Assessing Soil Quality of CRP and Grassland[1]

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Background

The Conservation Reserve Program (CRP) was established by the United States Department of Agriculture in the late 1980's. Some of the goals of CRP were to protect water quality of wetlands, diminish soil erosion, and enhance wildlife habitat. By landowners enrolling in CRP for long term contracts, some environmentally sensitive cropland was "set aside" from production. Not only did CRP enrollment protect soil quality, commodity market prices were propped up by diminishing the amount of grain flowing into the marketplace. During the late 1980's through mid-2000's commodity stocks were great enough that the extra land enrolled in CRP was not needed for production.

Starting in 2007 running through 2009, a large portion of CRP contracts in Wisconsin will expire. With the stronger commodity prices related to grain demand, many landowners are considering returning former CRP land to production. In these cases, the USDA has invested 10, 15, or even 20 years worth of payments into building the soil quality. A USDA websites indicated there currently is 530,000 acres enrolled in CRP in Wisconsin. Enrollment has been high in Winnebago County with just less than 9,000 acres. The four counties surrounding Lake Winnebago have a total of 32,000 acres enrolled in CRP.

Research and Education Objectives

1. Help CRP landowners determine if converting CRP to row-crops or pasture is a desirable land use.
2. Develop recommendations for transitioning CRP into production while protecting soil quality.
3. Help grazing farms better understand nutrient distribution and adjust nutrient management.

Materials and Methods

This study was designed to measure soil quality parameters such as organic matter, pH, available phosphorus (Bray1), available potassium, and water infiltration rates. Vegetative traits such as plant species present were also documented.

Owners of CRP contract lands were invited to participate in this study through a bulk mailing coordinated by the Farm Service Agency office in Winnebago County. More landowners volunteered to participate than there was funding for. A total of 28 properties were sampled encompassing 48 fields and 1200 acres. Data was collected from 150 total locations. Collection locations included privately-owned CRP land, public grassland managed by the US Fish and Wildlife Service and Wisconsin Department of Natural Resources, and pasture owned by dairy and beef grazing farm operators.

At sample locations, a soil probe was used to collect two composite samples within a 10-foot radius. Composite samples were collected to a one-inch and six-inch depth. Eight to ten cores were collected for each composite sample. Thatch layers were removed from cores prior to mixing. Soil samples were processed at the UW Soil and Forage Analysis Laboratory in Marshfield, Wisconsin.

Water infiltration data was collected at 42 locations. A 6" diameter water infiltration ring was inserted into the soil. The amount of time required to infiltrate two consecutive 1" precipitations was recorded. Plant species diversity and abundance were also documented at each location.

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Soil quality measurements were analyzed using STATISIX 9 software. Data was group for comparison in a few different manners. Data was grouped by soil properties. Three soil series were grouped as muck soils: Adrian, Houghton, and Willette. Four soil series were grouped as sandy soils: Brems, Nebago, Morocco, and Tustin. Three soil series were grouped as high organic matter (>6%): Kaukauna, Poy, and Zittau. The remaining fifteen soil series with less than <6% organic matter were grouped together. Kewaunee, Hortonville, and Manawa soil series were the most prevalent.

Additional comparisons were made between dominant vegetation types. Locations managed under grazing are identified as "pasture". Upland clay loam, loam, and silt loam locations were divided into "established prairie" where warm season bunchgrass species such as big bluestem, switchgrass, and Indiangrass were abundant or "cool season grasses" dominated by the rhizomatous smooth bromegrass and Kentucky bluegrass. "Reed canarygrass" was examined as a fourth vegetative category since it overwhelmingly dominated muck and high organic matter locations. Reed canarygrass is known to perform better than other grass species when the soil is poorly drained.

Results and Discussion

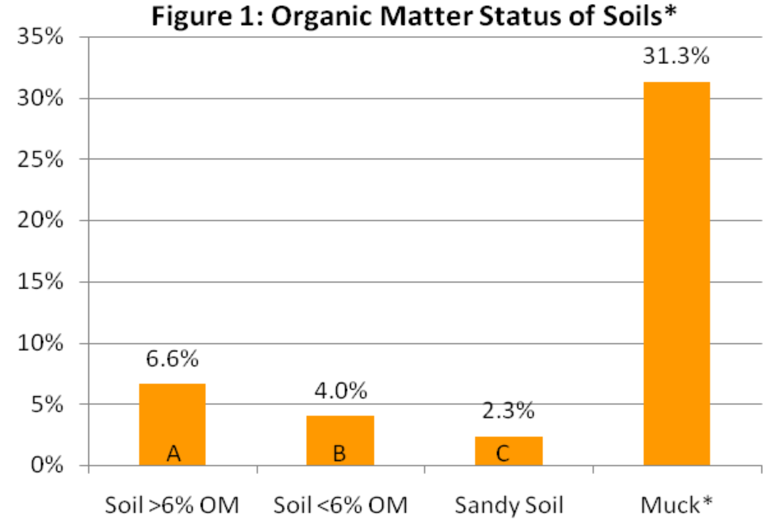
Since data is not available prior to establishment in grassland for the specific fields examined, soil quality data from the University of Wisconsin Soil Test Laboratory, http://uwlab.soils.wisc.edu/madison/, is used as the reference for comparison. From 2000-2004, the average soil in Winnebago County contained 3.8% organic matter, 52 ppm phosphorus, 134 ppm potassium, and a pH of 6.8. From 1986-1990, around the time of grassland establishment, the average soil in Winnebago County contained 3.8% organic matter, 38 ppm phosphorus, 125 ppm potassium, and a pH of 7.1.

Organic Matter

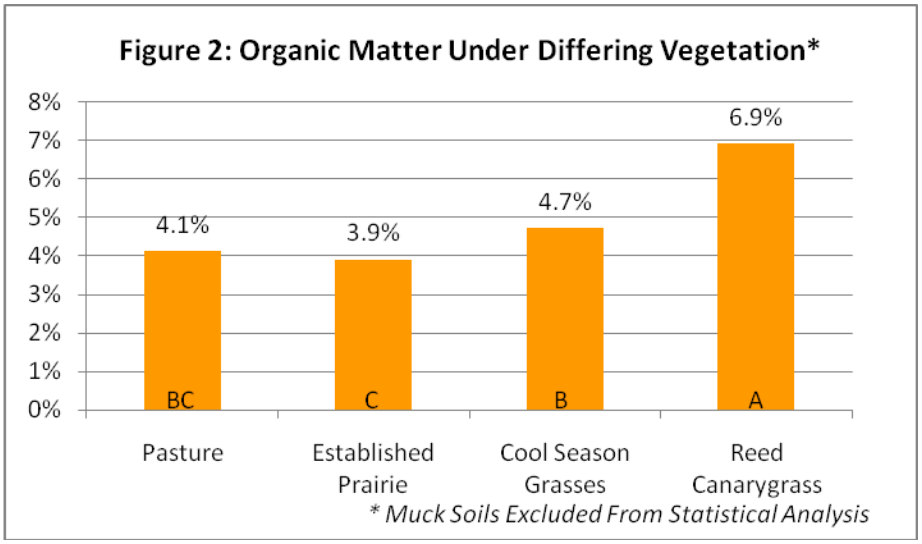
Grassland and CRP are often touted as a means to sequester carbon which has the potential to diminish atmospheric CO_2. Soil quality is significantly improved when carbon is held in the soil as organic matter. Muck soils clearly had the greatest percentage of soil organic matter with 31% and were dominated by reed canarygrass vegetation. Since muck soils clearly have different soil properties and are unlikely to be converted to cropland, a second group of analysis was preformed excluding muck soils. As demonstrated in Figure 1, soil group influenced the amount of organic matter with sandy soils containing the least organic matter and low-lying clay loam soils such as Zittau and Poy series with nearly three times as much organic matter. In Figure 1 and 2, data points with different letters are significantly different at a 90% confidence interval.

Figure 2 focuses more closely on vegetation types. Due to the close relationship between reed canarygrass and wet soil conditions, reed canarygrass locations clearly had the greatest organic matter. Pasture and established prairie had similar organic matter content at 4.1% and 3.9%, respectively. Locations with cool season grasses had a higher organic matter than prairie grass locations. Since Winnebago County has an average organic matter of 3.8%, these pasture and prairie grasses locations appear to be only slightly higher in organic matter than typical local soils. Data suggests organic matter in the upper six-inches of soil increases more with rhizomatous grasses than

Figure 1: Organic Matter Status of Soils*



** Muck Soils Excluded From Statistical* bunchgrass; however, the organic matter change at depths greater than six-inches is not known.



pH

While there were differences in pH, all soil and vegetation groups had appropriate pH for growing most crops, CRP, and forages. Sandy soils had the lowest pH at 6.5. The average pH of all other environments was between 6.8 and 7.4. While all fields should be soil sampled prior to transitioning to cropland, it is unlikely pH will create an obstacle to producing typical grassland or crop growth in Winnebago County.

Phosphorus and Potassium

Differences in fertility between soil groups and vegetation groups are shown in Table 1. Outliers with greater than 70 ppm P_2O_5 or 200 ppm K_2O have been removed from the statistical analysis conducted for Table 1. Ninety percent of the outliers were collected from high traffic pastures. These pastures will be discussed separately. Among soils, sandy soils were the only group to have greater phosphorus content. Pasture had greater phosphorus content than the other vegetation groups at 25 ppm. There is a close relationship between sandy soils and pasture because 86% of sandy soil samples were from pasture. Manure deposition from grazing livestock appears to have cycled phosphorus back to the soil efficiently.

Over all grassland environments examined, available phosphorus is much less than typical Winnebago County soils which averaged 52 ppm between 2000 and 2004. While soil fertility data is not available for these fields prior to grassland establishment, it is assumed there was some decline in available phosphorus where no livestock is present. The University of Kentucky found similar results in CRP research with pH and potassium remaining relatively constant during 10 years while phosphorus dropped considerably (Johnson and Quarles). According to interpretation categories established by “A2809 Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin” 55% of locations had soil test phosphorus below optimum for corn grain or other similar nutrient demand crops.

Soils with less than 6% organic matter had the highest available potassium at 112 ppm while muck soils had the least potassium with 63 ppm. Locations with cool season grasses had more available potassium than all other vegetation types. When high traffic pastures were removed from analysis, all remaining pastures and locations with established prairie or reed canarygrass had similar potassium between an average of 84 and 89 ppm. On average, potassium content was optimum for growing most crops; however ¾ of samples with “low” or “very low” potassium were collected from pastures. Considering numerous low potassium samples and the high fertility outliers were from pastures, data indicates uneven nutrient distribution on grazing farms. Samples collected from pastures had a standard deviation for phosphorus and potassium twice as large as the other vegetation types; thereby confirming greater nutrient variability across pastures. Overall soil test potassium was modestly lower than the county average of 134 ppm; however this would not create a crop production challenge for corn grain at most locations because less than ¼ of locations had below optimum potassium.

Samples collected near barns or close to pasture gates frequently had excessively high nutrient contents. Phosphorus was as high as 170 ppm and potassium as high as 500 ppm in these locations. Based on stocking rates, between five and twelve tons of manure per acre should have been deposited on pastures if evenly distributed. The average nutrient credit from manure was 26 lbs/a nitrogen, 30 lbs/a phosphorus, and 60 lbs/acre potassium.

Table 1. Phosphorus and Potassium of Soil and Vegetation Groups

Soil Group	P_2O_5 (ppm)	K_2O (ppm)
Soil >6% OM	19	90*
Soil <6% OM	19	112**
Sandy Soil	38*	85*
Muck	12	63
Vegetation		
Pasture	25*	86
Established Prairie	16	84
Cool Season Grasses	16	110*
Reed Canarygrass	15	89

***,* Indicate significant differences at P(0.10)*

Soil Stratification

Nutrient, organic matter, and pH stratification was common throughout sample locations; however, there was considerable variability between sampling locations. On average, organic matter was 25% higher in the top-inch of soil compared to the six-inch sample depth. Muck soils had 7% more organic matter in top-inch, sandy soils had 18% more organic matter in the top-inch, soils with less than 6% organic matter had 25% more organic matter in the top-inch, and high organic matter soils had 31% more organic matter in the top-inch. Excluding mucks, soils with higher 6" organic matter had greater accumulation of organic matter near the soil surface. This may be related to poorly drained conditions most often found in these soils which slow the rate of organic matter decomposition. Vegetation type did not influence organic matter stratification at top-inch to six-inch depths.

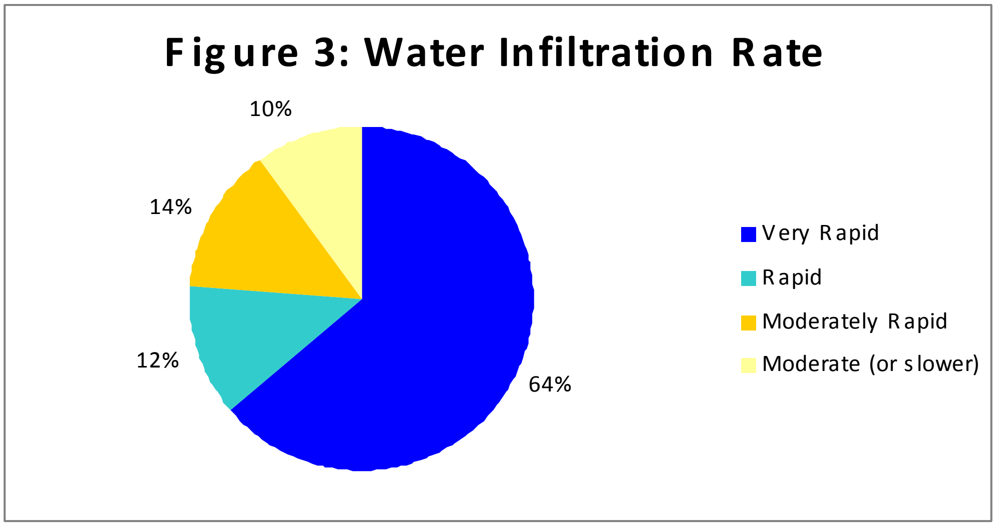
Nutrient stratification was consistent across soil types and vegetation groups. All soils averaged 36% more available phosphorus in the top-inch of soil compared to a six-inch sample. Similarly, potassium averaged 28% higher in the top-inch of soil regardless of soil type or vegetation. This stratification indicates deeper nutrient placement is important if fertilizing for crop production but special nutrient application strategies are not needed based on soil group or grassland vegetation type. High traffic pastures and other outliers had a different stratification pattern than the other soils. Phosphorus was 9% less at the six-inch depth and potassium was 5% more. Hoof action or leaching of nutrients from manure may have contributed to the more consistent nutrient distribution across depths at these locations. Analysis indicated there were slight differences in stratification of pH; however, the difference from the top-inch to a six-inch sampling depth was less than 0.2 pH. Considering most soils had a pH near neutral, special management for addressing pH stratification would not be necessary in these soils.

Infiltration Rates

Water infiltration rates, based on the second inch of water application, were very rapid. Table 2 describes the soil permeability classes historically used in soil surveying (USDA). Water inflitration was rapid or very rapid at 76% of the locations (Figure 3). Rapid infiltration is a good indicator of high porosity. Macropores and worm channels facilitated rapid water infiltration.

Table 2. Water Infiltration Rate and Class Guide

Infiltration Rate (minutes per inch)	Infiltration Rate (inches per hour)	Infiltration Class
<3	>20	Very Rapid
3 to 10	6 to 20	Rapid
10 to 30	2 to 6	Moderately Rapid
30 to 100	0.6 to 2	Moderate (or slower)



Management Recommendations

For Continuing in Grassland

CRP and grassland soils have modestly less nutrients than other lands; however, additional nutrients should not be needed if crop production is not planned. Grasses, forbs and legumes develop extensive root systems able to absorb nutrients from much lower in the soil profile than the six-inch sampling depth used in this study. While phosphorus frequently was low for corn production needs, 2/3 of the locations had optimum or higher phosphorus for CRP.

Continuing to avoid soil disturbance will allow earthworm and other soil organism to maintain excellent soil structure and digest organic matter. Earthworm population and soil organism communities are greater in untilled environments.

Control undesirable plant species. Numerous non-grazed locations had invasive plants such as Canada thistle, wild grape, and box elder. Follow herbicide recommendations in “A3646 Pest Management in Wisconsin Field Crops”, mow field borders or weed patches, and utilized prescribed burns in accordance with local laws and NRCS recommendations.

For Pasture

Invest in good perimeter fence. Interior fence can be adjusted later but perimeter fence is essential to establishing a long term grazing system. Utilizing Managed Intensive Grazing with frequent rotations helps improve performance of pasture. Seek assistance from a grazing planner to properly design the grazing system. Evaluate the forage species present and establish legumes or highly digestible grasses if they are lacking. Herbicide options such as fluazifop and sethoxidim are available to suppress grasses in preparation for interseeding legumes (Renz). pH should not be a problem for establishing pasture legumes. Most locations also had optimum or better potassium. If planting new legumes into the area, a starter phosphorus application may help improve establishment vigor, especially on areas where no manure has been deposited for numerous years. Once under active grazing, phosphorus should maintain from the manure.

Managing manure and nutrient distribution is challenging on grazing farms. Nutrients tend to be highly concentrated in pastures near the farmstead, near gates and lanes, and near water or shade yet can be very low in distant parts of a pasture. Some strategies that may help improve nutrient distribution include:

- Use portable water sources.
- Move animals frequently.

- Keep paddock sizes small.
- Move animals through pasture rather than lanes when weather permits.
- Have designated sacrifice areas where manure can be scraped and re-spread.
- Rotate outwinter and feeding areas.
- Apply fertilizer according to A2809 recommendations.

For Organic Certification
Former CRP land may be convenient locations for organic certification since disallowed inputs likely have not been applied for three years prior to transitioning. If herbicides, many commercial fertilizers, or treated seeds of any type had been applied to the land within three years, land will not be eligible for organic certification. There are a few dilemmas with converting former CRP into organic land. Since there will likely be undesirable vegetation, weed control will be difficult without herbicides. This may force an organic farm operator to resort to tillage to clear invasive plants, which will destroy much of the soil quality gains achieved while in CRP. Grazing or forage production may be the organic practice best suited for maintaining soil quality. Low phosphorus will also create a problem. Since there are few organic phosphorus fertilizer sources, manure applied over numerous years may be needed to bring the soil phosphorus to optimum levels.

For Converting to Row Crops
Ask “Why was this land enrolled in CRP in the first place?” Fields were entered into CRP for a variety of reasons. Most often it was to reduce erosion or address water concerns. Considering Winnebago County has numerous somewhat poorly drained and poorly drained soils, it is likely many of the CRP fields were enrolled because of repeated soil wetness problems. When factoring the low soil fertility and potential moisture problem of some fields, it might not be worth the hassle and cost to convert them back to cropland. Collect soil samples prior to killing the existing vegetation and prepare an example nutrient management plans in order to assess the cost of nutrients needed for optimum crop production.

Consider using no-till planting. This may be counter-intuitive, but leaving the land untilled will help water infiltration. Sixty-four percent of soils had 1” of water infiltrate in less than 3 minutes. Earthworms have invested twenty years of effort to build soil porosity. Many soil quality gains related to porosity will be destroyed or altered by tillage. Numerous research summaries and no-till farmers recommend no-till as an excellent way to return these fields to crop production. Research in Grant County, WI determined no-till was a “satisfactory practice” to convert CRP land to corn, provided the effects of grass residues were minimized (Wolkowski). In some locations, surface roughness will be too great for no-till planting; thereby requiring tillage. If no-till is not an option, consider strip-tillage. Surface residue problems may be alleviated by strip-tillage.

Strategies for converting to cropland (Johnson and Quarles, Loux et. al, Eggers):
1. Try no-till for one year before deciding tillage is required.
2. Leave buffers around streams, field edges, and grassed waterways in place.
3. Mow in late summer the year before planting. Check with the USDA office to ensure this is not in violation of CRP contract obligations.
4. Scout for legume content. If legumes are present, it may reduce your nitrogen requirement. If only grasses are present, some nitrogen may be tied up in decomposition next spring.
5. Spray with a burn-down herbicide early in fall when regrowth is between 6” to 12”.
6. Once plants are decaying, smooth out anthills and clumps of vegetation with a drag or very lightly surface disk.
7. Corn, soybeans, and small grains can all be successfully established with no-till. From an ease of establishment perspective, a CRP-soybean-corn-soybean recommendation is given by the University of Nebraska (Shapiro).

8. Check planter set-up carefully. Consider hiring a custom no-till operator.
9. Increase plant population slightly in case of erratic seed placement and insect feeding.
10. Use a 2X2 starter placement because nutrients are already 1/3 higher in the top inch of soil.
11. Use an insecticide seed treatment to protect against pest such as white grubs and wireworm, which may be more abundant in killed sod.
12. Select a variety with herbicide tolerance to control difficult perennial weeds that may emerge.
13. Corn hybrids with Bt protection against cutworm or armyworm may be helpful since they are attracted to grass residues and weeds, but corn rootworm protection should not be necessary.
14. Nitrogen availability can be erratic coming out of CRP. If planting soybeans, they should be inoculated. In corn, use an in-season nitrate test to determine if additional nitrogen will help yields.

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