2003-2005 On-Farm Research Results

USDA-SARE Producer Grant FNC-451-03 (Bert Paris) "Renovating Pastures with Outwintering and Fallowing," and Wisconsin USDA-NRCS-GLCI 2003 Applied On-Farm Research Grant (Carl Fredericks) "Soil and Root Variables in Outwintered and Fallowed Paddocks"

Compiled by Carl Fredericks, Grass Mapping Enterprises LLC, 10246 Gilbertson Road, Mt. Horeb, WI 53572 (608) 437-4395 rehlfred@mhtc.net, and Dr. Walter Goldstein, Research Director, Michael Fields Agricultural Institute, PO Box 990, East Troy, WI 53120 (262) 642-3303 wgoldstein@michaelfieldsaginst.org

Farms

Bert & Trish Paris, Belleville, Green County, Wisconsin
Bill & Roz Gausman, McFarland, Dane County, Wisconsin
Dan & Ruth Vosberg, South Wayne, Lafayette County, Wisconsin

Key Findings:

1) Most roots were concentrated in the top three inches of the eight inch topsoil profile regardless of farm or rest/grazing management.

2) Based on visual assessment, outwintered and rested paddocks had healthier roots than grazed control paddocks.

3) Paddocks with low root mass in 2004 on two farms responded more to outwintering and rest (higher root mass and forage yield in 2005) compared to paddocks having higher root mass on one farm.

4) Drought conditions in 2005 appear to have increased root growth in the lower layer of topsoil in the check (grazed) paddock on all three farms compared with 2004 data.

5) Outwintering and rest increased weed root growth, especially quackgrass in the paddock with the weakest cultivated grass stand (bromegrass and orchardgrass).

Project Overview

The Driftless region of Southwest Wisconsin has been cropped since the mid 1800s with a gradual decline in soil depth, organic matter, tilth, and water holding capacity. Permanent grass is desirable on these sloping and often shallow soils to minimize erosion and restore fertility. A growing number of dairy farmers in this region use managed grazing to increase their profitability and to enhance their quality of life.

Even managed grazing has the potential to deplete plant reserves and cause shallow-rooted, drought prone swards if stocking rates, or time spent on pastures during critical stages of plant growth, are excessive. In fact, rapid changes in species composition of swards in the Driftless area, associated with the winter of 2004-2005 and the 2005 drought, showed that pasture swards are dynamic and can shift or degrade quickly depending on stress and management. The symptoms of stress may include mats of roots at the soil surface and decreases in deep roots, stand death, a shift of pasture composition away from more productive species to quack grass and Kentucky bluegrass, drops in productivity under drought conditions, increases in growth response to N fertilizer, increased soil compaction and degraded soil structure, reduced nutrient release, delayed decomposition of manure, and reductions in the accumulation of organic matter in the soil. Botanical changes are significant: Though quackgrass is palatable, it is rhizomatous, does not form the mass of fine roots associated with sod formation and organic matter accumulation under grass, and has low mid-summer productivity. Bluegrass is a challenge on drier soils due to low productivity.

Symptoms of pasture degradation are commonly countered by overseeding grass and legumes or by applying mineral N fertilizer. Purchased nitrogen is an increasingly expensive input that is also not available to the growing number of organic grass dairy farms. Another option is to graze taller, more mature grasses in order to allow the swards to make more roots. Dairy farmers are often reluctant to manage this way because they need to harvest young plant tissues with optimal digestibility if they are to maintain milk production.

One promising method of pasture improvement using on-farm resources is a system of outwintering cattle followed by an extended rest period (a “fallow”) the following summer to regenerate beneficial plants and their roots. This method evolved on grass farms in southeast Minnesota, and our study involved three southern Wisconsin dairy graziers who learned about the practice from the Minnesota farmers.

Outwintering and Extended Rest

Paddocks are selected for improvement based on poor sward condition (weak grass stands and low yield), and suitability for outwintering (easy access by cattle, protected from extreme wind and snow drifting, location to other winter shelter). On the grazing farms in our study, outwintering means keeping stock (usually dry cows and heifers) outside in winter (December - March) instead of housing them in a barn. Hay is often placed in a paddock in the fall and rationed out with portable fence during the winter months, but on some farms is sometimes hauled regularly into the paddock if terrain and conditions permit. There are large labor savings (irregular or no daily feeding and bedding/manure handling chores), large reductions in equipment use, and animal health advantages (better ventilation, fewer leg & feet problems), but excellent management is needed to avoid frostbite and loss of condition during extreme cold and wind. Soil compaction, erosion and runoff from lanes and gateways can also be issues during thaws.

Cows are fed in paddocks during the day and have access to loose housing at night. If there is a thaw, animals are removed until the soil is frozen again. Stock are often on these paddocks until green-up if the soil is firm.

After green-up, the grass grows ungrazed until mid-July, when it is cut. Some farms leave the grass on the ground decomposing, others bale it for bedding or dry cow feed. The paddock is then rested until early September when it is grazed again, rested, and usually grazed again in November after killing frost. Paddocks are added to the regular grazing rotation the following year, and new outwintered paddocks are selected each winter to distribute nutrients around the farm.

Farmers using outwintering and extended rest feel that the combination of manure and waste feed, over three months of root growth, and (on some farms) decomposing plant remains adds mulch to the soil surface and increases root biomass, building soil organic matter and fertility.

Methods

The project objective was to study the impact of outwintering and extended rest (fallowing) on root health and productivity and pasture yields.

In order to monitor these changes, data was collected between 2003 and 2005 in two paddocks on each farm. Paddocks were selected by the farmers to be outwintered in 2003-2004 based on their need for improvement. Adjacent "check" paddocks part of the regular grazing rotation were chosen for comparison based on similar soil and slope conditions to those found in the outwintered paddocks.

Routine soil tests (P&K in ppm, pH, %OM analyzed at the University of Wisconsin Soil & Plant Analysis Lab) and sward composition were measured in all paddocks in October and November in all three years. Composition was measured by visually estimating percent composition in a 1.5 ft2 quadrat repeated 10 times per paddock. Outwintering practices were recorded in the winter of 2003-2004 (cow numbers, feeding, time spent on paddocks) and documented with photographs.

In 2004, available dry matter was measured in the check paddock before each grazing by clipping and weighing five 1.5 ft2 quadrats per paddock. Hay yield was estimated in the rested paddock by weighing forage in the windrows after it was mowed in July. Available dry matter was also measured before grazing in late summer and fall.

In 2005, available dry matter was measured in both paddocks before each grazing. Hay yields from a June cutting in the Vosberg paddocks were computed using estimated bale weight and dry matter.

Root samples were dug in June 2004 and early July 2005 and analyzed at Michael Fields Agricultural Institute to measure length and visually assess root health (see Appendix 1 for discussion of sampling and analysis methods).

Discussion of Results: Forage Production

Three methods of feeding were used on the outwintered paddocks. The Paris farm distributed round hay bales throughout the paddock, fenced off rows of bales with polywire, and fed a few at a time with ring feeders. The Gausman farm used feeder wagons of baleage and corn silage hauled daily into different parts of the paddock. The Vosberg farm used a bale unwrapper to feed strips of baleage each day in the paddock.

The Paris feeding method (round bales in ring feeders) resulted in the most animal impact in terms of pugging around feeding rings and the amount of residue (waste hay, manure) left on the ground (visual documentation). Although the soil phosphorous level in this outwintered paddock increased compared to the other two farms, the paddock size was smaller (3.1 acres compared with 6.1 and 7.1 acres

2003-2005 Soil Test Results showed steady or increasing soil organic matter and pH levels in all paddocks on all farms:

Paris (Meridian loam, 2-6% slopes, eroded, with areas of Fox loam, 6-12% slopes, eroded).

Outwinter					Check				
Year	pH	OM	P	K	Year	pH	OM	P	K
2003	6.1	2.9	69	151	2003	6.3	3.0	71	125
2004	6.7	3.1	95	279	2004	6.4	3.3	68	153
2005	6.7	3.0	144	234	2005	6.3	3.5	75	175

Gausman (Ringwood silt loam, 2-6% slopes; Plano silt loam, 2-6% slopes; small area of McHenry silt loam, 6-12% slopes, eroded).

Outwinter					Check				
Year	pH	OM	P	K	Year	pH	OM	P	K
2003	6.1	4.2	20	58	2003	6.0	3.8	16	87
2004	6.8	4.2	16	74	2004	6.4	4.1	12	56
2005	6.2	4.5	28	72	2005	6.0	4.6	23	103

Vosberg (Palsgrove silt loam, 6-12% slopes)

Outwinter					Check				
Year	pH	OM	P	K	Year	pH	OM	P	K
2003	6.8	3.6	27	85	2003	6.6	3.5	31	96
2004	6.8	3.8	26	107	2004	7.0	3.5	23	82
2005	6.8	3.5	35	94	2005	7.1	3.7	25	85

The Paris method of clipping the rested paddock growth in July and mulching it instead of baling and removing the grass resulted in measurable amounts of thatch on the ground late in the year compared to the other two farms. This probably lowered soil temperature and held soil moisture, but it also shaded grass and clover seedlings and may have reduced tillering. Decaying plant material may have also released phosphorus, which may have contributed to the increase in soil P levels in fall 2005.

Available dry matter yields on the check paddocks were similar on all three farms during the 2004 growing season. Paris and Gausman 2005 check yields were lower than 2004 yields, while Vosberg's were nearly identical to the previous year. Drought conditions in 2005 (rainfall about 8 inches below the 30-yr South Central Wisconsin April-October average) make direct comparisons with the 2004 data difficult.

MONTHLY HISTORICAL STATE CLIMATE SUMMARIES

Wisconsin State Climatology Office

South Central Wisconsin Divisional Average Precipitation (inches)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
2004	0.61	1.21	3.78	2.11	9.83	5.37	3.84	3.37	0.67	2.78	2.03	1.34	36.9
2005	3.19	1.57	1.18	1.45	3.18	2.55	4.16	2.54	3.22	0.69	3.85	0.95	28.5

30-yr normals (1971-2000)

AVE	**1.28**	**1.25**	**2.20**	**3.47**	**3.40**	**4.19**	**4.07**	**4.24**	**3.51**	**2.48**	**2.41**	**1.61**	**34.12**

In 2005, the Paris and Gausman outwintered and rested paddocks had much higher yields than the check paddocks. However, growth in late May and early June in these paddocks was tall and utilization was low, and the Paris yield is likely overstated due to weed growth (lambsquarters) in many of the round bale feeding areas. The Vosberg outwintered and rested paddock showed only a slightly higher yield increase compared to the check paddock in 2005:

2005 Outwinter/Rest Yields compared to 2004 and 2005 Check Yields

Farm	2005	2005	2004
	Outwinter/Rest	Check	Check
Paris	13,655 lb/acre	6855 lb/acre	9492 lb/acre
Gausman	11,259 lb/acre	6234 lb/acre	9309 lb/acre
Vosberg	9951 lb/acre	9614 lb/acre	9664 lb/acre

Both check and outwintered/rested paddocks had similar sward composition. Paris swards were dominated by orchardgrass and bromegrass with small amounts of clover. Gausman paddocks were a mixture of quackgrass and orchardgrass with lesser amounts of bluegrass, bromegrass and clover. Vosberg paddocks were dominated by bromegrass, although the check paddock showed a substantial (24 percent) amount of red clover in the fall of 2004 that had diminished a year later.

Sward Composition: Outwintered Paddocks (Measured October-November)

Farm	Year	%Grass	%Legume	%Weed	%Bare Ground	%Thatch
Paris	2003	87.1	1.9	5.2	6.3	0
	2004	69.5	1.5	12.5	9	7.5
	2005	90	1.5	2.5	0	6.0
Gausman	2003	71	8.8	4.2	16	0
	2004	73	12	2	13	0
	2005	79	13	4.5	3.5	0
Vosberg	2003	90	5	5	0	0
	2004	86	8	3.5	2.5	0
	2005	91	3.2	4.3	1.5	0

Sward Composition: Check Paddocks (Measured October-November)

Farm	Year	%Grass	%Legume	%Weed	%Bare Ground	%Thatch
Paris	2003	91.5	.5	5.2	3.5	0
	2004	88.5	4.7	0	6.3	0
	2005	82.0	5	4	9	0
Gausman	2003	80.5	7.5	6	6	0
	2004	87	6	0	7	0
	2005	92.5	2.7	1.8	3	0
Vosberg	2003	95	1	4	0	0
	2004	56.5	24.5	5.5	12.5	0
	2005	91.5	2	6.0	0.5	0

Discussion of Results: Root Production

In 2005 the cultivated grasses (bromegrass and orchardgrass) in both rested and grazed paddocks had more total root length, more healthy root length, and a higher percent of healthy roots than they had had in 2004 (see Table 1). Though there was more root dry weight in 2005 than in 2004, it was only significantly different for the 3-8 inch depth.

Table 1. Results obtained in 2004 and 2005 for root growth of brome/orchard grass roots.

	2004	2005	significance level	average
Length cm/cm3 (3-8 inches)	0.67	2.44	***	1.55
length cm/cm3 (0-3 inches)	1.01	6.18	***	3.59
length cm/cm3 (0-8 inches)	0.80	3.84	***	2.32
healthy length (cm/cm3 3-8 inches)	0.27	1.47	****	0.87
healthy length (cm/cm3 0-3 inches)	0.14	2.59	****	1.37
healthy length (cm/cm3 0-8 inches)	0.22	1.89	****	1.06
% healthy length (3-8 inches)	42	61	****	52
% healthy length (0-3 inches)	15	45	****	30
% healthy length (0-8 inches)	28	52	****	40
Dry weight (lbs/acre 3-8 inches)	183	605	*	394
Dry weight (lbs/acre 0-3 inches)	3323	4044	ns	3683
Dry weight (lbs/acre 0-8 inches)	3507	4649	ns	4078

In both years there was greater root length density and root dry matter accumulation in the top rather than the bottom soil profile (3.59 and 1.55 cm/cm3 and 3683 and 394 lb of dry matter/ac, respectively). The predominant weed was quackgrass in both years.

In 2004 the cultivated grasses in the Paris paddocks had the most total root length and healthy root length. The grass from the Gausman paddocks had the least, and the Vosberg grass was intermediate. However, the Vosberg grass had the highest % of healthy roots, and much more dry matter than in the Paris or Gausman roots (6,137, 2,927, 1,456 lb/ac, respectively). The amount of root growth by weeds was in the opposite order (939, 1,513, and 2,201 lb/ac for Vosberg, Paris, and Gausman paddocks, respectively).

In 2005 there was no difference in dry matter accumulation of cultivated grass roots for the three farms, but the Gausman paddocks had the greatest amount of weed roots (3,103, 871, and 717 lb/ac for Gausman, Paris, and Vosberg paddocks, respectively; see Charts 1 and 2). The highest total root length density for cultivated grasses was found in the Gausman paddocks, while Vosberg and Paris had similar but lower length densities. However, the density of healthy roots was considerably higher for Paris and Vosberg grass than for Gausman. Only 24% of the grass roots at Gausman were assessed as being healthy, but Paris and Vosberg grass roots were 77% and 56% healthy.

Chart 1: Effects of grazing and rest treatments on grass and weed root production in 2004

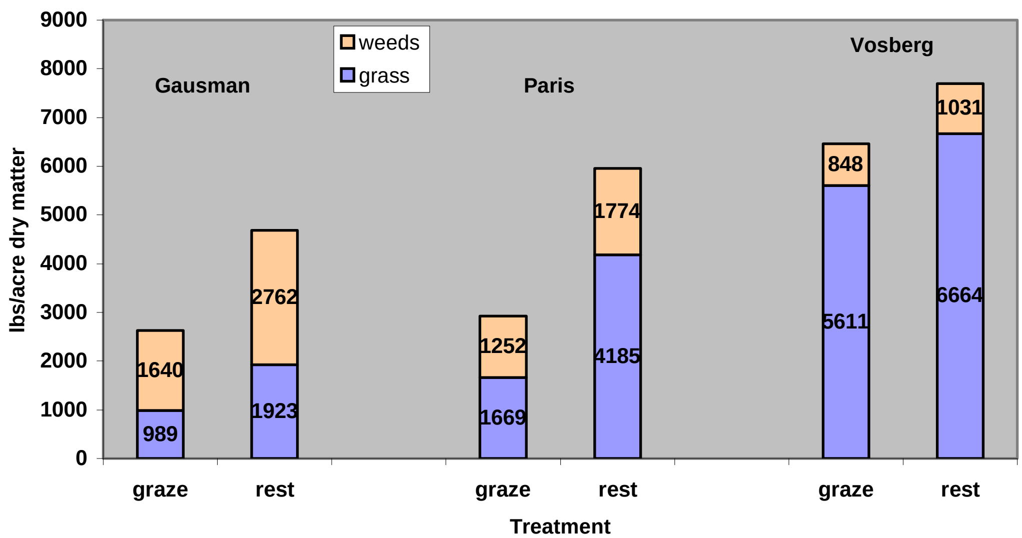
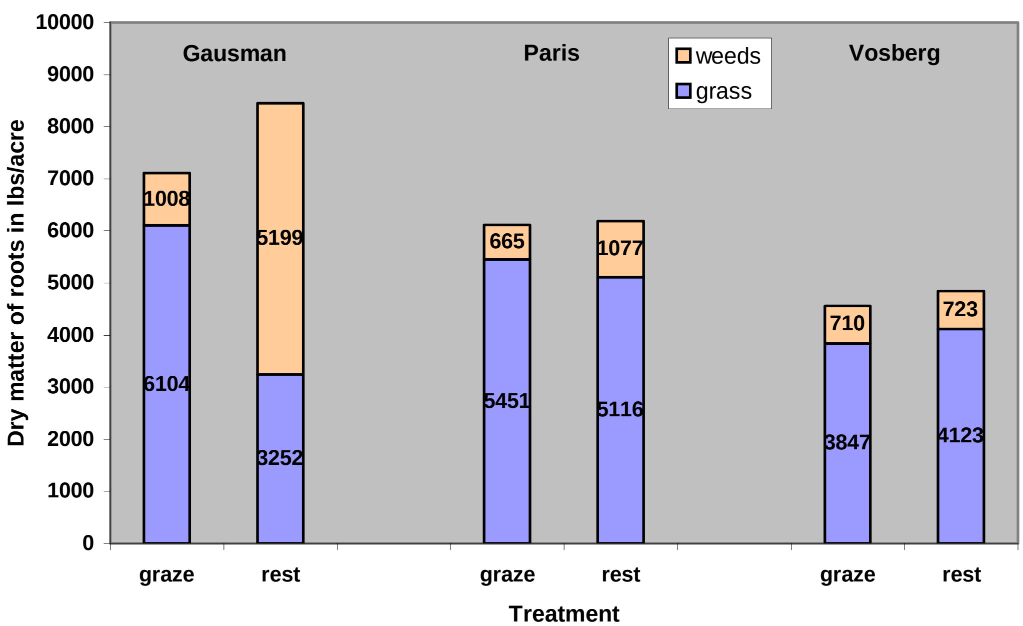


Chart 2: Dry matter production of roots of cultivated grasses and weeds in 2005



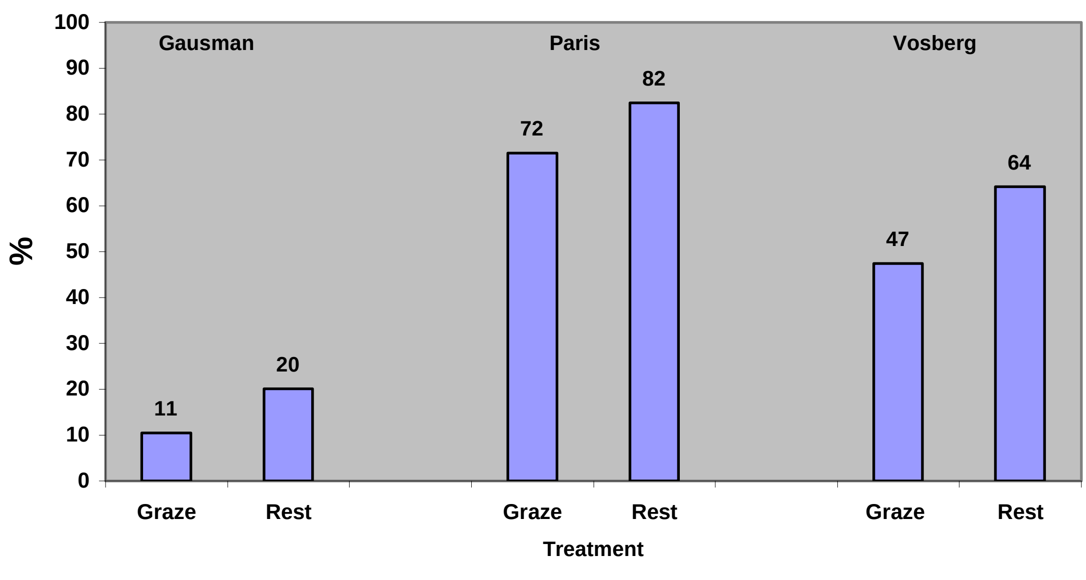
The effect that a resting regime had on root length density was variable according to farm and to farm and year. The rested pastures had about 54% more grass root dry matter than the grazed paddocks (4,258 and 2,756 lb/ac, respectively) in 2004. This increase was due to more grass root dry matter in the top 3 inches of the soil. The differences in root growth between rested and grazed paddocks were especially striking for the Paris and

Gausman paddocks (195 and 251% increases in root dry weight, respectively) where dry matter production of roots in the grazed paddock was low (1,669 and 988 lb/ac, respectively). The difference in root growth between rested and grazed paddocks was less striking for the Vosberg farm (119%) where dry matter production of the grazed paddock was high (5,611 lb/ac). Resting also increased root weight of weeds by 49% over the grazed treatment, but differences were least on the Vosberg paddock (21%) and greatest on the Gausman paddock (68%).

In 2004 resting did not have a significant effect on the root length density of either the upper layer of the soil or the total soil profile. However, resting did reduce both root length density in the lower layer of the soil by 22%, and healthy root length density by 22%. Also, there was a higher percentage of healthy roots in the grazed than in the rested paddocks (32% and 25% respectively).

In 2005 there was no significant difference in root weight between the grazed and rested paddocks. There were large increases in root weight in 2005 for the grazed paddocks at the Paris and Gausman farms. Furthermore, resting caused a large increase in weed root growth on both farms, but especially on the Gausman farm (1,008 and 5,199 lb/ac for the grazed and rested treatment, respectively). Resting was also associated with about 1/3rd less total root length density for the cultivated grasses. However, 61% of the rested grass roots were healthy while only 43% were healthy for the grazed treatments (Chart 3).

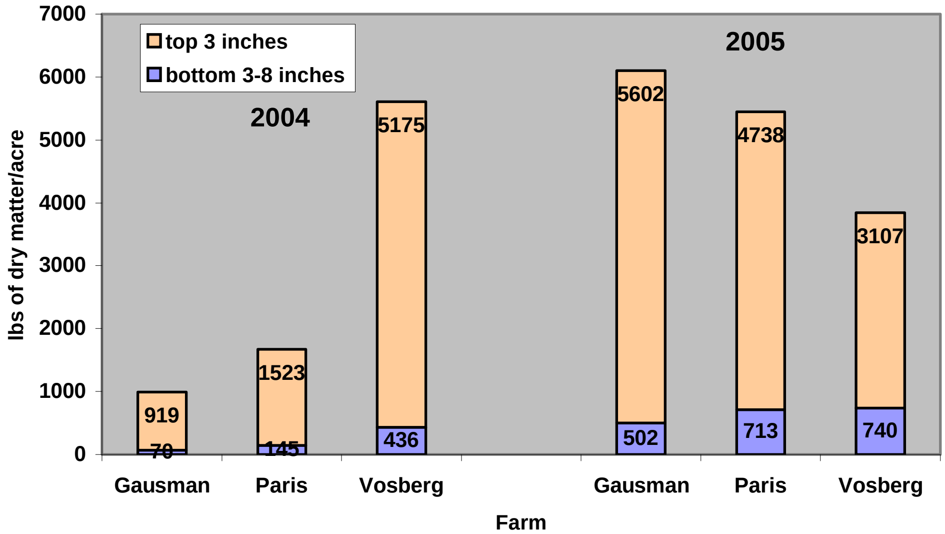
Chart 3: Effect of farm and treatment on % healthy roots in topsoil, 2005



Root Analysis Summary

The pasture systems are remarkable in that there was on average about 9 times more dry matter in the top 3 inches than in the bottom 3-8 inches of the soil. This suggests fragile systems, possibly either overgrazed or oxygen limited, that may be susceptible to drought stress when deep rooting becomes an issue in a drought year. The dry conditions of 2005 may have caused the grasses to allocate more of their resources into growing roots than in 2004. The increase of root dry weight in the deeper layers of the soil in 2005 again suggests that the plants were responding to drought by rooting deeper (Chart 4).

Chart 4: Dry matter production of roots in top and bottom layers of the topsoil 2004 and 2005 under grazing management.



Root length density appeared to be largely decoupled from root weight. There was no significant correlation between the root length density and root dry matter accumulation of the cultivated grasses. Roots in the lower level of the soil had a higher length to weight ratio than roots in the upper layers of the soil. Differences in the root length density of the cultivated grasses between the two depths of the soil were far less than the differences for dry matter accumulation.

Resting was associated with substantial increases in root dry matter of cultivated grasses during the year of rest (2004) in the top layers of the soil and with healthier roots during the first year of production after the rest (2005). However, resting was also associated with less root length density in 2005. Resting increased rooting of cultivated plants, increased their health and may have increased their efficiency. On the other hand, resting was also associated with greater root growth of weeds on the Gausman farm on both years.

There were major differences between farms for paddock health and an apparent link between the responses to outwintering in forage production and the initial root reserve and health condition on the three farms. Overall the Vosberg grass had the most roots and the healthiest roots in 2004, responded the least to resting by enhanced root production, competed the best against weed root growth, and responded the least to resting in 2005 by enhanced forage production. It could be questioned whether it was necessary to rest the Vosberg pasture.

In contrast, on the Paris and Gausman paddocks root reserves were relatively depleted and less healthy in 2004. The Gausman paddock especially had the least root weight and the most diseased roots in 2004. On those two farms, resting strongly increased grass root dry matter in 2004, weed root dry matter in both 2004 and 2005, and forage dry matter in 2005. It is likely that a substantial portion of this increase in top production was due to the growth of quackgrass, (especially on the Gausman rested paddock) as there were substantial increases in weedy grass roots in the rested paddocks on those farms both in 2004 and 2005. The reduced health of the roots of the cultivated grasses on that farm on both years probably enhanced the spreading of the quackgrass. This may not have been negative, as the quackgrass may have contributed to the large increase in above ground yield in 2005 that was associated with resting.

(See spreadsheet attachment for more detailed graphics and statistical analysis).

Questions and future research topics

This project is an example of what Baars et al (2004) describe as "experiential science" to develop "practical systems that work." We have been able to document changes in root length and health that are correlated with forage yields and management on three farms. However, several questions and future research needs emerge from our findings:

1) An economic analysis was not done as part of this project. What are the savings in reduced labor, equipment, bedding, and manure handling costs with outwintering compared with confinement facilities? Are there positive or negative impacts on animal health that affect profitability? What is the economic value of increased root growth?

2) Is it practical and beneficial to encourage root growth beyond three inches? Is this a matter of grass varieties and grazing management, or are factors like annual soil moisture and soil type and structure more important. Can alternating the timing of haying and grazing as proposed by Larin (1962) encourage deeper roots under the hay management?

3) North Dakota studies (Volk et al, 2003) suggest strong correlations between intensity of grazing management, grass root depth, and pasture condition. If root health determines stand dynamics, what management factors (manuring, fertilizing, grazing rhythms) affect root health under our higher rainfall conditions?

4) Which has more impact: manure (from outwintering or spreading) or rest? Manure increases yields, but can cause rank growth which lowers grass intake. Resting increases palatability by allowing manure to decompose. High soil P may be an issue on some paddocks on some farms. Shorter outwinter periods, larger paddock size, and increased feeding away from the outwintered paddock can be used to reduce manure amounts on the paddock.

5) Mulch management has a large impact on several variables including sward composition, grass tillering, legume content, soil moisture, and amount of decaying material on the soil surface. If legumes can be seeded in bare spots after outwintering, can they compete with tall grasses in rested paddocks? Will a shorter resting period (through June instead of August) encourage more legume growth?

6) What are the long-term phosphorus trends in outwintered paddocks? Do the long-term benefits of less runoff from more roots and stronger grass swards outweigh possible short-term soil phosphorus increases? Is phosphorus leaching from decaying plant material an issue?

Our results were influenced by the dry conditions of 2005. Long-term research on several farms will reduce year-to year variability, allowing more accurate forage yield and root growth data to be collected.

References

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Larin, I.V. 1962. Pasture Rotation. Published For the National Science Foundation and The (U.S.) Department of Agriculture by the Isreal Program for Scientific Translations, Jerusalem.

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Appendix 1. Root Analysis: Materials and Methods

Sod samples were taken on three farms in Dane, Green and Lafayette Counties (Gausmann, Paris, and Vosberg) on June 15th, 2004. Side by side pastures were sampled that either had been rotationally grazed before the sampling date or had cattle outwintered on them the previous winter and had not been grazed. Three soil sampling stations were established in each field along a transect of each field, and three subsamples were taken within 100 feet of the radius of each station in areas that were predominantly bromegrass. Hence 9 samples were taken from each treatment on a given farm. We removed soil monoliths by digging around the sides of a soil block and removing soil carefully from below. Monoliths were approximately 7 inches long, 7 inches wide, and 8 inches deep. They were removed with a 7 inch flat garden spades marked so as to guide sampling to a depth of 8 inches. Soil was placed on and wrapped in large piece of hardware cloth (2 x 3 feet with perforations of ½ inch), then placed into heavy plastic sacks for containment and transport.

For separating soil from roots, the hardware cloth covered monolith was first placed into a tipped up wheelbarrow. Monoliths were washed with water from a garden hose with a spray nozzle. As the wheelbarrow filled with water the water drained out of the front of the wheelbarrow unto a ½ mm screen placed in front of the wheelbarrow. In this way we were able to capture any roots that escaped the general mass of roots and add them back. While washing the roots we strived to keep them as intact as possible while removing most soil particles. Material was patted with towels to remove excess moisture. Tops were removed from roots. Fresh weight of roots were recorded. Roots that appeared to not be bromegrass (mostly quackgrass, Agropyron repens) were removed and dry matter of these other roots was determined. Remaining bromegrass roots were frozen in plastic bags at 0 F until analysis.

After having been frozen for several months the intact rooting system was dissected into root mass in the top 3 inches and root mass in the 3 to 8 inch zone. Roots were washed again and any fine soil remaining was removed. Roots were then scanned and analyzed using an Epson Expression 800 scanner linked to the WinRHIZO 2002c root program. Roots were analyzed for total root length and various other root characteristics (volume, surface area, etc.). We also did a color scan of roots to estimate root length that was black or dark brown (and presumed necrotic) and root length that was lighter brown or white (presumed healthy). Final dry matter was determined on the brome roots after analysis for length. We recognized that the additional washing after freezing may have led to dry matter losses in the brome root system.

Data for subsamples were averaged for each station and stations were treated as replicates. Data was analyzed using Statistical Analysis Systems package for General Linear Models. The experiment was treated as if it was a randomized complete block experiment, though treatments were not randomized within blocks. Analysis partitioned variance for farm, replicates, treatments, and farm x treatment interactions. Contrasts were used to compare farms, and to examine interactions between farms and treatments. Sampling was repeated at each station on July 5, 2005.

Appendix 2. Estimated Manure Deposited and Forage Fed on Outwintered Paddocks, December 2003-April 2004

Definitions/Assumptions:

Cow-days: # cows x days outwintered

Manure Production/Cow/Day (From Midwest Plan Service)
1000 lb lactating cow = 106 lb solid/day
1000 lb dry cow = 82 "
1400 lb lactating cow = 148 "
1400 lb dry cow = 115 "

Estimates for 1200 lb cow are midpoints of these figures.

Paris-2004

5270 cow-days (12/10 – 4/19 = 131 days but not including 16 days 2/26 – 3/12)
5270 x 127 = 669290 lb/2000 lb = 335 tons
Adjusted for 16 days not on paddock due to mud (12%) = 295 tons
Adjusted for time on paddock (approx 75% of day) = 221 tons
Adjusted for paddock size (3.1 acres) = 71 tons/acre manure on paddock (estimated)

Hay fed on paddock

140 round bales @ approx 1500 lb/bale = 105 tons as fed
(most bales "good" alfalfa est. 16-19% protein)
@ 20% feeding loss = 21 tons/3.1 acres = 6.8 tons/acre returned to paddock

Gausman-2004

7155 cow days (53 cows x 135 days)
7155 x 106 = 758430lb/2000 = 379 tons
Adjusted for time on paddock (approx 75% of day) = 284 tons
Adjusted for paddock size (6.1 acres) = 46.5 tons/acre manure on paddock (estimated)

Hay & corn silage fed on paddock

Approx. 62 tons hay, 60 tons silage
@20% feeding loss = 4 tons/acre returned to paddock

Vosberg-2004

6804 cow-days (42 days x 162 cows)
1200 lb dry cows = manure output approx. 98 lb/day
260 cow-days (4 days x 65 cows)
1200 lb lactating cows = manure output approx. 127 lb/day

699812 lb/2000 = 350 tons
Adjusted for time on paddock (50% of day) = 175 tons
Adjusted for paddock size (7.1 acres) = 24.6 tons/acre manure on paddock (estimated)

Baleage fed on paddock
75 1000 lb bales @ 15-18 percent protein
@20 percent feeding loss = 1 ton/acre returned to paddock

Manure spread on paddock
6 loads with 400 bu capacity spreader (50 percent bedding—old hay)

Appendix 3.
Forage Yields & Management in Outwintered/Rested and Check paddocks, 2004

Paris, 2004

Outwintered Paddock mowed July 8 4.9 ton/acre @ 35% moisture = 1.7 ton/acre dry matter
Grazed August 7-9 36 hours with milk cows (no dry matter measured)
Grazed September 17 2076 lb/acre available dry matter

Grazed check paddock yield, available dry matter (lbs/acre)
(80 cows, moved every 12 hours)

5/15	1544
5/28	1927
7/8	2297
8/6	2117
9/25	1607

TOTAL: 9492 lb/acre
(Light grazings in early spring and late fall not included).
2 applications ammonium sulfate mid and late summer @ 50 lb N/application on check

Gausman, 2004

Outwintered paddock mowed July 14
29 bales @ approx 1400 lb = 20.3 tons/6.1 acres =3.3 ton/acre
@40 percent moisture = 1.3 ton/acre dry matter
Grazed October 17 24 hours (estimated 1000 lb/acre available dry matter)

Grazed check paddock yield, available dry matter (lbs/acre)
(80 cows, moved every 12 hours)

5/3	1501
5/28	1577
7/10	2324
8/6	1814
9/30	2065

TOTAL: 9309 lb/acre
(Light grazings in early spring and late fall not included).

7/21 50 lb N on check
End of August 40 lb N on check

Vosberg, 2004

Outwintered Paddock mowed July 22
3.8 ton/acre @ 45.4% dry matter = 1.7 ton/acre dry matter

Grazed check paddock yield, available dry matter (lbs/acre)
(150 cows, moved every 12 hours)

5/15	2387
6/3	1955
7/10	(cows broke through fence and grazed; estimated 2000 available/500 removal).
7/23	2043
9/4	1927
10/14	1352

TOTAL: 9,664 lb/acre
(Light grazings in early spring and late fall not included).

6/17 48 lb N applied (60 % ammonium sulfate, 40 % urea) on check.
8/20 240 lb ammonium sulfate (50 lb actual N); 75 lb K; 40 lb DAP on both paddocks

Appendix 4. 2005 Grazed Paddock Yields (Available Dry Matter); Sward Height

Paris (80 cows, moved every 12 hours)

Outwinter				Check			
Date	yield	%DM	height	Date	yield	%DM	height
4/28	2023	23.4	8.2"	4/28	1403	25.9	4.6"
5/31	4160	21	18.4	5/31	3365	21	14.4
7/6	3644	31.3	12.2	7/19	1564	39.3	9.6
8/19	3183	22.4	14.8	11/3	523	40.75	3.8
11/3	645	40.75	4.75				
Total	13,655 lb/acre			Total	6,855 lb/acre		

30 lb N (ammonium sulfate) applied late June.

Gausman (80 cows, moved every 12 hours)

Outwinter				Check			
Date	yield	%DM	height	Date	yield	%DM	height
4/28	2578	24.4	7.4"	5/18	989	24.6	5.6"
5/18	1212	21.	6.0	7/6	3465	29.7	11.0
6/7	4365	26.2	14.2	11/2	1780	46.7	6.0
7/22	2045	32.2	12.6				
11/2	1059	46.7	4.8				
Total	11,259 lb/acre			Total	6,234 lb/acre		

Vosberg (150 cows, moved every 12 hours)

Outwinter				Check			
Date	yield	%DM	height	Date	yield	%DM	height
4/21	2182	21.8	7.6"	4/23	2615	21.3	8"
6/13	3200	30.0 (hay)		6/13	3150	30.0 (hay)	
7/30	2645	40	10.2	7/30	2256	40	9.2
11/1	1924	34	8.37	11/1	1593	34	7.67
Total	9,951 lb/acre			Total	9,614 lb/acre		

50 lb N (ammonium sulfate) applied 6/15/05

Sward height at Paris, Gausman, and Vosberg 4/21 is average height of five clipped quadrats. Sward height at Vosberg 7/30 and 11/1 is average of 30 measurements per paddock.