CRP TO CROPLAND: POTENTIAL LOSS OF CRP SOIL QUALITY BENEFITS

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Introduction and Background

The Conservation Reserve Program (CRP) was implemented in 1985 to protect environmentally fragile or highly erosive crop land from degradation and carbon loss to the atmosphere (CAST, 1992). Currently there are approximately 36 million acres, 8% of the nation's cropland, in the CRP program (FSA, 2006). Ethanol production, and the subsequent need for corn for the ethanol industry, may take land from CRP programs, potentially threatening the beneficial effects of the CRP program on soil quality. Here I'll present possible changes in soil quality resulting from putting CRP land into production.

Current ethanol production is approximately 4.4 billion gallons/year and is expected to increase to 6.5 billion gallons/year by the end of 2007 (Baker and Zahniser, 2006); an increase requiring 2.6 billion additional bushels/year of corn or 17.3 million acres of corn (at 150 bushels per acre). The competition for corn will naturally drive up corn prices, outweighing CRP payments, and provide incentive for producers to take land out of the CRP program. Each year over the next several years, 10 to 15% of CRP contracts are up for renewal, potentially 55% or approximately 20 million acres of CRP land could be lost (FSA, 2006) (Fig. 1). With this proportion of conservation land lost from the CRP program, it's important to assess the consequences for soil quality.

The definition of soil quality changes based on differing perspectives. One perspective on management for soil quality is management or "farming" for a healthy soil community. Some common measures of soil quality are percent organic matter, amount of organic carbon, amount of total carbon and nitrogen, amounts of microbial carbon and nitrogen, water content, infiltration rates, and aggregate stability (strength of the soil structure). Symptoms of a 'nonquality' soil or poor soil management could be erosion, nutrient leaching, poor water infiltration, or poor aggregate stability. What is behind these measures of soil quality? What builds soil quality? The answer to these questions is the growth and activity of soil organisms (Balser, 2004; Sylvia et al., 2005). Macrofauna such as moles and earthworms physically degrade and move soil and plant residues. This physical degradation increases surface area and ease of chemical degradation for smaller organisms such as bacteria and fungi to further degrade plant residues eventually into organic matter in the soil. Another physical aspect of microbial growth and organic matter is that organic matter and microbial residues act to "glue" soil particles together to create more stable aggregates. Ribbon-like fungal hyphae of also act to physically bind particles together. The resultant aggregation and aggregate stability from organic matter and fungal growth in turn act to reduce erosion, improve water infiltration, and feedback to improve the habitat for microbial growth. Another positive benefit of organic matter for soil structure and soil habitat is that, like a sponge, organic matter helps to hold nutrients (improved cation exchange capacity) and water.

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CRP and Soil Quality

Current evidence from a large body of research suggests that the CRP program is successful at improving soil quality in terms of organic matter (measured as organic carbon), microbial biomass, and soil physical characteristics (Karlen et al., 1998). Physically, soil bulk density has been shown to decrease in CRP lands (Baer et al., 2002) as well as increased resistance to erosion (Huang et al., 2002). A detailed look at these benefits will set the stage for examining how CRP benefits are lost when land is removed from the program.

Soil organic carbon (SOC) is a common measure of soil quality, as discussed in the introduction, and is a good index of the amount of organic matter in the soil (more organic carbon means more organic matter). SOC increases significantly at CRP sites versus crop land (Gebhart et al., 1994; Follett, 1997; Reeder et al., 1998; Follet et al., 2001; Lal et al., 2003), potentially sequestering 535 to 800 lb C/acre/yr (Follet et al., 2001), although some studies have shown little or no statistically significant increase in SOC (Huggins et al., 1997; Staben et al., 1997; Robles and Burke, 1998; Karlen et al., 1999; Huang et al., 2002). Microbial biomass and residues also increase in CRP versus cropland (Follett, 1998; Huggins et al., 1998; Karlen et al., 1998; Karlen et al., 1999; Amelung et al., 2001; Baer et al., 2002). Microbial activity, measured as carbon mineralization (the conversion of organic carbon into carbon dioxide through respiration) or nitrogen mineralization (the conversion of organic nitrogen such as protein into nitrate or ammonium), are also higher in CRP grasslands versus cropland (Schumaker et al., 1995; Reeder et al., 1998; Robles and Burke, 1998; Karlen et al., 1999; Baer et al., 2002).

Time could be a major factor in the level of SOC accumulation in CRP lands, as suggested by evidence that even when SOC is higher in CRP vs. cropland, SOC (Gebhart et al., 1994; Huggins et al., 1998) and microbial biomass (Amelung et al., 2001) are still significantly lower in CRP land compared to native grasslands. In addition there is evidence that SOC accumulation increases in CRP and fallow land over time (Burke et al., 1995; Baer et al., 2000; Baer et al., 2002; Murphy et al., 2006) suggesting that long term CRP enrollment may be needed to increase SOC back to native levels. Soil characteristics such as topography, climate, and texture may influence the degree to which organic carbon is sequestered in CRP lands (Follett 1998); for instance Reeder et al. (1998) found less relative carbon sequestration on clay loam vs. sandy loam soils, and Staben et al. (1997) found less accumulation on semi-arid lands that may be slower to accumulate organic matter. A third cause of variance in carbon sequestration on CRP versus croplands is microbial activity. An increase in carbon mineralization (conversion of organic carbon into carbon dioxide from microbial activity) as suggested by many studies may be the cause of low overall increase in organic carbon at some CRP sites (Staben et al., 1997; Robles and Burke, 1998; Karlen et al., 1999).

Another major measure of soil quality is the amount of nitrogen and microbial nitrogen transformations. Similar to organic carbon, total organic nitrogen is higher in CRP than cropland (Staben et al., 1997; Reeder et al., 1998), although the significance of this increase varies and is sometimes less significant statistically (Robles and Burke 1998). Inorganic nitrogen may be lower in CRP land (Baer et al., 2000; Baer et al., 2002), suggesting that microbial and plant efficiency at using and recycling nitrogen are higher in CRP lands, thus indicating a healthy soil community.

Removal of Land from CRP

There is a smaller but convincing body of research on the effects on soil quality on expired CRP land, all showing that soil quality gains from CRP are quickly lost. (Gilley and Doran 1997, Gilley et al. 1997, Gewin et al., 1999; Gilley et al. 2001; Dao et al. 2002). Gilley and Doran

(1997) found that 9 months after tilling CRP land in northern Mississippi, sediment loss had substantially increased and soil quality indicators including bulk density, total carbon, and microbial C and N decreased to levels similar to that of long-term cropped land. Similar results were reported for southwest Iowa (Gilley et al., 1997), Nebraska, South Dakota, and another Mississippi site (Gilley et al., 2001). Semi-arid Oklahoma soils show a similar increase in erosion when taken out of CRP management, but there is a smaller loss of organic carbon (this site had also shown smaller increases overall on CRP land compared to cropland) (Dao et al., 2002). At four sites in Washington State, Gewin et al. (1999) found that although the sites all had unique responses to being taken out of CRP management, all the sites quickly lost organic carbon.

Management to Preserve the Benefits of the CRP on Soil Quality

For the preservation of soil quality on expired CRP land, there is strong evidence that no-till should be used. Several studies have reported less SOC loss or degradation of soil quality when CRP land is cropped with no-till management (Shumacher et al., 1995; Karlen et al. 1996; Gilley and Doran 1997; Gilley et al. 1997; Follett ,1998; Huggins et al., 1998; Gewin et al., 1999; Dao et al., 2001) (although it may be difficult to fully keep SOC at CRP levels when returning the sites to cropland (Huggins et al., 1998). For instance, Gewin et al. (1999) found the least organic carbon lost in spring direct seed (no till) treatments as opposed to other tillage treatments.

Conclusions

It is well established that the CRP program enhances soil quality, although to varying degrees that may be due to time in the program, soil type, or microbial activity. The benefit of CRP management for soil quality also increases over time, and may take up to 50 years to reach native grassland levels of organic carbon and microbial biomass. Although it takes time and investment to improve soil quality parameters through the CRP program, the benefits could be quickly lost depending on the management practices. For instance, Gilley and Doran (1997) found that in 9 months, organic carbon levels had decreased to that of pre-CRP levels. Given these considerations, the best practice in easily degraded CRP lands is to keep them planted with perennial vegetation such as in CRP. If necessary to put these lands back into crop production, low disturbance tillage such as no-till should be employed.

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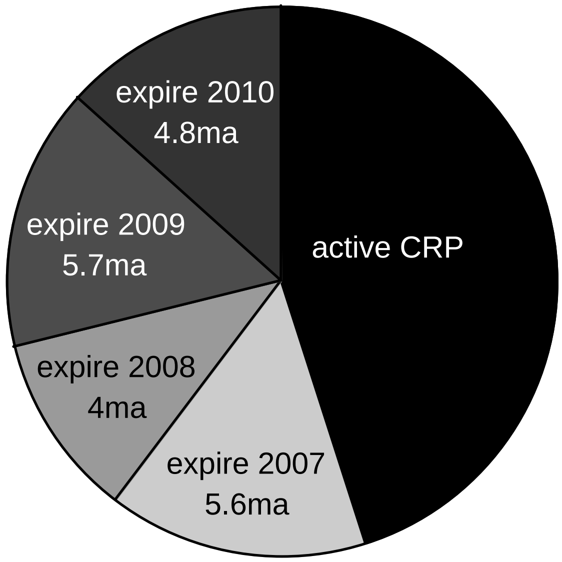
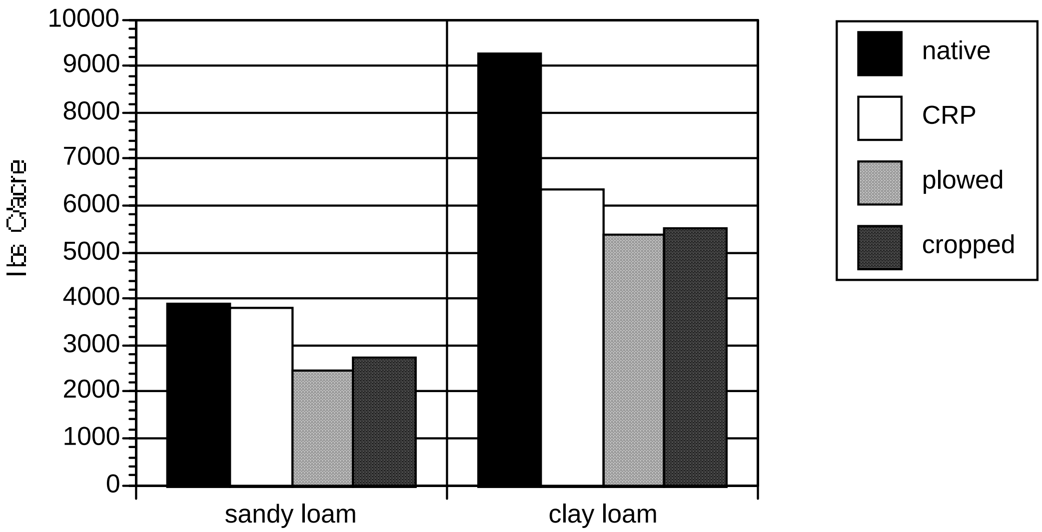
Figure 1: National CRP acreage potentially expiring by 2010
Current active CRP= 36.7ma nationally



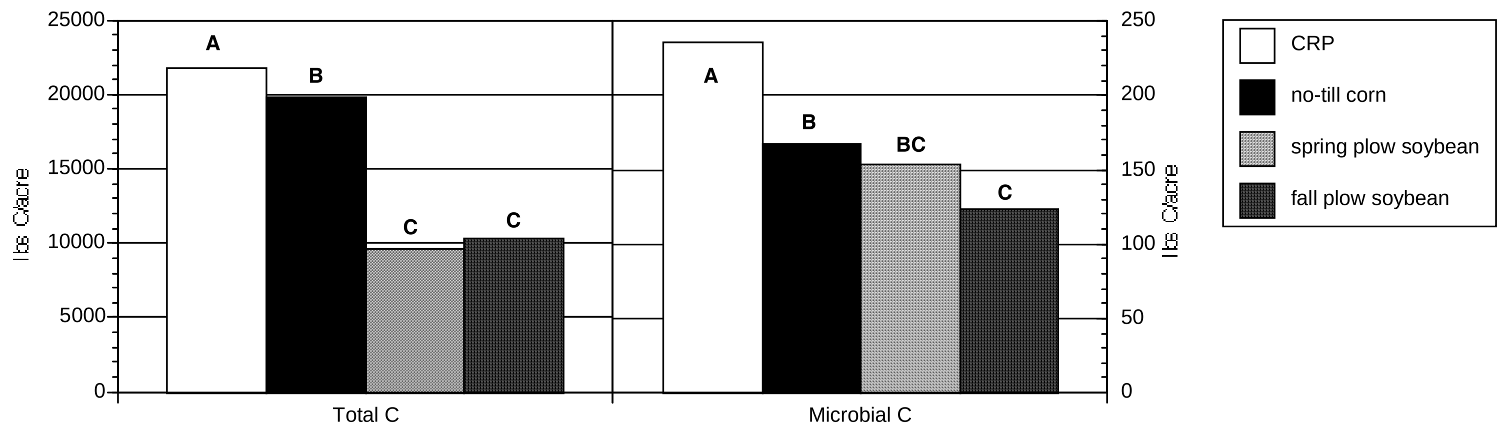
Adapted from FSA (2006)

Figure 2. Increase of organic carbon in CRP vs. cropland



Adapted from Reeder et al. (1998)

Figure 3. Tillage effects on soil and microbial carbon after CRP removal



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