Amending pasture soil to decrease weed presence while improving forage species composition and quality

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Abstract
Many farmers in the Northeast have pastures or hayfields that, over time, tend to show a decline in desirable forage species and quality as weed species increase. Common practice for pasture renovation includes mechanical cultivation, reseeding, and sometimes the use of herbicides, resulting in greater soil erosion and compaction, higher costs, and compromised natural resources. Recognizing that weeds thrive in particular conditions of low soil fertility, three one-acre test plots were amended with custom formulated blends to address mineral deficiencies, and compared to three adjacent one-acre control plots. As soil nutrition in the field increased, an increase was observed in palatable forage speices, such as fescue, orchard grass, quackgrass, timothy, red clover, and vetch. A decrease was observed in broadleaf weed species including aster, buttercup, chickweed, cinquefoil, goldenrod, hawkweed, daisy, strawberry, and yarrow. Forage species were also sampled and analyzed for nutritional content to compare forage quality in test and control plots, though minimal differences were observed in plant tissue analysis, with the exception of higher boron levels in the experimental plots.

Introduction
On many farms in the Northeast, pastures tend to decrease in appropriate forage species for grass-fed animals while increasing in weed species over time, likely in response to decreasing soil fertility. When soil nutrition is compromised, the vigor and stand density of desirable forage species decline, allowing weed species to establish as forage quality diminishes. Because animals tend to graze species they find palatable while avoiding weed species, farmers with weed-dominated pastures need to increase the amount of hay or grain fed to pastured animals, thus increasing their operational costs. Additionally, in weed-dominated fields with low soil fertility levels, nutrition available to the animals may be compromised, necessitating the feeding of often-expensive supplements to maintain optimum animal health.

Most weeds grow in a narrowly defined window of allowable soil conditions (Weeds and Why They Grow, McCaman 1994). Common problem weed species such as goldenrod, buttercup, asters, and hawkweed are examples of non-palatable species that are diminished by changing soil nutritional levels and generally indicate low soil pH, calcium, phosphorus, and trace element levels. Comparatively, desired forage species such as timothy, fescue, orchard grass, red clover, alfalfa, and reed canary grass thrive in more alkaline conditions with higher soil fertility (University of Maine Cooperative Extension). Because forages are quite competitive with weeds when provided with proper nutrition (*Hay Crop and Pasture Weed Management,* University of Tennessee Cooperative Extension), and because many of the desired forage species are already present (in small amounts) in the fields, species composition begins to shift towards desirable forage species and away from weed species when fertility levels are raised.

Methods
This study was conducted during the 2011 and 2012 growing seasons in mid-coast maine on a six-acre section of pasture arranged in a randomized complete block design, consisting of three replications of one acre test plots and three replications of one acre control plots. Initial soil tests were obtained from each plot in spring 2011 to determine starting fertility levels and were repeated in spring 2012 to

monitor progress and to make necessary nutritional adjustments. The soil tests revealed deficiencies in calcium, magnesium, phosphorus, potassium, nitrogen, sulfur, boron, zinc, copper, and manganese. Approximately 2,900 lbs of amendments per acre were spread on the three experimental plots with a drop spreader pulled behind a tractor in July 2011. The remaining three control plots did not receive any amendments. The amendment recipe included hi-cal lime, gypsum, soft rock phosphate, magnesium sulfate, sulfate of potash, manganese sulfate, dolomitic lime, sul-po-mag, humates, zinc sulfate, sodium nitrate, myco-seed treat, and copper sulfate. In 2012, an additional application of limestone, marl, sulfate of potash-magnesia, humus, soft rock phosphate, gypsum, brown phosphate rock, calcium borate, copper sulfate, zinc sulfate, and humates was applied at a rate of 1,000 lbs per acre. All ingredients in the blends were selected to meet USDA organic certification requirements.

Species composition was measured in each plot using the beaded string method (Northeast Cover Crop Handbook, Sarrantonio 1994), in which a string marked in three-foot increments is stretched across the plot in transects and the researcher records which species is growing beneath each mark. Weed and forage species composition were measured two times throughout the growing season: in June during first-cut (of hay), and again in September during second-cut. To measure forage quality, plant tissue samples from each plot were collected twice throughout the growing season, once in June and again in September. Plant tissue samples were obtained by cutting every tenth plant (whether a weed or forage species) along the beaded string and bulking the cuttings as a representation of the entire plot. After plant sampling, all plots were mowed to simulate grazing and to prevent weed species from going to seed.

Results

Soil tests in 2012 indicated an increase in Ca, Mg, S, pH, conductivity, and P levels, with a slight increase in N and K in amended plots when compared to the control group. Species composition analysis in both June and September of 2012 indicated an increase in fescue, orchard grass, quackgrass, timothy, vetch, and red clover in the amended plots, as well as a decrease in aster, buttercup, chickweed, cinquefoil, goldenrod, hawkweed, junegrass, daisy, strawberry, and yarrow when compared to the control plots. All species that demonstrated a decrease in the pasture thrive in conditions of low calcium, and many of those species also favor low phosphorus environments. Comparitively, species that showed an increase thrive in soils with higher Ca, Mg, S, P, and pH.

Nutritional analysis included nitrogen, phosphorus, potassium, calcium, magnesium, aluminum, boron, copper, iron, manganese, sulfur, and zinc levels, but showed no major differences between amended and unamended plots, with the exception of elevated boron levels in the amended plots.

Conclusion

Increased fertility in the amended plots demonstrated a correlation to an increase in some palatable forage species and a decrease in some non-palatable species. Weed species that thrive in soils with low Ca and low P showed a decrease in overall field composition after the addition of an amendment blend containing Ca and P. Palatable forage species that thrive in soil conditions high in Ca, Mg, S, and P demonstrated an increase in overall field composition after the addition of Ca, Mg, S, and P. While some change was observed in the forage species composition of the pastures studied, weed species are still present and soil fertility levels are still low to moderate. Future research is essential to discover the further effects on forage species composition of increasing soil fertility levels to maximum capacity.