PRACTICAL FARMERS OF IOWA
COOPERATORS' PROGRAM Farmer-Led Research

EXPERIMENT

2024

Bale-Grazing Effects on Soil and Pasture Plant Communities

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In a Nutshell:

- Bale-grazing is a way of feeding livestock in the winter by providing bales of hay to animals out on the land, instead of indoors.
- By spreading bales around, farmers can distribute fertilizer deposition and wear across the pasture.
- Adam Ledvina bale-grazes goats on pasture and was curious to learn how animal traffic near the unspooled bales affected the soil and plant community.

Key Findings:

- Areas covered by the tracks of the unspooled prairie hay bales had higher species diversity.
- Soil under the areas of unspooled bales had higher phosphorus, potassium, and micronutrients than non-bale-grazed areas.
- Bale-grazed areas also had deeper soil penetrability.

Cooperators

Adam Ledvina, Chelsea, IA

Funding

The Builders Initiative

BACKGROUND

Bale-grazing is a practice of feeding grazing livestock from bales, outside. It is common in environments where herds stay outside through the winter, but the winter pasture productivity is not high enough to support them. As common as it is, there is a huge diversity within the practice, with every farm doing what works for them, with their locally available equipment and fodder. Bale-grazing contrasts with the practice of feeding animals hay in feeders in barns in the winter — by having the animals out on the land as they eat the hay, their waste goes directly back to enriching the soil [1]. However, having too many animals in an area for too long can churn up or compact the soil. Soil compaction and scarification are reduced by spreading animals around to different feeders. Bale-grazing management therefore needs to consider the number of animals, the plant populations' robustness, the moisture conditions, and other local factors to optimize the practice [2], [3].

Goats grazing from an unrolled bale at Adam Ledvina's. Photo taken winter 2024.

Many farmers put their bales out in feeders outdoors, but there is a growing trend of rolling out round bales into strips of hay across the landscape. This approach is more flexible than fixed feeders, which can concentrate animals in the same area over time. Furthermore, feeders may pose specific challenges to an operation. Adam Ledvina faced a couple of specific issues with his metal feeders. His hay includes a diverse mix of plants, including some roughage (sticks) that the goats would pass over. The portions of inedible sticks built up in the feeders, blocking the goats' access to the ungrazed portions of the bales at the back

of the feeder. This would require him to manually clear out the feeder or reduce the feed efficiency of the bale if the back section went uneaten. Also, his goats sometimes got their horns stuck in feeders. This is dangerous, especially during the winter when immobility can lead to hypothermia.

Ledvina also wanted to improve the quantity, quality, and biodiversity of his forage. The prairie that he mowed for hay had a great variety of plant species, but his pastureland was less diverse. Rolled-out bale-grazing disperses the seeds of those hay plants in the bale with mature seedheads across the field with the unrolled bale, then provides them with tilling (via the goats' hooves), fertilizer, and mulch from the uneaten dregs of the strip. Bale-grazing may help also more indirectly establish help new plants grow by fostering a protected, high-nutrient, mulched area for seeds in the latent seed bank to benefit from.

There are drawbacks and disadvantages to bale-grazing, too. Maintaining open water sources through the winter may require work, or capital. Also, hay ends up on the ground, some goes uneaten, decreasing feed efficiency. Though, as noted above, the feed efficiency of one system, relative to others, may depend on the quality and characteristics of the feedstuff. Ledvina's mixed-quality hay allowed his goats to pick through to find the stuff they liked, leaving the rest as mulch to stabilize the soil and hold the manure in place. Goats eating hay from the ground could increase the risk of parasites, and although many worms and larva may be dormant in the cold, the effects are not clear [2], [4], [5].

TABLE 1: Timeline of bale-grazing trial at Adam Ledvina's 2023-2024.

DATE	ACTIVITY
September 1, 2023	Baled prairie hay
December 5, 2023	First set out bales
March 15, 2024	Last bale out
May-August, 2024	Field not grazed
June 9, 2024	Plant species survey
August 1, 2024	Field hayed
September 30, 2024	Penetrometer measurements and soil samples taken

METHODS

Ledvina hayed mixed prairie into round bales. Prairie hay has a higher diversity of plants, with a greater range of digestibilities, than monocultural timothy or alfalfa hay.

Round bales were unrolled, either by hand, by gravity (downhill), or by bale roller arm off the bed of a truck. As the bale unrolls it leaves a swath of hay four feet wide (the height of the bale) by approximately 100 yards.

Ledvina has a herd of 500 head of goats. He rolled out one bale every other day throughout the winter, from December 5, 2023, through March 15, 2024. Near the end of winter Ledvina invested in the afore-mentioned bale-roller arm, which allowed him to unspool the bale from the back of his moving truck, giving him more control over the layout of the strip. The field was not grazed after the end of the bale-grazing, so observations on the effects of the treatment were not swayed by goat activity after the end of treatment.

Measurements

This trial involved four sets of paired measurements comparing bale-grazed pasture within the strip covered by an unrolled bale, and non-bale-grazed pasture outside the strip. These measurements were soil compaction, soil scarification, soil nutrient concentrations, and species counts.

The effects of soil compaction were measured via a manual 'push' penetrometer. Ledvina measured the depth at which the soil resisted with 300 pounds per square inch. Measurements were taken within the five of the grazed bale strips, with paired measurements 10 feet outside the boundaries of the strip.

Scarification was measured observationally in the summer after the bale-grazing, with plant density within the strips visually compared to the land outside the strips.

Nutrient distribution was measured via aggregate samples taken within the bale-covered strips, and outside the strips. Five test spots were selected. A pair of samples was taken at each spot, one within the track of the bale and the other 10 feet outside. The samples for each treatment (inside vs outside the track) were aggregated, then the two aggregated samples were sent to Ward Laboratories for testing. The samples were tested for soil pH, soluble salt concentration, soil organic matter, nitrate ppm,



There it goes! Goats quickly come to investigate hay left in the track of a rolling bale, in this series of stills taken from a video taken by Ledvina, winter 2024.

phosphorus ppm, sulfate ppm, chloride ppm, and elemental ppm measurements of potassium, calcium, magnesium, sodium, zinc, iron, manganese, copper, and boron.

Native prairie species establishment was measured by a species count. Four treatment areas were defined: bale-grazed upland, non-bale upland, bale-grazed lowland, and non-bale lowland. Within each of these treatment areas, Ledvina used a thrown hula-hoop to define areas where he surveyed the growing plant species.

By taking pairs of observations, with samples and/or measurements in and out of the treatment swath taken close to each other, we aimed to reduce the variability between our samples. This way, more (or ideally, all) of the difference between the members of the pairs should be attributable to the treatment.

Data analysis

There seem to be qualitative differences between the areas covered by the unspooled hay and the surrounding, uncovered ground, but because many of the measurements taken as part of the study were not replicated, we cannot robustly quantify those differences.

The summer field observations and plant species surveys were taken in pairs, comparing like local environment with like. This approach is helpful for drawing comparisons with limited resources; those comparisons could be used to inform a more robust survey in the future.

Similarly, while the aggregate soil tests give a representative sample of the differences between the treatments, they cannot be statistically analyzed.

Penetrometer measurements were replicated. We used Fischer's LSD at a 95% confidence level to determine if there were significant differences between bale-covered land and control. The difference between the two means is compared with the LSD. A difference greater than or equal to the LSD indicates the presence of a statistically significant treatment effect, meaning one treatment outperformed the other and the farmer can expect the same results to occur 95 out of 100 times under the same conditions. A difference smaller than the LSD indicates the difference is not statistically significant and the treatment had no effect. We can perform this analysis because Ledvina replicated the bale-grazed and non-bale-grazed areas in his pasture (**Figure A1**).

RESULTS AND DISCUSSION

The depth at which the soil provided 300 psi of resistance was significantly deeper in bale-covered area, compared to non-bale-grazed areas (**Figure 1**). This could be indicative of better rooting and denser stands of plants within the track of the bales. Ledvina observed denser, taller, and lusher plant growth in the areas where the bales unrolled. The tracks of the bales were visible the summer following the bale-grazing as lush stripes across the landscape; strips not made of leftover decaying bale material but by flourishing plants (photo next page).

The bales seem to have been successful at introducing new species to the field. The survey of plant species counted four more species in the lowland bale area than the lowland control, and 12 more species within the upland bale track than outside it (**Table 2**). These seeds came from the prairie that was hayed to make the bales, and the bale tracks provided an effective environment for their establishment, with goats' hooves pressing them in, the bale's mulch sheltering them, and goats' waste fertilizing them. The soil tests found much higher nutrient concentrations in the aggregate sample from within the bales' track than the sample from outside the tracks (**Table 3**). Potassium was 3.5 times higher and phosphorus was six time higher; micronutrients were all also higher within the bale than without, except calcium, which was 20% lower in the bale-grazed area.

All these results together suggest that unrolled bales, grazed by goats in the winter, can potentially improve soil and plant stand conditions in future growing seasons.

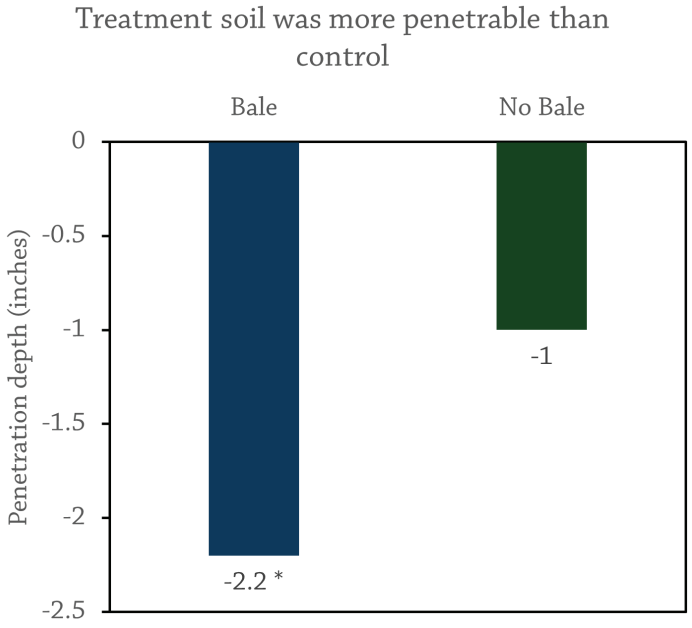

FIGURE 1: The average depths at which penetrometer resistance reached 300 psi for the two treatments. Bale-grazed areas were significantly easier to penetrate than the non-bale-grazed areas; the ' * ' indicates that the result differs significantly from the control.

TABLE 2. Species found within sampled areas

AREA	COUNT	SPECIES
Bale-graze, lowland pasture	14	Bergamont, Burdock, Fescue, Grape Vine, Partridge Pea, Plantain, Poison Ivy, Queen Anne's Lace, Red Clover, Smooth Brome, White Clover, White Heath Aster, Wild Parsnip, Yarrow
No bale-graze, lowland pasture	10	Fescue, Foxtail, Grape Vine, Poison Ivy, Queen Anne's Lace, Sand Burr, Smooth Brome, White Clover, White Clover, Wild Parsnip
Bale-graze, upland pasture	19	Bergamont, Big Blue Stem, Common Mullen, Foxtail, Heath Aster, Indian Grass, Marestail, Orchard Grass, Pumpkin, Queen Anne's Lace, Red Clover, Saw-tooth Sunflower, Smooth Brome, Snakeweed, Solidago, Switch Grass, Vervaine, White Clover, Yarrow
No bale-graze, upland pasture	7	Foxtail, Heath Aster, Marestail, Queen Anne's Lace, Smooth Brome, White Clover, Yarrow

TABLE 3. Soil analysis test results comparing aggregate samples from 5 pairs of locations

TREATMENT	OBSERVATION SITE	pH	ORGANIC MATTER %	P ppm	K ppm	Ca ppm	Mg ppm	S ppm	Na ppm	Zn ppm	Fe ppm	Mn ppm	Cu ppm
Bale-graze	5 bale-graze sites	6.8	7.8	140	623	1618	347	16.6	11	5.79	42.4	12.1	1.05
No bale-graze	5 samples 10 ft from bale-graze	7.1	5.1	23	175	2052	417	9.6	5	1.40	13.2	2.6	0.47

Photo taken by Ledvina showing tracks of bales across a pasture hill as stripes of taller, denser stands of plants. Photo taken summer 2024.

CONCLUSIONS AND NEXT STEPS

Because the measurements in the trial were taken in pairs, one inside and one outside of the strip left by the unrolled bale, we have been able to examine the effects of the bale on the local soil and plant communities. Over time, more and more of bale-grazed a field would once have been covered by a strip. Care and planning could be invested in covering the field as efficiently as possible or targeting problem areas with more frequent coverage. For a farmer already practicing bale-grazing, this information could help inform plans for how to arrange bales to ameliorate target problem areas. Ledvina was pleased with the additional forage diversity that the bales introduced. He wrote that "The amount of phosphorus, potassium, and organic matter increased more than we expected. With this data we intend to use bale-grazing as a tool to boost nutrients across our farm and cut our chemical fertilizers". Ledvina intends to bale-graze all of his pasture this winter.

Going forward, it would be interesting to compare bale-grazing as a system to indoor wintering and feeder usage, in terms of average daily gain and feed efficiency, though many of the benefits of bale-grazing suggested by this trial lay outside of these traditional economic measures of livestock feed conversion. Furthermore, how the local arrangement of feed, fertilization, and disturbance compared to other bale-grazing set-ups (e.g. scattered bales) could be explored. At a landscape level, or a whole farm operation level, are soil fertility, plant diversity and productivity, and goat nutrition benefited from spreading the bale-grazing out across the land? This trial suggests that they are, but further work will be needed to prove it.

APPENDIX — TRIAL DESIGN AND WEATHER CONDITIONS

Bale graze
No bale graze
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No bale graze
Bale graze
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FIGURE A1. Experimental design used by Adam Ledvina.

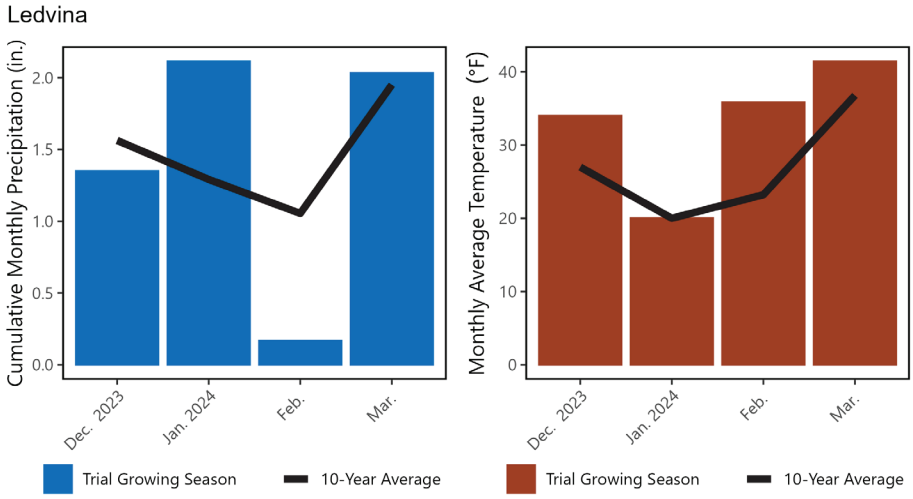

FIGURE A2. Monthly cumulative precipitation and average temperatures in Chelsea over the course of the experiment, December 2023 – March 2024 [6], [7].

REFERENCES

[1] J. J. Bachler, "Winter Feeding Beef Cattle: A Review on Bale Grazing in the Northern Great Plains," 2019, Accessed: Jan. 29, 2025. [Online]. Available: https://library.ndsu.edu/ir/handle/10365/30957

[2] S. Hart, Ed., "Grazing System and Management for Goat Production," Prof. Agric. Work. J. PAWJ, 2020, doi: 10.22004/ag.econ.319746.

[3] "Bale Grazing 101 | UGA Forage Extension Team." Accessed: Jan. 29, 2025. [Online]. Available: https://site.extension.uga.edu/forageteam/2020/09/bale-grazing-101/

[4] M. Chamas, "Goat Grazing to Reduce Parasite Loads," Practical Farmers of Iowa, Cooperators' Program Research Report, 2014. Accessed: Jan. 29, 2025. [Online]. Available: https://practicalfarmers.b-cdn.net/wp-content/uploads/2018/12/goat-grazing-to-reduce-parasites.pdf

[5] "Prevent Parasites Through Grazing Management." Accessed: Jan. 29, 2025. [Online]. Available: https://extension.psu.edu/prevent-parasites-through-grazing-management

[6] A. H. Sparks, "nasapower: A NASA POWER Global Meteorology, Surface Solar Energy and Climatology Data Client for R," J. Open Source Softw., vol. 3, no. 30, p. 1035, Oct. 2018, doi: 10.21105/joss.01035.

[7] A. Sparks, nasapower: NASA-POWER Data from R. (2024). [Online]. Available: https://CRAN.R-project.org/package=nasapower

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