LAND USE BIODIVERSITY INDEX AS A SOIL QUALITY INDICATOR

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ABSTRACT

Decreases in land cover diversity can lead to decreases in soil quality. This study proposes using the National Resources Inventory (NRI) to develop a biodiversity index as a biological indicator of soil quality. Index values for Major Land Resource Areas in the southeastern United States were calculated using land-use based upon whether the Primary Sampling Unit was either 1) all cropland, 2) multi-cropped, 3) cropland with at least one non-cropland use, or 4) cropland having some vegetative diversity (cover crop, buffer strip, etc.). Forestland and range/pasture land-uses provided high biodiversity index values for most of the southeastern United States. Cropland enrolled into the Conservation Reserve Program was attributed with the increase from 1982 – 1997 of those acres with a score of 4. Irrigated cropland tended to have lower index values than non-irrigated cropland. Corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Max.] seed yields tended to decrease as index values increased. Using the NRI did show promise for developing a biodiversity index.

KEYWORDS

Southeastern USA, soil resources, row crops, soil quality

INTRODUCTION

Approximately 20,000 plant species worldwide are used by humans for food and medicines (Pimental *et al*., 1997). However, market conditions have reduced the number of major crops to less than 15. Currently, rice, corn, and wheat comprise 60% of the world's food supply (Wilson, 1988). It is this monoculture production style or lack of land cover diversity that has led to nutrient leaching loss, invasion by weedy species, and high incidences of diseases and pests – all of which decrease soil quality.

Conserving land cover diversity helps in organic waste disposal, N_2-fixation, biological control of pests, plant pollination, and agriculture sustainability. Increases in human population and activities are decreasing natural habitats that many species require for their existence. Some threats to United States agriculture are the results of the loss of pollinators and natural enemies of pests. Effective policies and conservation programs must be implemented to protect land cover diversity for a safe and protective environment for future generations.

Soil quality is comprised of three properties: physical, chemical, and biological. Indicators are needed that relate to soil functions. Although it is impossible to assess changes in all soil properties, tracking changes in a select set could serve as indicators of changes in soil quality.

Cover crops play a major role in conservation technology. Cover crops reduce soil erosion, improve soil aggregation, recycle nutrients, and suppress weed growth. Cover crops also reduce incidence of insects and pathogens by increasing biodiversity. This study proposes a biodiversity index as part of the biological aspect of soil quality at the field level and higher.

METHODOLOGY

The NRI offers a reliable method for determining biodiversity. It is a statistically designed survey to track trends in land cover use with over 300,000 of Primary Sampling Units (PSUs) (Nusser and Goebel, 1997). Land cover use is collected at several points within each PSU. Using the NRI, a diversity index for the field level up to a broader scale (state, regional, etc.), was developed.

Data from the NRI (1982, 1987, 1992, and 1997 inventory years) were used to estimate biodiversity at the Major Land Resource Area (MLRA) scale. Scoring was as follows:

1=all points within a PSU on cropland with the same crop (cultivated and non-cultivated)

2=all points within a PSU on cropland (cultivated and non-cultivated) with at least one different crop

3=all points within a PSU on cropland (cultivated and non-cultivated) with at least one point with a non-cropland land cover/use (range, pasture, or forest)

4=all points within a PSU on cropland (cultivated and non-cultivated) with at least one point having veg-

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etation diversity [Conservation Reserve Program (CRP), cover crop, buffer strip, etc.].

Scores for each PSU were weighted according to acres at each point. The sum of all PSUs within each MLRA was then divided by the number of PSUs to determine an index value.

RESULTS

The NRCS has divided the 13 southeastern states into two regions. The South Central region includes Arkansas, Louisiana, Oklahoma, and Texas with the Southeast region covering the remaining nine states. For this study, areas outside these two regions but still within a MLRA were included in the analyses.

Range-, crop-, and forestland are the three major land cover types in the southeastern United States (USDA-NRCS, 2000). In 1997, total acres (million) were 163.4, 150.9, and 148.6 for range, crop, and forest, respectively. Total acreage decreased for all three land-uses from 1982 to 1997. Acres (16.6 million) enrolled in the CRP were a major factor for the decrease of cropland acreage.

Forestland and rangeland/pasture are the dominant land-uses in the Southeastern and South Central States, respectively (USDA-NRCS, 2000). Therefore, these sections had most of their respective MLRAs with index values greater than 2.75 during 1982 – 1997 (Table 1).

The total number of acres with a score of 3 or less declined from 1982 to 1997 while the number of acres with a score of 4 increased (Table 2). This increase was attributed to the CRP and USDA's efforts to promote buffer strips.

As might be expected, irrigation tends to increase the number of acres of a particular crop grown in an area. This increase, in turn, decreases land cover diversity. Irrigated cropland tended to have low diversity index scores (data not shown). Soil loss on irrigated, non-irrigated, and total cropland is shown in Table 3. As diversity index values increased from 1.45 to 2.50, soil loss generally decreased. Erosion on irrigated cropland was generally less than for non-irrigated cropland.

Corn and soybean data from the Census of Agriculture were analyzed to estimate influence of diversity on seed yield at the national level. Generally, yields decreased as diversity increased (Table 4). These decreases were attributed to fewer acres under irrigation.

CONCLUSIONS

This method suggesting a land cover diversity index did show a relationship to soil quality. Cropland with little land cover diversity (monoculture or all cropland with no conservation practice or vegetative diversity) tended to have higher soil loss. This was especially true for irrigated cropland.

Additional studies with this index will include evaluating soil cover factors (C-factor in the Universal Soil Loss Equation and V-factor in the Average Annual Wind Erosion Equation) recorded in the NRI. Bloodworth *et al*. (unpublished data) determined critical soil cover factors for sequestering soil carbon. Therefore, this index could be used to identify areas, which are increasing biodiversity and sequestering soil carbon.

Table 1. Total acres by diversity index value ranges, 1982-1997. The diversity index value is explained in the methodology section.

Diversity Index value	Year 1982	1987	1992	1997
	---------- acres ----------			
1.45 - 2.00	16,136,600	8,914,900	0	288,400
2.00 - 2.25	301,300	6,519,600	14,296,300	13,641,700
2.25 - 2.50	8,002,300	7,298,200	6,813,800	6,459,500
2.50 - 2.75	7,069,500	3,036,600	1,449,000	1,347,600
2.75 - 3.00	81,072,100	82,136,200	80,712,400	77,359,900

Table 2. Total acres by biodiversity index value, 1982-1997. The diversity index value is explained in the methodology section.

Year	Diversity index value 1	2	3	4
	---------- acres ----------			
1982	12,297,800	5,432,900	94,851,100	0
1987	10,564,500	5,495,300	91,830,800	14,900
1992	9,020,900	5,162,600	89,063,500	24,500
1997	9,888,900	4,729,800	91,277,400	83,800

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Table 3. Soil loss for irrigated and non-irrigated cropland, by land cover diversity score, 1982-1997. The diversity index value is explained in the methodology section.

Index	Irrigated	Non-irrigated	Total
	-------- tons acre^{-1} year^{-1} -------		
1982			
1.45 - 2.00	11.4	18.0	15.4
2.00 - 2.25	3.9	6.2	6.1
2.25 - 2.50	4.9	14.2	10.3
2.50 - 2.75	13.9	17.2	16.3
2.75 - 3.00	5.6	8.1	7.8
1987			
1.45 - 2.00	†	†	†
2.00 - 2.25	19.1	29.8	25.1
2.25 - 2.50	6.2	12.8	10.2
2.50 - 2.75	2.6	3.0	3.2
2.75 - 3.00	8.7	10.8	10.5
1992			
1.45 - 2.00	†	†	†
2.00 - 2.25	8.0	11.0	9.7
2.25 - 2.50	3.6	9.1	6.5
2.50 - 2.75	2.1	25.5	2.2
2.75 - 3.00	7.9	8.2	8.5
1997			
1.45 - 2.00	5.1	3.8	3.8
2.00 - 2.25	11.3	13.3	12.3
2.25 - 2.50	3.4	6.4	5.0
2.50 - 2.75	2.3	2.0	2.1
2.75 - 3.00	6.5	7.2	7.2

† Soil loss not estimated

Table 4. Corn and soybean seed yield as influenced by land cover/use diversity, 1982-1997. The diversity index value is explained in the methodology section.

Index	Corn	Soybean
	--------- bu acre^{-1} ---------	
1982		
1.45 - 2.17	100.2	29.3
2.17 - 2.50	101.6	30.8
2.50 - 2.66	87.5	23.5
2.66 - 2.85	88.8	28
2.85 - 3.00	83.3	24.2
1987		
1.45 - 2.17	115.1	33.8
2.17 - 2.50	112.0	31.2
2.50 - 2.66	99.0	28.2
2.66 - 2.85	100.2	30.5
2.85 - 3.00	89.1	27.5
1992		
1.45 - 2.17	114.4	32.7
2.17 - 2.50	118.6	32.7
2.50 - 2.66	87.9	28.8
2.66 - 2.85	104.2	30.4
2.85 - 3.00	91.5	27.4
1997		
1.45 - 2.17	112.5	35.2
2.17 - 2.50	117.0	35.6
2.50 - 2.66	106.9	34.3
2.66 - 2.85	115.7	33.2
2.85 - 3.00	105.9	28.2

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