Soil Quality Considerations in the Conversion of CRP Land to Crop Production

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INTRODUCTION

Soil quality not only effects productivity, but is also related to the health of other resources including air, water, plants, and animals. The National Research Council (NRC, 1993) in their book on soil and water quality stated "protecting soil quality, like protecting air and water quality should be a fundamental goal of national policy." They suggest enhancement of soil quality should be the first step toward increasing water quality.

In this paper, I will briefly discuss the concept of soil quality, the beneficial effects of CRP on soil quality, concerns of returning CRP land to crop production, and conclude with a discussion of alternative systems to protect the soil quality benefits obtained from ten years of grass cover.

SOIL QUALITY CONCEPT

Soil quality is a composite picture of the condition of a specific soil to function for a specific use. Simply put, soil quality is *the capacity of a soil to function* (Pierce and Larson, 1993; Karlen et al., 1997). Soil quality, as defined, is an integration of the kind of soil, its natural ability to function, and its use and management. The functions of soil are (Karlen et al., 1997):

1. Sustaining biological activity, diversity, and productivity;
2. Regulating and partitioning water and solute flow;
3. Filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposition;
4. Storing and cycling nutrients and other elements within the earth's biosphere; and
5. Providing support of socioeconomic structures and protection for archeological treasures associated with human habitation.

Soil quality encompasses two general points of view: (1) an inherent property of a soil; and (2) the dynamic nature of soils as influenced by human use and management decisions (Larson and Pierce, 1991; Pierce and Larson, 1993). Inherent properties of a soil are an integration among the factors of soil formation--climate, topography, vegetation, parent material, and time (Jenny, 1941). Each soil, therefore, has an innate capacity to function, e.g., all other properties being equal, a loamy soil has higher water holding capacities than a sandy soil; thus the loamy soil has higher inherent quality for storing water.

The second view of soil quality is an integration of the kind of soil, its natural ability to function, and its use and management. This view is often referred to as soil health and is the focal point for the assessment of soil quality (National Research Council, 1993; Doran and Parkin, 1994; Larson and Pierce, 1991, Larson and Pierce, 1994; Harris and Bezdicek, 1994; Acton and Gregorich, 1995; Karlen et al., 1997). For example, a loamy soil has an inherent capacity to store water, but this capacity can be limited by management practices that cause compaction, lower organic matter content, or reduce aggregate stability.

Proposed methods for measuring soil quality use soil properties or indicators that reflect the capacity of soil to function (Larson and Pierce, 1991, Pierce and Larson, 1993, Doran and Parkin, 1994) as illustrated in figure 1. In this paper, I use selected indicators to show how CRP has affected soil quality.

BENEFICIAL EFFECTS OF CRP ON SOIL QUALITY

About 55% of the 36.5 million acres of CRP lands are located in the Great Plains (Lindstrom et al., 1994). One of the main purposes for the CRP program is to protect the environment from excessive soil erosion and sedimentation of streams and lakes. Therefore, a main impact of CRP on soil quality is the reduction in erosion which is estimated to be an average of 19 t ac^{-1} for land enrolled in CRP (Lindstrom et al., 1994). Other positive benefits CRP may include higher organic matter, better aggregation, increased pore space associated with water held at field capacity, and structural improvement. Lindstrom et al. (1994) cited studies showing improvements in soil structure as soon as 3 yr after CRP but mentioned it takes about 10 to 12 yr to reach maximum benefit of grass cover.

Gebhart et al. (1994) studied soil organic carbon levels in CRP land, adjacent crop land, and native pasture in Texas, Kansas, and Nebraska. After 5 yr of CRP, the soil averaged 21% more organic carbon than adjacent crop land. Native pastures had the greatest amount of soil organic carbon. Their results fit with other studies that show it takes about 50 to 60 years of grass sod system to fully recover soil organic matter levels after intensive cropping. Others (Karlen et al., 1996; Allan, et al., 1996) showed little difference in total soil organic carbon between CRP and adjacent cultivated land in Iowa and Minnesota, but found significant differences in soil biomass carbon and microbial respiration. In cases where total organic carbon was not significantly higher in CRP, residue management and reduced or no-tillage was practiced in the cropped areas. In Iowa, fungal hyphal length and ergosterol concentration were significantly higher for CRP than for cultivated areas. Percentage of water stable aggregates were higher in CRP than in cropped areas for both states. Bulk density was generally lower in CRP areas than in cropped areas for both IA and MN. Allan et al. (1996) suggest that labile carbon pools quickly build up in CRP to permit larger aggregates and greater aggregate stability than in cropped areas.

Gilley et al. (1997) showed that runoff was significantly less on undisturbed CRP plots than on no-till CRP or moldboard plowed CRP land. They also showed significantly less soil loss on CRP and no-till CRP plots as compared to moldboard plow plots.

Zobeck et al. (1995) discussed the differences of soil properties among grass sod, newly cultivated sod and a continuously cultivated Amarillo fine sandy loam in Texas. They showed grass sod had higher organic carbon levels and aggregate stability and lower clod density in the surface layer than the other treatments. The effects of grass sod on aggregate stability persisted after 7 years of moldboard plowing when compared to the continuously cultivated plot.

CONCERNS OF RETURNING CRP LAND TO CROP PRODUCTION

Many studies have shown dramatic decreases in soil organic matter in the surface layer in very short time periods when grass sod is moldboard plowed (Lindstrom et al., 1994, Gilley, et al., 1997, Karlen et al., 1996). Lindstrom et al. (1994) found that carbon losses in 19 days after plowing were greater than carbon contained in the stubble of the previous wheat crop and that C loss was directly related to tillage intensity. They also suggest that the break down of pore continuity is among the first changes that occur with tillage of grass sod. Break down of the macropore structure resulted in increased runoff with tillage of sod areas. The break down of the macropore structure was avoided in no-till systems. The rapid loss of organic matter is also controlled by no-till systems. However they state that the degree to which no-till can prolong the benefits of grass sod is not known. The study by Zobeck et al. (1995) showed that after 7 years of continuous moldboard plowing of grass sod that organic matter contents in the surface layer were the same as the surface of the continuously cultivated plot.

Gilley et al. (1997) showed that cropping of CRP land and tillage management affected the soil surface layer by decreasing the total soil organic matter content and infiltration rate, and increased soil loss and soil nitrate-N contents. Increases in nitrate-N contents in the moldboard plow plots is interpreted as a negative effect on soil quality because of higher potentials for losing N from leaching or runoff. Soil loss in no-till systems was low and close to values from CRP land. Soil organic matter was less on no-till areas than CRP but significantly higher than the moldboard plow sites. They showed that in only one year after moldboard plowing CRP, most of the beneficial effect of CRP to soil quality had been lost. In a study in Mississippi, Gilley and Doran (1997) showed a 28% loss in soil organic carbon, a 57% loss in microbial C, a 70% loss in microbial N, and a 78% decline in mineralizable N within 9 months of moldboard plowing a CRP site.

ALTERNATIVES SYSTEMS TO PROTECT SOIL QUALITY BENEFITS

Many studies have indicated that no-till systems are desirable for maintaining the benefits of CRP in cropped areas (Lindstrom et al., 1994; Gilley et al., 1997; Karlen et al., 1996). Reasons for using no-till are to reduce the rapid decline in organic matter contents caused by moldboard plowing, to maintain the continuity of macropores and stability of soil aggregates, and to protect the soil surface from excessive runoff and soil erosion. Karlen et al. (1996) suggest that in Iowa no-till should be used to protect the benefits of CRP land but also suggested use of cover crops to help cycle excess nitrogen during the non-growing period and to maintain soil organic matter levels, as well as use of buffer strips, narrow strip intercropping, and other conservation practices that help reduce slope length.

No-till systems react differently in different climatic regimes with respect to soil quality benefits. In the semiarid southern Great Plains, Jones et al. (1994, 1995) describe the effects of no-tillage on soil characteristics. In these areas no-till systems have higher runoff because of limited amounts of surface residues and subsequent surface sealing crusts. However, even though no-till had lower infiltration rates than stubble mulch systems, water erosion was not significantly different and available water content was higher in no-till than stubble mulch presumably because of lower surface water losses from no-till. They concluded, because of the increased water contents of no-till systems nitrogen leaching may be a potential environmental concern. They also showed that increased runoff from no-till did not appear to be a potential problem for pesticides in runoff waters. They conclude that more intensive cropping with less fallow may be possible using no-till management.

Unger (1994a,b) studied the effects of tillage systems and residue management for winter wheat and grain sorghum production in the Southern Great Plains and showed that a wide range of tillage systems is adapted for the region and the use of practices that retain surface residues such as no-till are effective in areas under limited irrigation conditions. Unger (1968) concluded that tillage systems were important on wheat fallow systems and, of the systems studied (one-way, stubble-mulch, and delayed stubble-mulch), that delayed stubble mulch system resulted in the highest soil organic matter contents. He showed that continuous wheat had 25% higher soil organic matter contents that the wheat-fallow cropping system.

SUMMARY

Soil quality is simply the capacity to function. Critical functions for agricultural production include sustaining productivity and biological activity, regulating and partitioning water flow, filtering and buffering, and storing and cycling nutrients. Important indicators of the capacity of the soil to function include soil organic matter contents, microbial biomass, aggregate size and stability, soil erosion, and mineralizable N and C. The effects of CRP were to increase all of the values of these indicators while reducing runoff and erosion. Concerns of returning CRP to crop production include the rapid loss of soil organic matter, increases in runoff and erosion, and loss of aggregate and continuity of soil macropores.

Use of no tillage systems is recommended for maintaining the benefits derived from CRP. Short of no tillage, other systems that minimize the use of tillage and maximize the maintenance of residues on the soil surface are recommended. In addition practices such as the use of cover crops, where feasible, sod based rotations, buffer strips, and other conservation practices related to erosion control and maintenance of soil organic matter contents are also recommended to help maintain CRP benefits.

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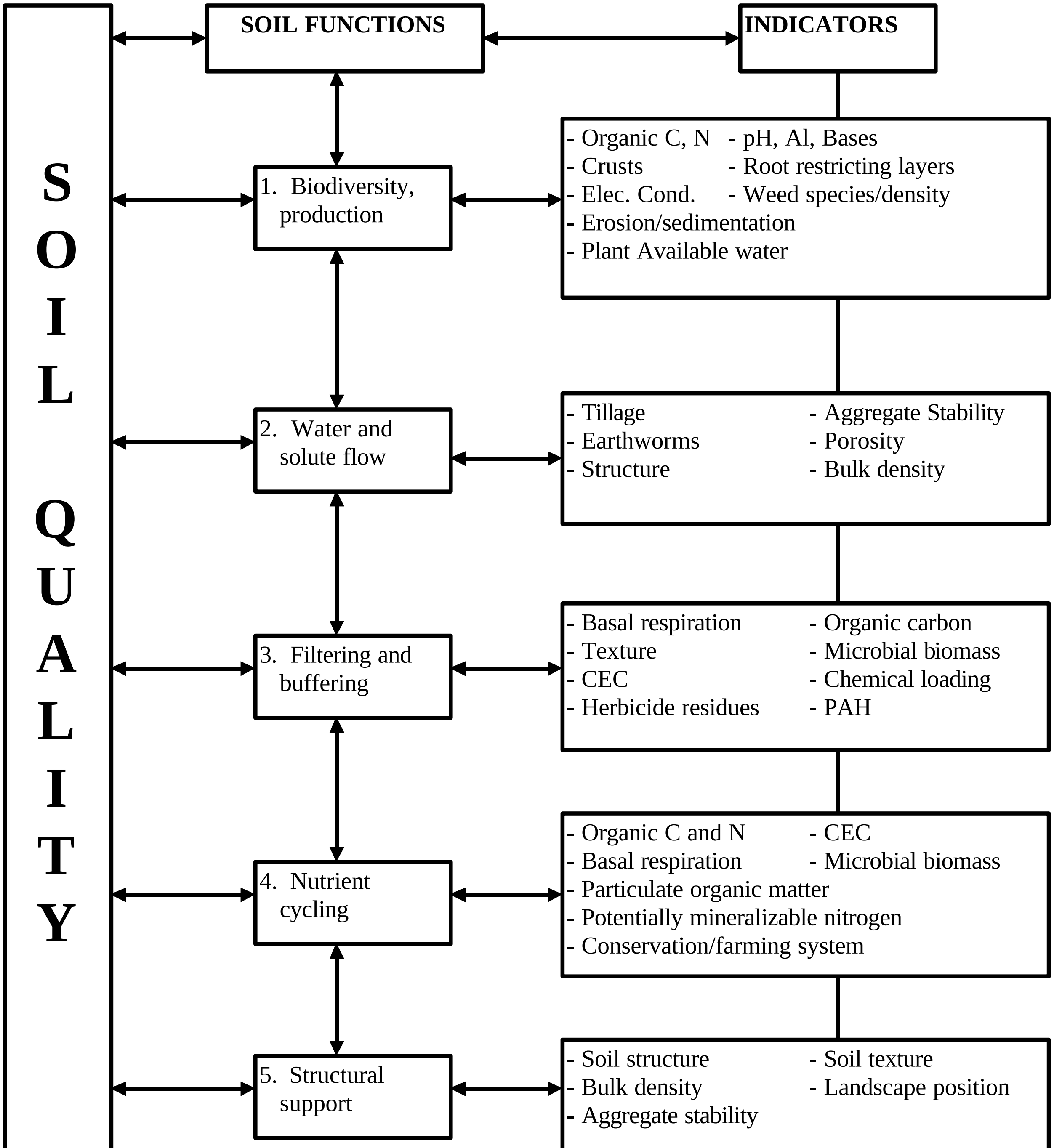

Figure 1. Graphical representation of the concept of soil quality using soil function and indicators of soil quality (after Seybold et al., 1996).