Perennial Forage in the Crop Rotation

A crop rotation that delivers soil health, resiliency, and reduced N leakage from the cropping system is an *extended* rotation.

Extended Crop Rotation

An extended crop rotation is longer than a two-year alternation between corn and soybean.

Extended Rotation Benefits

- Reduce erosion
- Reduce N leakage
- Reduce fossil fuel use
- Break up pest cycles
- Reduce purchased N fertilizer
- Improve soil health

Examples of extended crop rotations:

- Rotation into alfalfa for a minimum of one year
- Rotation into oats + alfalfa for a year followed by alfalfa for at least one additional year
- Rotation into some other crop than corn or soybean (a "Third Crop;" see Rural Advantage, http://ruraladvantage.org/programs/third-crops/)

Perennial forage is a highly beneficial addition to a crop rotation. It puts roots in the ground that are alive all year round, although they may be dormant part of the year. Living roots in the ground anchor soil in place more effectively than any other erosion prevention practice.

Alfalfa is generally the perennial forage type with the highest market value and thus the forage that has been most studied in cropping systems trials. Other perennial forage

species or forage mixtures can be equally beneficial in terms of improving soil health, capturing nutrients, and preventing erosion.

Research at Iowa State University and the University of Minnesota has demonstrated that a 3- or 4-year extended rotation is similar in profitability to a 2-year corn/soybean cropping system. Year-to-year variations in crop prices, input costs, and weather will determine which system is more profitable in any given year.

Marsden Farm Research, Iowa State University, average of years 2006-2011			
	Cropping System		
	2-year corn/soybean	3-year corn/soybean/oat	4-year corn/soybean/oat+alfalfa/ alfalfa
Corn yield (bu/ac)	194	199	202
Soybean yield (bu/ac)	50	55	57
Return to mgmt. ($/ac)	$188	$194	$171

The Marsden Farm study included use of manure on all corn acres for the cost of hauling and spreading.

Source: *Energy and Economic Returns by Crop Rotation***.** September 2012. Ann M. Johanns, Craig Chase, and Matt Liebmann. Iowa State University Extension. www.extension.iastate.edu/agdm/crops/html/a1-90.html

Variable-Input Crop Management Study (VICMS), University of Minnesota, average of years 1993-1999		
	Cropping System on soil with high initial fertility	
	2-year Corn/soybean	4-year Corn/soybean/oat+alfalfa/ alfalfa
Corn yield (bu/ac)	139	139
Soybean yield (bu/ac)	40.7	43.1
Alfalfa yield (tons/ac)		5.11
Net Return ($/ac)	$153	$172

Sources:

Long Term Effects of Crop Management: Yield. Results from the VICMS study at the Southwest Research and Outreach Center, Lamberton, Minnesota. http://swroc.cfans.umn.edu/prod/groups/cfans/@pub/@cfans/@swroc/documents/asset/cfans_asset_236359.pdf

Long Term Effects of Crop Management: Profitability. Results from the VICMS study at the Southwest Research and Outreach Center in Lamberton, Minnesota http://swroc.cfans.umn.edu/prod/groups/cfans/@pub/@cfans/@swroc/documents/asset/cfans_asset_236361.pdf

These calculations of crop rotation profitability do not account for the less direct and long-term benefits of an extended rotation, such as reduced soil erosion leading to increased future productivity; or reduced N leakage from the system.

Placement of Crop Rotations to Reduce Soil Erosion

Research in Iowa has shown that matching length of the crop rotation to the slope of the ground is successful at reducing erosion below the "tolerable rate," T (5 tons/acre/year of soil loss).

Annual Row Cropping on slopes >15% can lead to soil loss of 80 tons/acre/year: 16 times the tolerable rate.

% Slope	Crop Selection for Soil Loss < T
< 5%	2-year corn/soybean
5% - 14%	6-year corn-soybean-corn-oat+forage-forage-forage
>14%	Permanent perennial forage

The crop rotations featured in this research were selected to represent crops that would accompany a shift toward more livestock in the region. Other crops with similar

characteristics could be chosen. For instance, wheat could be substituted for oats. A permanent agroforestry planting could take the place of permanent perennial forage on steeper slopes.

Landscape Impacts of Strategic Placement of Crop Rotations

In the same study, Iowa researchers modeled soil loss at the watershed scale for a region of 26 watersheds in western Iowa. Shifting the entire region to the cropping systems matched to slope was successful at reducing soil loss below T for the whole region; and also reduced nitrate-N leakage in all watersheds.

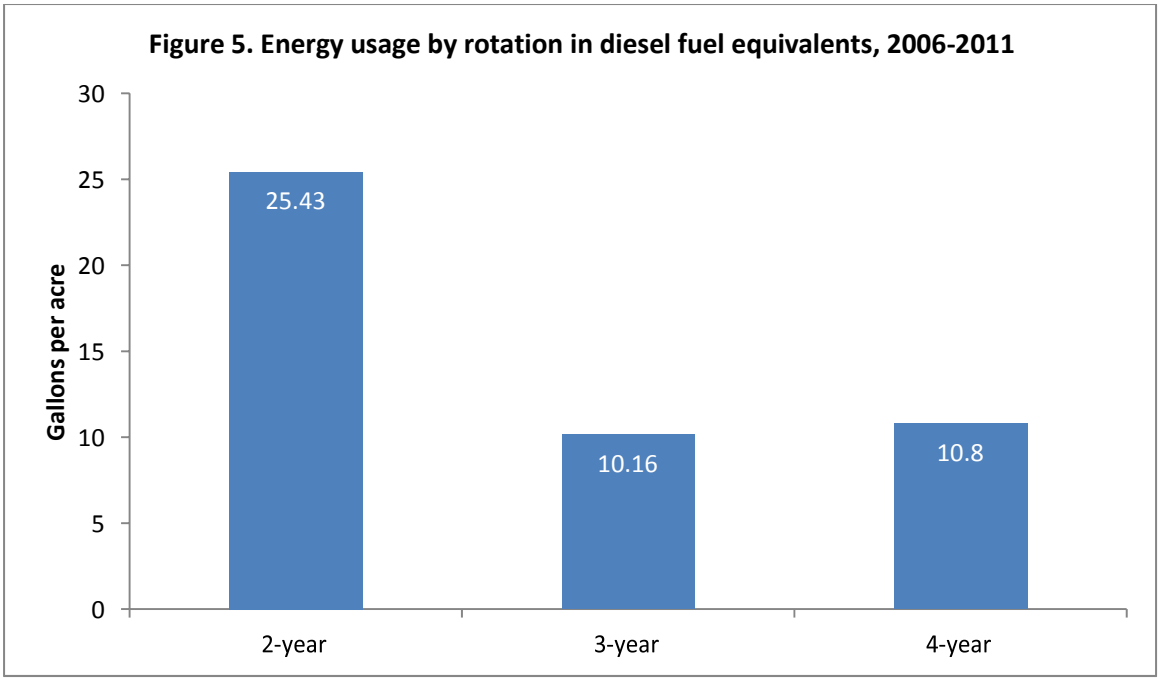
	Current system: heavily row-cropped	**Alternative system: matching cropping system to slope**
Annual soil loss range	2 to 10 tons/acre/year	0.5 to 2.5 tons/acre/year
Annual N leakage range	9 to 27 lbs./acre/year	< 9 to 18 lbs./acre/year

Reference:

Impacts of integrated crop-livestock systems on nitrogen dynamics and soil erosion in western Iowa watersheds. 2005. Burkart, M., D. James, M. Liebman, and C. Herndl. J. Geophys. Res., 110, G01009, doi:10.1029/2004JG000008.

Reduction in Purchased Inputs

The Iowa State University's Marsden Farm study showed a clear reduction in the amount of fossil fuel required for an extended rotation when compared to a two-year corn-soybean rotation. Figure 5 from the publication, "Energy and Economic Returns by Crop Rotation," is reprinted here:



The diesel fuel equivalent calculated for each rotation included the direct use of diesel fuel to run field equipment and the use of energy for grain drying; plus the energy embedded in other inputs: seed, N-P-K fertilizer, herbicides, insecticides.

Source: Energy and Economic Returns by Crop Rotation. Ann Johanns, Craig Chase, and Matt Liebman. 2012. http://www.leopold.iastate.edu/sites/default/files/pubs-and-papers/2012-09-energy- and-economic-returns-crop-rotation.pdf

Nitrogen Supply from Perennial Forage

A good stand of alfalfa on medium-textured soil can provide up to 190 lbs./acre of N to the subsequent corn crop. This amount is reduced if the stand is poorer or the soil is sandy.

Because breakdown of plant matter in the soil takes place gradually over time, the plowed-down alfalfa crop will also supply nitrogen to the second year of corn after the alfalfa is plowed down. The fair stand of alfalfa on medium-textured soil could supply 50 lbs./acre of nitrogen to the second-year corn.

Other legumes besides alfalfa can also supply significant N. Red clover and birdsfoot trefoil stands can supply approximately 80% of the N supplied by a comparable alfalfa stand. Sweetclover, red clover, vetch, and peas used as a plow-down crop also supply N.

See *Using Legumes as a Nitrogen Source* (below) for more detail about calculating the N credit from legume crops.

Source: Using Legumes as a Nitrogen Source. June 1997. L.G. Bundy, K.A. Kelling and L. Ward Good. University of Wisconsin Extension, publication #A3517. http://ipcm.wisc.edu/download/pubsNM/Usinglegumes.pdf

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Soil Health

Research at the University of Minnesota's Southwest Research and Outreach Center at Lamberton, MN showed a clear advantage to a four-year crop rotation in several measures of soil health.

In either a high-input or low-input system that included moldboard plowing, merely shifting from a two-year corn-soybean rotation to a four-year corn-soybean-oat+alfalfa – alfalfa system caused an increase in each of five indicators of soil health.

A change to a four-year rotation plus reduced tillage resulted in even larger increases in percentage of stable aggregates, total carbon, and microbial carbon.

Indicators of soil health measured in this study:

• Total organic carbon

an estimate of total soil organic matter

• Mineralizable nitrogen

a measure of the amount of plant available N that can be released over time from the soil organic matter

• Particulate organic matter

an estimate of "active" organic matter

• Large stable aggregates

A measure of how well the soil holds together. Aggregate stability affects workability, root growth, and water infiltration.

• Microbial biomass carbon

an estimate of the number of microorganisms in the soil

Source: Long-Term Effects of Crop Management: Soil Quality
http://swroc.cfans.umn.edu/prod/groups/cfans/@pub/@cfans/@swroc/documents/asset/cfans_asset_236360.pdf