ECOLOGICAL INTEGRITY OF WETLAND SOILS: TESTING OF SOIL ORGANIC MATTER AND TOTAL ORGANIC CARBON AS PARAMETERS FOR RESILIENCY OF WETLAND SOILS

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INTRODUCTION

Worldwide, natural resources are diminishing (Mitsch 1993). Humans are using more resources which results in stressed systems (Lubchenco et al. 1991). Information about resilience, the ability of a system to respond to stress, is needed. A resilient system is one that is able to return to its original characteristics within a reasonable time after a disturbance (Holland 1996). Developing indicators would aid in evaluating stressed areas and would allow them to be monitored for improvement or regeneration (Lubchenco et al. 1991).

According to Rapport et al. (1985), the health of an ecosystem is based on parameters that are significant to that ecosystem. Many factors are involved in determining the state of the ecosystem. Some changes in these factors are not recognized; therefore, characteristic values for a group of indicators are needed rather than relying on a single factor (Rapport et al. 1985). Monitoring indicators, such as biogeochemical indicators, can lead to early detection of stress, to protection of the integrity of the ecosystem, and to maintenance of the ecosystem. Using biogeochemical indicators can provide a systematic approach including both the organismal and environmental aspects of an ecosystem (Smith 1997). The need for knowledge about wetland resilience after disturbance is becoming more critical (Mitsch and Gosselink 1993).

Wetlands play an important role in landscape biogeochemical processes as they are linked to terrestrial and aquatic ecosystems (Walbridge and Lockaby 1994). Bottomland hardwood forests represent one of the most prevalent types of riparian ecosystems in the United States (Mitsch and Gosselink 1993). The majority of these wetlands have been highly subjected to timber harvesting and agricultural usage. Southeastern bottomland hardwood wetlands are characterized by increased organic matter accumulation due to higher clay content commonly found in these systems and highly variable decomposition rates (Patrick 1981; Griffin et al. 1992). These characteristics are tightly linked to primary productivity and the capacity of the forested wetlands to recover from disturbance (Griffin et al. 1992). The unique biogeochemical functions of bottomland hardwood wetlands are driven mostly by hydrology, biotic processes, and soil chemistry (Walbridge and Lockaby 1994). However, the driving factors regulating decomposition and nutrient processes in forested wetlands are poorly understood (Lockaby et al. 1996).

The need for additional baseline information about ecosystem resilience has also been documented by Brinson and Rheinhardt (1996). Reference wetlands are defined as sites within a specified geographic region that range in ecological integrity and successional stage (Brinson and Rheinhardt 1996). Reference sites should be representative of typical wetlands of the same class; they should not be unusual or unique (Brooks and Hughes 1988). According to Bailey (1980), Mississippi and Virginia are within the same ecoregion, Ecoregion 2 or the subtropical ecoregion (Figure 1). Therefore, we have made the assumption that all wetlands within this area may exhibit similar characteristics; another assumption that can be made is that reference wetlands can be used throughout an ecoregion for standards against which created or restored wetlands will be compared.

The purpose of this project is twofold. The first part focuses on determining whether mature forested wetlands within two separate watersheds located in the subtropical ecoregion are, in fact, similar in regard to soil nutrients. Mature wetlands refer to wetlands that have not been timber-harvested for an extended period of time. The mature wetlands in the Chowan River watershed have not been cut in over 80 years. The mature wetlands in the Yazoo-Tallahatchie River watershed have not been cut in over 60 years. The comparison of the mature wetlands will determine if, in fact, all mature wetlands within this study are similar. The second focus is to compare biogeochemical differences among wetlands of different successional stages within the Yazoo-Tallahatchie watershed, Mississippi. By determining if timber-harvested wetlands of different successional stage are different from mature wetlands, then some estimate of resiliency can be made. The objectives of this study were to: (1) determine if there are significant differences in soil organic matter (SOM) and total organic carbon (TOC) content between mature wetlands located in the Chowan River watershed Virginia, and mature wetlands of the Yazoo-Tallahatchie River watershed, Mississippi; and (2) determine if there are significant differences in SOM and TOC content among wetlands of different successional stages located in the Yazoo-Tallahatchie watershed.

SITE DESCRIPTION

Study sites located within northern Mississippi are part of the Yazoo-Tallahatchie River floodplain and are found in Leflore County (Figure 2). The Yazoo-Tallahatchie watershed consists primarily of rural land. All sites were surrounded by agricultural fields. The taxa for this area consisted primarily of broad-leaved deciduous taxa. Soil texture analysis will be performed. Fourteen sites were examined in this study. Replication was used when available. In order to confirm similar soil types, soil classification of each site was determined using *Soil Survey of Leflore County, Mississippi* (USDA 1959). All sites were sampled during the period of August through September 1997. No standing water was present at the time of sampling. The age groups consist of 6-12 months since cutting (three sites), five years since cutting (one site), 10-11 years since cutting (two sites), and 60+ years since cutting (three sites). Two mature forested wetlands (80+ years since cutting) examined in this study were located in Virginia within the Chowan River watershed. The Chowan River watershed consists of primarily rural land and all sites were surrounded by agricultural fields. The wetlands consist of broadleaved deciduous taxa and similar soil texture consisting primarily of silt and clay with some fine sand. These sites were sampled during the summer months of 1995 (Smith 1997).

METHODS

Ten soil cores were randomly sampled from the topographic low of each of the wetlands in Mississippi. Twenty soil cores were taken from the topographic low of the wetlands located in Virginia (Smith 1997). All samples were frozen until processing and were handled in the same manner with respect to freezing and thawing prior to extraction to minimize variability between treatments. The top 5 centimeters were used to represent the most recent influx of nutrients into the wetlands. Testing for SOM and TOC was performed on this portion of the sample. Each sample was homogenized and sieved through a 2.0 mm sieve to remove gravel and plant debris (Robertson et al. 1997). Particles that are smaller than 2.0 mm were stored in air tight jars in the dark until further processing.

Soil organic matter was measured by loss on ignition (LOI) at 550°C for five hours. One sample from each wetland was tested for carbonates by treating with 4*N* HCl and observing effervescence (Craft et al. 1988). No carbonates were present in any soils collected. Total organic carbon was analyzed by using the standard procedure for a Leco CN 2000 Carbon and Nitrogen Analyzer (Leco Corporation, St. Joseph, Michigan). Soil organic matter and TOC values were corrected to oven-dried weight by drying a subsample at 105°C overnight.

All treatments were normally distributed based on Kilmogorov-Smirnov test for normality. The Levene Median test for homogeneity of variances indicated that the SOM variances for both objectives were equal among treatments, while all TOC variances were unequal. One-Way Analysis of Variance (ANOVA) ($p < 0.05$) was performed on the two watershed treatments for SOM. A Kruskal-Wallis ANOVA ($p < 0.05$) was performed on the two watershed treatments for TOC. One-way ANOVA was performed on SOM among the various successional stage wetlands located in the Yazoo-Tallahatchie River watershed. A Kruskal-Wallis One-Way Analysis of Variance of TOM was performed among the various successional stage wetlands located in the Yazoo-Tallahatchie River watershed. All statistical analyses were performed using Sigma Stat (Jandel Scientific 1995).

RESULTS

The one-way ANOVA determined significant differences in SOM concentrations between the two watershed treatments ($p = 0.0437$). The SNK test indicated that the Chowan River wetlands contained significantly higher soil organic matter than the Yazoo-Tallahatchie River wetlands (Figure 3). There was no significant difference in TOC between the treatments. Both SOM (246.90 mg/g) and TOC (132.47 mg/g) content were higher in the wetlands located in the Chowan River watershed (Table 1).

There were no significant differences found in SOM among the different successional stages (Figure 4). The five year successional wetland showed the highest SOM content (179.53 mg/g), while the mature wetlands were slightly less (177.66mg/g). The ten year successional wetlands have a SOM content of 162.30 mg/g. The one year successional wetlands have the least amount of SOM (131.15 mg/g) (Table 1). There were no significant differences in TOC concentrations among the different successional stages (Figure 5). The mature wetlands exhibited the highest TOC content (80.03 mg/g), the five and ten year successional stages, slightly lower (77.25 mg/g and 72.31 mg/g, respectively), and the one year successional stage, the lowest (48.95 mg/g) (Table 1).

DISCUSSION

Results from this study indicate that SOM data can be used in determining significant differences between wetlands located in the Yazoo-Tallahatchie River watershed and the Chowan River watershed. However, TOC did not show any significant differences between the two watersheds. Data from this study indicate that the SOM and TOC values were higher in the mature wetlands in the Chowan River watershed than in the wetlands in the Yazoo-Tallahatchie River watershed. Differences in these values might be attributed to the ages of the parental material in the soil

(Brady 1974). The alluvial soils in the Mississippi Delta were more recently developed than soils along the Chowan River watershed (Brady 1974). Newer soils have a tendency to be more mineral than organic. For this reason, soils from this study in the Chowan River watershed would appear to have more SOM and TOC. Another possible explanation for these results could be that wetlands along the Chowan River have more standing water for longer periods of time than wetlands along the Yazoo-Tallahatchie River. In wetlands, hydrology affects organic accumulation (Mitsch and Gosselink 1993). Poor drainage can lead to the accumulation of organic matter (Mitsch and Gosselink 1993; Patrick 1981).

Statistically, there is not a significant difference in SOM between any of the timber-harvested sites and the mature sites. These data show that the one year sites tend to have the lowest amount of SOM, while the mature sites have the most. No statistical differences were seen in TOC analyses between treatments. However, the same general trend is also seen in TOC as was seen in SOM. Mature sites tend to have the greatest amount of TOC, with the one year sites having the least amount. This could be associated with the reestablishment of vegetation within a wetland. With the exception of the five year site, there tends to be a general trend of increasing amounts of SOM and TOC as years since timber-harvest increase. Since soil is so variable and only one five year site was available to sample, this site may represent an anomalous value.

CONCLUSION

Increased knowledge of the effects of timber harvesting and the subsequent resilience of wetlands is vital for sustainable management of these resources. Soil organic matter and TOC in this study did not prove to be statistically significant indicators of wetland resilience after timber-harvesting.

Preliminary results are inconclusive to determine differences between mature wetlands within two watersheds in Ecoregion 2. Upon completion of the total Kjeldahl nitrogen and total phosphorus analyses and comparisons, results may provide sufficient evidence to support the hypothesis that all wetland soils along Ecoregion 2 are similar.

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Table 1. Summary of the soil organic matter (SOM) and total organic carbon (TOC) means for study sites in the Chowan River watershed, VA and the Yazoo-Tallahatchie River watershed, MS. Mature wetlands are represented by M. Numbers represent (1,5,10) successional stage and years since timber harvest. A, B, and C represent replicates.

Wetlands	Mean SOM (mg/g)	Mean TOC (mg/g)
Chowan MA	221.192	112.39
Chowan MB	272.613	152.57
Yazoo-Tallahatchie MA	189.320	86.855
Yazoo-Tallahatchie MB	170.908	72.960
Yazoo-Tallahatchie MC	172.742	80.270
Yazoo-Tallahatchie 1A	160.514	71.134
Yazoo-Tallahatchie 1B	142.675	50.282
Yazoo-Tallahatchie 1C	90.2710	25.429
Yazoo-Tallahatchie 5A	179.530	77.245
Yazoo-Tallahatchie 10A	149.061	70.399
Yazoo-Tallahatchie 10B	175.546	74.228

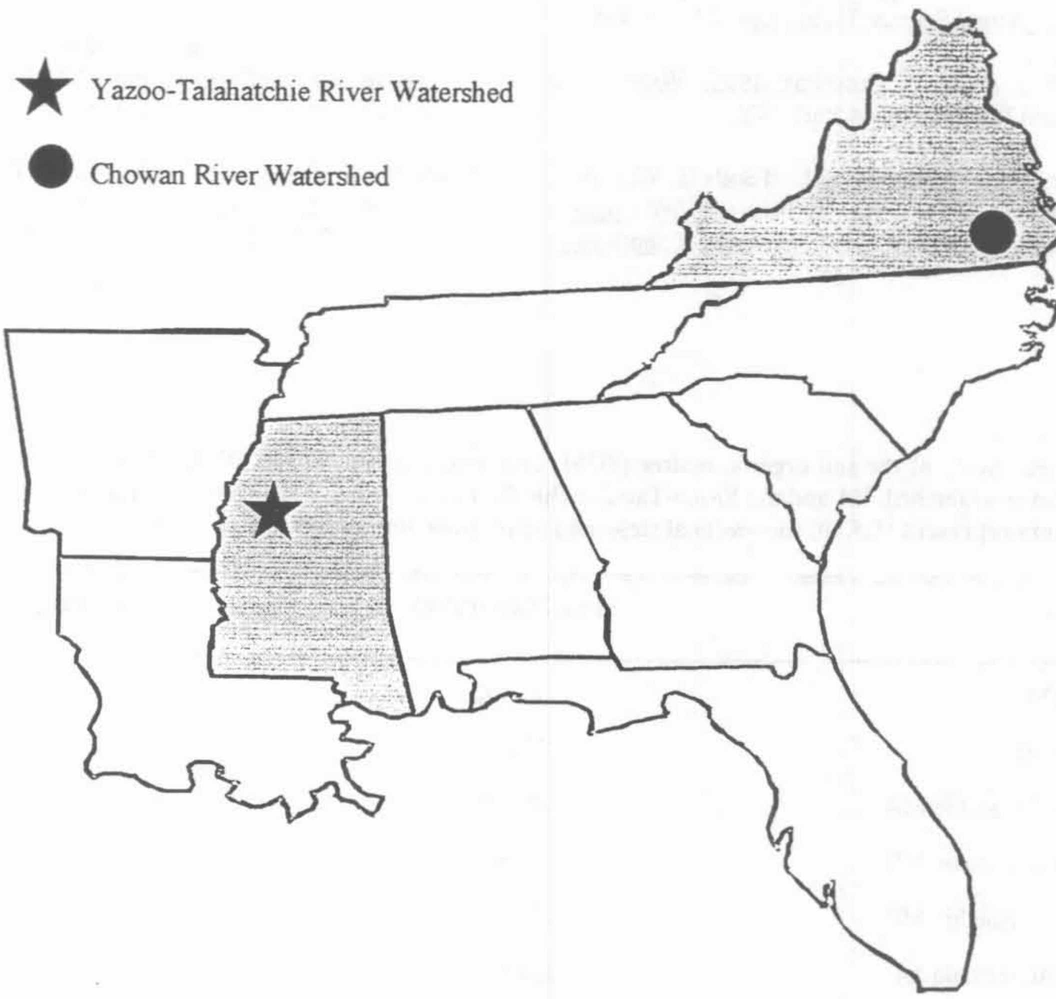

Figure 1. Locations of the Chowan River and Yazoo-Tallahatchie River Watersheds within the U.S. Forest Service Ecoregion 2 (Bailey, 1980).

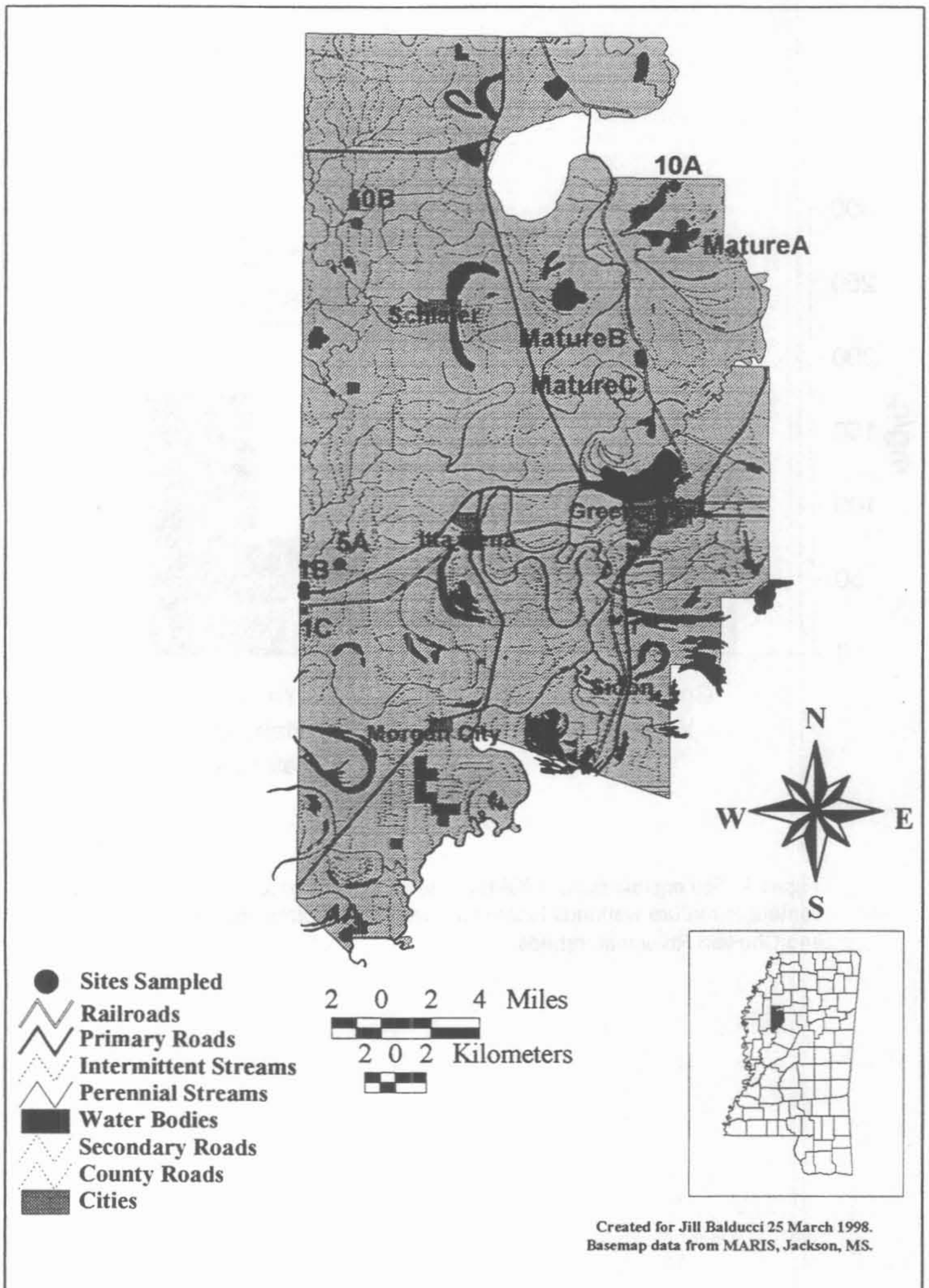

Figure 2. Sites Sampled by Jill Balducci, Summer 1997, Leflore County, Mississippi

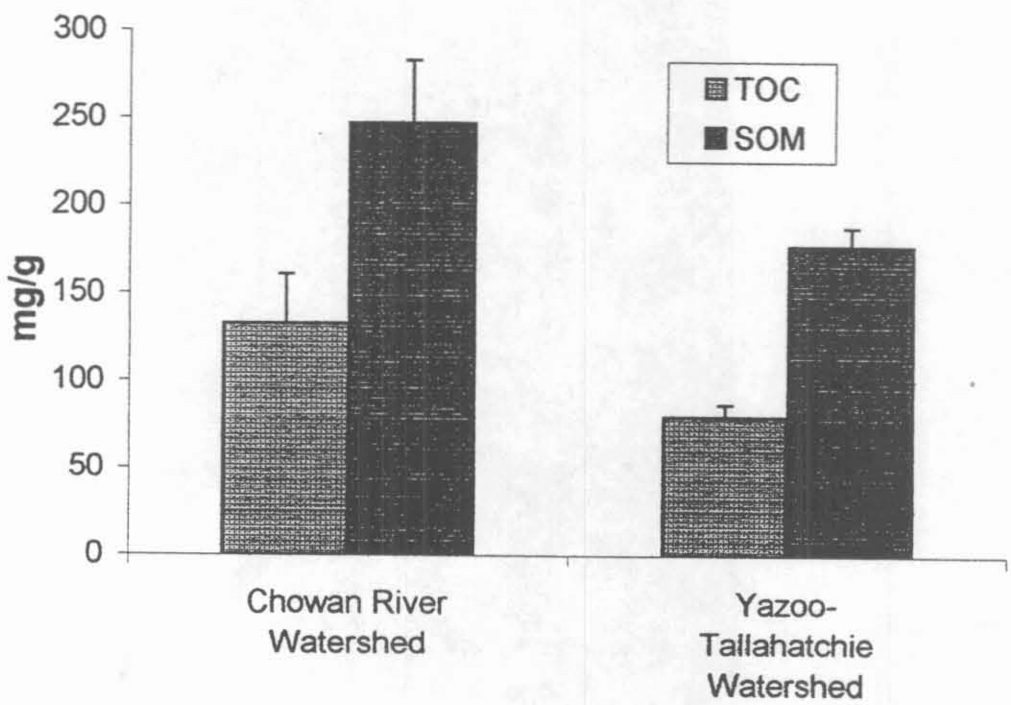

Figure 3. Soil organic matter (SOM) and total organic carbon (TOC) content in mature wetlands located in the Yazoo-Tallahatchie River and Chowan River watersheds.

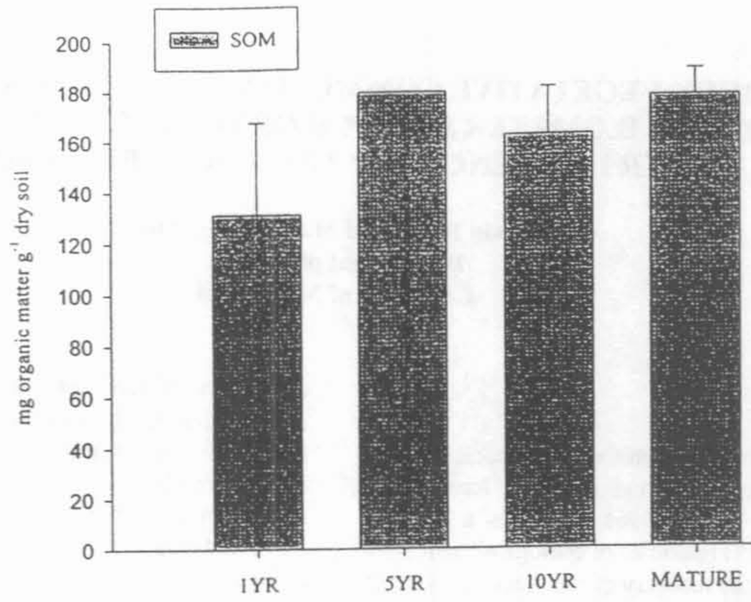

Figure 4. Soil Organic Matter for Timber-Harvested Sites in the Yazoo-Tallahatchie River Watershed.

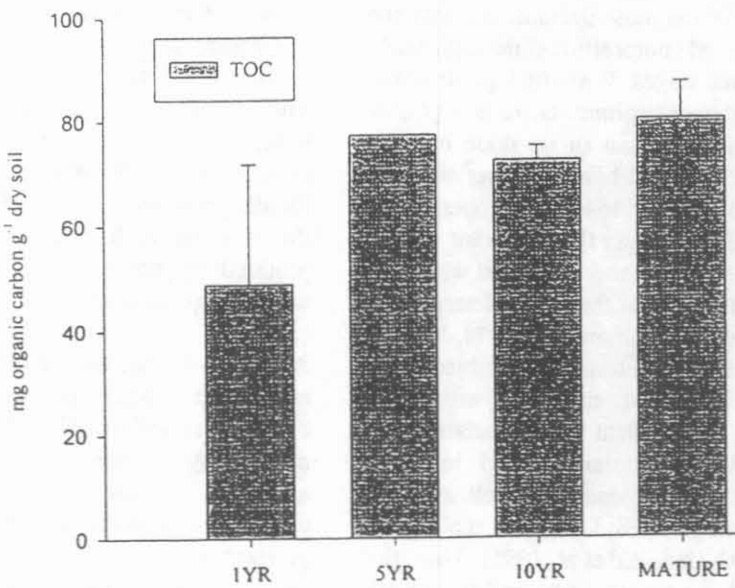

Figure 5. Total Organic Carbon for Timber-Harvested Sites in the Yazoo-Tallahatchie River Watershed.