NebGuide

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Perennial Grass or Grass-Legume in Rotation with Annual Crops

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Annual crop production is not always profitable on some land. This land often has a history of erosion. Including perennial grass or a grass-legume mixture in the rotation may be a means to improve soil productivity and profitability while achieving other benefits.

An extended rotation, for example, a 9- or 10-year rotation, including three or more years of perennial grass or perennial grass-legume mixture (often referred to as perennial grass below) followed by six years of annual crops, may be appropriate for some fields if several of the following apply:

- Summer grazing land or hay is in high demand.
- Maintaining or increasing ruminant livestock production is a farm objective.
- The land is highly erodible.
- Profitability of annual crop production is low on some land.
- Annual crops yields may be increased by a more diverse rotation.
- Land productivity may be improved by increasing soil organic matter and soil aggregation.
- Desire to sustainably farm current Conservation Reserve Program (CRP) land.
- Diversification may increase farm profit and/or reduce financial risk.
- Nutrient loss to leaching is a concern.
- Perennials in the rotation may improve weed or pest management.
- Precipitation or irrigation is sufficient for a high success rate in perennial establishment.
- Enhanced landscape aesthetics through crop diversity is of interest.
- Increased habitat for mammals, birds, pollinators, and predator insects is desired.

A major constraint to maintaining or increasing ruminant livestock production in parts of Nebraska is low availability of late spring to early fall grazing. Alleviating this constraint by supplemental feeding of baled crop residues is an option. Including perennial grass or grass-legume mixtures in crop rotations is an alternative.

Some cropland is highly erodible. Sheet erosion associated with raindrop splash and slow down-slope movement of soil is not very obvious but typically accounts for more soil loss than rill and gully erosion. Most farmers keep erosion to sustainable levels, often combining no-till, terraces, contour farming, crop rotation, or other practices. Most erosion in Nebraska occurs as sheet erosion on a relatively small proportion of cropland with moderate to high erosion potential combined with management inappropriate to erosion control.

Annual crop production on marginal lands is often of low or negative profitability as illustrated by a spatial analysis for counties in northeast, east-central, and south-

Table 1. Estimated profitability of rainfed corn production at grain price levels of $3.50, 4.50, and 5.50 per bushel in three eastern Nebraska counties.

Profit or loss, $/ac	Burt			Dixon			Nemaha		
	3.50	4.50	5.50	3.50	4.50	5.50	3.50	4.50	5.50
	Acres of current corn producing land								
<–$200	6,230	2,228	609	15,681	3,524	3,298	3,286	1,933	1,347
–$200–0	120,938	36,634	16,233	195,372	19,763	12,448	95,846	12,837	4,634
$0–200	117,745	108,069	47,392	13,009	192,148	74,429	61,849	102,783	42,714
>$200	23,654	121,636	204,334	0	8,626	133,887	29,722	73,150	142,007

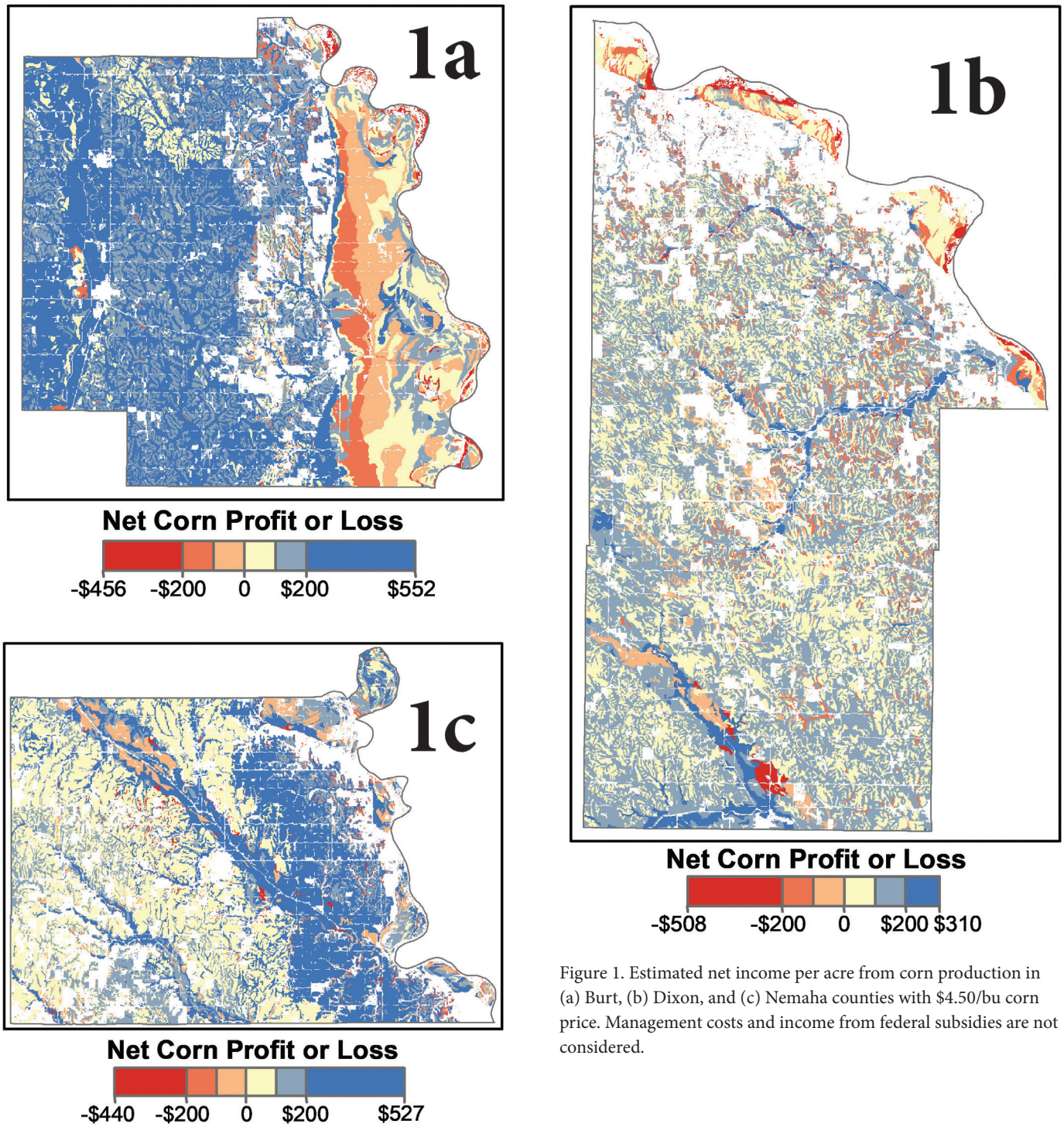

Figure 1. Estimated net income per acre from corn production in (a) Burt, (b) Dixon, and (c) Nemaha counties with $4.50/bu corn price. Management costs and income from federal subsidies are not considered.

east Nebraska (federal subsidies to crop production and management costs were not considered). Land rental (2015 Nebraska Farmland Values and Rental Rates), rainfed corn production cost estimates (2015 Nebraska Corn Production Budgets), the five-year average county yield adjusted for the NRCS soil unit productivity index, and 30-m grid SURGO soil map layers were used in this analysis. The results show that nonsubsidized rainfed corn production is not profitable with $3.50/bu corn on 47, 94, and 52 percent of the land currently used for corn production in Burt, Dixon, and Nemaha counties, respectively *(Table 1)*. For $4.50/bu corn price, nonsubsidized rainfed corn production is not profitable on 11 percent of the current cropland in these counties *(Figure 1)*. There may be an opportunity to improve the profitability and productivity of such land by including perennial grasses in the crop rotation, or with permanent pasture.

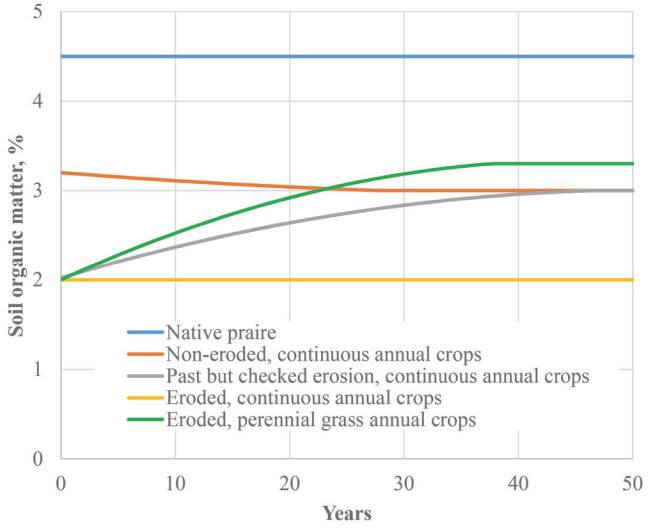

Figure 2. A hypothetical illustration of soil organic matter content for a silty clay loam soil of eastern Nebraska as affected by erosion and cropping system.

Potential Benefits of Including Perennial Grass in Crop Rotations

Including perennial grass in crop rotations can have considerable profit potential for mixed beef cow-crop operations by increasing mid-spring to mid-fall grazing. Annual crop yield is likely to be increased by including perennial grass in the rotation.

- Perennial weed management may be easier.
- Some insect pests may be reduced while others, such as white grubs, wireworms, and armyworms, may increase.

Perennial grass sod formation and permanent ground cover can directly reduce erosion while improved soil aggregation and water infiltration may persist for several years of subsequent annual crop production, especially where soil organic matter is currently low such as due to erosion.

- Soil organic matter is likely to increase due to reduced erosion and increased root biomass production with benefits to soil chemical, physical, and biological properties NebGuide G2283, *Soil Management for Increased Soil Organic Matter*.
- Much current CRP land might be sustainably and profitably productive by appropriate inclusion of perennial grass in rotation with annual crops.
- Cropping system resilience to climate extremes may be improved because of reduced erosion and runoff, increased soil organic matter and other soil improvements, and commodity diversification.
- Leaching of nutrients to groundwater is likely to be reduced with the deep root systems of perennial grass and legumes recovering nitrate, sulfate, and other nutrients that have leached below the rooting depth of annual crops.
- Increased soil water holding capacity associated with increased soil organic matter is expected to contribute to reduced percolation beyond the reach of annual crops while the perennials will use some of this deeper water.
- The profit potential may be increased due to higher annual crop yields and less
- nonprofitable production.
- Crop diversification can contribute to reduced financial risk associated with climate variation and price fluctuations.
- Reduced runoff and erosion reduces nutrient transport to surface water.
- Nitrous oxide and ammonia emission from cropland to the atmosphere is associated with the amount of N applied, which can be reduced with perennial grass, and especially perennial grass-legume mixtures, in the rotation.

In addition, appropriate management of the perennial grass is likely to provide wildlife habitat, and the crop

system diversification may enhance the aesthetic value of landscapes.

Constraints to Including Perennial Grass in Crop Rotations

It may take a full growing season to establish perennial grasses/legumes with a temporary lack of or reduced productivity during the grass establishment year. The inclusion of perennial grass or grass/legume mixtures in the crop rotation may be site specific with fragmentation of fields, e.g., the practice may be applied to one or two >20 acre fields in what is now 160 acres of annual crop. Planning and design will be needed to minimize disruption of field operations. Inclusion of perennial grass will likely require application of more information, management, and equipment. The practice, especially if grazing is involved, appears most appropriate for crop and cow-calf herd mixed operations that already have the prerequisites for grazing management. Others will find the hay production option more compatible with their operation. Controls on pesticide use may need to be tightened. Labor and management allocation may be more challenging. Adequate demand for the grass is necessary.

Establishing and Managing Perennial Grasses in Crop Rotations

Cool-season grasses grow rapidly in the spring producing about 70–80 percent of the annual herbage by July 1. Cool-season grasses go semi-dormant during hot months if soil water is inadequate, and grow again in the late summer and fall until freezing conditions end the growth period. Little grazing is available from cool-season grasses during the seeding year.

Grass species and varieties. Rapid establishment is desirable, especially when stands will be maintained for only a few years as part of a rotation. Therefore, species with good seeding vigor and rapid establishment, like orchardgrass, festulolium, perennial ryegrass, and red clover, often should be used. Longer-lived species like smooth bromegrass, intermediate wheatgrass, and alfalfa might be included as part of a mixture with the more rapidly establishing species. See EC120, *Certified Perennial Grass Varieties Recommended for Nebraska*.

Many varieties have been verified as adapted and productive in eastern Nebraska. The most recommended grass varieties include:

- smooth bromegrass–Badger, Lincoln, Newell, Peak, and Rebound;
- orchardgrass–Akaroa, Athos, Baridana, Duke, Extend, Intensiv, Latar, Mammouth, Niva, Persist, Pizza, Satin, and Sparta;
- intermediate wheatgrass–Beefmaker and Haymaker;
- perennial ryegrass (none tested);
- tall fescue (only use endophyte-free or novel endophyte varieties)–Drover, Jesup, Max Q, Martin, Mozark, Tuscany II; and
- festulolium, especially for southeast Nebraska–Hykor.
- Alfalfa variety selection should be specific for grazing or hay.

A single species can be sown but sowing a mixture of species and varieties may improve establishment, adaptation to variations in the field and climate, and extend the vegetative growth period. Select certified seed of high quality to assure varietal quality and vigorous seedlings, while avoiding the introduction of a weed species. Sow at suggested seeding rates *(Tables 2* and *3)*.

Preparation and sowing. It is desirable to suppress weeds in annual crops during the years prior to sowing grass. Avoiding herbicide carryover from the annual crop to grass establishment is important. See NebGuide G1705, *Establishing Dryland Forage Grasses*.

Preservation of ground cover by no-till sowing of grass protects seedlings from blowing soil particles, and reduces erosion and evaporation of soil water. Sowing into soybean stubble usually is more successful than sowing into corn stalks. If sowing following corn, it may be good to remove some stover but maintain 12–18 inches of standing stalk. If sowing follows a small grain crop, some straw removal may be needed to prevent excessive mulch while preserving some standing stubble. If tillage is necessary, firm the seedbed with a roller/packer or with rainfall or irrigation before sowing to prevent deep seed placement and to help ensure good seed to soil contact.

Adjust the drill so it covers the seed 1/8 to ½ inch deep on heavier soils but ½ to 1 inch deep for sandy soil. Good seed to soil contact is important. Use grassland drills with seed agitators in the seed box to maintain a uniform mix of seed and to prevent blocking of seed tubes. Also, a positive feed mechanism helps to provide uniform seed distribution. Seed furrows will be opened with double disk openers, and packer wheels will cover the seed and pack the soil for good seed-soil contact. Seedling stands may be improved by sowing one-half of the seed in one direction and then again at a right angle to the first sowing.

Seed is best sown either late summer between August

Table 2. Recommended seeding rates for grass and legume monocultures.

Grass or legume species	Seeding rate, lb/ac
Orchardgrass	4–8
Perennial ryegrass	20–30
Tall fescue	10–15
Festulolium	15–20
Smooth brome	8–12
Intermediate wheatgrass	12–15
Red clover	8–15
Alfalfa	10–18

Table 3. Seeding rates of select mixtures.

Mixture	Seeding rate, lb/ac
Orchardgrass	2–3
Festulolium	4–6
Perennial ryegrass	5–10
Red clover	2–10
Orchardgrass	2–3
Tall fescue	4–7
Smooth brome	3–6
Orchardgrass	2–3
Tall fescue	3–6
Intermediate wheatgrass	3–6
Alfalfa	4–8

1 and September 15 or during spring between March 1 and April 30. Spring seeding often has more weed challenges than late summer seeding but soil water availability is more reliable in the spring.

Oats may be sown as a companion crop at 15 to 20 lb/ac. Manage the oats to protect grass establishment without too much competition. Fall-sown oats will winter-kill. Spring-sown oats should be cut for hay before heading.

When a legume is included in the mix with grass, the protein content of the herbage is expected to increase and result in some biological fixation of atmospheric N. Grazing management may be complicated if livestock prefer more or less of the legume. Weed control will be more costly due to reduced herbicide options. Unless legumes dominate the stand, optimum yield is likely to require application of fertilizer N, which in turn will hinder N fixation by the legumes.

Weed control. Grass seedlings grow slowly and compete weakly with weeds. Poor weed control causes frequent failure of grass establishment, primarily due to light interception and soil water depletion. Early and frequent shredder-mowing when weeds are about twice the height of the grass seedlings while cutting only leaf tips of the grass can control many weeds, especially broadleaf weeds. Avoid clipping cool-season grasses after August 30. In a grass-only seeding, broadleaf weeds can be sprayed with 2,4-D ester (1 pt/ac of 4 lb/ac acid equivalent) after grass seedlings have at least five leaves, or earlier if the weed canopy is sufficient to intercept the herbicide for little contact of the herbicide with grass leaves. In the fall after sowing in the previous year or in the spring, application of 2,4-D ester between September 15 and October 15 may give beneficial weed control.

Table 4. Fertilizer Rates for perennial cool-season grass in eastern Nebraska*

Nutrient and criteria	Recommended rates, lb/ac
Nitrogen	
Zone I, grazed	80–120
Zone I, hay	100–150
Zone II, grazed	50–80
Zone II, hay	60–90
Phosphate (P_2O_5), based on Bray-1P	
0–5 ppm†	40
6–15 ppm	20
16–25 ppm	10
Potassium, based on soil test K	
< 40 ppm	90
41–75 ppm	60
76–124 ppm	30

*Source: EC155, chapter 20.

†The soil test P values for Olsen P and corresponding Bray-1 P values are 0–3 and 0–5 ppm; 4–10 and 6–15 ppm; and 11–17 and 16–25 ppm.

Grazing in year 1. Cool-season grass can be lightly grazed to reduce companion crop and weed competition during the year of establishment. Avoid grazing when the soil is wet and make sure seedlings are rooted well enough so they are not uprooted by grazing. End grazing by August 30 to allow the grass to store energy and harden for the winter. Limit the grazing periods to no more than a week, such as through rotational grazing, and always leave at least 4–6 inches of grass growth.

Fertilizer and lime use for cool-season grasses (EC155, *Nutrient Management for Agronomic Crops in Nebraska*, chapter 20). Fertilizer N rate recommendations are made by rainfall zones and grass use, and fertilizer P and K rates are based on soil test values *(Table 4)*. This NebGuide has a rainfed eastern Nebraska focus, including zones 1 and 2. Zone 1 is southeastern Nebraska with Jefferson, Saline,

Saunders, and Washington counties included as the most western or northern counties in the zone. Zone 2 lies west and north of zone 1 with Harlan, Buffalo, Valley, Garfield, and Knox included as the most western counties in the zone.

The recommendations call for 50 percent more fertilizer P and 33 percent more fertilizer K if legume is in the species mix. Perennial grasses or grass-legume mixes are not likely to have profitable responses to application of other fertilizer nutrients.

Soil pH should be above 5.5. This is typically the case if soil has been well-managed for soybean production. Apply any needed lime in the annual crop phase of the rotation for more profit potential.

Termination of cool-season grass. The cool-season grass must be terminated before rotating back to annual crops.

The timing of termination is flexible and may be determined more from economics than from agronomic factors. The grassland period should generally be at least four years to achieve significant soil improvement and sufficient payoff from the grassland phase. If the payoff from the grassland is satisfactory relative to the potential payoff with annual crops, grassland termination and rotation back to annual crops may be delayed indefinitely.

Termination with a glyphosate application in late October is an option, especially if soil water depletion is a concern. In higher rainfall areas, termination may be done in the spring. As the inclusion of perennial grass in rotation with annual crops will often be on land of moderate or high erodibilty, tillage should be avoided or limited to reduce field roughness such as due to mole mounds or badger digging.

The remaining herbage and root mass can cause immobilization of N during the year after termination. Therefore, soybean is a preferred crop to follow termination. If the crop following termination is corn or another non-legume, 30–40 lb/ac fertilizer N should be applied in addition to the UNL recommendation. See NebGuide G1970, *Soil Fertility Considerations for Land Coming Out of Conservation Reserve Program (CRP)* and EC155, *Nutrient Management for Agronomic Crops in Nebraska*. The soil should be sampled and analyzed, and application of P, K, and Zn should be made according to the soil test values.

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