm profit.

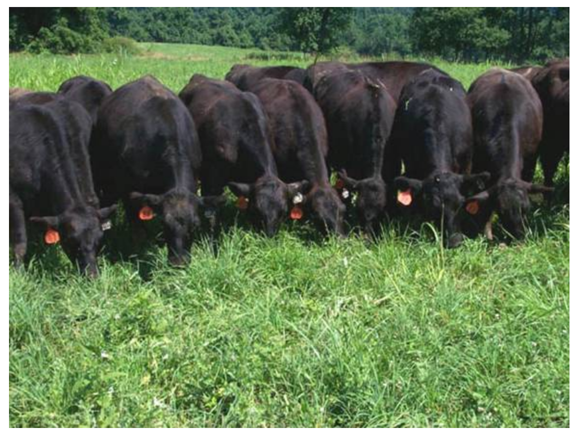


Over the past few years, we have evaluated a variety of production practices for dairy and beef farms. These studies emphasize the evaluation of management effects on farm performance, environmental impact and economics.

Organic Dairy Production. With increasing production costs and a stable or declining real price for milk, smaller dairy farms in the Northeast are having greater difficulty remaining economically viable. Organic production may provide another option for sustaining smaller farms. The organic dairy market has experienced dramatic growth in recent years with a current shortage in milk production. A major deterrent to the adoption of organic production is a three year period required for transition from conventional practices. Considering the growing demand for organic milk and the possible risk in transition, an analysis was done to compare economic and environmental impacts of organic dairy farms to those of conventional dairy farms in this region. Whole-farm simulation was used based upon extensive information gathered from four actual farms in Pennsylvania. From this analysis, we conclude:

- Organic production is a viable option for improving the economic return of smaller dairy farms, but long-term sustainability of this advantage is dependent on the persistence of a substantial margin between conventional and organic milk prices.
- Organic production may create environmental concerns. Farm level accumulations of soil P and K are a concern on farms that heavily utilize poultry manure as a crop nutrient source, and runoff loss of P is a concern on organic farms using annual crop production because of the greater number of tillage operations required for weed control.

Grassland Beef Production. Beef producers must consider management strategies and technologies for reducing potential adverse environment effects of their farms while maintaining or improving profit. One choice is between using perennial grassland or corn as the primary forage source. Perennial grass based production systems are generally regarded as more favorable due to reduced nutrient losses to the environment and potential human health benefits through improvements in meat fatty acid composition. Simulation of an Angus cattle producing farm in northeastern Maryland illustrated that the conversion of the farm from a corn and permanent pasture system to all grassland with more intensive rotational grazing has provided both environmental and economic benefits.



- Simulated nitrogen loss through ammonia volatilization was increased 16%, but nitrate leaching was reduced 25%, denitrification loss was reduced 50%, and surface runoff loss of P was reduced 75%.
- This conversion increased the annual net return of the farm by $15,000 by eliminating the greater machinery, fuel, seed, fertilizer, and chemical costs incurred in corn production.

Other Recent Studies.

- Increasing the cutting height in corn silage production was found to not be an economically beneficial strategy for improving forage quality.
- Use of a free-stall barn, bottom-loaded slurry storage, and direct injection of manure into the soil reduced ammonia emissions by 35-50% and total phosphorus loss about 20% compared to other commonly used dairy housing and manure handling systems, typically with some improvement in farm profitability.
- Compared to conventional tillage with a moldboard plow, use of conservation tillage and no-till systems reduced phosphorus loss by 46% and 57%, respectively, with small increases in farm profitability.
- A conceptual perennial cow production system provided small environmental and economic benefits compared to traditional dairy farms in Pennsylvania.

Providing Assistance to Producers and their Advisors. The evaluation of alternative production systems provides information that helps direct and encourage producers, and those consulted by producers, toward management options that improve their farm's potential impact on the environment while improving profitability. For those interested in analyzing and comparing production systems, a version of the farm simulation model is available from our home page [http://ars.usda.gov/naa/pswmru]. The model, including an integrated help system and reference manual, can be downloaded and installed on any computer using a Microsoft Windows® operating system.

University Park Pennsylvania USDA-ARS Biofuel Research Program

Management and Life Cycle Assessment of Bioenergy Crop Production

Background. The focus of the program has been on the potential use of marginal croplands for biofuel production conducting research at multiple scales on the ecology and management of grasslands, developing sustainable bioenergy production systems including investigation of suitable biomass crops for the Northeastern US, and life cycle assessment of a range of bioenergy crop production systems, including net greenhouse gas emissions, energy balance, and the impact of climate change.

For additional information contact Dr. Paul R. Adler (Research Agronomist, USDA-ARS Pasture Systems and Watershed Management Research Unit, Building 3702, Curtin Road, University Park, PA 16802-3702; 814-865-8894; paul.adler@ars.usda.gov).

Marginal croplands: survey of conservation lands in the Northeastern US

We surveyed 34 sites across the northeast US (NY, PA, NJ, MD, and VA) during late August through mid-October in 2002 and 2003 that included CRP, CREP, wildlife habitat improvement program (WHIP), mine reclamation, and other conservation lands as a resource assessment for biomass production.

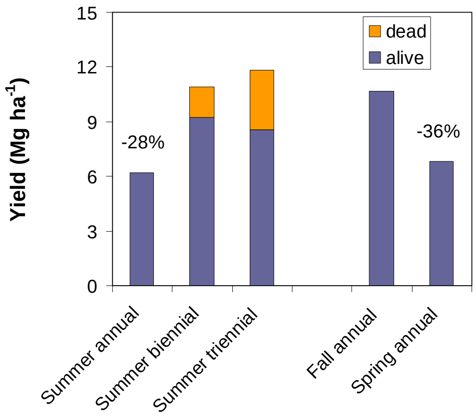
•More than 280 plant species were identified across all sites with an average species richness of 34 species per 0.1 ha (range of 12 to 60 plant species).

•Aboveground biomass at these sites averaged 6.6 Mg ha^{-1}
•The top 5 native plant species accounted for more than 65% of plant cover; top 5 exotic plants accounted for only 12%. Switchgrass, big bluestem, and indiangrass cover correlated with biomass yield best among plant species.

Adler, P.R., Sanderson, M.A., and Goslee, S.C. 2005. Management and composition of conservation lands in the Northeastern United States, p. 187-200. In Thomas G. Barnes and Linda R. Kiesel (ed.) Proceedings of the Fourth Eastern Native Grass Symposium. The University of Kentucky Department of Forestry, Lexington, KY, October 3-6, 2004.

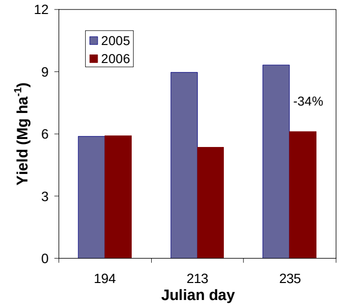
Grassland management practices: seasonal harvest time and frequency

The season when switchgrass is harvested can affect the yield and quality of its biomass (stem, leaves) to make biofuels like ethanol and feedstock for thermochemical conversion. Based on recent studies in central Pennsylvania over the last five years, for example, switchgrass yield generally decreased when harvest was delayed from fall to spring—except for winters with little snowfall. However, biofuel quality generally improved.



Biofuel yield – Based on studies underway in central Pennsylvania, long term, mid- to late-summer annual yields were similar to spring-harvest yields after the initial high yield the first year of summer harvest. Energy yields from gasification and ethanol are similar per unit biomass between seasons.

Switchgrass yield of annual summer harvest after August 1 decreased in succeeding years, stabilizing at yields similar to mid-July harvests.

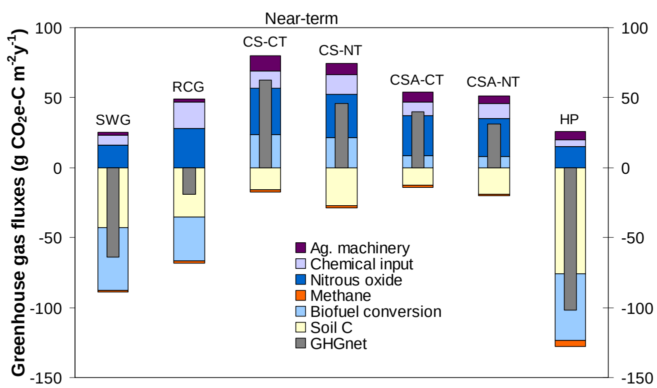


Biofuel quality – summer (> 1% N, highest in other elements, < 18% water content), fall (0.5% N, other elements lower, typically > 30% water content), spring (0.5% N, other elements lowest compared with other seasons, typically < 10% water content).

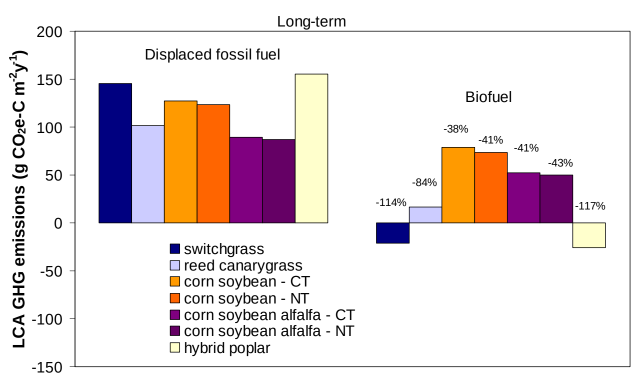
Adler, P.R., M.A. Sanderson, A.A. Boateng, P.J. Weimer, and H.G. Jung. 2006. Biomass yield and biofuel quality of switchgrass harvested in fall or spring. Agron. J. 98:1518–1525.

Life cycle assessment: greenhouse gas emissions

Sources and sinks – Displaced fossil fuel was the largest greenhouse gas sink followed by soil carbon sequestration. N_2O emissions were the largest greenhouse gas source.



Adler, P.R., S.J. Del Grosso, and W.J. Parton. 2007. Net greenhouse gas flux of bioenergy cropping systems using DAYCENT. Ecol. Appl. (In press, ESA press embargo date March 2007).



Net greenhouse gas emissions – Compared with the life cycle of gasoline and diesel (displaced fosil fuel), ethanol and biodiesel from corn rotations reduced greenhouse gas emissions in the long term by about 40%, reed canarygrass by about 85%, and by about 115% for switchgrass and hybrid poplar.

Research Scientists at the Pasture Systems and Watershed Management Research Unit

Ray B. Bryant - Research Leader/Soil Scientist
Uses soil information systems to assess resource potential for grazing lands and predict the impacts of farm management at field, farm, watershed, and regional scales. (ray.bryant@ars.usda.gov)

Paul R. Adler - Agronomist
Conducts research at multiple scales on the ecology and management of grasslands for production of biofuels, on production practices that impact their value as wildlife habitat, and life cycle analysis of energy crop rotations. (paul.adler@ars.usda.gov)

Curtis J. Dell - Soil Scientist
Conducts research on soil organic matter and nutrient cycling. Evaluates the impact of soil management and manure application on soil quality, greenhouse gas production, and soil carbon storage. (curtis.dell@ars.usda.gov)

Gary Feyereisen - Hydrologist
Conducts research on hydrology of the near-stream environment, hydrologic processes controlling nitrogen and phosphorus transport in natural systems, and hydrology/water quality interactions at the watershed scale. (gary.feyereisen@ars.usda.gov)

Sarah C. Goslee - Plant Ecologist
Studies the factors controlling plant species diversity in managed grasslands; including climate, soils, biotic interactions and landscape pattern. Develops methods to support pasture productivity and sustainability by managing plant community composition. (sarah.goslee@ars.usda.gov)

Peter J. A. Kleinman - Soil Scientist
Conducts research on nutrient cycling and water quality, focusing on interactions between agricultural management and landscape processes controlling nutrient transport. (peter.kleinman@ars.usda.gov)

C. Alan Rotz - Agricultural Engineer
Conducts research on farming systems for dairy or beef production. Uses modeling approaches to evaluate and refine strategies for improving the efficiency, profitability, and environmental sustainability of farms. (al.rotz@ars.usda.gov)

Matt A. Sanderson -Agronomist
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Research focuses on identifying critical nitrogen sources and flow pathways in the landscape, quantifying losses to the environment, and reducing losses with alternative agriculture management practices. (john.schmidt@ars.usda.gov)

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Develops and evaluates feeding management strategies to improve the economic and environmental sustainability of pasture-based animal systems through improved nutrient utilization, animal productivity, and animal health. (kathy.soder@ars.usda.gov)

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Researches land management effects on nutrient and sediment fate and transport through explanatory and predictive models. Evaluates the impact of land management selection and placement on field, farm, and watershed scale losses. (tamie.veith@ars.usda.gov)

Please visit our website (http://www.ars.usda.gov/naa/pswrmu) for more information about the research unit. Or, call 814-863-0939, fax at 814-863-0935.

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