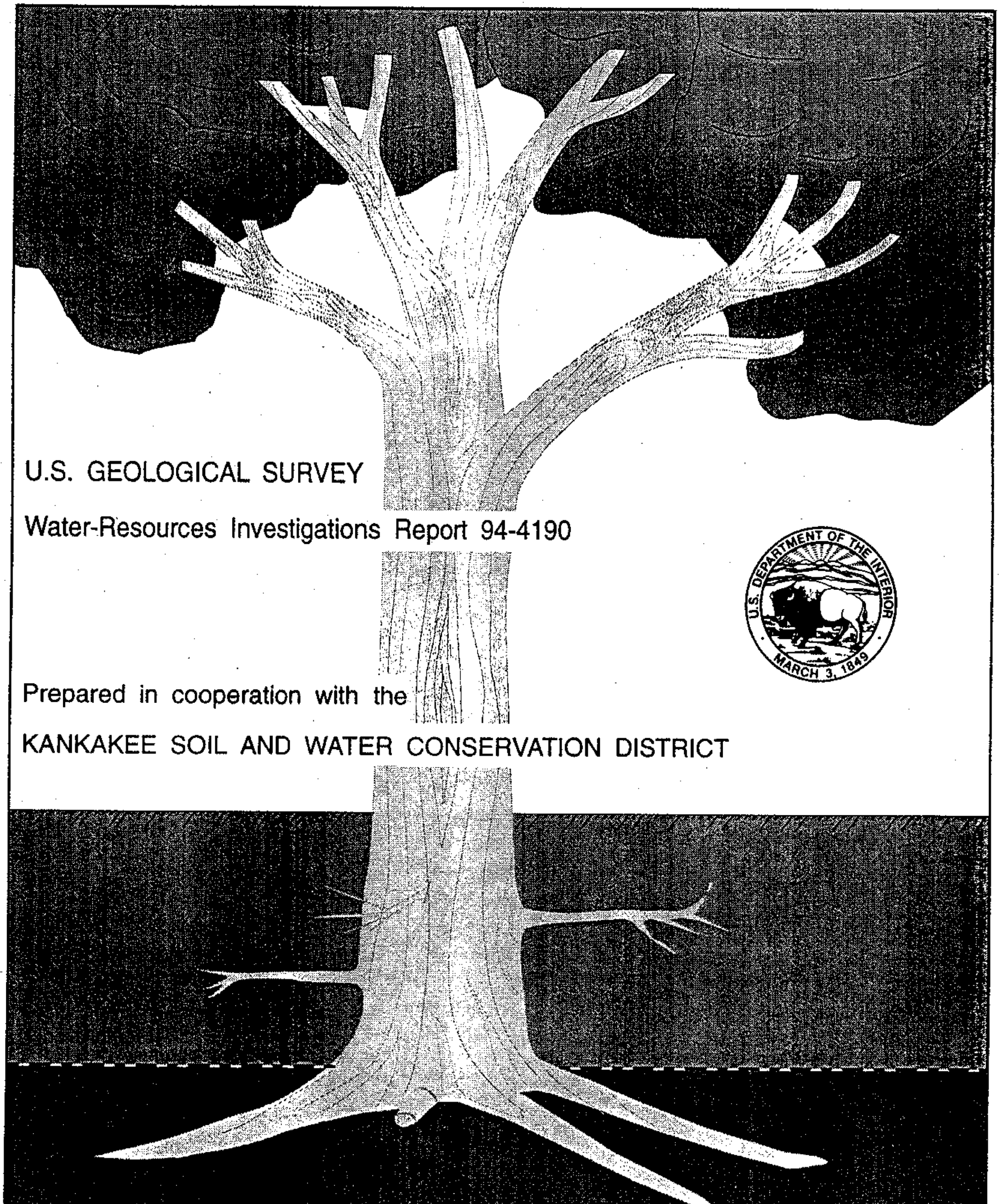
DENDROGEOMORPHIC ESTIMATE OF CHANGES IN SEDIMENTATION RATE ALONG THE KANKAKEE RIVER NEAR MOMENCE, ILLINOIS



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 94-4190

Prepared in cooperation with the

KANKAKEE SOIL AND WATER CONSERVATION DISTRICT

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By Richard L. Phipps, Gary P. Johnson, *and* Paul J. Terrio

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1995

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CONVERSION FACTORS

Multiply	By	To obtain
millimeter (mm)	0.03937	inch
centimeter (cm)	.3937	inch
meter (m)	3.281	foot
kilometer (km)	.6214	mile
square kilometer (km^2)	.3861	square mile
cubic meter per second (m^3/s)	35.31	cubic foot per second
centimeter per kilometer (cm/km)	.6336	inch per mile
centimeter per year (cm/yr)	.3937	inch per year
hectare (ha)	2.471	acre

Dendrogeomorphic Estimate Of Changes In Sedimentation Rate Along The Kankakee River Near Momence, Illinois

by Richard L. Phipps, Gary P. Johnson, *and* Paul J. Terrio

Abstract

Changes in sedimentation rates were estimated using root-burial depth and tree-age data at six selected data-collection sites along the Kankakee River near Momence in Kankakee County, Illinois. Five sites were in backwater areas away from the river channel, and one site was on a natural levee near the channel.

A summary of the dendrogeomorphic data at the six sites indicates that sedimentation rates were greater after 1950 than before 1950. Greater sedimentation rates after 1950 were observed at four of the five backwater sites, whereas no change in sedimentation rate after 1950 was observed at the fifth backwater site. The observed rates could have been affected by any combination of soil erosion, soil compaction, or increased streamflow. A greater sedimentation rate after 1950 was observed at the levee site, which appeared to have been affected by erosion from a flood in 1950. Effects of erosion were not observed at any of the other sites. No erosional effects and soils not susceptible to compaction at the five backwater sites indicate that neither erosion nor compaction affected observed sedimentation rates. The effect of increased streamflow in the Kankakee River Basin since the early 1900's on the observed sedimentation rates is not known.

INTRODUCTION

The Kankakee River originates near South Bend, Ind., and joins the Des Plaines River southwest of Chicago near Wilmington, Ill., to form the Illinois River (fig. 1). Historical evidence indicates that De La Salle and Father Hennipen, who traveled down the river in 1679, were probably the first Europeans to see the Kankakee River (Houde and Klasey, 1968). At that time, the meandering upper part of the river was a 5- to 8-km-wide marsh presently referred to as a riverine wetland. The river and bordering wetlands extended from the headwaters in Indiana to Momence, Ill. The river downstream from Momence, then as now, had fewer meanders and was not bordered by wetlands. As the region was settled, the riverine wetland, unsuitable for agriculture, was at first left undrained and was referred to as the Grand Marsh, a prime area for hunting and fishing.

From the time of settlement, the Kankakee River Basin outside the Grand Marsh has been intensively farmed. Houde and Klasey (1968) note that by "around 1860" parts of the river in Indiana were being channelized for draining the marsh and reducing the extent and frequency of flooding. By 1918, the entire main stem of the river in Indiana had been completely channelized (U.S. House of Representatives, 1916 and 1931). The channelization reduced the length of the river in Indiana from about 385 km to about 130 km. The reduction in length greatly increased the gradient of the Indiana part of the river. The average gradient of the prechannelized Kankakee River was estimated to be about 8 cm/km. After channelization, the average gradient was estimated to

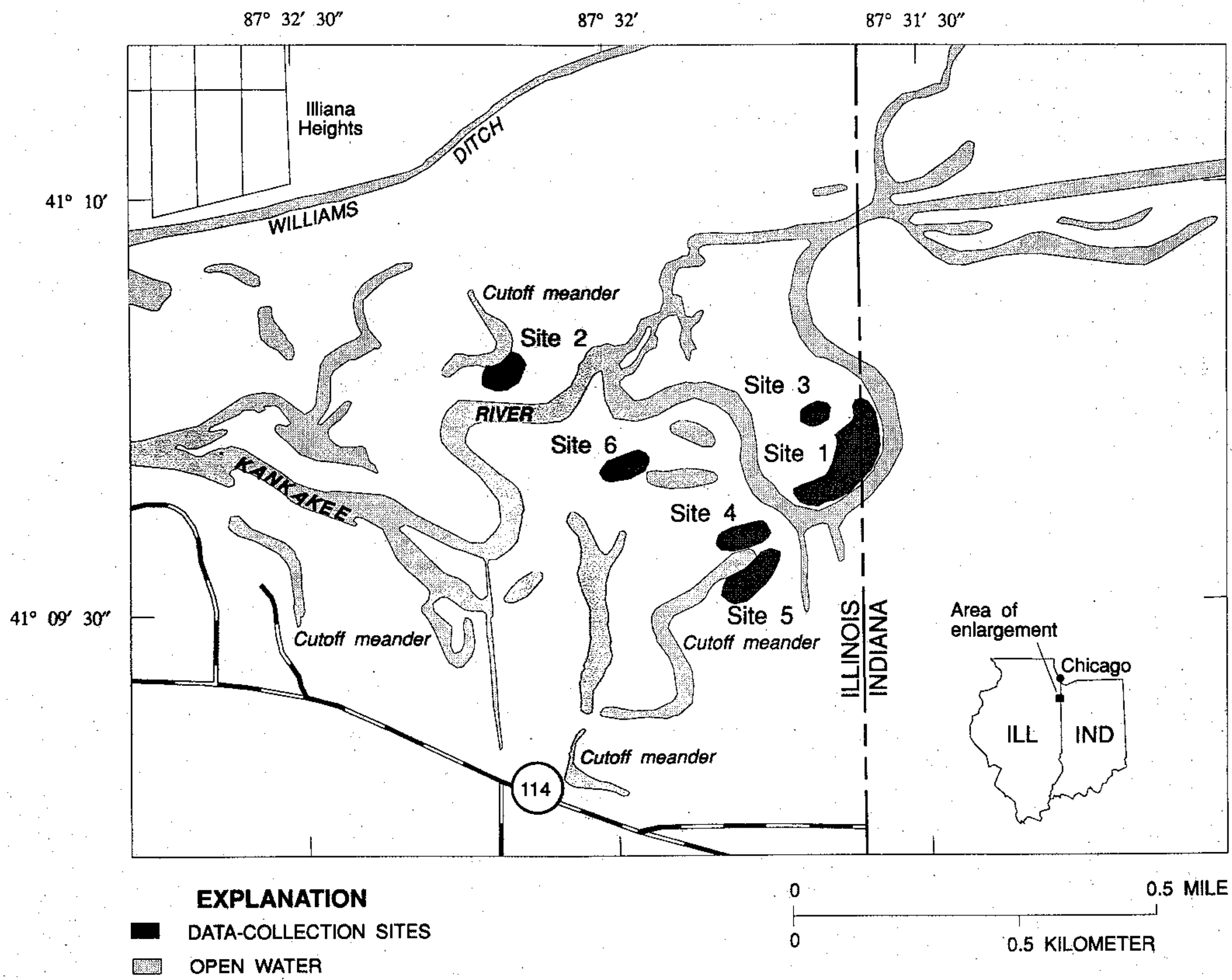

Figure 2. The locations of the six data-collection sites within the study area in the Momence Wetland, Illinois and Indiana.

palustris L.) and a band of buttonball bush (*Cephalanthus occidentalis* L.) often ring the open, standing water of these old backwater meanders. The major tree species nearest the meanders (sometimes intermixed with the buttonball bush) is silver maple, although there might also be green ash (*Fraxinus pennsylvanica* Marsh.). Ash trees increase in abundance farther from the standing water. The maple forest around the backwater meanders could be described as an ash-maple phase of the elm-ash-maple flood-plain forests.

Oaks are found with silver maples in areas at slightly higher elevations that are less frequently flooded than the areas adjacent to meanders. The oaks almost always include swamp white oak (*Quercus bicolor* Willd.), with bur oak (*Q. macrocarpa* Michx.) and pin oak (*Q. palustris* Muenchh.) likely present but less abundant. Better drained sandy areas, such as natural levees along the channel, have elm (*Ulmus americana* L.) as the predominant species intermixed with the ubiquitous silver maple. The forest of the natural levees could be described as an elm-maple phase of the elm-ash-maple flood-plain forests.

Acknowledgments

Much assistance with this project was provided by a local confederation of citizen groups known as The Alliance to Restore the Kankakee (ARK). The endless enthusiasm of ARK for this project, and the eagerness of its membership to help in any way possible, is gratefully acknowledged.

DENDROGEOMORPHIC ESTIMATE OF CHANGES IN SEDIMENTATION RATES

Sigafoos (1964) demonstrated that sedimentation rates on flood plains could be determined by excavating root systems and by taking increment cores for age determination from trees in flood plains. The burial depth of the original lateral roots of a tree is an estimate of the amount of sediment deposited, and the age of the tree estimates the length of time during which the sediments accumulated (fig. 3). By examining a number of trees of various ages, the relation between net sedimentation depth and time can be examined. This dendrogeomorphic technique has since been applied in western Tennessee (Hupp and Bazemore, 1993), along the Cache River in eastern Arkansas (Hupp and Morris, 1990), and in riverine wetlands in southeastern Virginia (Hupp and others, 1993). The methods utilized in this study follow those described in Hupp and Bazemore (1993).

Tree seedlings normally develop lateral roots just below, and parallel to, the soil surface. When sediments are deposited around trees in wetlands, the water level in the soil is not necessarily raised appreciably. Thus, the original roots are not killed by water saturation from a raised water level in the soil. Further, no lateral roots are typically found below the original lateral roots because there is no tap root from which they could grow. The original lateral roots or their locations can be identified in many wetland tree species, even though the root systems of the trees may be buried by a meter or more of accreted sediment. Because the original lateral roots were formed just below the surface on which the seedling became established, the depth of sediment from the present surface to the level of the original lateral roots is an approximation of the net depth of sedimentation since the establishment of the seedling. By determining the age of the tree, the net sedimentation rate for a given time interval (the age of the tree) can be determined.

Trees in areas where appreciable amounts of sediment are deposited become partially buried by the sediment. Burial may completely cover the root crown at the base of the tree. The trunks of such trees are similar to utility poles, with no root crown exposed above the soil surface (fig. 4). Many trees in and around the backwater meanders of the study area have this appearance.

Sedimentation after the establishment of the seedling usually results in new roots being formed in the sediment deposits above the original lateral roots. These new roots form as root sprouts (adventitious lateral roots) (fig. 3) from the buried part of the tree trunk (main stem). The new roots tend to be horizontal, as were the original lateral roots, and may be mistaken for the original roots.

The development of any particular root depends on a variety of factors and conditions, such as rate and frequency of sediment-deposition events, soil drainage, and depth to water table during the growing season. Roots at all levels are sometimes found to be about the same size. Alternatively, roots at a particular level will sometimes grow larger than roots at other levels. The largest lateral roots might be at the level

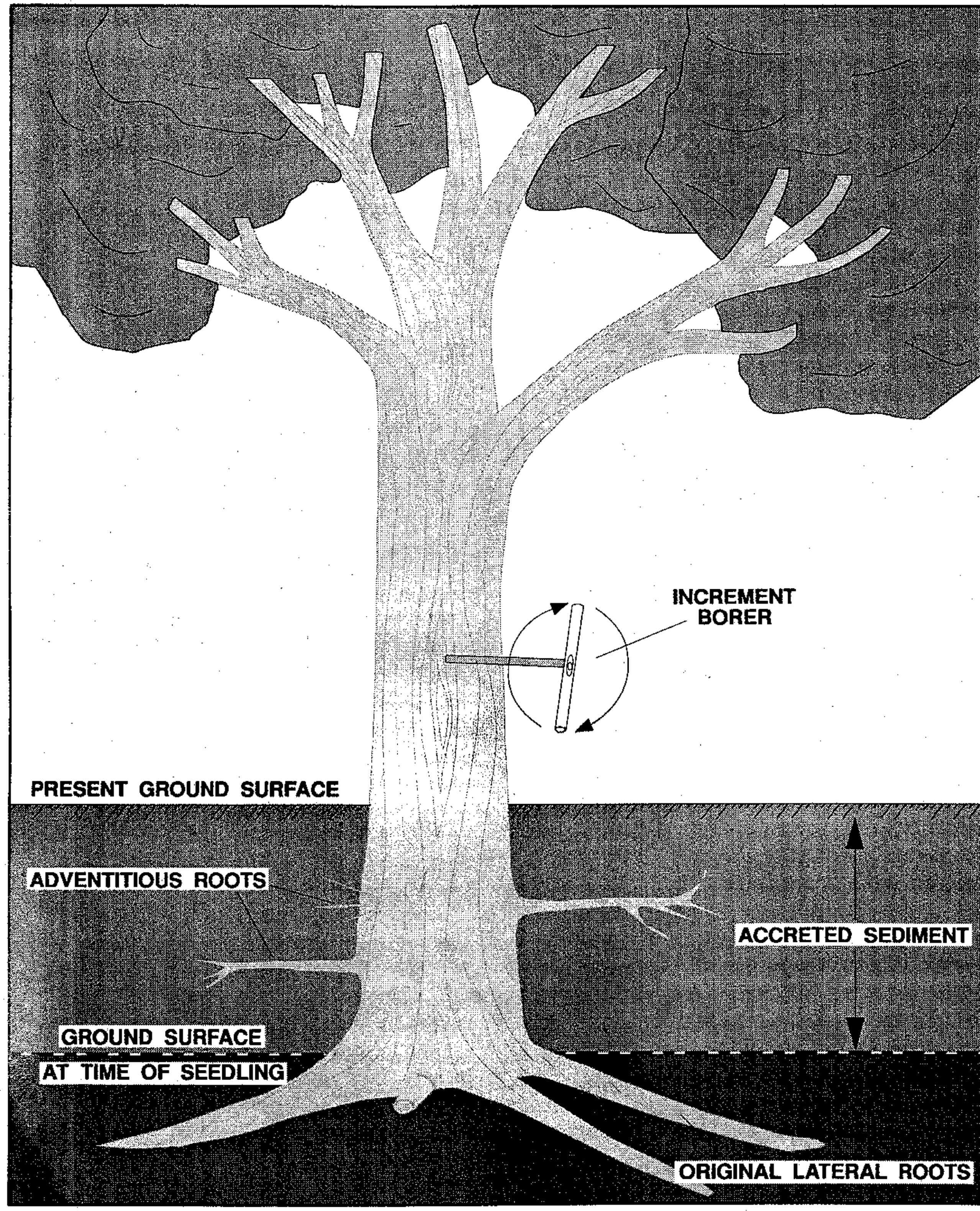

Figure 3. A tree in a flood plain and increment borer.

Figure 4. Trees resembling utility poles in a flood plain.

of the original lateral roots or might be any roots above the original roots. Sometimes lateral roots at the level of the original roots may be small and difficult or impossible to detect. In such cases, the point below which no more vertical stem can be detected is assumed to be the level of the original roots, and, hence, an approximation of the level of the surface on which the seedling became established.

The sedimentation rate is estimated from the amount of sediment measured at a particular time, without regard to when the sediment was deposited. The resulting estimates of sedimentation rate, therefore, represent net sedimentation rates over the lifetime of the tree, without consideration of when the sediments were deposited. The sediments could have been in place for decades or could have been deposited during the most recent flood prior to sampling.

By determining whether the historical trend of sediment deposition on the flood plain has been increasing, decreasing, or remaining stable, the trend of sand movement in the channel can be inferred. During floods, water overflows the channel and sediments might be deposited on the flood plain. Sand (sediment particles between 0.062 and 2.0 mm in diameter) is heavy enough that it is typically transported along or near the bottom, or bed, of river channels. In the Kankakee River, sand transport is largest during floods (Bhowmik and others, 1980), although some sand is moved slowly along the channel bed during most flow conditions. Therefore, the historical trend of sand movement in the channel might be reflected in the depositional trend of sediments on the flood plain.

The dendrogeomorphic analyses for this study were done with samples from depositional areas and do not provide a quantitative analysis of the entire flood plain. No attempt was made to determine what part of the flood plain or channel was depositional and what part was erosional. Thus, determination of change in sedimentation rate over time should not be related to the amount of sediment deposited on the flood plain or the amount of sediment transported in the river channel. Only under certain conditions could the analyses be applied to quantify sediment transport in the channel or sedimentation rate for the entire flood plain. The dendrogeomorphic analyses for this study examine whether the rate of sediment deposition has increased, decreased, or remained constant over time in areas of known deposition.

Site Selection

Four factors were used in selecting sites along the Kankakee River to collect sediment depth and tree age data. First, an appreciable thickness of sediment deposited during the lifetime of the trees growing on the site was needed for analysis. Although using sites where there was no sediment accretion would have helped to determine areas of deposition and erosion, such sites would not provide data on changes in sedimentation rates. Because a large part of the sediment in the Kankakee River is sand, sand deposits were sought. The few forested sand deposits found were within 4 km downstream from the Illinois-Indiana State line and within about 20 m of the channel.

Forested sites with relatively large amounts of sediment deposits were difficult to find. Localized areas of sediment deposition were not typical of the entire flood plain. According to Bhowmik and others (1980, p. 81):

> "It appears that during flood stages, when the velocity of water is relatively high and the water is very turbulent, most of the suspended sediment carried by the river consists of sandy materials."

This statement was made in reference to movement of sediment in the channel. Much of the water that leaves the channel and spreads across the broad flood plain moves relatively slowly. The slow-moving water across the flood plain cannot transport sandy material, and only finer sediment (silt and clay) is deposited on the flood plain. Few forested areas of deposition and few forested areas with erosional features were found during this study.

Areas surrounding old cutoff meanders in the backwater areas away from the river channel contained the most prominent depositional features. The old cutoff meanders, locally called sloughs, were scattered along both sides of the river between the State line and Momence (fig. 2). Most of the backwater cutoff meanders are in undisturbed, undeveloped, forested areas. Sediments are deposited among the trees near the meanders and deposits increase in thickness toward the standing water in the center of each backwater area, indicating that the sediments slowly settled from ponded flood water. Five of the six data-collection sites were in these backwater areas.

Second, an acceptable site had to contain trees of species from which reliable data could be obtained. The most reliable data were collected from ash trees near the Kankakee River. Though oaks also were acceptable, few were found at most acceptable sites along the river. At some potential sites, ash trees were present but too widely scattered to utilize. Silver maples were present at most depositional areas. Unfortunately, unlike the ash, the original lateral roots of the silver maple were very hard to distinguish. The ease of finding the seedling root location of ash trees was dependent on the development of the root system. If the soil was well drained, then roots that began at the level of the original lateral roots may have grown outward and downward to depths below the original lateral roots. Wright (1959) refers to the extensive root system of green ash that, under favorable conditions, may penetrate to 1.4 m but makes no reference to a tap root. No ash-tree roots were observed resembling a tap root. No evidence that any of the roots were attached below the original lateral roots was found; thus, the positions of the original lateral roots were distinct.

Third, several trees representing a range of ages had to be contained in an acceptable site in order to estimate changes in sedimentation rates. The depth of sediment that accumulated during the lifetime of an old tree does not in itself indicate whether the sedimentation rate has increased or decreased during the lifetime of the tree; it only indicates the net total deposition during the lifetime of the tree. The measured net deposition could have been affected by any combination of depositional or erosional processes. If sedimentation rates have increased with time, then net sedimentation rates from older trees will be biased to greater values because of recent greater sedimentation rates. Likewise, if present sedimentation rates are smaller than in the past, the net sedimentation rates for older trees will be biased to lesser values. To determine whether or not deposition may have increased during the last few decades, emphasis was placed on finding sites with trees of various ages.

Fourth, several trees of an acceptable species that were fairly close together to minimize natural variability of sedimentation rates had to be contained across an acceptable site. The amount of sediment deposited per unit time (sediment depth divided by tree age, D/A) varied considerably from one site to another. For this reason, the size of the sites was kept relatively small (about 0.4 ha) so there was little chance of significant depositional variation across the site.

The combined effect of these four factors effectively reduced the number of potential sites. Resulting acceptable sites were generally depositional areas around backwater ponds that contained a group of ash trees of variable ages.

Data Collection

Sediment depth was determined as the distance from the present soil surface to the level of the original lateral roots. Holes were dug on opposite sides of each tree from which data were to be collected. If sediment depths on opposite sides were markedly different, or otherwise seemed questionable, one of the holes was enlarged or a third hole was dug to allow for a more careful examination of root distribution. Numerous smaller elms were completely excavated and taken to the laboratory for examination and measurement. If the roots were large, then the depth measurement was made to the approximate center of the roots. Measurements were taken about 0.5 m, laterally, from the center of the tree, though this distance varied depending on the size of the tree. Sediment depths were measured to the nearest centimeter. Although the measurement of the level of the original lateral roots and the level of the soil surface directly above the point of the root measurement could be inexact, repeated measurements by USGS personnel almost always were within 1 cm of the original measurement. After the data were collected, the holes were filled and the trees were tagged for possible future reference.

Tree age was estimated by counting rings from an increment core of the tree, and then estimating the number of rings at the center that were not included on the core sample. Typically, a single core was extracted with an increment borer (fig. 3) from each sample tree and the age of the tree was determined by examining the core under a dissecting microscope in the laboratory. Increment cores were usually taken from standard breast height (1.4 m) for larger trees and from as near to the present soil surface as practicable for smaller trees. Rings near the centers of the trees were usually large, indicating rapid growth in trunk diameter in youth. Rapid growth in diameter implies rapid growth in height, and rapid growth in height indicates that the difference in age determinations between samples taken at ground level and those taken at breast height would be small. Age determinations were done on some trees from both breast height and near the ground surface, and little or no difference was found in the age determinations. Sample height, side of the tree sampled, and tree diameter were recorded for each tree. Increment cores were taken and processed in accordance with standard procedures (Phipps, 1985).

Data Presentation and Analysis

Site 1, where the youngest trees were found, was located on a natural sand levee at an inside bend on the north side of the Kankakee River (fig. 2). This site was well drained and may be described as an elm-maple site. Most of the trees sampled at this site were elm. Because the original rooting level of elms are less easily determined than those of ash, emphasis was placed on sampling any ash that were present.

The data from Site 1 are presented in table 1. Numerous trees were relatively small and were completely excavated. In the well drained soil of the levee, some of the elms developed what appeared to be a short tap root. This is consistent with a study by Guilkey (1957) that noted the American elm can develop a tap root in deep, well drained soils. When these roots were present, it was usually not possible to determine the position of the original lateral roots. Data from these trees are not included in table 1, resulting in gaps in the numbering system.

The ages of the trees at Site 1 ranged from 9 to 69 years. The thickness of sediment covering the original lateral roots of older trees generally increased with tree age, but distinct exceptions were noted, as illustrated by the relation of sediment depth to tree age for the first three trees listed in table 1. Of these trees (BS2-1, BS2-2, and BS2-5), tree BS2-1 was 13 years

Table 1. Dendrogeomorphic data collected at Site 1 near Momence, Ill.
[cm, centimeters; cm/yr, centimeters per year; --, no data available]
Dbh: Diameter at breast height (1.4 meters).
Inside date: Date of innermost tree ring. Number in parentheses is estimated number of missed center rings; p indicates that the pith was reached in the core.
Tree age: Age including minimum number of missed center rings.
Sediment depth: Net sediment accumulation during lifetime of tree.
D/A: Sediment depth divided by tree age (net sedimentation rate).
Tree species: Either ash (*Fraxinus*) or elm (*Ulmus*).

Tree number	Dbh	Inside date	Tree age (years)	Sediment depth (cm)	D/A (cm/yr)	Tree species
BS2-1	--	1980 (p)	13	15	1.2	Elm
-2	12	1958 (4)	39	13	.33	Elm
-5	7	1958 (1-2)	36	38	1.1	Ash
-6	7	1958 (p)	35	44	1.3	Elm
-9	8	1972 (1)	22	30	1.4	Elm
-10	13	1939 (p)	54	16	.30	Elm
-11	8	1957 (p)	36	10	.28	Elm
-12	--	1956 (p)	37	18	.49	Elm
-13	--	1980 (p)	13	20	1.5	Elm
-14	--	1934 (1-2)	60	18	.30	Ash
-16	--	1981 (p)	12	11	.92	Elm
-18	9	1934 (1-2)	60	27	.45	Elm
-21	--	1953 (p)	40	37	.93	Ash
-22	--	1924 (p)	69	22	.32	Elm
-23	25	1957 (p)	36	27	.75	Ash
-24	25	1954 (p)	39	32	.82	Ash
-25	41	1958 (2-3)	37	32	.86	Ash
-26	14	1971 (2-3)	24	27	1.1	Elm
-27	--	1955 (p)	38	29	.76	Elm
-29	--	1984 (p)	9	27	3.0	Elm
-31	--	1960 (1)	34	48	1.4	Elm
-32	--	1957 (p)	36	36	1.0	Elm
-34	--	1963 (p)	30	34	1.1	Elm

old and 15 cm of sediment covered the roots, and tree BS2-5 was 36 years old and 38 cm of sediment covered the roots. It appears that sediment was accumulating at these trees at a rate of about 1 cm/yr. On the other hand, tree BS2-2 was the oldest of the three trees (39 years) but the amount of sediment deposited (13 cm) was the least for the three trees; a few disparities between tree age and sediment depth may be normal and natural; however, this disparity is extreme and is discussed below.

The relation of depth of sediment to tree age at Site 1 underwent a distinct shift about 35 to 40 years ago as shown in figure 5. Because of the limited number of data, a linear best-of-fit line was determined to describe the relation of depth of sediment to tree age for periods before and after the distinct shift in this relation. A flood in 1950 seems to have removed 20 cm or more of sediment from Site 1. Streamflow records indicate a maximum discharge for the period of record on April 25, 1950, at the streamflow-gaging station at the Kankakee River at Momence (U.S. Geological Survey, 1964, p. 450), which could have removed sediment from Site 1. From these data alone, it is not known if sediment was eroded at Site 1 every time the levee was overtopped, or if sediment was eroded only during extreme floods. If the latter is the case, little sediment may have been eroded during the lifetimes of the younger trees.

Data for the first three trees shown in table 1 (BS2-1, BS2-2, and BS2-5) are identified in figure 5. Trees BS2-1 and BS2-5 appear to have developed on the ground surface after the erosional event, and tree BS2-2 appears to have become established on the newly eroded, unstable surface. The condition of this

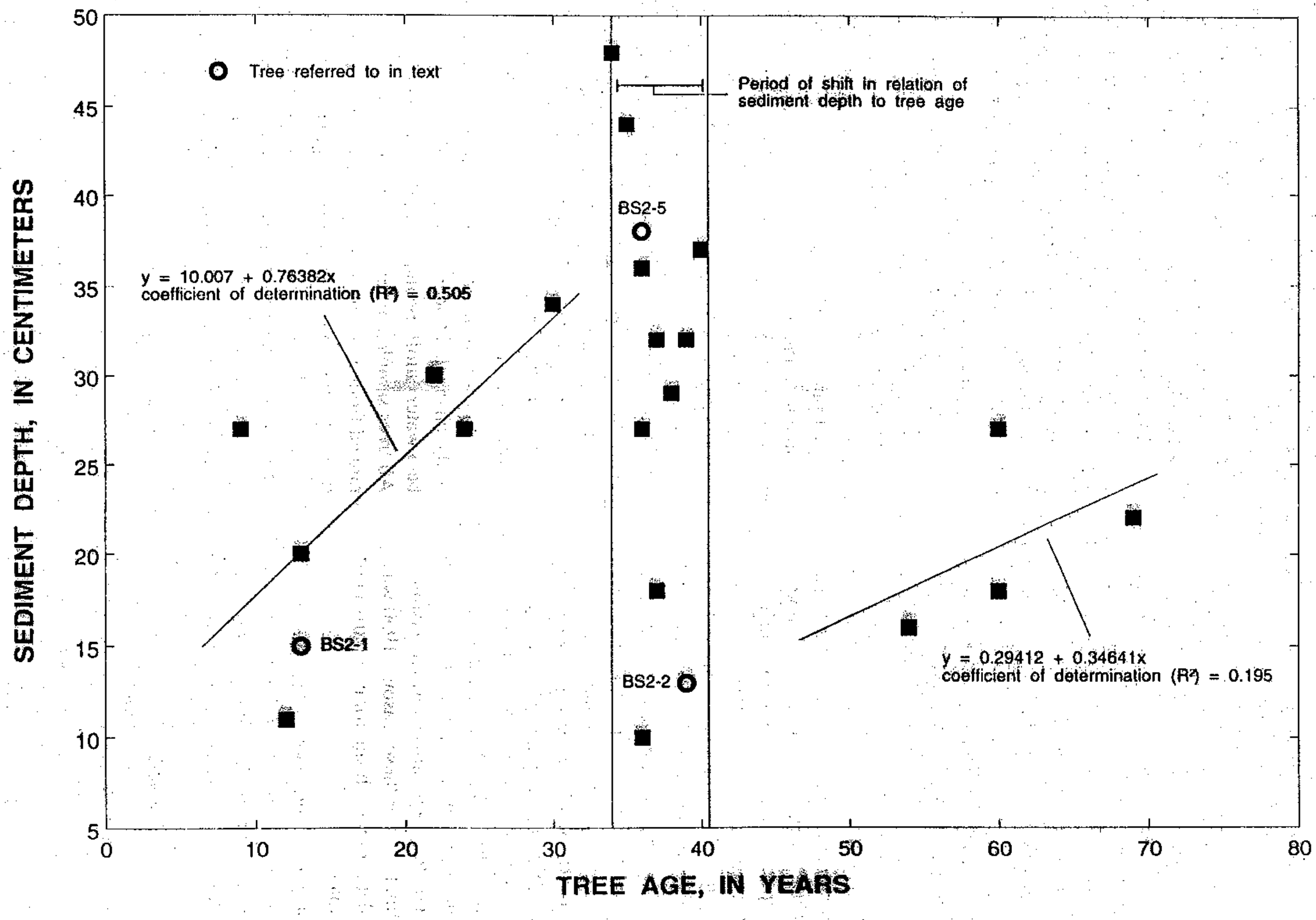

Figure 5. Relation of sediment depth to tree age, Site 1 near Momence, Ill.

surface would account for both the relatively large number of trees established 30 to 40 years ago and the apparent variation in amount of sediment deposition among trees established during those years.

The data from Site 1 (table 1) were separated into two age groups to represent trees that became established either before or after 1950. Computed values of the net sedimentation rate at each tree are included in table 1, whereas the average sedimentation rates for the two age groups are included in table 2. The net sedimentation rates of the pre-1950 trees were likely biased to smaller values by the apparent erosion in 1950.

If it is assumed that erosion around trees established before 1950 was due largely to the 1950 flood, and that the amount of sediment eroded around all trees at Site 1 was essentially the same, adding a constant depth to all of the older trees to compensate for the 1950 erosional event would allow for better comparison of the two groups. Regression lines defining the slope of sediment deposition and tree age for periods before and after 1950 (fig. 5) indicate that the net sedimentation rate since 1950 was greater (steeper slope of regression line) than prior to 1950.

Reasons other than the apparent erosion at Site 1 during the flood of 1950 also justified separating the data into two groups. Studies completed around 1980 reported that the Kankakee River was near equilibrium around 1950, and that no further increases in sedimentation should be seen (Gross and Berg, 1981; Ivens and others, 1981). In addition, the data from every site, when separated into groups of trees established before and after 1950, also show a division around 1950 (fig. 6). For these reasons, 1950 was used to divide data from each site for comparison of sedimentation rates.

Site 2 was on the north side of the channel, downstream from Site 1 (fig. 2) in an area where no erosional features were present. Site 2 was near a backwater cutoff meander and may be described as an ash-maple site. The data for Site 2 are presented in table 3 and are shown graphically in figure 7. Tree ages ranged from 28 to 47 years, with net sediment deposition during the lifetimes of the trees that ranged from 14 to 25 cm. The data were divided into two groups of trees established before or after the 1950 flood (table 4). A smaller difference in net sedimentation rate from Site 1 between the pre- and post-1950 groups resulted at Site 2. The pre-1950 group still had a smaller net sedimentation rate (0.42 cm/yr) than the post-1950 group (0.54 cm/yr). The smaller net sedimentation rate of the pre-1950 period could have been caused by recent erosion, but no active erosional features were present.

Site 3 also was on the north side of the channel, but farther from the channel than Site 1 (fig. 2). This was an ash-maple site near a backwater cutoff meander quite similar to Site 2. The trees sampled ranged in age from 34 to 60 years, and the net sediment deposition during the lifetimes of the trees ranged from 22 to 30 cm (table 5). As with Site 2, the range of tree age and sediment depth are relatively narrow. The data are graphically shown in figure 8 and are summarized into the pre- and post-1950 age groups in table 6. Again, the age and sediment data indicate that sediments may have been accumulating at a larger rate in more recent years. The smaller net sedimentation rate of the pre-1950 period indicates that there might have been some erosion during the period, but no active erosional features were found.

Site 4 was in an ash-maple site on the south side of the channel, adjacent to a small ditch between a backwater cutoff meander and the channel (fig. 2). All trees sampled at this site were ash. Tree ages ranged from 32 to 76 years, and sediment accumulation during the lifetimes of the trees ranged from 13 to 64 cm (table 7). All data are shown in figure 9. The data were then summarized into pre- and post-1950 age groups (table 8). Erosion was not evident at Site 4, as was noted for Site 1 on the north

Table 2. Pre-1950 and post-1950 sedimentation rates at Site 1 near Momence, Ill.

[D/A, sediment depth divided by tree age; cm/yr, centimeters per year]

Group	Number of trees	Age range (years)	Year range (years of germination)	D/A range (cm/yr)	Average D/A (cm/yr)
Pre-1950	4	54-69	1924-39	0.30-0.45	0.34
Post-1950	19	9-40	1953-84	0.28-3.0	.93

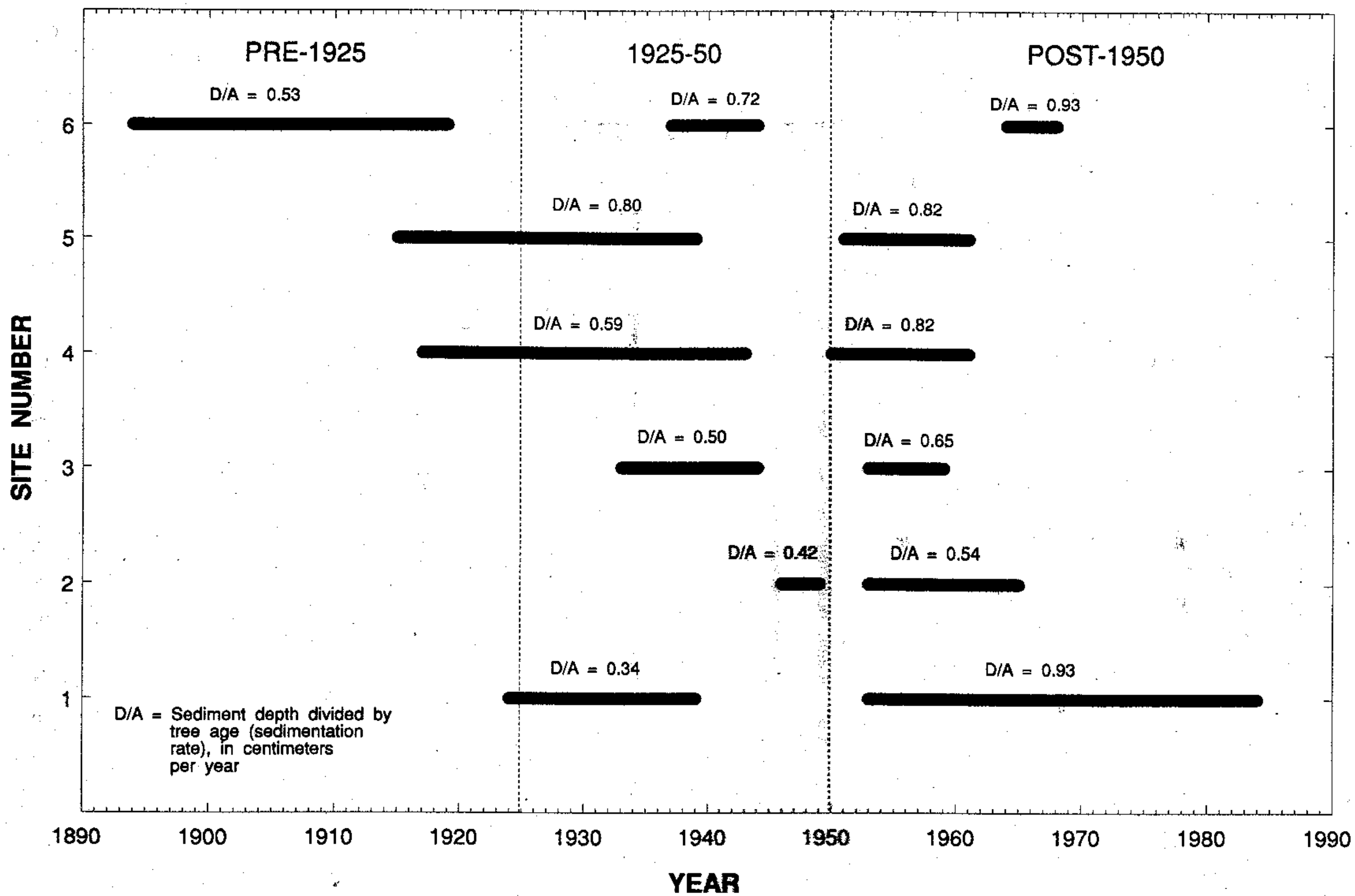

Figure 6. Distributions of tree ages at the six data-collection sites and net sedimentation rates for trees in various age groups in the Momence Wetland near Momence, Ill.

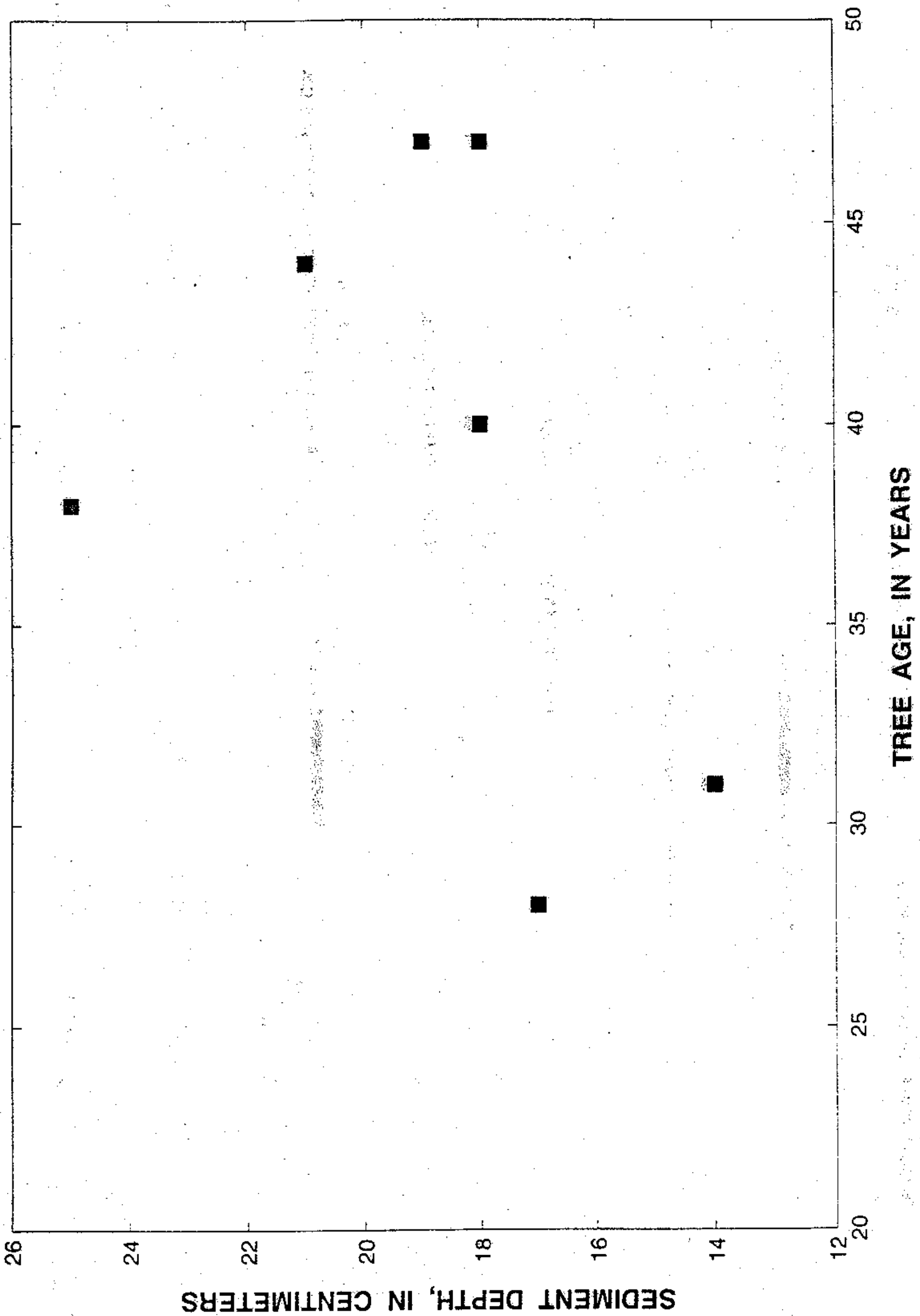

Figure 7. Relation of sediment depth to tree age, Site 2 near Momence, Ill.

Table 3. Dendrogeomorphic data collected at Site 2 near Momence, Ill.
[cm, centimeters; cm/yr, centimeters per year]
Dbh: Diameter at breast height (1.4 meters).
Inside date: Date of innermost tree ring. Number in parentheses is estimated number of missed center rings; p indicates that the pith was reached in the core.
Tree age: Age including minimum number of missed center rings.
Sediment depth: Net sediment accumulation during lifetime of tree.
D/A: Sediment depth divided by tree age (net sedimentation rate).
Tree species: Either ash (*Fraxinus*) or elm (*Ulmus*).

Tree number	Dbh	Inside date	Tree age (years)	Sediment depth (cm)	D/A (cm/yr)	Tree species
BS3- 1	38	1946 (p)	47	18	0.38	Ash
- 2	22	1949 (0-1)	44	21	.48	Ash
- 3	18	1946 (p)	47	19	.40	Ash
- 4	21	1955 (0-1)	38	25	.66	Ash
- 5	13	1965 (0-1)	28	17	.61	Ash
- 6	23	1953 (0-1)	40	18	.45	Ash
- 7	23	1962 (p)	31	14	.45	Ash

Table 4. Pre-1950 and post-1950 sedimentation rates at Site 2 near Momence, Ill.
[D/A, sediment depth divided by tree age; cm/yr, centimeters per year]

Group	Number of trees	Age range (years)	Year range (years of germination)	D/A range (cm/yr)	Average D/A (cm/yr)
Pre-1950	3	44-47	1946-49	0.38-0.42	0.42
Post-1950	4	28-40	1953-65	0.45-0.66	.54

Table 5. Dendrogeomorphic data collected at Site 3 near Momence, Ill.
[cm, centimeters; cm/yr, centimeters per year]
Dbh: Diameter at breast height (1.4 meters).
Inside date: Date of innermost tree ring. Number in parentheses is estimated number of missed center rings; p indicates that the pith was reached in the core.
Tree age: Age including minimum number of missed center rings.
Sediment depth: Net sediment accumulation during lifetime of tree.
D/A: Sediment depth divided by tree age (net sedimentation rate).
Tree species: Either ash (*Fraxinus*) or elm (*Ulmus*).

Tree number	Dbh	Inside date	Tree age (years)	Sediment depth (cm)	D/A (cm/yr)	Tree species
BS4- 1	23	1934 (0-1)	59	29	0.49	Ash
- 2	33	1934 (1-2)	60	27	.45	Ash
- 3	22	1935 (0-1)	58	30	.52	Ash
- 4	27	1953 (p)	40	26	.65	Ash
- 5	22	1946 (2-3)	49	27	.55	Ash
- 6	12	1959 (p)	34	22	.65	Ash

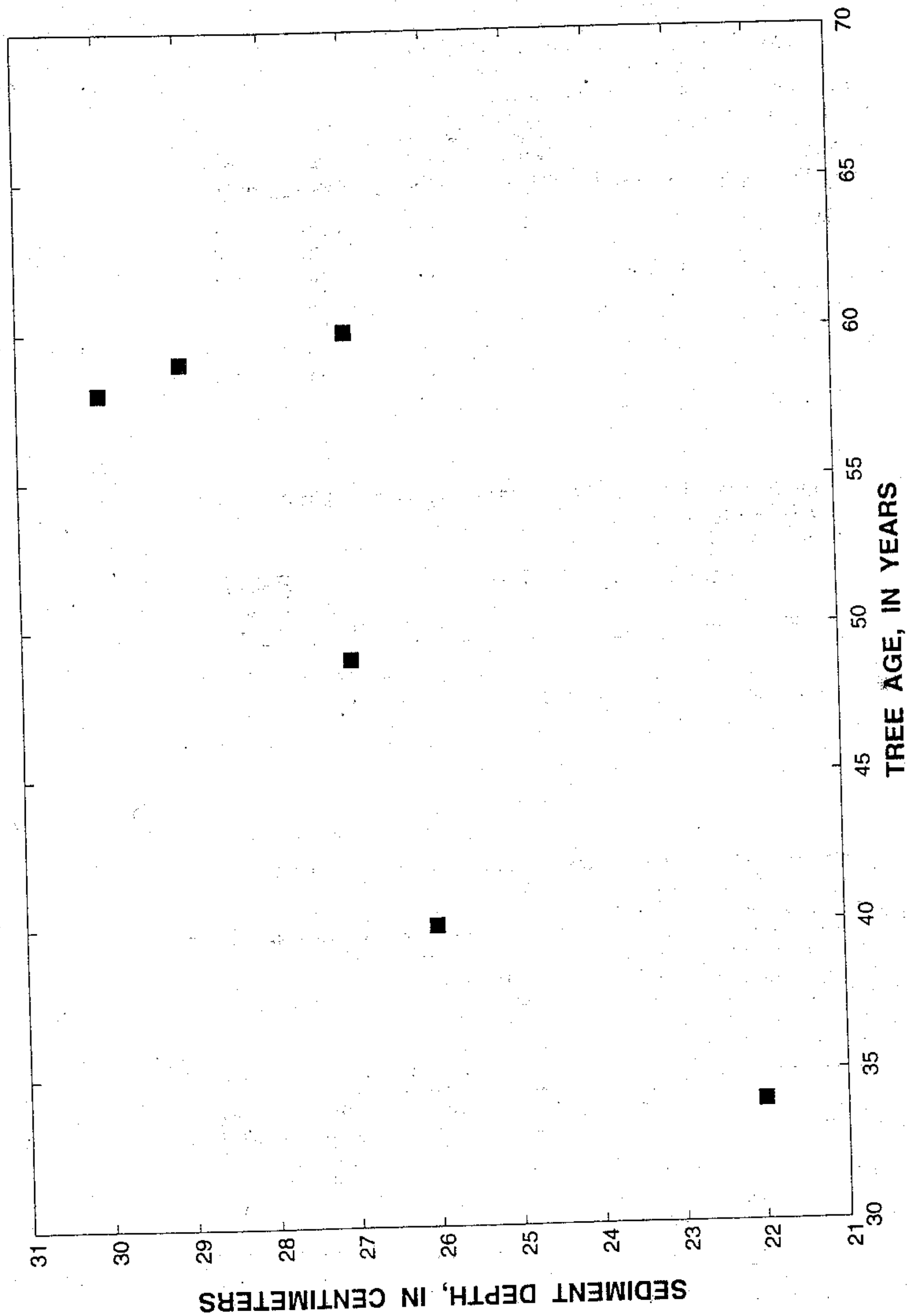

Figure 8. Relation of sediment depth to tree age, Site 3 near Momence, Ill.

Table 6. Pre-1950 and post-1950 sedimentation rates at Site 3 near Momence, Ill.

[D/A, sediment depth divided by tree age; cm/yr, centimeters per year]

Group	Number of trees	Age range (years)	Year range (years of germination)	D/A range (cm/yr)	Average D/A (cm/yr)
Pre-1950	4	49-60	1933-44	0.45-0.55	0.50
Post-1950	2	34-40	1953-59	0.65	.65

Table 7. Dendrogeomorphic data collected at Site 4 near Momence, Ill.

[cm, centimeters; cm/yr, centimeters per year; --, no data available]

Dbh: Diameter at breast height (1.4 meters).

Inside date: Date of innermost tree ring. Number in parentheses is estimated number of missed center rings; p indicates that the pith was reached in the core.

Tree age: Age including minimum number of missed center rings.

Sediment depth: Net sediment accumulation during lifetime of tree.

D/A: Sediment depth divided by tree age (net sedimentation rate).

Tree species: Either ash (*Fraxinus*) or elm (*Ulmus*).

Tree number	Dbh	Inside date	Tree age (years)	Sediment depth (cm)	D/A (cm/yr)	Tree species
BS1-1	12	1963 (2-3)	32	38	1.2	Ash
-2	20	1932 (1-2)	62	23	.37	Ash
-3	18	1932 (p)	61	13	.21	Ash
-4	12	1955 (p)	38	15	.39	Ash
-7	14	1941 (p)	52	23	.44	Ash
-8	18	1940 (1-2)	54	25	.46	Ash
-9	28	1927 (2-3)	68	56	.82	Ash
-10	9	1917 (0-1)	76	64	.84	Ash
-11	12	1952 (2-3)	43	40	.93	Ash
-12	4	1955 (0-1)	38	37	.97	Ash
-13	--	1954 (p)	39	24	.62	Ash
-14	33	1934 (p)	59	26	.44	Ash
-15	14	1945 (2-3)	50	18	.36	Ash
-16	30	1940 (1-2)	54	37	.69	Ash
-17	21	1935 (1-2)	59	51	.86	Ash
-18	17	1937 (1-2)	57	55	.96	Ash

Table 8. Pre-1950 and post-1950 sedimentation rates at Site 4 near Momence, Ill.

[D/A, sediment depth divided by tree age; cm/yr, centimeters per year]

Group	Number of trees	Age range (years)	Year range (years of germination)	D/A range (cm/yr)	Average D/A (cm/yr)
Pre-1950	11	50-76	1917-43	0.21-0.96	0.59
Post-1950	5	32-43	1951-61	0.40-1.2	.82

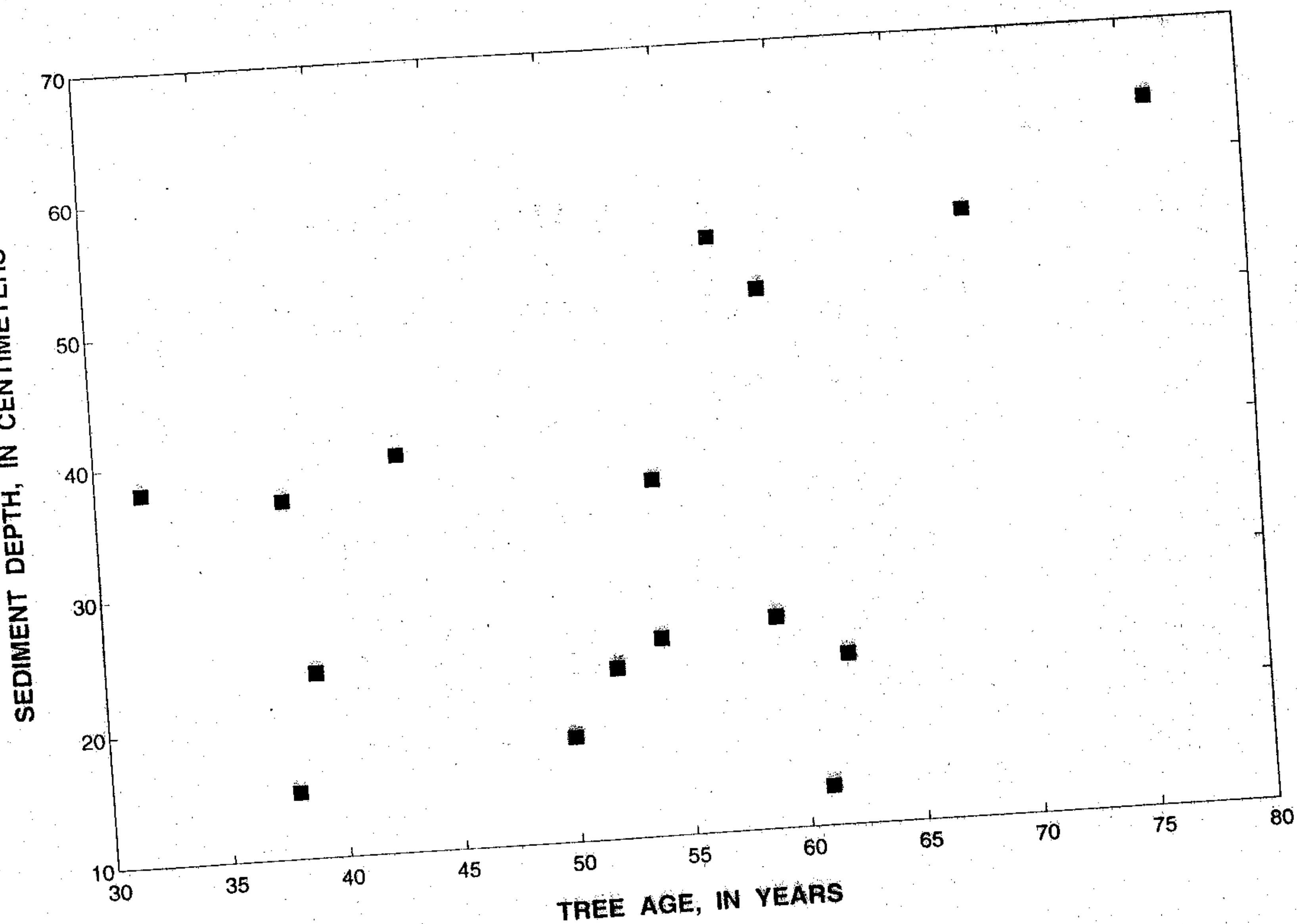

Figure 9. Relation of sediment depth to tree age, Site 4 near Momence, Ill.

side of the channel. The net sedimentation rate was greater during the post-1950 period than during the pre-1950 period, similar to Sites 2 and 3.

Site 5, an ash-maple site near a backwater cutoff meander, was on the south side of the channel, southeast from Site 4 (fig. 2). Tree ages ranged from 32 to 78 years, and the sediment depths for the lifetimes of the trees ranged from 27 to 62 cm (table 9). The data from Site 5 indicate essentially the same net sedimentation rate for the pre- and post-1950 periods (table 10). A graph of the data (fig. 10) implies a linear trend; that is, no shift is present in the data as at Site 1.

Site 6 was about 500 m downstream from Site 4. Site 6 was an ash-maple site near another backwater cutoff meander on the south side of the channel (fig. 2). Tree ages ranged from 25 to 99 years, and sediment depths during the lifetimes of the trees at this site ranged from 17 to 61 cm (table 11). Four trees sampled here were older than trees sampled at any other site. At least four trees at Site 6 pre-dated completion of channelization in Indiana (about 1918).

Because of the number of older trees at Site 6, data were summarized by grouping into three age groups: pre-1925, 1925-50, and post-1950. The youngest age group (post-1950) included only two trees. The summarization table (table 12) shows the smallest net rate of sediment accumulation for the pre-1925 group (0.53 cm/yr), with a greater rate for the 1925-50 group (0.72 cm/yr), and with the post-1950

Table 9. Dendrogeomorphic data collected at Site 5 near Momence, Ill.

[cm, centimeters; cm/yr, centimeters per year]

Dbh: Diameter at breast height (1.4 meters).

Inside date: Date of innermost tree ring. Number in parentheses is estimated number of missed center rings; p indicates that the pith was reached in the core.

Tree age: Age including minimum number of missed center rings.

Sediment depth: Net sediment accumulation during lifetime of tree.

D/A: Sediment depth divided by tree age (net sedimentation rate).

Tree species: Either ash (*Fraxinus*) or elm (*Ulmus*).

Tree number	Dbh	Inside date	Tree age (years)	Sediment depth (cm)	D/A (cm/yr)	Tree species
BS1E-1	18	1954 (0-1)	39	34	0.87	Ash
-2	23	1937 (0-1)	56	49	.87	Ash
-3	32	1937 (p)	56	48	.86	Ash
-4	40	1939 (0-1)	54	47	.87	Ash
-5	24	1953 (2-3)	42	38	.90	Ash
-6	28	1961 (p)	32	27	.84	Ash
BBS-1	32	1954 (1-2)	40	29	.73	Ash
-2	44	1915 (p)	78	62	.79	Ash
-3	15	1937 (p)	56	42	.75	Ash
-4	18	1953 (p)	40	30	.75	Ash
-5	39	1931 (0-1)	62	47	.76	Ash
-6	27	1937 (0-1)	56	41	.73	Ash
-7	52	1918 (p)	75	56	.75	Ash

Table 10. Pre-1950 and post-1950 sedimentation rates at Site 5 near Momence, Ill.

[D/A, sediment depth divided by tree age; cm/yr, centimeters per year]

Group	Number of trees	Age range (years)	Year range (years of germination)	D/A range (cm/yr)	Average D/A (cm/yr)
Pre-1950	8	54-78	1915-39	0.73-0.87	0.80
Post-1950	5	32-42	1951-61	0.73-0.90	.82

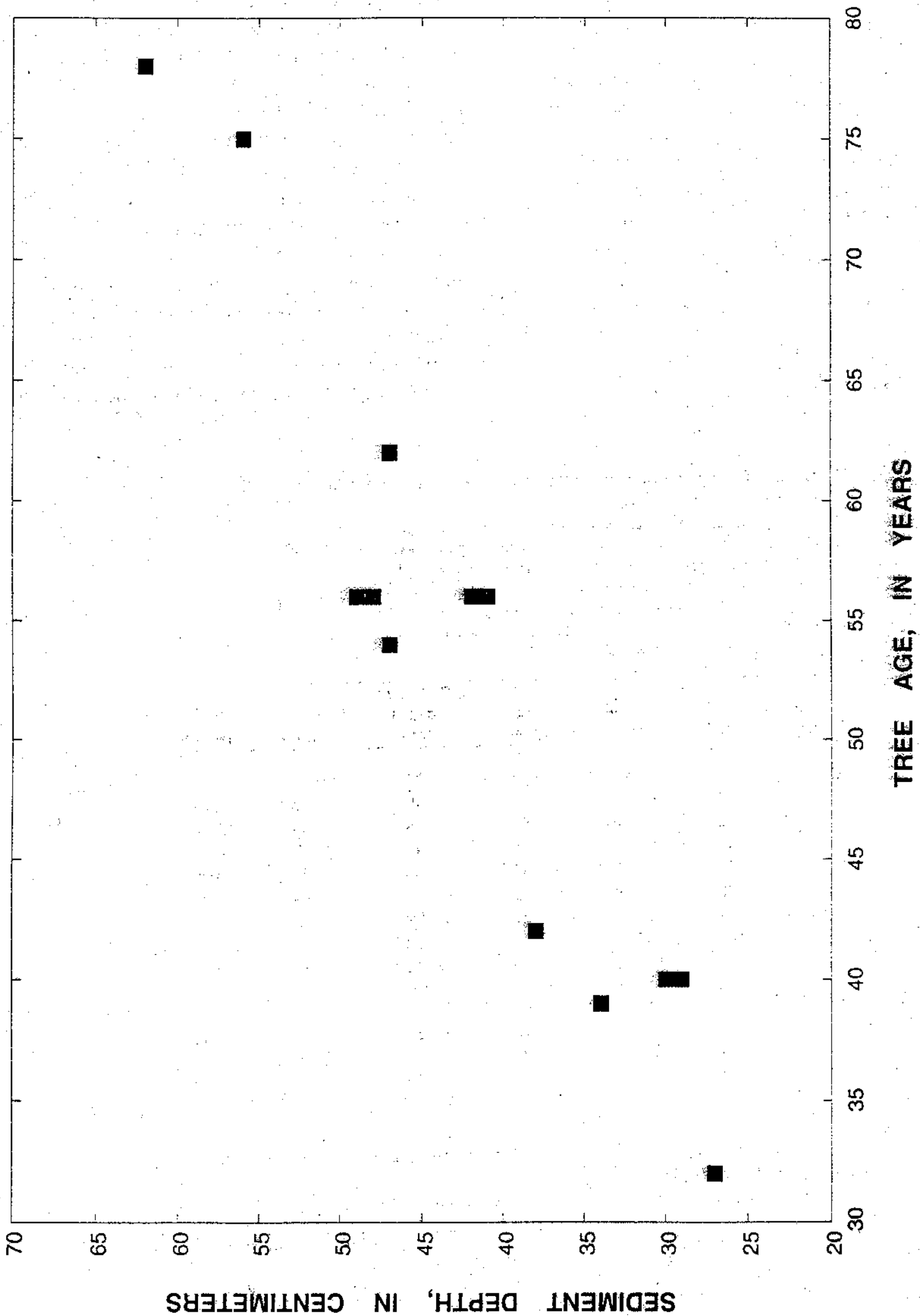

Figure 10. Relation of sediment depth to tree age, Site 5 near Momence, Ill.

Table 11. Dendrogeomorphic data collected at Site 6 near Momence, Ill.

[cm, centimeters; cm/yr, centimeters per year; --, no data available]

Dbh: Diameter at breast height (1.4 meters).

Inside date: Date of innermost tree ring. Number in parentheses is estimated number of missed center rings; p indicates that the pith was reached in the core.

Tree age: Age including minimum number of missed center rings.

Sediment depth: Net sediment accumulation during lifetime of tree.

D/A: Sediment depth divided by tree age (net sedimentation rate).

Tree species: Either ash (*Fraxinus*), elm (*Ulmus*), or oak (*Quercus*).

Tree number	Dbh	Inside date	Tree age (years)	Sediment depth (cm)	D/A (cm/yr)	Tree species
R-1	35	1903 (3-5)	93	53	0.57	Ash
-2	--	1922 (3-5)	74	38	.51	Ash
-3	--	1947 (3-5)	49	32	.65	Ash
-4	--	1894 (p)	99	55	.56	Ash
-5	--	1965 (1-2)	29	34	1.2	Oak
-6	14	1938 (p)	55	24	.44	Ash
-7	20	1937 (p)	56	61	1.1	Ash
-10	25	1938 (1-2)	56	40	.71	Ash
-12	13	1937 (p)	56	37	.66	Ash
-13	42	1938 (1-2)	56	43	.77	Ash
-14	28	1939 (1-2)	55	40	.73	Ash
-15	7	1970 (2-3)	25	17	.68	Ash
-16	29	1910 (2-3)	85	50	.59	Ash
-17	20	1897 (p)	96	42	.44	Ash

Table 12. Pre-1925, 1925-50, and post-1950 sedimentation rates at Site 6 near Momence, Ill.

[D/A, sediment depth divided by tree age; cm/yr, centimeters per year]

Group	Number of trees	Age range (years)	Year range (years of germination)	D/A range (cm/yr)	Average D/A (cm/yr)
Pre-1925	5	74-99	1894-19	0.44-0.59	0.53
1925-50	7	49-56	1937-44	0.44-1.1	.72
Post-1950	2	25-29	1964-68	0.68-1.2	.93

group having the greatest rate (0.93 cm/yr). The pre-1925 period probably included much of the channelization activity in Indiana. Sediment deposition during that time period might have been expected to have been exceptionally large during channel construction but appears to have been just the opposite. A graph of the data from Site 6 is shown in figure 11.

Interpretation of the Data

The net sedimentation rate for the pre-1950 period at Site 1 (0.34 cm/yr) is about 3 times smaller than for the post-1950 period (0.93 cm/yr) (table 13), indicating that either little or no deposition resulted before 1950 or there has been erosion of material from

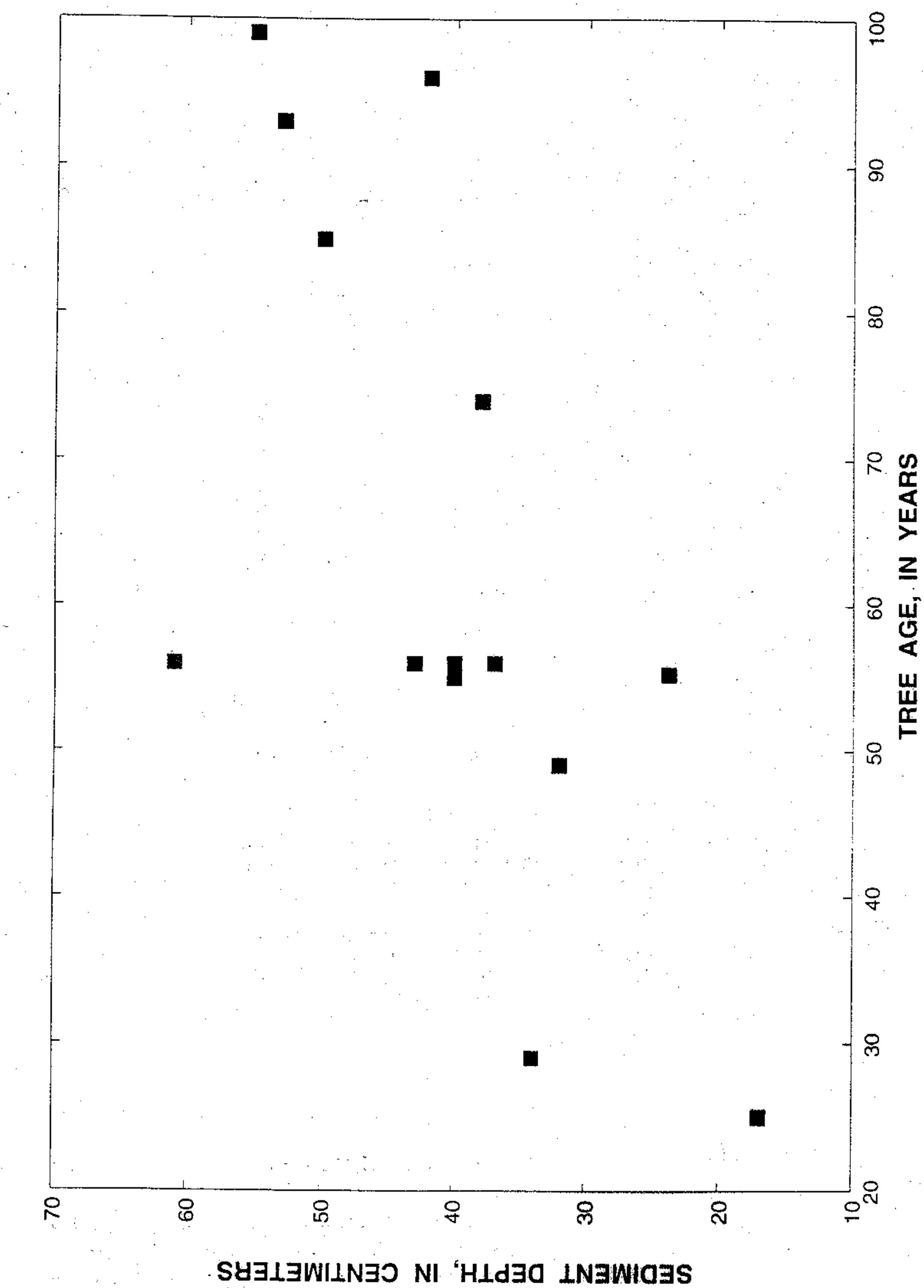

Figure 11. Relation of sediment depth to tree age, Site 6 near Momence, Ill.

Table 13. Summary of net sedimentation rates at data-collection sites near Momence, Ill.

[D/A, sediment depth divided by tree age; Average D/A, average of D/A of every tree at that site; Ages, range of tree ages]

Site	Pre-1950 Ages	Pre-1950 Number of trees	Pre-1950 Average D/A	Post-1950 Ages	Post-1950 Number of trees	Post-1950 Average D/A
1	54-69	4	0.34	9-40	19	0.93
2	44-47	3	.42	28-40	4	.54
3	49-60	4	.50	34-40	2	.65
4	50-76	11	.59	32-43	5	.82
5	54-78	8	.80	32-42	5	.82
6	49-56	7	.72	25-29	2	.93
6	74-99	5	.53			
Average of all D/A			0.59			0.75

the site. Large, relatively old elm trees on the natural levee indicates that the levee was present before 1950. It is likely sediment was deposited before 1950, but much of the sediment deposited between the time the older trees were established and 1950 appears to have been eroded. Active erosional features on the levee at Site 1 also suggest the possibility that erosion might have altered depths of sediment deposits.

The data collected at Sites 2 and 3 also showed an increase in net sedimentation rates from before 1950 to after 1950 (table 13). The net sedimentation rate of the earlier period was smaller, indicating the possibility of sediment loss by erosion, but no active erosional features were present. Because no such features were present and because the area has remained essentially unchanged over the past several decades, it is assumed that loss of sediment by erosion was minimal.

The Kankakee River upstream from Momence to the State line has very little gradient and inundates the Momence Wetland when it overflows its banks. Flow velocities on the relatively wide flood plain of the river, except near the channel, are assumed to be very low. The absence of active erosional features supports this assumption.

Data from Sites 4 and 6 (table 13) also indicated increasing net sedimentation rates during the lifetime of the trees. Data at Site 5 (table 13) also indicated an increase in net sedimentation rate from pre- to post-1950, but not such a marked increase as other sites.

One factor that could have caused a change of the sedimentation rate is a change in streamflow. An increase in streamflow usually will cause an increase in sediment transport in a stream. Also, it is assumed in the dendrogeomorphic method that if an area is inundated more frequently, more sediment will settle on the flood plain, resulting in greater sedimentation rates. Bhowmik and others (1980, figs. 18 and 21) used mean annual discharge data from the USGS streamflow-gaging stations to point out that streamflow in the Kankakee River Basin had been increasing for perhaps the last 50 years (fig. 12). Their analysis was repeated for this study with data through 1992. The increases in streamflow have continued since the 1980 study (fig. 12). The increasing streamflow does not seem to be unique to the Kankakee River Basin. Blanchard and Schmidt (in press) reported "significant upward trends" in streamflow at 23 of 25 stations in the upper Illinois River Basin during 1978-86. The 25 stations represented drainage areas with urban, agricultural, and mixed land uses. Many factors can affect streamflow, such as changes in channel geometry (for example, straightening or dredging of a channel and draining of a wetland); quantity, duration, and intensity of rainfall; and changes in land-use practices.

Precipitation data through 1992 were obtained (National Oceanic and Atmospheric Administration, 1921-92) at two rain-gaging stations in the upper Kankakee River Basin–at Wheatfield and Plymouth, Ind. (fig. 1). Data from these stations are shown in figures 13 and 14. The precipitation data show an upward trend since the early 1900's and provide at least one explanation for the observed increases in streamflow.

Less likely causes of the observed increases in net sedimentation rates are erosion and compaction, which might have reduced the actual sediment depth.

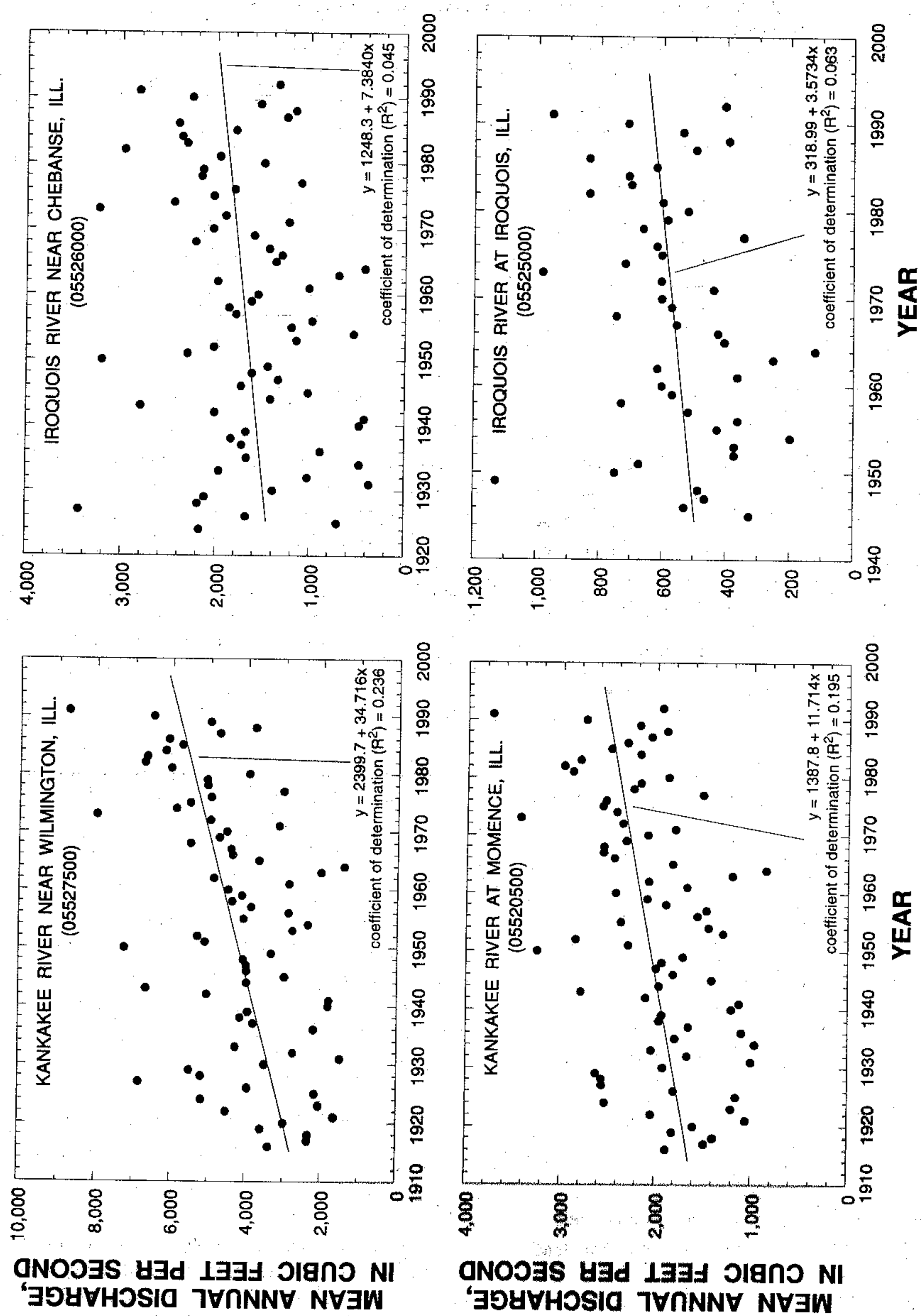

Figure 12. Mean annual discharge at four streamflow-gaging stations in the Kankakee River Basin through 1992.

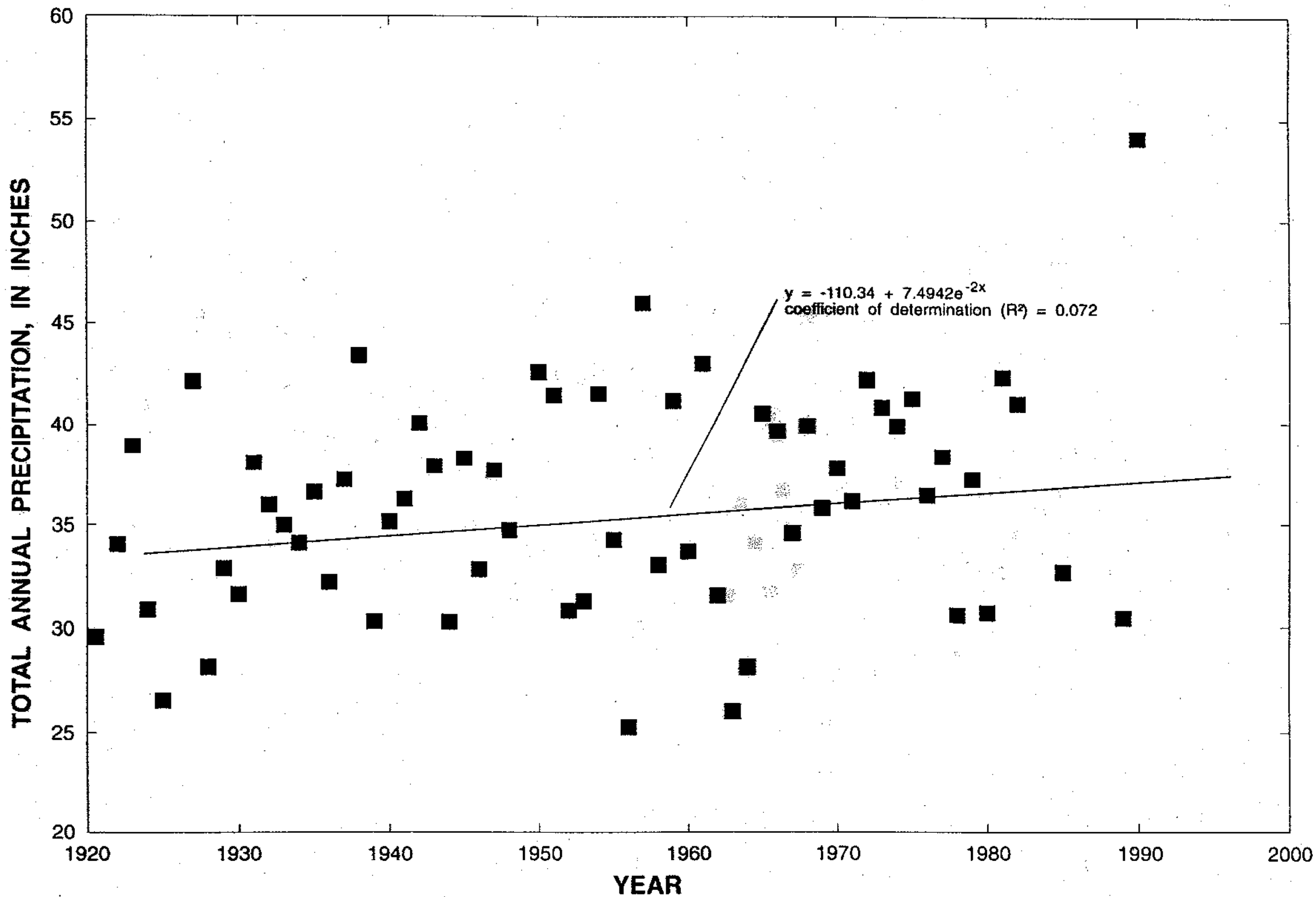

Figure 13. Total annual precipitation, Wheatfield, Ind., 1921-91.

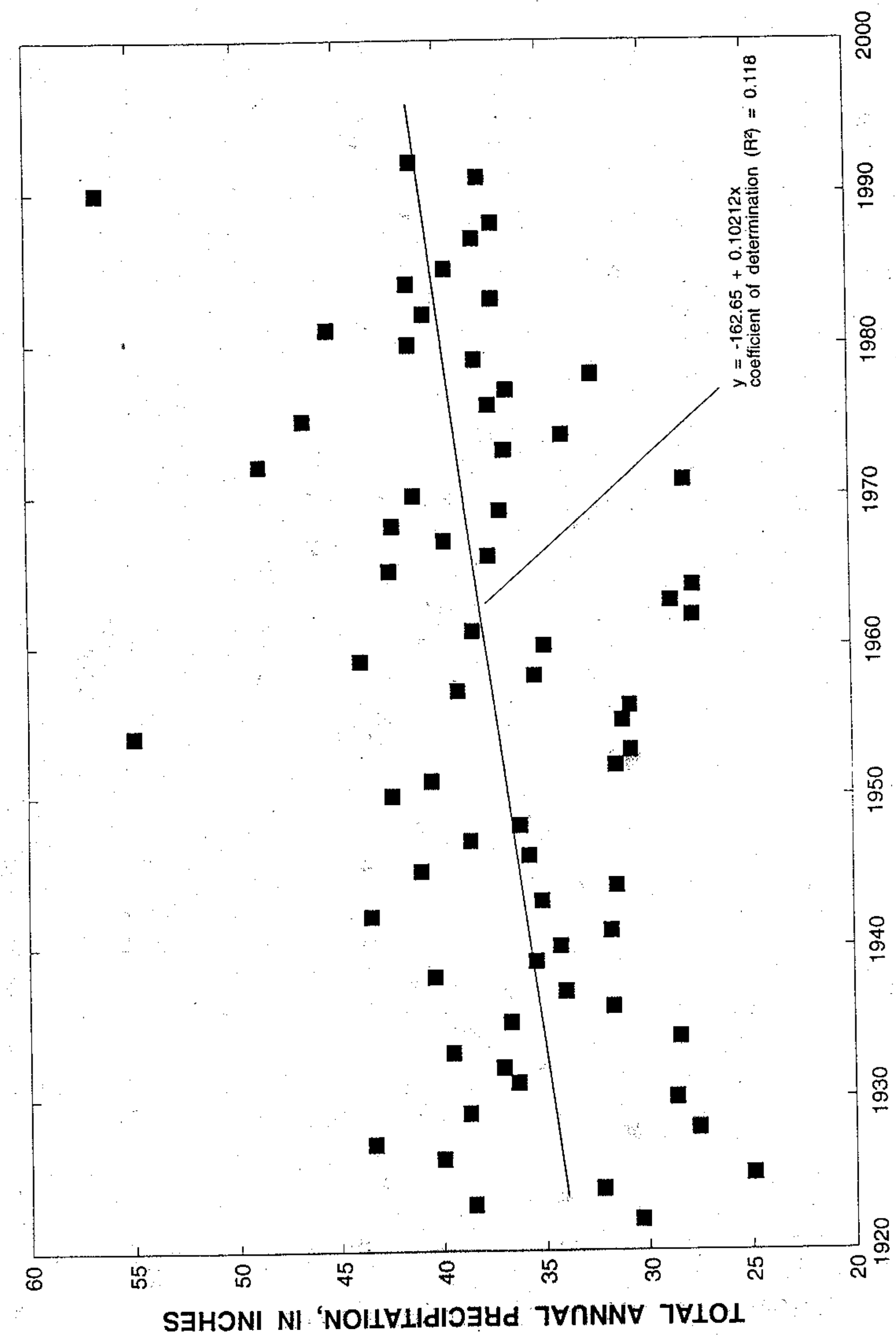

Figure 14. Total annual precipitation, Plymouth, Ind., 1922-92.

Erosion during earlier years and little or none in more recent years would have resulted in increasing net sedimentation rates, but no evidence indicated that erosion was a cause. Soil compaction depends on how easily material making up the soil may be consolidated. Soils of the study area are described as Gilford fine sandy loam and are grouped in the coarse-grained soil classes SM and SC in the Unified Soil Classification System (U.S. Department of Agriculture, 1990). This type of soil is not easily compacted.

A study in the Momence Wetland, about 10 km downstream, showed that study area was flooded at a discharge of around 113 m^3/s (Mitsch and Rust, 1984). USGS personnel noted on several occasions that the data-collection sites were inundated at a lower discharge (around 85 m^3/s). The estimated period of inundation of the study area at 85 and 113 m^3/s is shown in table 14. This inundation period was calculated for different time periods and shows that the area is more subject to inundation in recent years than about 50 years ago.

Dendrogeomorphic determinations of sediment depth as described in this report are primarily based on sedimentation in backwater meanders. A major assumption of this study was that sedimentation on the flood plain has some association with sand movement in the channel. The relation between sand movement in the channel and sediment deposition on the flood plain, however, has not been determined. In order for the rate of sediment deposition in the backwater areas to reflect the rate of sediment transport in the river channel, sediment at the sites around the meanders must be from the channel and not from other sources. Other than the river channel, two possible sources of sediment in the backwater meanders are (1) reworked bank material from lateral movement (meandering) of the channel, and (2) locally eroded material.

Reworking of former bank material is unlikely. Comparison of the most recent 7½-minute topographic map (1973) of the area with older maps (15-minute topographic map, 1924) and with present channel configuration indicates that the main channel in the study area has not moved appreciably since channelization in Indiana was completed around 1918. Further, the number and size of large canopy trees between the backwater cutoff meanders and the present channel also indicate that the channel has remained in its present location for at least 30 years. It does not appear that sediment deposits around the backwater meanders sampled in this study include sediment from lateral movement of the channel.

It is unlikely that the sediments deposited in the study area were eroded from local areas. The area between State Highway 114 and the data-collection sites (fig. 2) is forested and has remained forested because it is too poorly drained to be suitable for cultivation. The sediment deposits in the study area completely encircle the cutoff meanders but do not extend between the meanders and State Highway 114. It is unlikely that sediment in the study area was transported from farmland across the poorly drained, heavily vegetated area south of the river. Elimination of these two possible sources would indicate that sediments associated with the cutoff meanders are material that was transported in the river channel; that is, by floodwaters of the Kankakee River.

Table 14. Estimated period of inundation of data-collection sites along the Kankakee River near Momence, Ill.

[m^3/s, cubic meters per second. Data for the streamflow-gaging station at Kankakee River at Momence, Ill. (05520500)]

Time period	Assuming 85 m^3/s will inundate sites		Assuming 113 m^3/s will inundate sites	
	Percent of time sites are inundated	Number of days per year sites are inundated	Percent of time sites are inundated	Number of days per year sites are inundated
1905-92	21	77	12	44
1905-50	17	62	8	29
1950-92	25	91	15	55
1980-92	29	106	19	70

SUMMARY AND CONCLUSIONS

Past sedimentation rates were estimated for six sites along the Kankakee River near Momence, Ill., utilizing a dendrogeomorphic technique. Five sites were areas of sediment deposition near backwater cutoff meanders containing mostly ash and maple trees. The sixth site was on a natural sand levee on an inside bend of the channel containing mostly elm and maple trees. Net sedimentation rate at each tree sampled was estimated as the total depth of sediment accumulated (depth of original lateral root burial) divided by the age of the tree. Examination of root burial depth of trees of a variety of ages permitted estimation of net sedimentation rates before and after 1950. The following is a summary of the analysis of the dendrogeomorphic data:

1. Dendrogeomorphic evidence indicated a greater net sedimentation rate for trees established after 1950 compared to trees established before 1950, at all but one site along the upper reaches of the Kankakee River in Illinois. No data indicated that the net sedimentation rate of the trees established after 1950 was less than the rate of the trees established before 1950.

2. Possible explanations for apparent increased sedimentation rates since 1950 include erosion, soil compaction, and increased streamflow. No evidence of erosion was observed, except at Site 1, indicating that effects from erosion were minimal. Data indicated a major erosional event at Site 1 that might have resulted from a flood in 1950. Soils at all the study sites are not easily compacted, indicating that effects of compaction were minimal. Streamflow at four gaging stations in the Kankakee River Basin has increased over the period of record of each station, possibly resulting in increased sedimentation. The degree to which increased streamflow has caused increased sedimentation is not known. Not enough data were collected to determine if sedimentation is increasing at a rate commensurate with streamflow increases.

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GLOSSARY

Active erosional feature. A characteristic of an area that seems to be presently eroding; for example, a gully that appears freshly cut.

Adventitious roots. Roots that sprout from, and at right angles to, a root or stem. Adventitious roots may develop on buried stem wood.

Backwater. A general term referring to standing water that is away from the moving water of the stream but whose level is affected by that of the stream. Backwater areas in the Momence Wetland contain the old cutoff meanders.

Bottomland. An informal term that refers to the flat land on either side of a stream. It usually includes the flood plain and surrounding area.

Channelization. Modification of a stream to confine it to an artificial (usually straight) ditch or channel.

Cutoff meander. See meander.

D/A. Sedimentation rate; that is, sediment depth divided by tree age.

Dendrochronology. The science that is concerned with the study of tree rings for the information that may be obtained from them.

Dendrogeomorphology. A branch of science that combines dendrochronology and geomorphology. Dendrogeomorphology involves the use of tree rings to obtain information of hydrologic interest.

Depositional area. An area in which material is deposited, such as an area of sediment deposition.

Diffuse-porous. Refers to a type of wood. Trees in the Momence Wetland that have diffuse-porous wood include such tree species as silver maple, willow, and sycamore.

Dissecting microscope. A microscope specially designed to provide a wide view at low power (magnification).

Equilibrium. With reference to a river, equilibrium implies that the geomorphic and hydrologic processes that form the river are in balance. When in equilibrium the sedimentation rate should be neither increasing nor decreasing.

Flood plain. A plain (flat surface) along either side of a river through which, over many centuries, the river will meander. Leopold and others, 1964, defined the flood plain as the surface that is flooded, on the average, about once every 1.5 years. By this definition, a riverine wetland, such as the Momence Wetland, is usually flooded at least once every year and occupies a surface lower than the flood plain; however, throughout the report this lower surface is referred to as bottomland or flood plain.

Hydrology. The science dealing with the nature and properties of water.

Increment core. A small pencil-shaped core that may be taken from a tree with an increment borer. Tree rings may be viewed on increment cores. Increment cores thus provide a means by which tree ages may be determined while doing little or no damage to the tree.

Lateral roots. Roots that grow more-or-less horizontally, or laterally, from a vertical axis or stem.

Marsh. Wetland. Sometimes a marsh is considered as a type of wetland that contains grass and few or no trees. The terms marsh and wetland are used interchangeably in this report.

Meander. A bend in the river. As a meander becomes more extreme, it has an increased chance of being cut off from the river. A small cutoff meander may be referred to as a slough. Large cutoff meanders are often called oxbows or oxbow lakes.

Original lateral roots. Lateral roots that develop just below the soil surface on which the seedling became established.

Riverine wetland. A wetland along a river.

Root crown. The base of the tree trunk from which lateral roots arise. The root crown is characteristically wider than the tree trunk above it.

Sediment. Gravel, sand, silt, and clay that may be moved by river water.

Sedimentation. The process of sediment accumulation at any particular location.

Sedimentation rate. Sediment deposited per unit time. In this report, sedimentation rate is calculated as sediment depth divided by tree age, and is referred to as D/A.

Slough. A very wet area that usually contains at least some standing water. As used herein a slough is synonymous with backwater and cutoff meander.

Suspended sediment. Sediment that is small enough to be held in suspension by the upward component of turbulence in moving water. Generally, particles less than 0.062 mm diameter are considered small enough to be constantly suspended and moved with the water column.

Tap root. A root that grows vertically along the main axis of the tree.

Tree ring. An annual growth layer of a woody plant. When viewed in cross section, such as on a stump top, the annual growth layer appears as a ring.

Water table. In a nonconfining soil, such as that of a flood plain, it is the level at which water stands in a well. Though usually below the surface of upland soils, the water table of a wetland may often be above the surface.

Wetland. A low, wet area that usually contains some standing water. The water table in a wetland is close to the surface most of the time. A wetland is expected to be inundated for at least a short time every year.

Phipps and others—DENDROGEOMORPHIC ESTIMATE OF CHANGES IN SEDIMENTATION RATE ALONG THE KANKAKEE RIVER NEAR MOMENCE, ILLINOIS—USGS/Water-Resources Investigations Report 94-4190