DISTRIBUTION PATTERN OF EASTERN RED-CEDAR, *JUNIPERUS VIRGINIANA* L., IN IOWA

by

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Approved:

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INTRODUCTION

A previous study of distribution patterns of eastern red-cedar (Juniperus virginiana L.) indicated that scattered trees in pastures, roadsides and fence lines were definitely related to trees in windbreaks and landscape plantings in Henry County, Iowa (Graf, 1965). Naturally established red-cedar trees were usually not more than one-half mile from the planted seed source. Recognition of this pattern of naturally established trees radiating from an older planted seed source in Henry County and a preliminary survey across the northern, central and southern regions of Iowa indicated that the distribution pattern of red-cedar in the state of Iowa should be studied. Recent rapid invasion of red-cedar trees into pastures and increased abandonment and razing of homesteads made it imperative that this study be conducted at this time.

Many studies of distribution of various species of trees and also some limited surveys on cedar populations have been conducted. However, the study of a "distribution pattern", referring to the relative location of a seed source and naturally established red-cedar trees along with their increasing invasion of prairie and uncultivated land has not previously been completed for the entire state of Iowa.

It becomes increasingly more difficult to determine the distribution pattern of red-cedar in relation to planted trees where many homesteads have been razed. Even during the months of this study, some fence rows have been cleared and farm buildings torn down with the subsequent cutting of trees and filling in of basements. This general activity suggests that before long the windbreaks which contained the planted seed sources for the new invading cedar growth will be removed.

In an effort to observe all of the possible differences in the distribution of red-cedar in Iowa, sixteen townships in four counties were selected for study. In these townships most of the variations in topography, soil and climate that might influence plant distribution can be found. Distribution is used here in the broad sense to handle the relative location of old or original trees and more recently established ones. The exact spatial arrangement of individual trees, their density and age structure of stands are not objectives of this study. Pattern as used by Dice (1952), Odum (1959), Arnold (1964) and Sanders (1969) is not applicable here.

The silvicultural characteristics of eastern red-cedar are not being examined in this study; however, they would be important in the final analysis of ecological factors responsible for the present distribution of red-cedar. Success of red-cedar depends upon an adequate seed source and suitable habitat; both conditions are easily met over most of Iowa today because of the activities of man. Little has been done to define the natural boundaries of the occurrence of eastern red-cedar in Iowa despite the alarming increase of unwanted trees in pastures, roadsides and other restricted-use areas. Is this increase a recent trend or has eastern red-cedar been a common tree in the prairie-forest ecotone of presettlement Iowa? The lack of the occurrence of red-cedar in the early records of Henry County, Iowa (Graf, 1965) suggest that an examination of early records in selected other portions of the state might be a fruitful endeavor. The numerous place names, Cedar Falls, Cedar Rapids, Cedar River and Cedar County, obviously have some reference to eastern red-cedar.

Rivers served as the early routes of transportation into Iowa. Written accounts of surveyors and travelers along them would be important sources of information in this study because they included records of early vegetation. Four main rivers were selected to obtain the locations of pre-settlement eastern red-cedar trees.

REVIEW OF LITERATURE

General

The presettlement distribution and communities of species has been approximated in studies using the original land survey field notes and plats as dependable sources of data (Lutz, 1930; Kenoyer, 1933; Gordon, 1940; Potzger and Potzger, 1950; Dick-Peddie, 1955; Bourdo, 1956 and Jones and Patten, 1966). Additional information about early vegetation obtained from local residents and accounts by early travelers (Gordon, 1940; Maycock and Curtis, 1957 and Steyermark, 1959) is less desirable because of its tendency to be biased; however, in many situations even these sources are not available.

Historical records and repeated photography over a period of years illustrate the vegetation changes that have occurred in the arid southwest United States and northwest Mexico (Hastings and Turner, 1965). The part man and climate have played in the increase of woody plants is emphasized.

Gordon (1940) also reconstructed the original vegetation from data in the original land survey records and compared it to the present vegetation of southwestern New York. The witness trees recorded in this survey of 1799 were regularly found where only that species exists today, suggesting that the intervening years had not altered the tree species pattern of existence to any appreciable degree.

A qualitative and quantitative comparison of the presettlement trees of 1819 and present day forests in Marion and Johnson Counties, Indiana, was based on the original records and twenty $10m^2$ quadrats done recently on a relict stand (Blewett and Potzger, 1951). It was concluded from this

that present-day surveys of small stands of relict forests show quite accurately the same association complexes and quantitative representation of species as in the presettlement forest. However, a shift from bur oak (Quercus macrocarpa) to white oak (Quercus alba) was suggested by Dick-Peddie (1955) in Iowa stands. He reconstructed Iowa forests from the original land survey field notes in Allamakee, Jackson, and Lee Counties, and three belt transects six miles wide across the state. The genus Quercus dominated the forest. Red-cedar was only found in one county. These records may be compared to the present day distribution by Aikman and Gilly (1949).

Lutz (1930) also based his study of the original forest composition in northern Pennsylvania on data from the early land survey notes. It was assumed that the number of times a species was referred to in the field notes indicated its abundance.

Cooper (1960) has studied the post-settlement changes that have occurred in southwestern pine forests. The influence of settlers on the distribution pattern is illustrated by the changes that occurred in the forest after their arrival. The original pattern of open, parklike forests were arranged in definite groups each containing ten to thirty trees of a common age. Small numbers of seedlings were dispersed among the mature pines and grasses carpeted the ground. After the arrival of settlers, the overpopulation of trees in an area was due to heavy grazing and trampling by domestic animals. Age and size class determination in the study illustrated the pattern of distribution. Fire as a factor in establishing and maintaining the present climax forest of cedars and hemlocks through infinite time in western United States was emphasized in a later publication (Cooper, 1961).

The relative frequency, density and dominance of the present Great

Lakes forest species, as determined by the quarter method, were compared with the vegetation described by early missionaries and explorers in the 1600's (Maycock and Curtis, 1957). The present spatial relationship of stands to each other and their correlation with moisture difference was emphasized.

The distribution of presettlement vegetation types was correlated with the texture and reaction of soils in the Black Belt of Sumter County, Alabama (Jones and Patton, 1966). The forest and prairie areas were delineated from data in the original land survey field notes and plats. The soil characteristics were obtained from modern soil maps. A strong correlation was found between the areas of low density and alkaline clay soils, and dense forests and acid loam soils. Red-cedar constitutes less than 0.3% of the trees encountered.

Becraft (1923) stressed the correlation of the distribution of black oak along the Skunk River in Hamilton and Story Counties, Iowa, with soil origin. This study was continued by Trenk (1925) and a historical summary of tree distribution in Iowa was published.

The distribution of all trees cited in the original land survey notes in Kane County, Illinois, were mapped from these records (Kilburn, 1959). A correlation between topographical sites and forest types was determined.

Forest cover types, determined in 152 one-twentieth acre circular plots in upper Michigan, were compared with the original survey field notes and plats (Bourdo, 1956). Forty-nine of the marked trees in the original survey were located in the present field study.

In Trumbull County in Ohio, Shanks (1937) reconstructed the primeval forest from data in the original land survey records and compared it with

small virgin stands. Kenoyer (1933) did the same in southwestern Michigan.

Early Distribution of Red-cedar

A comparison of present-day and presettlement occurrence of red-cedar indicated that it was present in every Missouri Ozark county at both times (Steyermark, 1959). Data from the original survey records were compared with (1) thousands of specific areas observed in the Ozarks between 1925 and 1959 and (2) detailed forest surveys of 1936 and 1937 (Steyermark, 1940, 1951, 1955, 1959). The geological history of the Ozarks suggested that red-cedar has either continuously or on numerous occasions occupied the present limestone bluffs and glades. The relative occurrence of red-cedar on glades and limestone bluffs and of present and presettlement forested and prairie areas is reported.

Another study of the distribution of red-cedar in Missouri based on age classes indicated that the bluffs, knobs and glades were colonized first, then old fields, and most recently "worn-out", acidic and sandy lands (Hall, 1955). The explosive invasion of juniper within the last 100 years is attributed to the "wearing-out" and final abandoning of more and more land which had once been deciduous forest.

Notes on the distribution of trees in Iowa date back to man's earliest arrival (Gleason, 1922). Most of the early accounts simply record the presence of a plant or vegetation type in a geographical area. Pike (1889) mentions that red-cedar was present in the ash-maple timber on the east bluffs of the Mississippi River. The associated species, the density and the extent of the distribution of cedar are not recorded in this account. Reports of the occurrence of red-cedar trees on many rocky bluffs bordering rivers in Iowa do not describe the abundance or the exact location of

species (Greene, 1907). Pammel (1902) related the distribution of eastern red-cedar in Iowa to the extent of Merriam's Alleghenian Transition Zone in the boreal region of Iowa (Merriam, 1898). The distribution of red-cedar in the Alleghenian Zone reaches its greatest development along the Mississippi to the Missouri and then north along the Missouri. The zone extends further eastward in southeastern Iowa than in any other part of Iowa. Red-cedars were collected on rocky bluffs of the Des Moines River in Boone County and along the Cedar River near Burlington, Iowa, in 1871, by The Reverend Isaiah Reid of Nevada, Iowa (Bessey, 1871).

The presence of red-cedar in Iowa is recorded in a few early histories. Nichols (1944), an early settler in Iowa Falls, Iowa, stated in his book, Pioneer Days in Iowa Falls, that the banks of the Iowa River were covered with cedar when the early settlers founded the city. The statement that a red-cedar cross was placed on top of the stone house which was erected over Julien Dubuque's grave indicates that red-cedar trees grew in the vicinity (Negus, 1864). Julien Dubuque, the first white man to make a permanent settlement in Iowa, died in 1810 and was buried on a bluff overlooking the Mississippi River.

According to historical accounts, a river and creek in Iowa were named after the trees which grew along these waterways. The "unusual growth of red-cedars" where the Iowa and Cedar Rivers join was explained by the formation of many sandbars which were congenial to a vigorous growth of red-cedar trees (Nicollet, 1843; Pike, 1889). The Cedar River was so named because the Sauk and Fox Indians called it Moskwahwakwah, meaning "cedar" (Peterson, 1941). The luxuriant growth of cedars on the sides and summits of the hills along a stream in Clayton County, Iowa, influenced John Finley,

in the summer of 1834, to name this stream Cedar Creek (Price, 1864).

Early references to red-cedar plantings in Iowa appeared in the Iowa State Horticultural Society Bulletin. Red-cedar trees were planted in Spring, 1862, by Dr. Benjamin Green of Adel (Green, 1867). Red-cedar was listed among the trees growing in the arboretum, gardens and ornamental grounds of Iowa State Agricultural College in 1875 (Report of Trustees of Iowa State College). The lack of evergreens in Iowa was reported in a special article in the 1867 publication of the Society by D. W. Adams from Waukon, Iowa, who complained that the only native evergreens in Iowa were "a few scattered and stunted white pines and red-cedars on some rocky bluffs, and a few small patches of balsam fir on the Yellow and Upper Iowa Rivers" (Adams, 1867). Shimek, who knew the vegetation of Iowa well, made the most detailed notes on the flora of Iowa prior to 1937. He listed Juniperus virginiana L. as a new plant in Emmet, Dickinson and Johnson Counties in 1896 (Shimek, 1896), suggesting that it had recently appeared there. Pammel (1902) also discussed the lack of evergreens in the state; red-cedar with the widest distribution, extended all the way across the state, especially in the north, but not so far west in the southern half of the state.

Present Distribution of Red-cedar

The distribution of red-cedar in Iowa has been recorded in botanical surveys of limited geographical areas. Density, abundance, age, and the relative location of individual plants has usually not been recorded. Therefore, about all that can be gained from these studies is a rough determination of the frequency of occurrence.

Red-cedar has been regarded as common in the state since 1930 (Cratty, 1932); Campbell and Grau, 1948; Thorne, 1955). Cratty also stated that

red-cedar was frequently planted and that red-cedar was frequent as an escape from these plantings. Red-cedar trees were present in homestead groves in Muscatine and Louisa Counties (Brown and Brown, 1939); at the mouth of the Cedar River (Conard, 1952); in rare quantities in dry open woods in Iowa County (Easterly, 1951); in calcareous soils in Cedar County (Fay, 1951); in the Wapsipinicon, Maquoketa and Bellevue State Parks (Cooperrider, 1960) and on bluffs northwest of Waukon (Shimek, 1948) to name a few specific areas.

In a botanical survey of Lee County, Iowa, Fults (1932) recorded 93 plant families along roads, fences and creeks, from pastures and in undrained areas which are suitable habitat for red-cedar; Davidson (1960) gave specific locations in his study of plant communities in southeast Iowa; Fay and Thorne (1953) reported red-cedar on limestone ledges along Rock Creek, Wapsipinicon River and on the south shore of the Cedar River.

Suitable habitat for eastern red-cedar has most often been described as limestone outcroppings or calcareous soil (Keeler, 1904; Smith, 1917; Harper, 1926; Munns, 1938; Erickson, Brenner and Wraight, 1942; Preston, 1948; Arend, 1950; Braun, 1950; Fay and Thorne, 1953; Williamson, 1957; Hall, 1955; Harlow and Harrar, 1958; Curtis, 1959; Steyermark, 1959; Lorio, 1963). An uncultivated area which has been disturbed but which is not rapidly eroding or excessively shady is also suitable habitat for red-cedar (Brenner, 1943; Clark, 1954; Vedel, 1961; Graf, 1965).

Red-cedar has been observed growing in a wide variety of topographic, edaphic, and climatic conditions (Keeler, 1904; Gifford, 1902; Munns, 1938; Calvin and Eisenminger, 1943; Deitschmann, 1950; Parker, 1952; Bode and MacDonald, 1946; Fowells, 1965).

The distribution pattern of eastern red-cedar was mapped in a general survey of Henry County, Iowa, (Graf, 1965) in which three intensive study areas were established in Marion, Jackson and Wayne Townships. There the occurrence of naturally established red-cedar trees was related to the presence of planted trees in near-by homesteads, previous homesteads, and cemeteries, usually appearing not more than one-half mile away from the planted trees. A determination of ages based on numerous increment borings indicated that the naturally established trees were consistently and considerably younger than the planted seed-bearing trees. Therefore, it was concluded that the planted red-cedar trees have functioned as the main seed sources. This distribution pattern of naturally established red-cedar trees radiating from a planted seed source was substantiated by historical data from the original land survey records.

METHODS

County Surveys

The present distribution of red-cedar trees was surveyed in the four corner townships in four Iowa counties (Figure 1). These counties, Fayette, Henry, Montgomery and O'Brien, are each one county in from the corner state lines. The criteria for selecting these counties were to avoid direct influence from possible seed sources in adjoining states and to include variations of climate in Iowa. The sixteen township study areas within these counties provided a systematic sample of the variations in topography, soils, agricultural land use and possible red-cedar habitat in the state.

The relative locations of planted trees and naturally established trees were recorded adjacent to and along all roads in the townships indicated on the general highway and transportation maps of Eden, Clermont, Oran and Putnam Townships in Fayette County; Jefferson, Scott, Salem and Baltimore Townships in Henry County; Lincoln, Douglas, West and East Townships in Montgomery County, and Floyd, Hartley, Caledonia and Waterman Townships in O'Brien County (Figures 2, 3, 4, 5).

Locations of planted trees at each presently occupied homestead, deserted homestead and cemetery along the roads were recorded by estimating two age classes: (1) trees under forty years and (2) trees over forty years of age. Planted trees were divided into these two age classes to determine the influence of old and new planted seed sources on natural establishment. The age of forty years was selected because natural establishment was possible from planted trees of this age which had served as abundant seed sources for a maximum of fifteen years. Estimations of age

Figure 1. Map of township study areas in Iowa

Location of a township presettlement red-cedar tree survey

Location of a township presettlement and present-day red-cedar tree survey

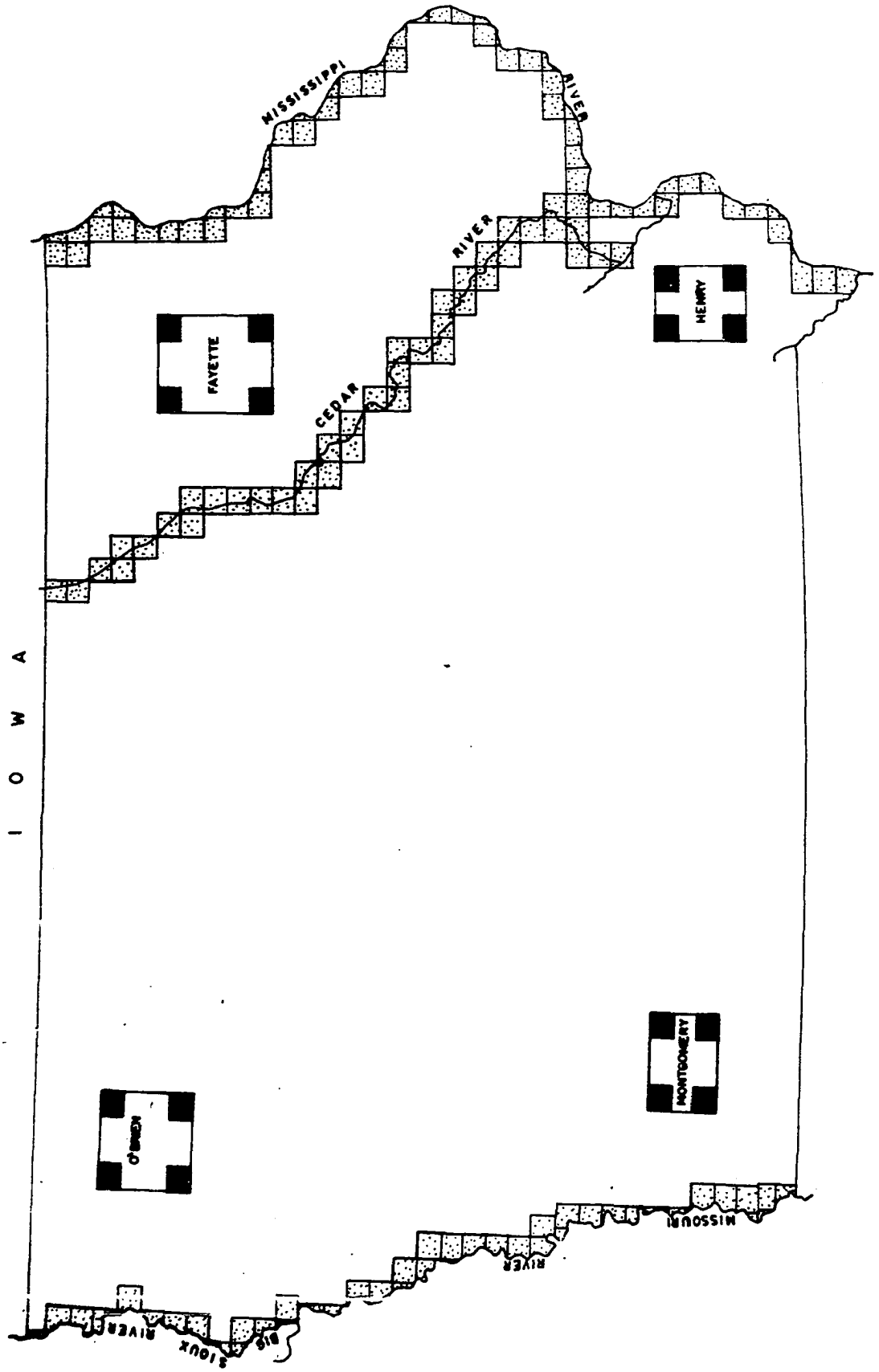

MISSISSIPPI
RIVER
CEDAR
RIVER
FAYETTE
HENRY
I O W A
O'BRIEN
MONTGOMERY
MISSOURI
RIVER
SIOUX
RIVER

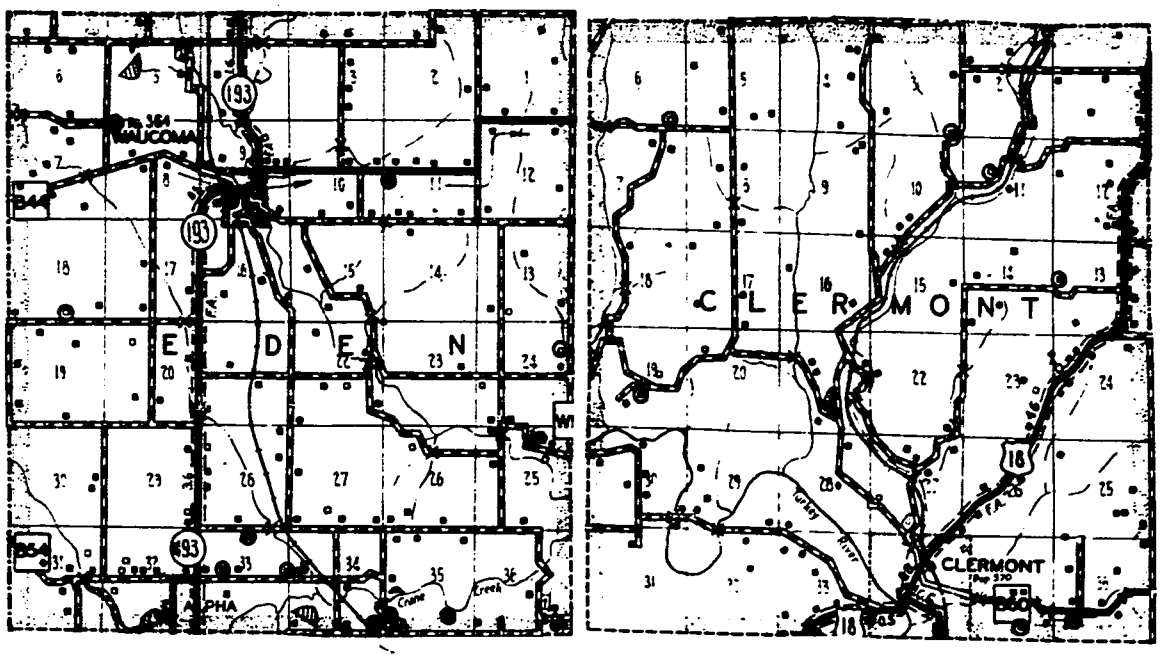
Figure 2. General highway and transportation map of Eden, Clermont, Oran and Putnam Townships, Fayette County, Iowa

Scale 1" = 2 miles

■ Location of a house

◙ Location of a house that has been abandoned since 1964

FAYETTE


WAUCOMA
EDEN
ALPHA
CLERMONT
CLERMONT
Crane Creek
Turkey River

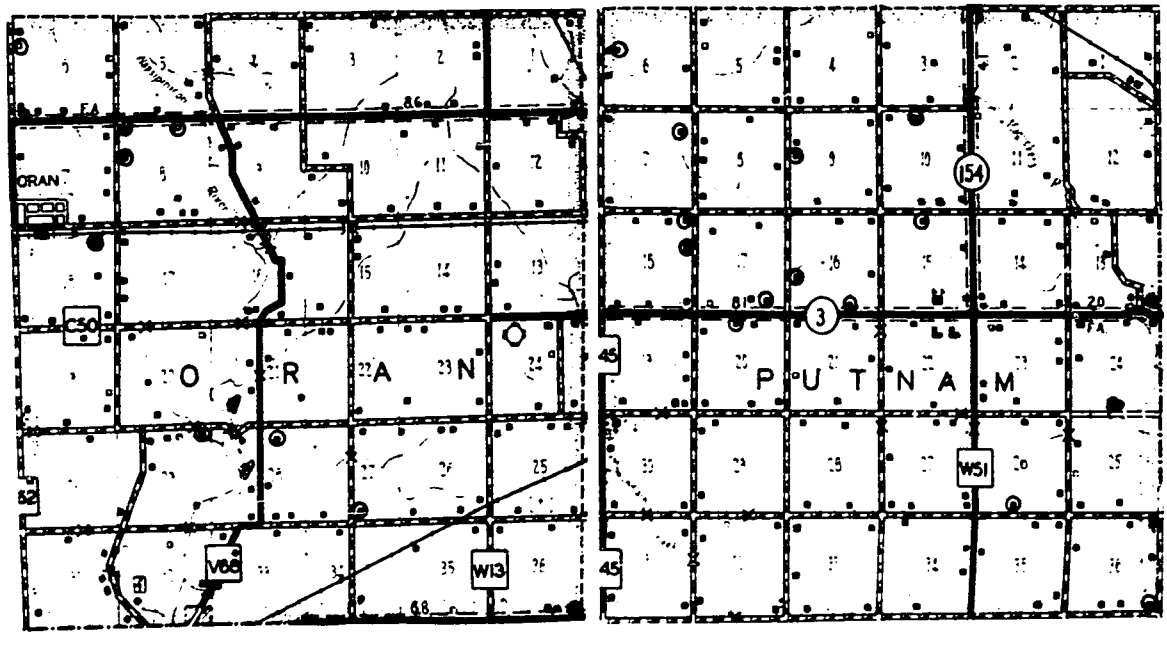
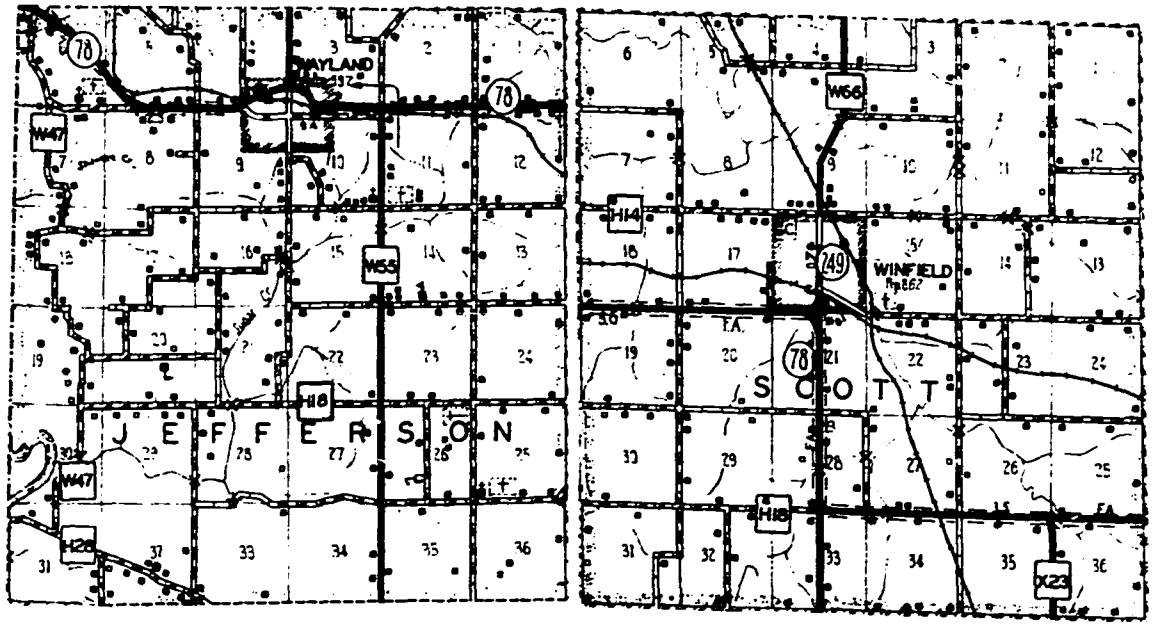

ORAN
ORAN
PUTNAM
Turkey River

Figure 3. General highway and transportation map of Jefferson, Scott, Salem and Baltimore Townships, Henry County, Iowa

Scale 1" = 2 miles

■ Location of a house

HENRY


JEFFERSON
SCOTT
WINFIELD
MAYLAND

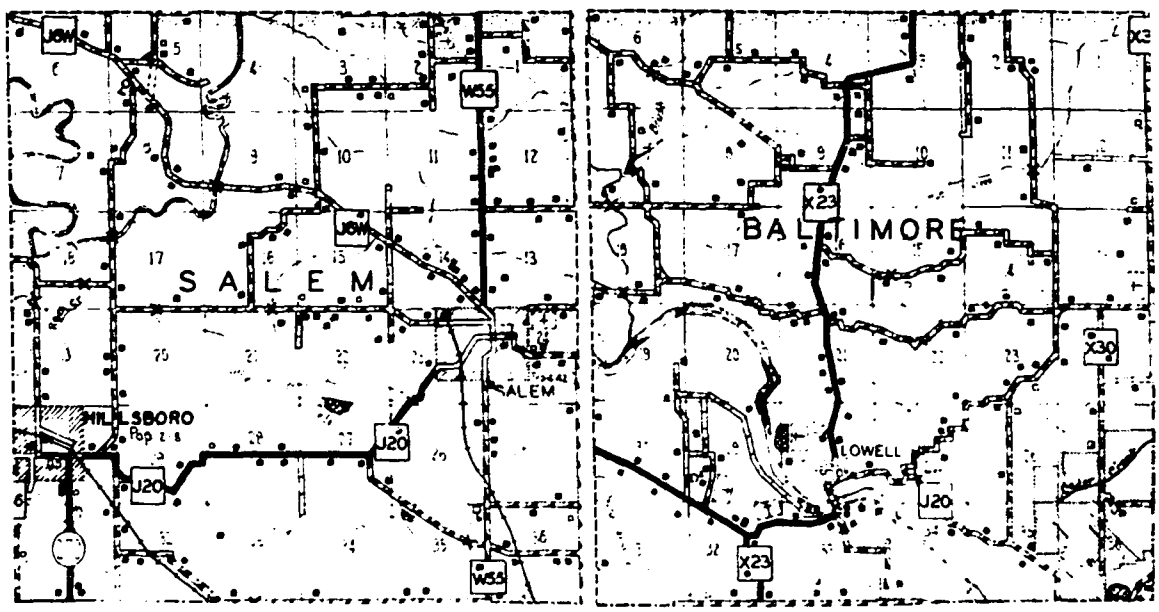

SALEM
BALTIMORE
HILLSBORO
LOWELL

Figure 4. General highway and transportation map of Lincoln, Douglas, West and East Townships, Montgomery County, Iowa

Scale 1" - 2 miles

■ Location of a house

◙ Location of a house that has been abandoned since 1964

MONTGOMERY

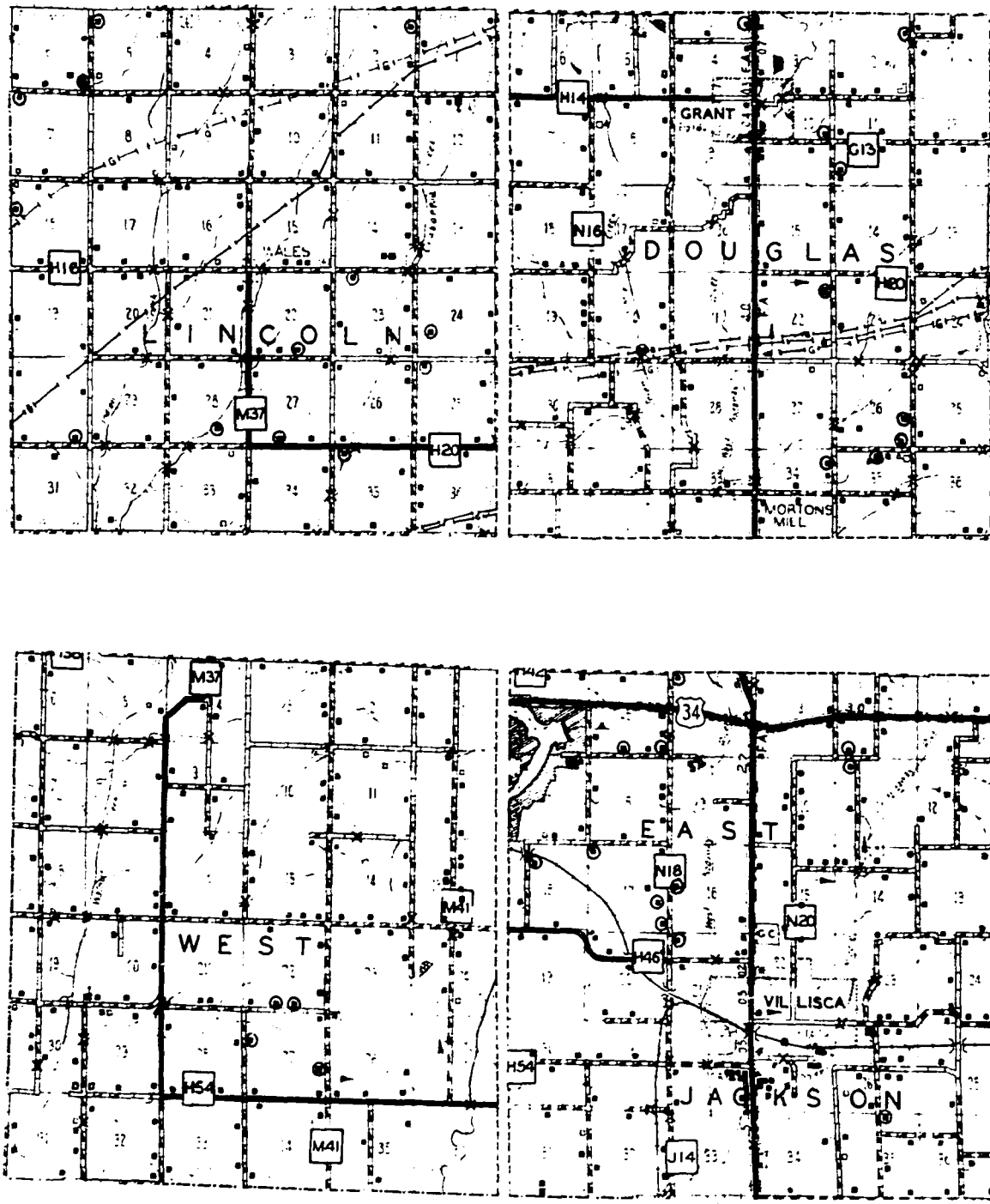

L I N C O L N
WALES
H16
M37
H20
H14
GRANT
G13
N16
D O U G L A S
H80
MORTONS MILL
W E S T
M37
M41
H54
M41
E A S T
34
N18
N20
H46
VIL LISCA
H54
J A C K S O N
J14

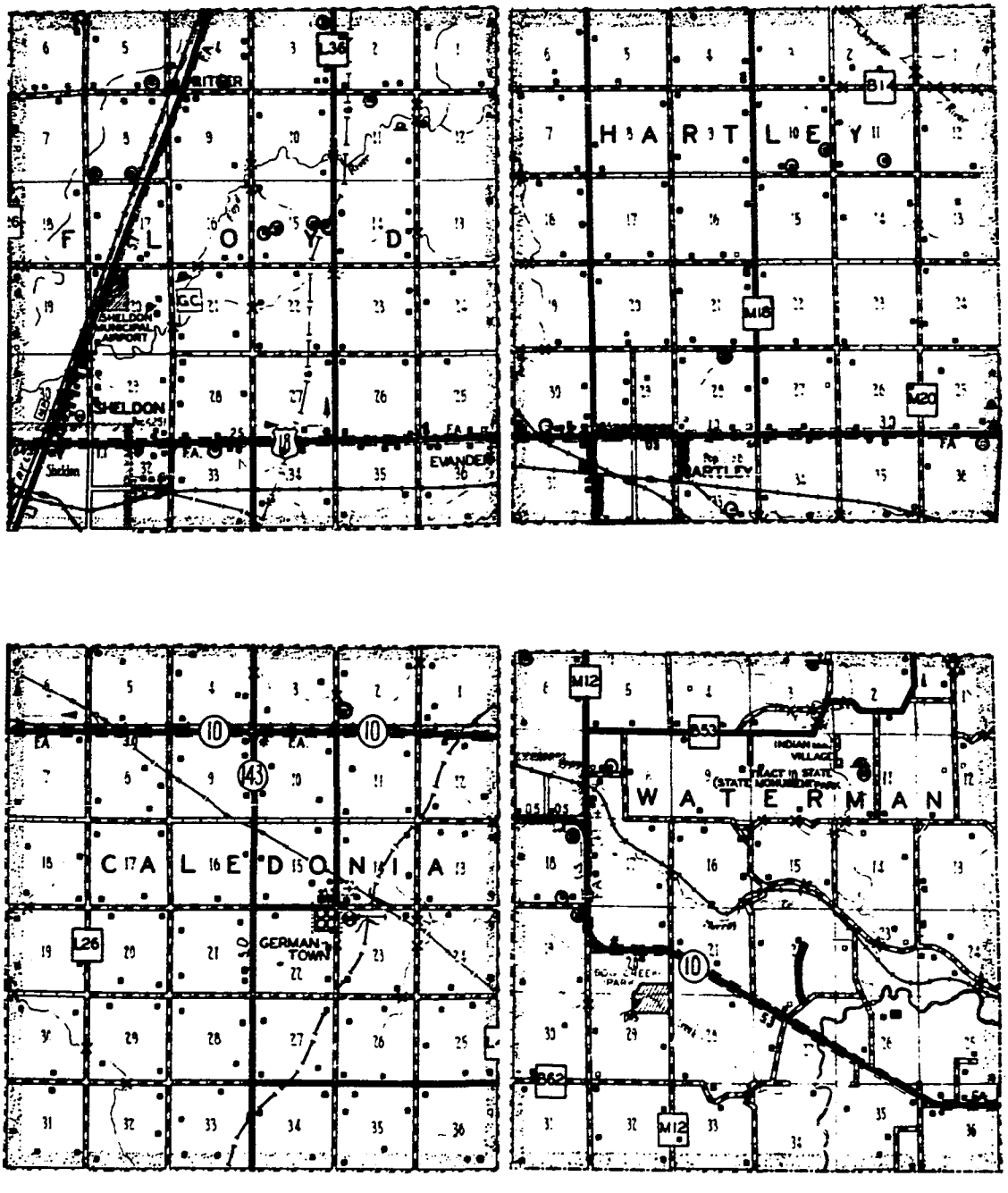
Figure 5. General highway and transportation map of Floyd, Hartley, Caledonia and Waterman Townships, O'Brien County, Iowa

Scale 1" = 2 miles

■ Location of a house

◙ Location of a house that has been abandoned since 1964

O' BRIEN

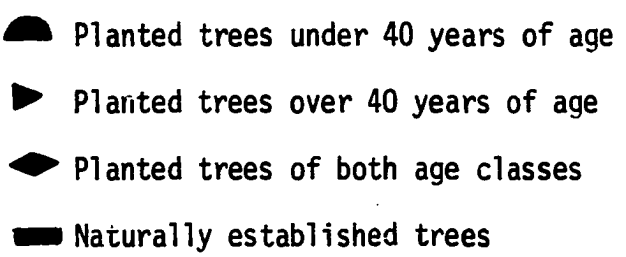

FLOYD
SHELDON
HARTLEY
CALEDONIA
GERMAN-TOWN
WATERMAN
INDIAN MACE VILLAGE
(STATE MONUMENT)
EVANDER
Sheldon

were based on numerous cross-sections and increment borings (Weaver and Clements, 1938; Graf, 1965) (Tables 6, 7, Appendix A). Growth rates were compared in cross-sections at ground level and at 4½ feet above ground level in a naturally established red-cedar tree on an upland pasture and one growing on a rock bluff. Cross-sections were surfaced on a milling machine, using a six-inch sweep fly cutter revolving at 3000 rpm's. After these sections were burnished with very fine sandpaper, growth rings were more easily observed. Increment borings were usually taken 4 feet above ground level. The cores were preserved in 8 mm. glass tubes for further study.

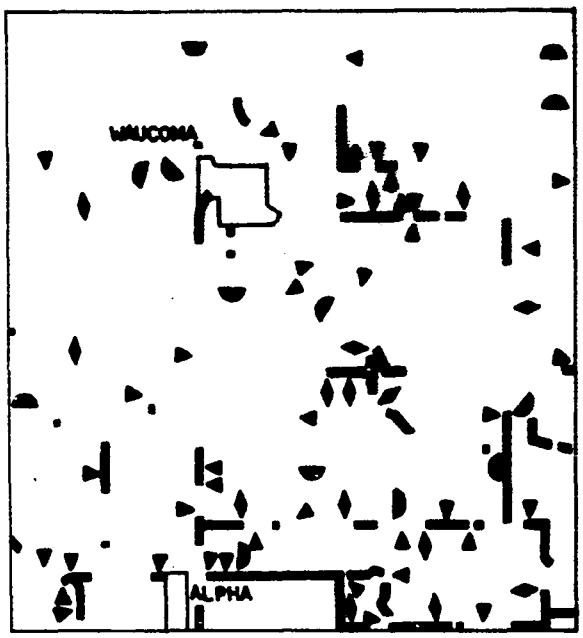
Locations of planted red-cedar trees and naturally established trees in pastures, fence lines and roadsides were recorded directly on the township maps from observations made from a slow-moving automobile (Daubenmire, 1936; Gordon, 1940; Graf, 1965). Frequent stops were made, and trees in areas visible from the road were observed with 10x50 binoculars. The approximate locations of individual naturally established trees were indicated only in isolated areas where individual trees were separated by several acres of land. Otherwise, the areas of medium and dense red-cedar aggregations were shown by broad solid lines (Figures 6, 7, 8, 9).

The percentage of potential sites occupied by red-cedar plantings over forty years, plantings under forty years, and plantings of both age classes and the frequency of sites with planted trees and adjacent natural establishment were calculated for sixteen townships, four counties and four county totals (Figures 6, 7, 8, 9). The significance of the differences in the number of potential sites with red-cedar plantings within each county and among the counties was determined from a chi square test.

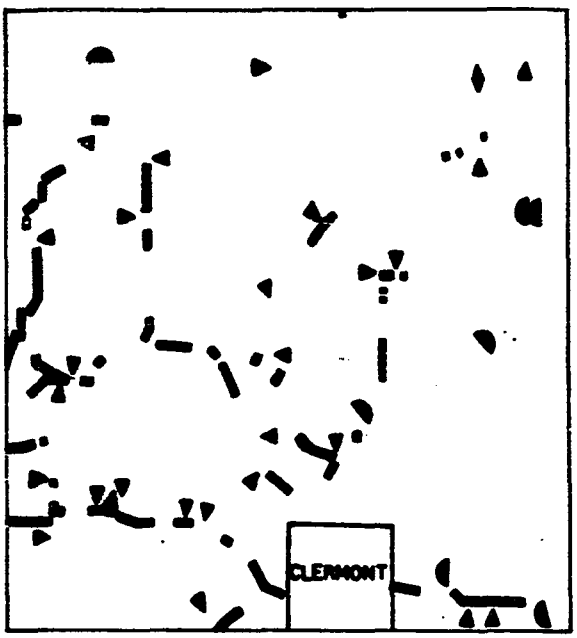
Figure 6. Distribution map of red-cedar trees in Eden, Clermont, Oran and Putnam Townships, Fayette County, Iowa, in 1969



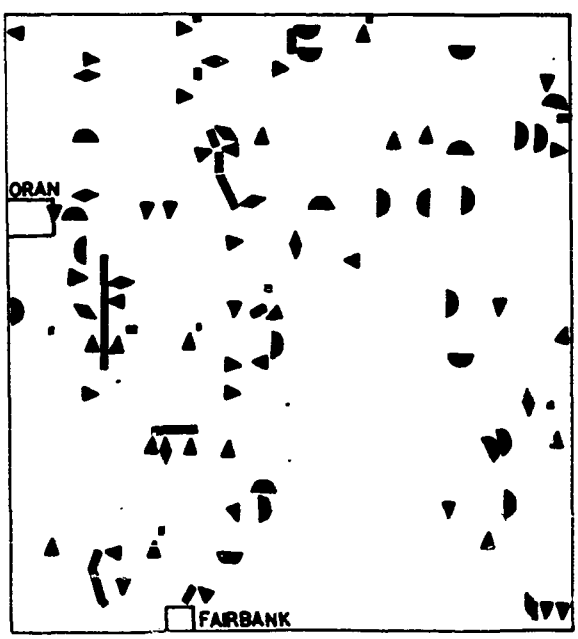
FAYETTE



EDEN TOWNSHIP



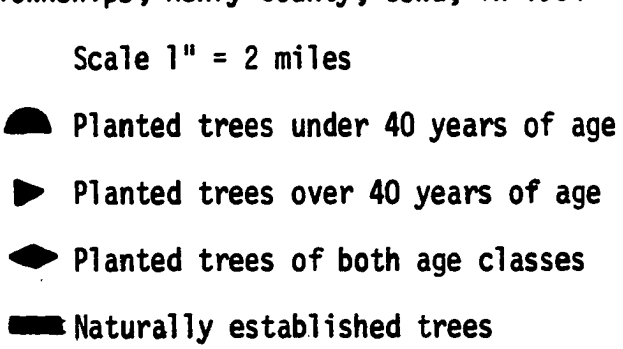
CLERMONT TOWNSHIP



ORAN TOWNSHIP

PUTNAM TOWNSHIP

Figure 7. Distribution map of red-cedar trees in Jefferson, Scott, Salem and Baltimore Townships, Henry County, Iowa, in 1964



HENRY

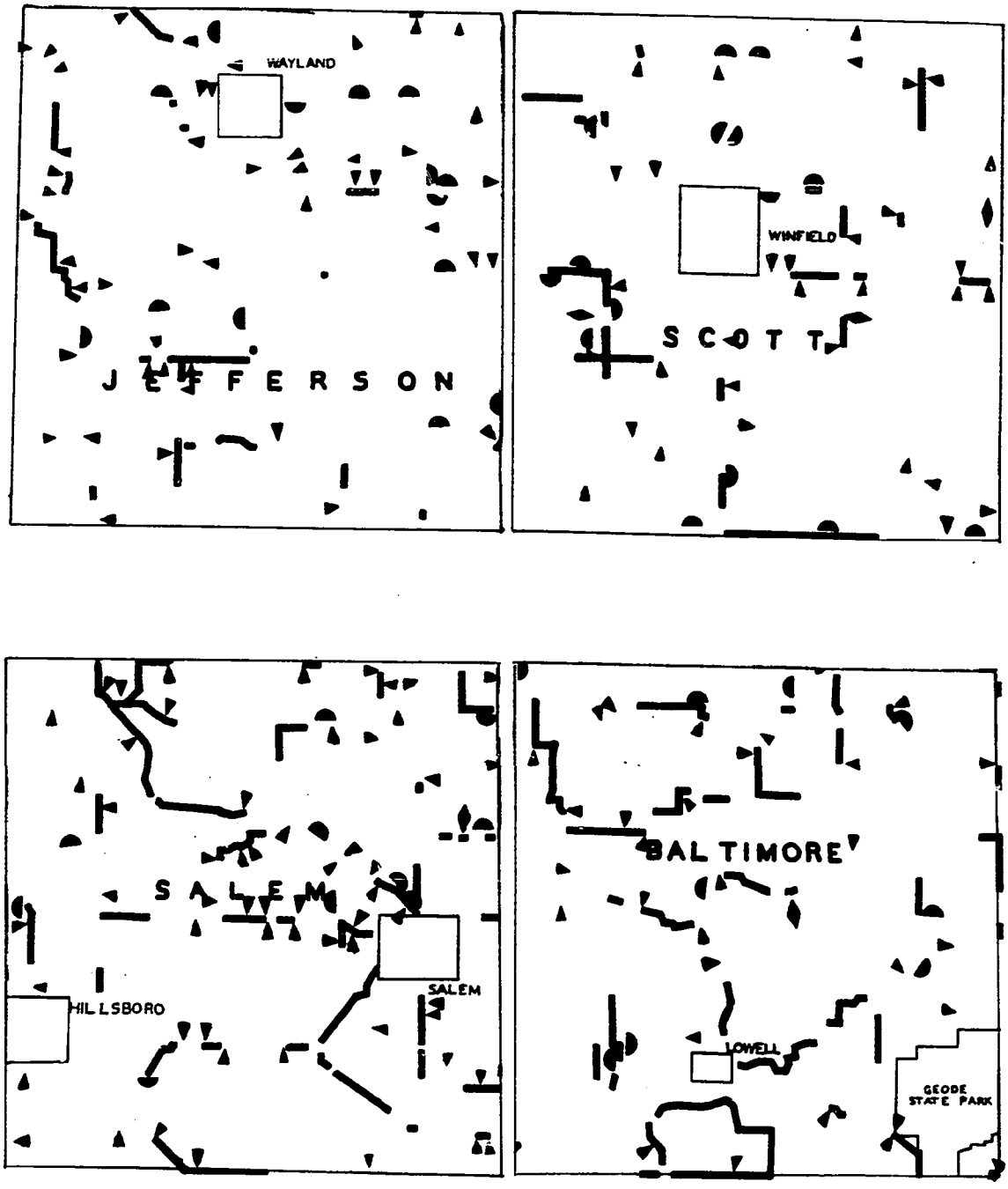
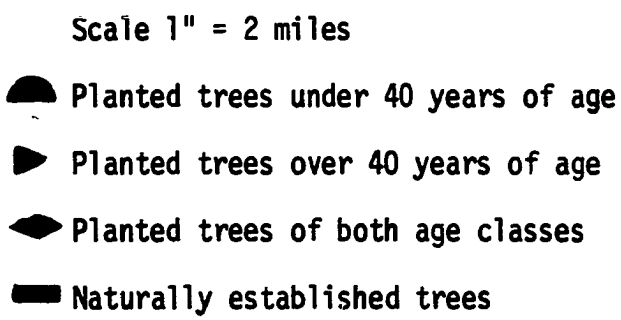
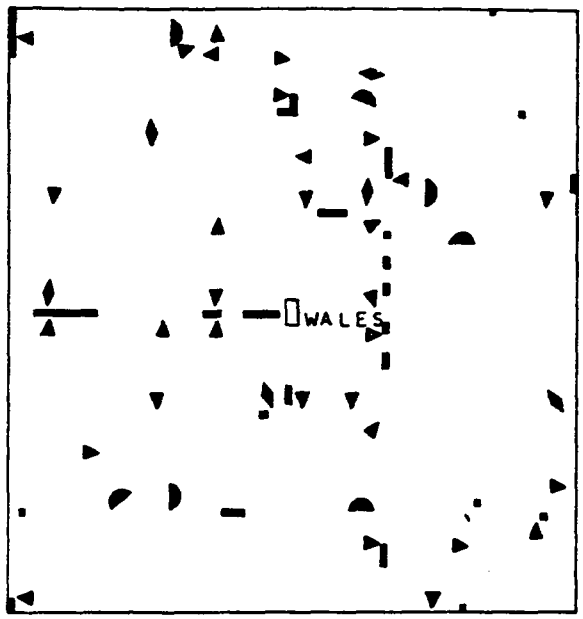

WAYLAND
JEFFERSON
WINFIELD
SCOTT
SALEM
HILLSBORO
SALEM
BALTIMORE
LOWELL
GEODE
STATE PARK

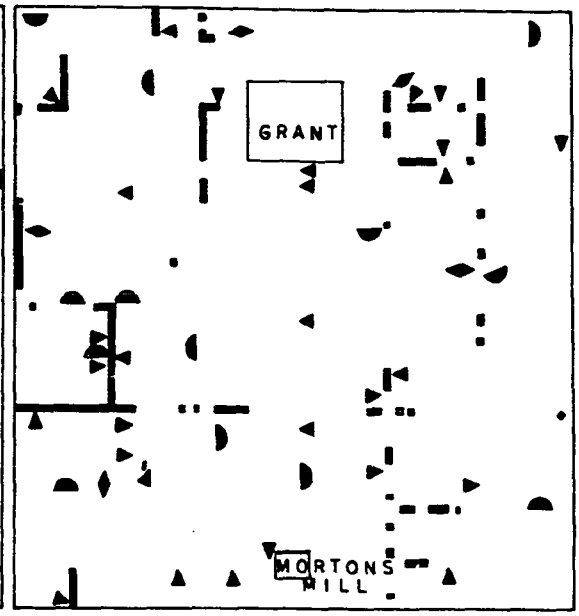
Figure 8. Distribution map of red-cedar trees in Lincoln, Douglas, West and East Townships, Montgomery County, Iowa, in 1967-1969



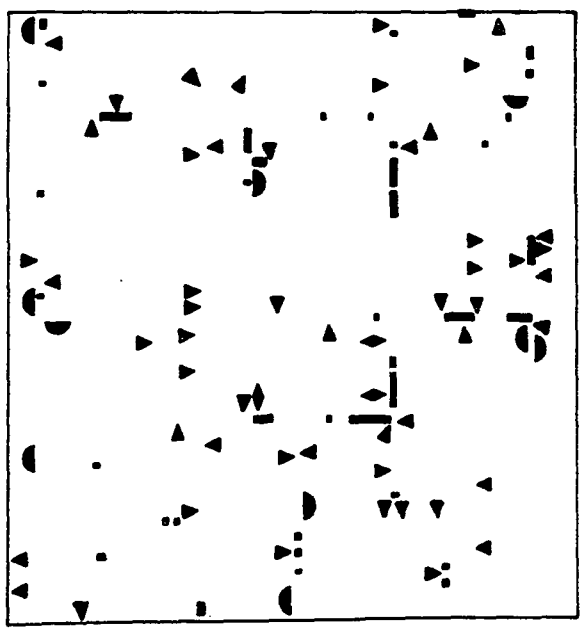
MONTGOMERY



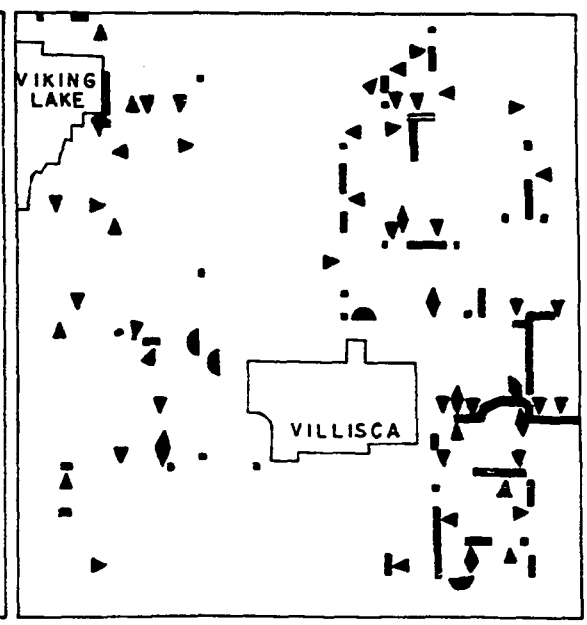
LINCOLN TOWNSHIP



DOUGLAS TOWNSHIP

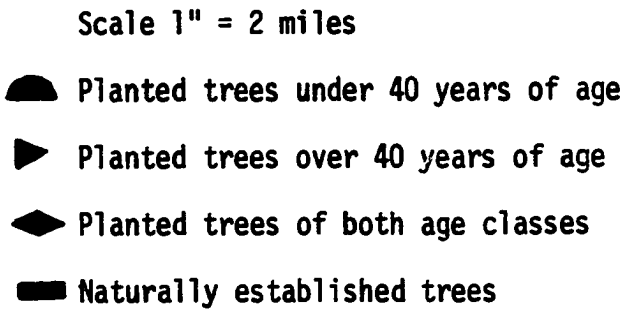


WEST TOWNSHIP

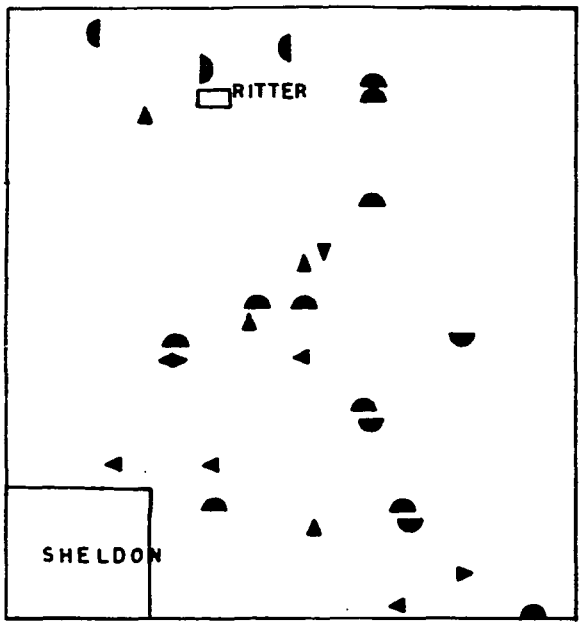


EAST TOWNSHIP

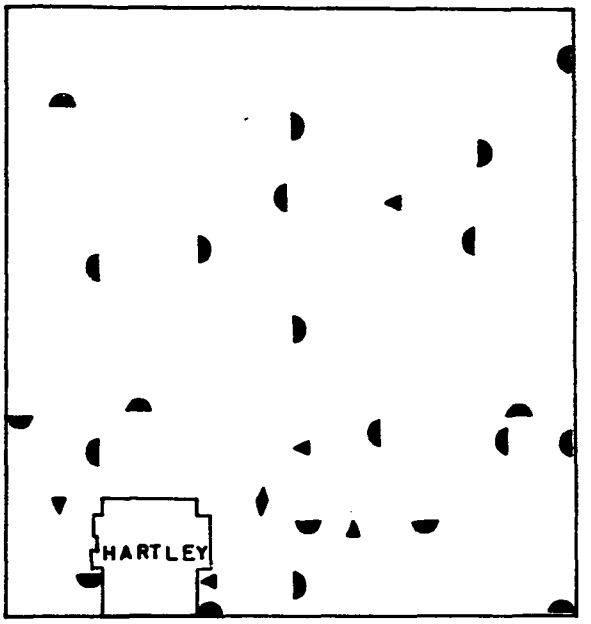
Figure 9. Distribution map of red-cedar trees in Floyd, Hartley, Caledonia and Waterman Townships, O'Brien County, Iowa, in 1967-1969



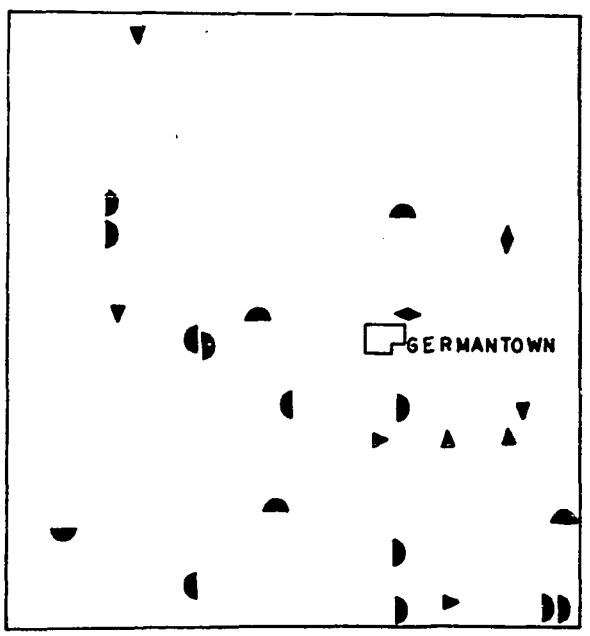
O' BRIEN



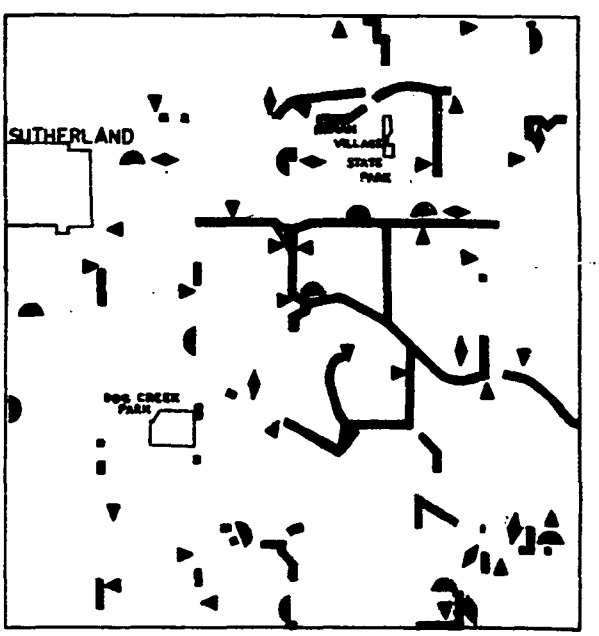
FLOYD TOWNSHIP



HARTLEY TOWNSHIP



CALEDONIA TOWNSHIP



WATERMAN TOWNSHIP

Trees along approximately 265 miles of roads in Fayette County, 231 miles in Henry County, 276 miles in Montgomery County and 294 miles in O'Brien County were recorded. A total of approximately 1066 miles in the four counties was traversed. Roads in cities, towns and state parks were not included in this survey. The surveys of Fayette, Montgomery and O'Brien Counties were made in 1967-1969. The Henry County survey was completed in 1964 (Graf, 1965). Most of these surveys were made in June, July and August.

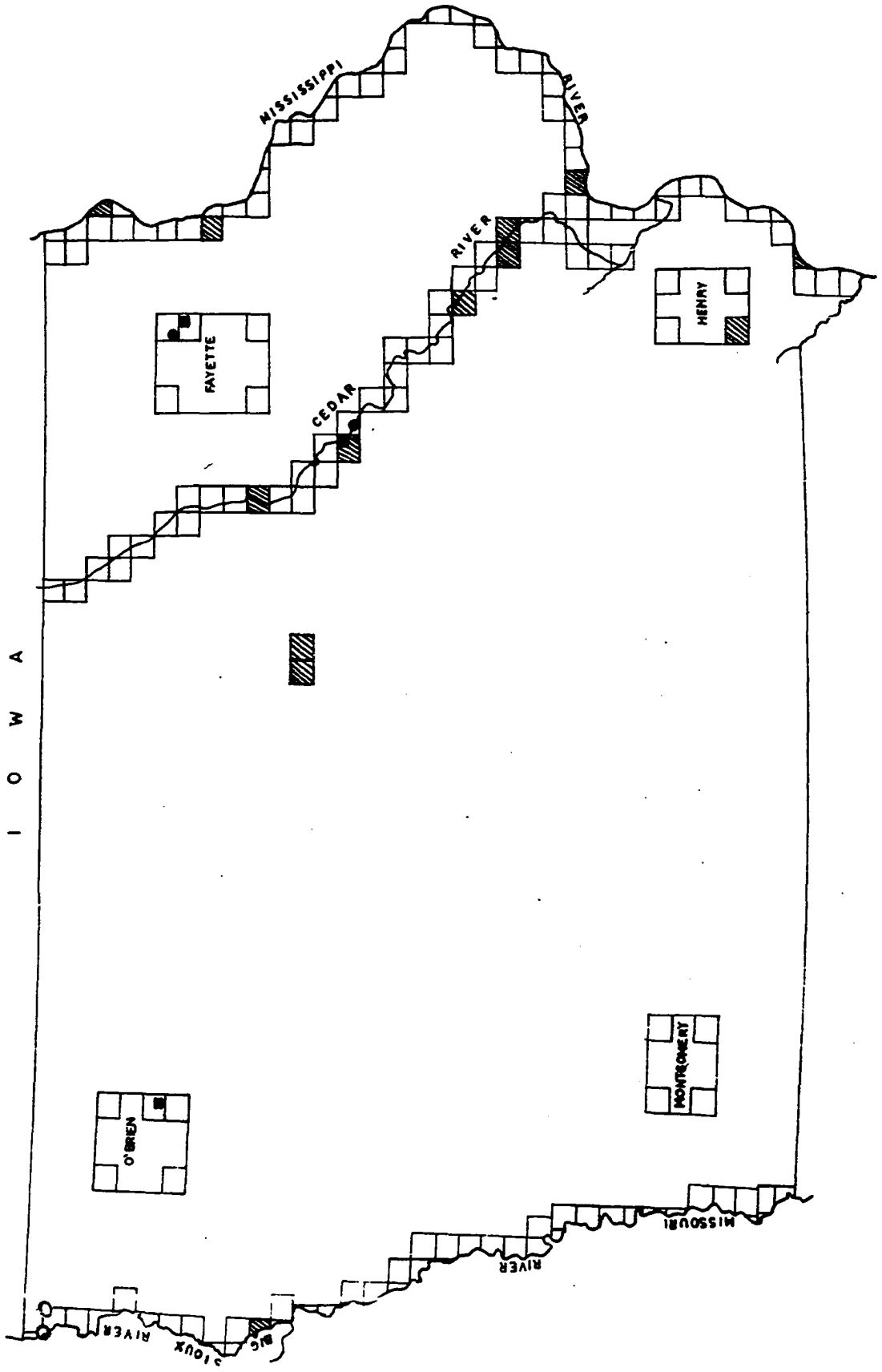
Three sources of historical information pertaining to plant distribution were utilized to determine the presence or exact locations of red-cedar trees before 1900. They were (1) the original land survey field notes and plats, (2) written accounts of early travelers and settlers and (3) statements from local residents. The original land survey field notes and plats of 1832-1859 which are available in the office of the Secretary of State, Land Office, in the State Capitol Building, Des Moines, Iowa, and on microfilm from Trygg Land Office, Ely, Minnesota, were the most accessible and detailed source of information. Approximately 3017 section corners and quarter section corners in the sixteen township study areas were included in the presettlement survey of red-cedar trees. Although there was no systematic way of interviewing local residents, those who were interviewed at random were always very willing to furnish personal data from their past associations and to direct the author to locations that might otherwise have been overlooked. The many miles covered in this study offered ample opportunity for the chance introduction to the old settlers and their families who are living today.

Surveys along Rivers

Locations of presettlement red-cedar trees and posts were recorded at section corners and quarter section corners in townships along four principle rivers of Iowa (Figure 10). Government microfilms of the original land survey field notes of Iowa were read in their entirety for the 144 townships along these rivers and all reference to red-cedar including witness trees and corner posts were recorded. Vegetation at approximately 3526 section corners and quarter section corners was listed in these field notes for the townships along the Missouri and Big Sioux Rivers, 6072 along the Cedar River and 5453 along the Mississippi River. A total of approximately 15,051 corners were included in these field notes. In addition to these specific locations of presettlement trees, general locations of presettlement eastern red-cedar trees were obtained from written accounts by early travelers and settlers. These accounts probably are accurate since there is little chance of confusing eastern red-cedar with white cedar or any other similar species. Juniperus communis with a completely different growth form of a prostrate or semiprostrate nature, would be difficult to confuse with eastern red-cedar.

The following criteria were used in selecting the townships along rivers: (1) the abundance of suitable habitat for red-cedar, i.e., many limestone bluffs and outcroppings, (2) the present occurrence of red-cedar trees, (3) the presence of seed sources, (4) the availability of some of the earliest records of vegetation along navigable rivers and (5) a minimum of tree removal in these areas. The Cedar River was selected because its proper name suggested the presence of eastern red-cedar along its banks and bluffs as recognized by the Sauk and Fox Indians.

Figure 10. Distribution map of presettlement red-cedar trees based on the original land survey field notes and plats and on special study areas


MISSISSIPPI
RIVER
CEDAR
RIVER
FAYETTE
HENRY
I O W A
O'BRIEN
MONTGOMERY
MISSOURI
RIVER
SIOUX
RIVER
BIG

OBSERVATIONS AND RESULTS

County Distribution

The locations of planted red-cedar trees are shown on the township survey maps of Eden, Clermont, Oran and Putnam Townships in Fayette County; Jefferson, Scott, Salem and Baltimore Townships in Henry County; Lincoln, Douglas, West and East Townships in Montgomery County and Floyd, Hartley, Caledonia and Waterman Townships in O'Brien County (Figures 6, 7, 8, 9). Planted seed sources at presently occupied homesteads (Figures 11, 12), at presently unoccupied or deserted homesteads (Figures 13, 14, 15) and in cemeteries (Figure 16) were observed in each township which was studied.

Where landscape plantings had been removed or trunks were hollow, ages of old planted trees were determined from interviews with local residents (Figures 11, 12). The megasporangiate and microsporangiate red-cedar trees in the yard of the Ralph Watts home were planted before 1865[1] (Figure 11). Two large red-cedar trees in the yard of the Max Miller nome were brought from Virginia in 1865[2] (Figure 12). These trees were removed recently during highway improvement. Landscape plantings, vacant houses and filled-in basements mark the location of former homesites and possible early centers of red-cedar seed production (Figures 13, 14, 15). Only a lilac bush arch and a trash-filled former basement remain today where a house with many large red-cedar trees in the front yard once stood (Figure 13). This planted seed source for the dense stand of naturally

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[1]Watts, Ralph. 1967. Age of planted red-cedar trees. Section 29, Jackson Township, Henry County, Iowa. Personal interview.

[2]Miller, Max S. 1965. Age and origin of planted red-cedar trees. Mt. Zion, Iowa, Van Buren Township, Van Buren County. Personal interview.

Figure 11. Megasporangiate (right) and microsporangiate (left) trees planted in the Ralph Watts homestead before 1865, but hollow trunks prevented exact aging by increment borings (Section 29, Jackson Township, Henry County)

Figure 12. Largest planted red-cedar tree observed in Iowa (near Mt. Zion, Iowa, on Highway #1 at the Max S. Miller home, December 20, 1965)

Figure 13. Former homesite indicated by lilac bush arch (background) and trash-filled former basement in what is presently a pasture containing many red-cedar trees (Section 35, Eden Township, Fayette County, Summer, 1969)

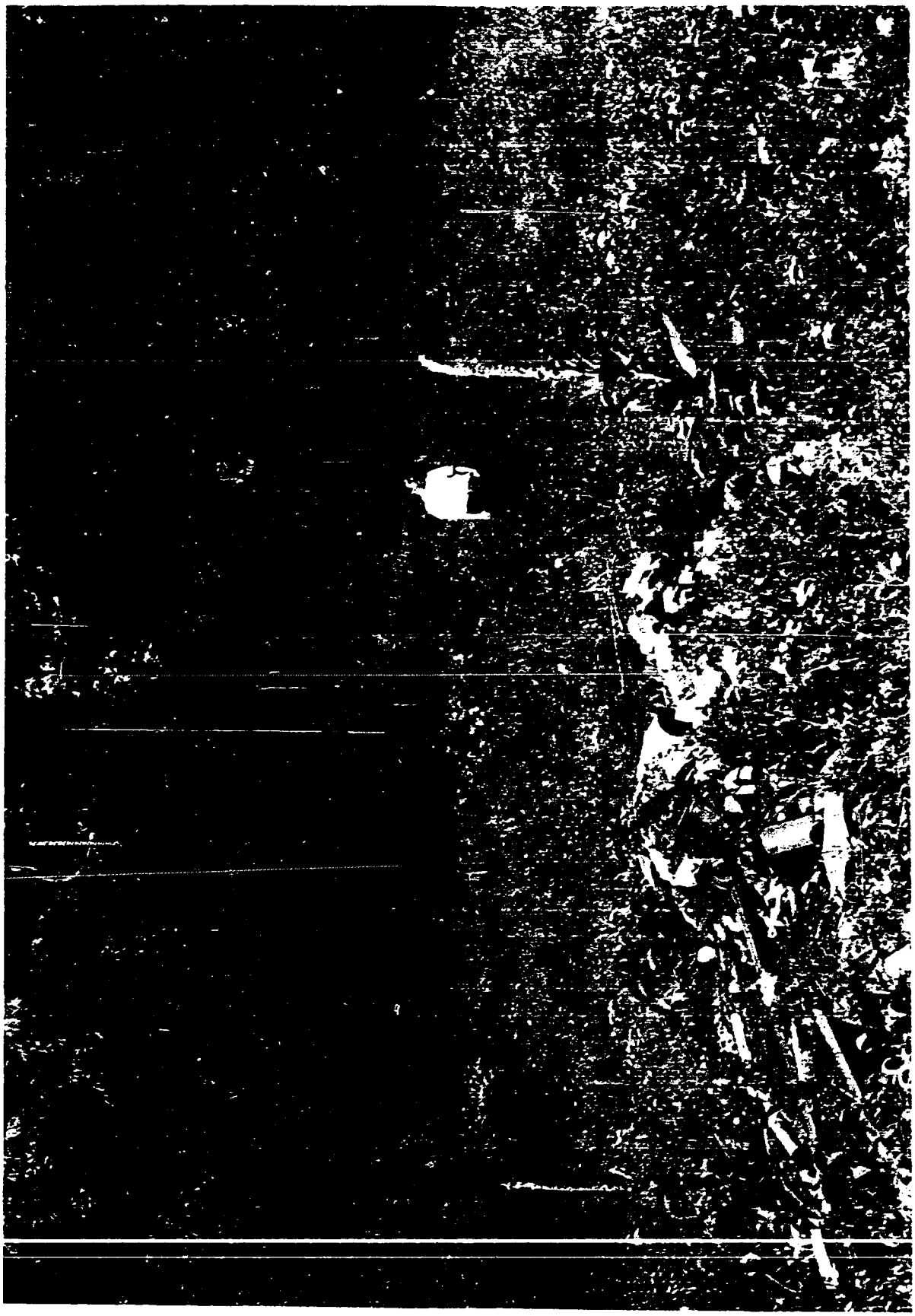


Figure 14. Deserted homestead with windbreak of red-cedar trees (background)
Section 34, Eden Township, Fayette County, Summer, 1969)

Within one mile of this homestead six former homesites have been completely razed in the past ten years

Figure 15. The large red-cedar trees and the remants of a cave are the only evidence of a former homesite (Grange Township, Woodbury County, Iowa)

Figure 16. Lowell cemetery, with red-cedar trees present, located on a hill just north of Lowell, Iowa (Section 28, Baltimore Township, Henry County); the oldest readable grave marker is dated 1837

established red-cedar trees in the surrounding pastures would have been overlooked if a local resident had not directed the author to this site[3]. At many of these former homesites the red-cedar landscape plantings or windbreaks remain (Figure 14). Within approximately one mile of this site, there were six homesteads that have been razed in the past ten years[4,5]. The wide-spread abandonment of homesteads was also observed in Fayette, Montgomery and O'Brien Counties where 86 homesteads in 12 townships have been vacated or razed in the past five years (Figures 2, 4, 5) (Table 1).

Table 1. Number of homesteads abandoned in the past 5 years

Fayette County		Montgomery County		O'Brien County	
Eden Township	10	Lincoln Township	7	Floyd Township	10
Clermont Townmship	7	Douglas Township	9	Hartley Township	1
Oran Township	9	East Township	4	Caledonia Township	1
Putnam Township	13	West Township	10	Waterman Township	5
Total	39	Total	30	Total	17

Three County Total 86

Presently occupied homesteads, deserted homesteads and cemeteries are potential sites for red-cedar plantings. The number of potential sites for plantings is compared in Table 2 with the number of sites on which red-cedar actually occurred. Data for the four townships in each county are

[3]Niles, Rex. 1969. Red-cedar distribution notes. Section 36, Eden Township, Fayette County, Iowa. Personal interview.

[4]Brockway, Barry. 1969. Red-cedar distribution notes. Section 35, Eden Township, Fayette County, Iowa. Personal interview.

[5]Winter, E. J. 1969. Red-cedar distribution notes. Section 25, Eden Township, Fayette County, Iowa. Personal interview.

Table 2. Comparison of sites with and without planted red-cedar trees

Location	No.(%) of sites without planted trees	No.(%) of plantings over 40 yrs.	No.(%) of plantings under 40 yrs.	No.(%) of plantings with both age classes	No.(%) of sites with plantings	Total sites
Fayette County						
Eden Township	92 (56)	43 (26)	13 (8)	15 (9)	71 (44)	163
Clermont Township	94 (73)	27 (21)	7 (5)	1 (1)	35 (27)	129
Oran Township	85 (52)	45 (27)	24 (14)	11 (7)	80 (48)	165
Putnam Township	102 (58)	36 (21)	25 (14)	12 (7)	73 (42)	175
Totals	373 (59)	151 (24)	69 (11)	39 (6)	259 (41)	632
Montgomery County						
Lincoln Township	93 (68)	31 (23)	7 (5)	6 (4)	44 (32)	137
Douglas Township	85 (64)	29 (22)	13 (10)	5 (4)	47 (36)	132
West Township	85 (57)	52 (35)	10 (7)	3 (2)	65 (43)	150
East Township	101 (64)	46 (29)	4 (3)	7 (4)	57 (36)	158
Totals	364 (63)	158 (27)	34 (6)	21 (4)	213 (37)	577
Henry County						
Jefferson Township	147 (71)	47 (23)	14 (7)	--	61 (29)	208
Scott Township	111 (69)	31 (19)	15 (9)	3 (2)	49 (31)	160
Salem Township	95 (59)	55 (34)	9 (6)	1 (1)	65 (41)	160
Baltimore Township	111 (73)	31 (20)	9 (6)	1 (1)	41 (27)	152
Totals	464 (68)	164 (24)	47 (7)	5 (1)	216 (32)	680
O'Brien County						
Floyd Township	114 (81)	10 (7)	16 (11)	1 (1)	27 (19)	141
Hartley Township	91 (76)	5 (4)	22 (18)	1 (1)	28 (24)	119
Caledonia Township	111 (82)	7 (5)	16 (12)	2 (2)	25 (18)	136
Waterman Township	60 (54)	28 (25)	13 (12)	10 (9)	51 (46)	111
Totals	376 (74)	50 (10)	67 (13)	14 (3)	131 (26)	507
Four County Totals	1577 (66)	523 (22)	217 (9)	79 (3)	819 (34)	2396

listed separately, a county total is calculated and a total for the four counties is computed at the bottom of the table. The resulting figures are expressed as per cent of potential sites having planted red-cedar trees over forty years of age, planted trees under forty and planted trees of both age classes.

The number of plantings in individual townships varies from 25 in Caledonia Township (O'Brien County) to 80 in Oran Township (Fayette County), and the number per county varies from 131 in O'Brien to 259 in Fayette County. The number of potential sites for plantings in individual townships varies from 111 in Waterman Township (O'Brien County) to 208 in Jefferson Township (Henry County), and per county the number varies from 507 in O'Brien County to 680 in Henry County.

The number of plantings over 40 years of age in individual townships varies from 5 in Hartley Township (O'Brien County) to 55 in Salem Township (Henry County), and the number per county varies from 50 in O'Brien County to 164 in Henry County. The number of plantings under 40 years of age in individual townships varies from 4 in East township (Montgomery County) to 25 in Putnam township (Fayette County), and the number per county varies from 34 in Montgomery County to 69 in Fayette County.

The townships with the smallest and largest number of plantings and potential sites for plantings are located in the counties with the smallest and largest total number of plantings and potential sites for plantings. A larger number of plantings is correlated with a larger number of potential sites.

Montgomery County has the highest percentage of plantings over 40 years of age and the lowest percentage of plantings under 40 years; the

opposite is true in Hartley Township (O'Brien County) and in O'Brien County. Less than ten percent of the potential sites for plantings had red-cedar trees of both age classes. Only trees over 40 years of age were present at 22% of the potential sites for plantings in the four counties compared to 9% of the sites with only trees under 40 years. The percentage of potential sites occupied by red-cedar plantings in the individual townships varies from 18 in Caledonia Township (O'Brien County) to 48 in Oran Township (Fayette County).

The deviations of various age classes of red-cedar, and the number of potential sites with and without plantings in and among counties is reported in chi square values in Table 3. The number of sites with plantings under 40 years of age, plantings of both age classes and the total number of plantings deviate significantly in Fayette County. The number of sites without planted red-cedar and the total number of potential sites for plantings differs significantly in Henry County.

The number of plantings of all age classes and the number of potential sites with and without planted red-cedar differ significantly among the four counties. This heterogeneity is also generally true in O'Brien County; planted trees under 40 years of age and the total number of potential sites for plantings is the only exception. There is no significant difference in the distribution of red-cedar plantings in Montgomery County.

The distribution of naturally established red-cedar trees is illustrated on the township survey maps (Figures 6, 7, 8, 9). Red-cedar trees in pastures, roadsides and fence lines usually radiate from a center of planted trees. The distance from the naturally established trees to the

Table 3. Deviations from the mean in red-cedar distribution within counties and between counties in Iowa*

Location	x^2-values of sites without planted trees	x^2-values of plantings over 40 yrs.	x^2-values of plantings under 40 yrs.	x^2-values of plantings with both age classes	x^2-values of total no. of plantings	x^2-values of total no. of sites
Fayette County	1.57	5.26	13.26	11.36	18.92	7.62
Montgomery County	1.93	9.65	5.29	1.67	5.20	2.95
Henry County	12.52	10.54	2.62	3.80	6.74	11.58
O'Brien County	19.72	26.64	2.55	16.29	13.70	4.71
Four County Totals	16.65	67.17	15.53	31.53	41.90	27.71

*P = .01, with 3 degrees of freedom

nearest planted seed source was usually not more than one-half mile. No naturally established red-cedars were observed in Floyd, Hartley, and Caledonia Townships in O'Brien County (Figure 9) (Table 4). The percentage of sites with plantings over 40 years of age having naturally established red-cedar within one-half mile varies from 9% in Putnam Township (Fayette County) to 29% in Salem Township (Henry County), and per county the percentage varies from 5% in O'Brien County to 20% in Montgomery County. Less than 8% of the total number of potential sites for plantings with nearby naturally established red-cedar had plantings under 40 years of age and this is true for plantings of both age classes. For the four counties 20% of the potential sites for red-cedar plantings have nearby natural establishment, and 15% of the total number of sites have plantings over 40 years of age. Planted red-cedar trees under 40 years of age seldom have nearby naturally established trees. Planted red-cedar trees over forty years of age and trees under forty years were observed in all the cities and towns in the sixteen township surveys; however, no counts were made.

The location of two red-cedar witness trees, in the original land survey, May, 1849, between Sections 29 and 32, Clermont Township, Fayette County (Township 95 North, Range 7 West of the 5th Principal Meridian) are shown in Figure 10. These trees which were eight and seven inches in diameter were marked as bearing trees to a meander post which was set in the bank of the Turkey River. The meander post was 42 chains and 83 links or 171.3 rods from the section corner. They were the only cedar trees that were recorded as witness trees in the original land survey records of the sixteen township study areas. One corner out of approximately 3017 section

Table 4. Relation of naturally established red-cedar trees to planted trees

Location	No.(%) of sites with plantings over 40 yrs. with nat.est.trees	No.(%) of sites with plantings under 40 yrs. with nat. est. trees	No.(%) of sites with plantings of both ages of nat. est. trees	No.(%) of sites with plantings with nat. est. trees	Total no. of sites
Fayette County					
Eden Township	37 (22)	6 (4)	11 (7)	54 (33)	163
Clermont Township	24 (19)	3 (2)	--	27 (21)	129
Oran Township	24 (14)	9 (6)	8 (5)	41 (25)	165
Putnam Township	16 (9)	8 (5)	10 (6)	34 (19)	175
TOTALS	101 (16)	26 (4)	29 (5)	156 (25)	632
Montgomery County					
Lincoln Township	21 (15)	2 (2)	--	23 (17)	137
Douglas Township	22 (17)	6 (4)	2 (2)	30 (23)	132
West Township	34 (23)	9 (6)	--	43 (29)	150
East Township	40 (25)	3 (2)	5 (3)	48 (30)	158
TOTALS	117 (20)	20 (4)	7 (1)	144 (25)	577
Henry County					
Jefferson Township	24 (12)	3 (1)	--	27 (13)	208
Scott Township	16 (10)	8 (5)	1 (1)	25 (16)	160
Salem Township	47 (29)	9 (6)	1 (1)	57 (36)	160
Baltimore Township	26 (17)	8 (5)	1 (1)	35 (23)	152
TOTALS	113 (17)	28 (4)	3 (1)	144 (21)	680
O'Brien County					
Floyd Township	--	--	--	--	141
Hartley Township	--	--	--	--	119
Caledonia Township	--	--	--	--	136
Waterman Township	23 (21)	8 (7)	7 (6)	38 (34)	111
TOTALS	23 (5)	8 (2)	7 (1)	38 (7)	507
Four County Totals	354 (15)	82 (3)	46 (2)	482 (20)	2396

and quarter section corners in these sixteen townships had red-cedar present in 1849. In the original survey field notes of the sixteen townships, a general reference was made to some cedars along the creek in Section 18, Salem Township, Henry County.

Presettlement Trees along Major Rivers

The general locations of presettlement red-cedar trees along the Mississippi, Missouri, Big Sioux and Cedar Rivers are illustrated in Figure 10. The presence of red-cedar trees was recorded in 11 of the 144 townships or fractional townships in Iowa along these four rivers. The occurrence of red-cedar trees was recorded in one of the 18 Iowa townships along the Big Sioux River, six of the 40 townships along the Cedar River and four of the 57 townships along the Mississippi River. No red-cedar trees occurred in the original land survey field notes of the 29 Iowa townships along the Missouri River. The townships along these rivers were surveyed between 1832 and 1859.

The exact locations of red-cedar witness trees, corner posts, stands of trees and stumps or posts are listed in Table 8 (Appendix B). Two red-cedar corner posts were recorded in the original land survey field notes in northwest Iowa near the Big Sioux River. Two red-cedar witness trees, eight and four inches in diameter, were recorded along the Cedar River. Two corners out of approximately 15,051 section and quarter section corners had living red-cedar present between 1832 and 1859.

Although no quantitative study was made of associated species, oak, hickory, maple, elm, cottonwood and willow were recorded in the original survey notes. Oak and hickory were common in the state, and cottonwood was very frequent along the Missouri River.

DISCUSSION

Present Distribution Pattern

All evidence supports the general observation that eastern red-cedar has become much more abundant in Iowa since presettlement times. The present distribution is statewide in relation to the abundant seed sources of planted trees and the extensive areas of suitable habitat. It was observed in the sixteen township surveys that there are many seed sources of red-cedar in each township, and the extensive network of roadsides, fence lines, and waterways, and the abundance of cleared or partially cleared timberland, abandoned farmland, and rough topography provide much suitable habitat. The prominent limestone bluffs along the Mississippi, Cedar, Iowa and Turkey Rivers provide much suitable habitat (Figure 17). The loess hills along the Missouri River in western Iowa provide an almost continuous area of suitable habitat from north-central Iowa to the southern border (Figure 18). Red-cedar is prevalent on rock outcroppings throughout Iowa (Figures 19, 20), and it also occurs on a few marshy areas in northeast Iowa (Figures 21)(Fowells, 1965).

The amount of suitable habitat in each intensively studied township is related to the topography and agricultural use of the land. The general topography of a township can be ascertained from the location of highways. Roads are usually located on the more accessible ridges in a hilly region, and they are usually uniformly arranged along section lines on relatively flat land (Figures 2, 3, 4, 5). Much suitable habitat is available on the steep ridges and hillsides in Eden and Clermont Townships (Fayette County), Salem and Baltimore Townships (Henry County), East Township (Montgomery County) and Waterman Township (O'Brien County). The level topography in

Figure 17. Old specimens of red-cedar on limestone bluffs above the Iowa River, Iowa Falls, Iowa

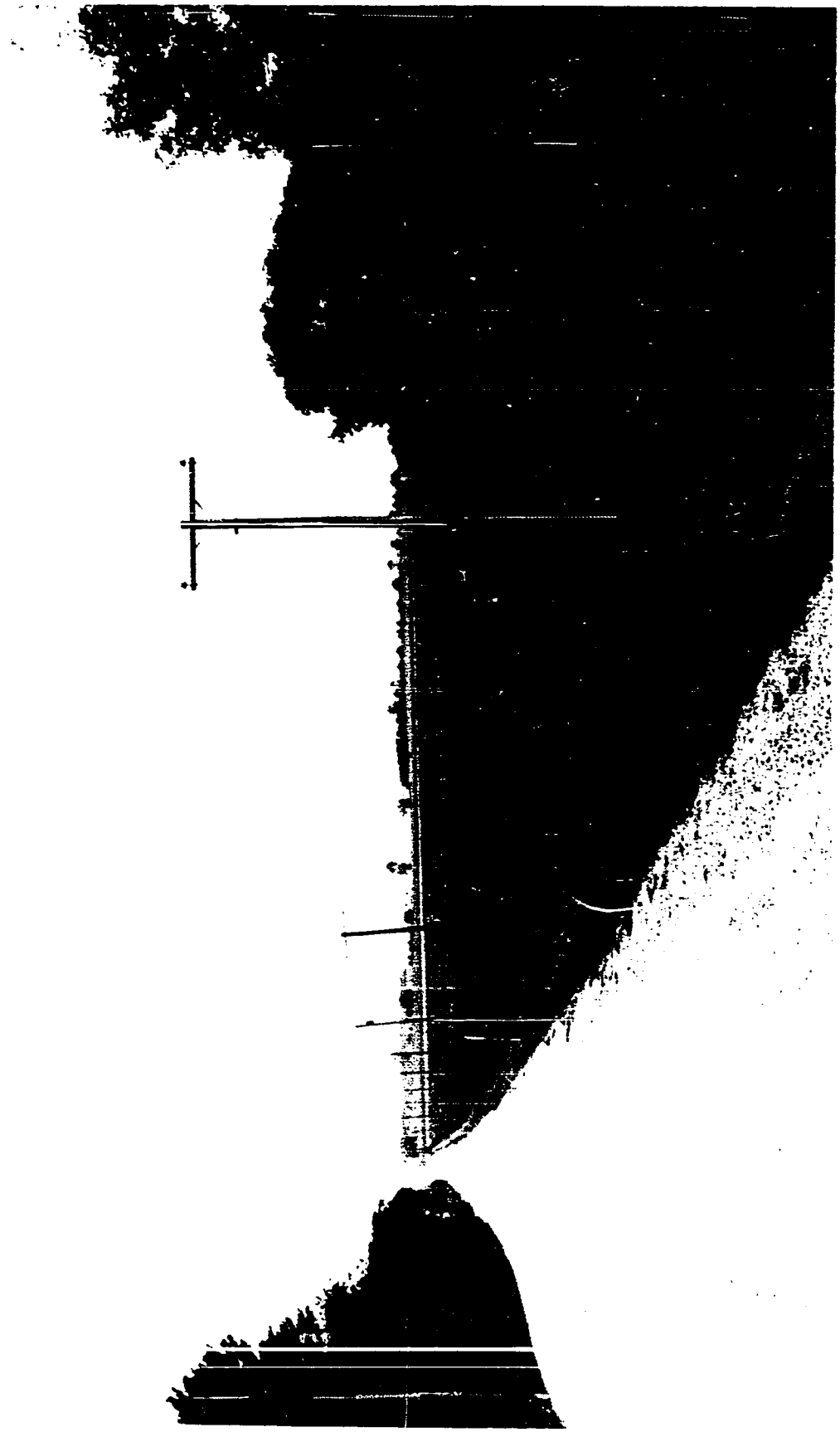
Figure 18. Distribution of young red-cedar on loess foothills of Missouri River Valley (Five miles west of Castana, Iowa, Monona County, facing northeast, November, 1967)

Figure 19. Establishment of red-cedar on a limestone outcropping, Section 1, Pleasant Valley Township, Fayette County, from which all red-cedar trees were removed in 1957; photograph taken in 1969

Figure 20. Neatly pruned red-cedars naturally established on thin, limestone soil approximately 2 miles northeast of Monticello, Iowa, on Highway #151; photograph taken July 13, 1965

Figure 21. Red-cedar establishment on marshy land in northeast Iowa. (Section 22, Eden Township, Fayette County, July 23, 1969)

The red-cedar windbreak (left) provided an adequate seed source.



Putnam Township (Fayette County), Scott Township (Henry County), Lincoln and West Townships (Montgomery County) and Caledonia, Floyd and Hartley Townships (O'Brien County) facilitates intensive farming and consequently, suitable habitat for red-cedar is limited mainly to roadsides and fence lines.

Most of the great soil groups, principle soil association areas and principle surface materials in Iowa were represented in this survey (Oschwald, Riecken, Dideriksen, Scholtes, and Schaller, 1965). Planted and naturally established red-cedar trees were found in all these soil variations. Although there is only one soil association, Galva-Primghar-Sac, in O'Brien County, no naturally established red-cedar trees were observed in Caledonia, Floyd and Hartley Townships and an abundance of naturally established trees was found in Waterman Township. In Fayette County, although the same soil association, Kenyon-Floyd-Clyde, is present in Eden and Putnam Townships, Putnam Township had few naturally established trees compared to the abundance of such trees in Eden Township.

Soils above neutral pH generally are considered to be the preferred habitat for red-cedar; however, systematic observations indicated that soil acidity is probably not necessarily a limiting factor in red-cedar distribution (Arend, 1950; Einspahr, 1955; Lowry, 1958, 1960). The occurrence of red-cedar in Iowa on coal-spoil sites of 4.7 - 7.8 pH has been reported (Arend and Collins, 1948). Red-cedar was not observed growing in sandy soils, although Nicollet (1843) and Gifford (1902) reported that red-cedar grew well on sand bars along the Cedar River.

Most of the climatic extremes which exist in Iowa are represented in the study areas (Oschwald, Riecken, Dideriksen, Scholtes and Schaller, 1965).

The widespread occurrence of eastern red-cedar from North Dakota to Texas to the Atlantic, although locally represented by ecological variants, indicates that it is not restricted by climate in Iowa. The occurrence of red-cedar seedlings and mature trees in every township study area indicates that red-cedar grows well under various climatic conditions (Fowells, 1965; Johnson and Cobb, 1923). The abundance of red-cedar trees older than 40 years is evidence that red-cedar trees withstood the drought of 1934 (Albertson and Weaver, 1945; Stiles and Melchers, 1935; George, 1965).

Red-cedar survival is better in an open canopy or completely open area than under a closed canopy; however, they will tolerate partial shade (Gifford, 1902; Baker, 1949; Parker, 1952; Meade, 1955; Wells, 1961). Campbell and Grau (1948) stated that red-cedar trees are very shade tolerant. Red-cedar trees were observed competing favorably with the oak-hickory timber in Fayette County (Figure 22) with reproduction and establishment of red-cedar still occurring under the hardwoods.

The wide adaptability of red-cedar probably accounts for its common use in windbreaks and landscape plantings in Iowa. Red-cedar also produces low foliage, which is good cover for pheasants, as a part of a well designed woodlot or windbreak. Esthetic and religious reasons also influenced man's selection of red-cedar. Peattie (1950) stated that our forebears planted the red-cedar in graveyards because its evergreen boughs symbollically suggested eternal life and its apical shoot pointed toward heaven. Whatever the reason for planting red-cedars, it has been planted widely in Iowa since early settlement times although there have been fewer landscape plantings in the last 40 years (Table 2).

The seed sources for most of the naturally established red-cedar are assumed to be the planted trees in presently occupied homesteads,

Figure 22. Red-cedar in center of photograph competing favorably with Quercus macrocarpa, Quercus alba and other hardwoods species (Section 29, Clermont Township, Fayette County, July 23, 1969)

unoccupied homesteads and cemeteries. The mapping of plantings and naturally established trees along all the highways in the sixteen townships, observations across the northern portion of Iowa (Highway #18), the central portion (Highway #30) and the southern portion (Highway #34), and a previous detailed study of Henry County and areas in Monona and Woodbury Counties support this relationship of naturally established trees to nearby planted red-cedar seed sources in Iowa (Graf, 1965) (Figures 23, 24). The simple, accurate, detailed method of mapping a tree species as obvious as red-cedar reveals the real affinities of its origin and history (Dansereau, 1942, 1957; Munns, 1938).

Naturally established red-cedar trees act as local centers of distribution (Figure 25). Nearly pure stands of young trees frequently develop near naturally established seed sources (Table 6, Appendix A). The youngest seed-bearing tree observed in Iowa was six years old. Also a tree with 247 growth rings was producing seed. Heavy seed production was observed on trees more than 100 years old. Previous reports have suggested that red-cedar trees begin bearing seeds at ten years of age and continue at least as long as 175 years. The best seed producers are from 25-45 years of age, with heavy crops of seed produced every two or three years (Williamson, 1957).

Further study should be conducted on the methods of red-cedar seed dispersal. Gravity-induced movement by rain and erosive forces of running water may function in local dispersal of the berry-like fruit of the red-cedar (Figure 25). Robins, cedar waxwings and starlings were observed feeding on the fruit and often completely stripped a tree in a few hours (Tuyson, 1943). Parker (1951) observed that germination of red-cedar seeds

Figure 23. Aerial photo of naturally established red-cedar trees (foreground) within one-half mile of a planted seed source, Robert Frary (Section 20, Jackson Township, Henry County, Iowa); fifteen planted red-cedar trees in the frontyard of this homestead were 130 years old, the oldest naturally established red-cedar sampled was 68 years old; photographed, Spring 1969

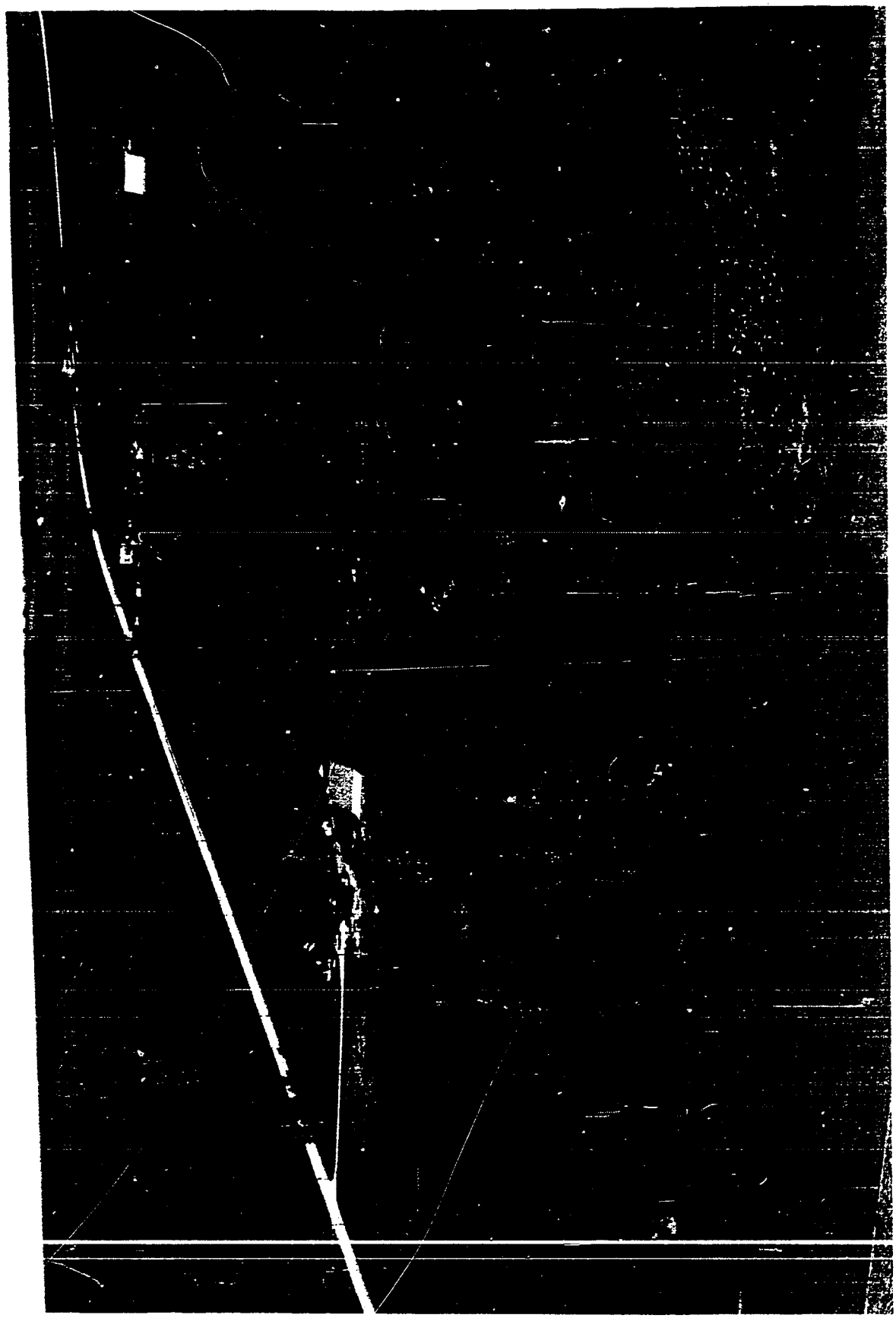


Figure 24. Aerial photo of a dense stand of red-cedar between two planted sources; old red-cedar planted in farmstead in center, the other source out of the photograph (See Figure 11)
(Section 29, Jackson Township, Henry County, Iowa, Spring, 1969)

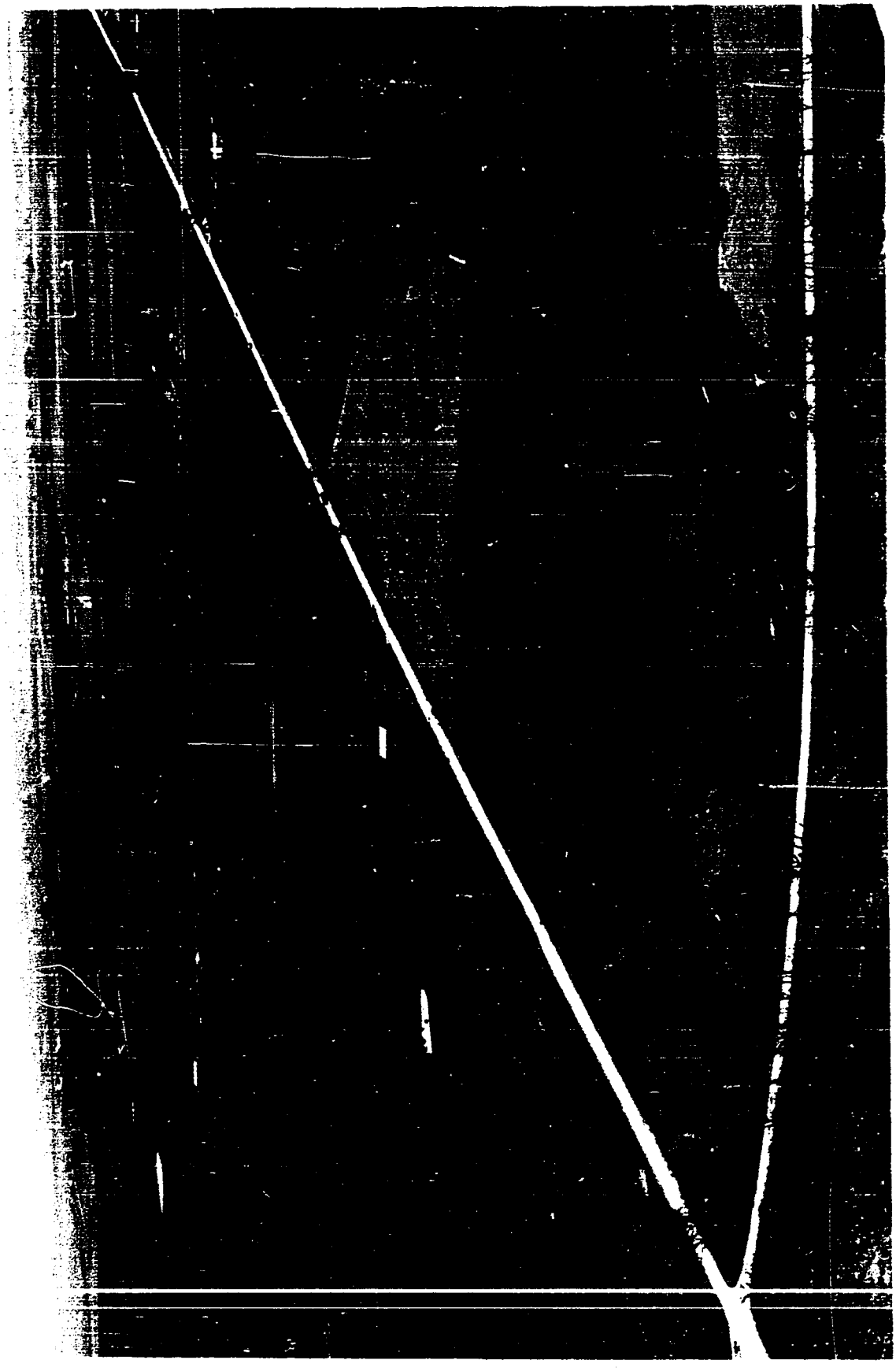


Figure 25. A pure stand of red-cedar established near mature naturally established trees (background)
(Section 26, Tippecanoe Township, Henry County, Iowa, Winter, 1964)

is improved when consumed by certain birds but they are destroyed when eaten by doves. Thirty-six species of birds throughout the world eat red-cedar berries (Barrows, 1895; Kalmbeck, 1918; McAtee, 1918).

Age determinations were based on numerous increment borings and cross-sections of naturally established and planted trees (Tables 6, 7, Appendix A). A naturally established red-cedar on an upland site on the margin of an oak-hickory woodland was cut at ground level (Figure 26) and one on a rock bluff was cut also (Figure 27). Both trees were approximately 6½ inches in diameter at 2 feet above ground level and approximately 18 feet tall. Trees on these two very diverse sites were selected to observe the variation in growth rates influenced by the important site factors of soil depth and drainage (Fowells, 1965).

Cross-sections were cut at ground level and at 4½ feet above ground level (Figures 26, 27). The cross-section of the tree grown on the rock ledge had 247 rings at ground level and 215 rings at 4½ feet. The tree grown on an upland pasture had 38 rings at ground level and 29 rings at 4½ feet. Nine rings were produced in the first 4½ feet of the red-cedar in the upland pasture, and 32 rings were produced in the first 4½ feet of the tree on the rock ledge. Based on ring differences at these two heights, trees 4½ feet tall on upland pasture sites should have 9 growth rings and trees 4½ feet tall on extreme sites should have approximately 32 growth rings. It is obvious the growth rate is reduced in thin soil (Afanasiev, 1949). Thirty cross-sections of red-cedar trees grown on upland sites, cut at 4 feet above ground level average 5 growth rings produced between ground level and 4 feet.

Figure 26. (1) A naturally established red-cedar (center) growing on an upland pasture site (Jackson Township, Henry County, Robert Frary farm)

(2) Cross-section cut at ground level, from base of the tree shown in (1), 38 growth rings present

(3) Cross-section cut at 4½ feet above ground level, from base of tree shown in (1), 29 rings present.


3
1
2

Figure 27. (1) A red-cedar growing on a rock bluff over-hanging the Cedar River

The number of growth rings produced at various heights were counted in this tree on an extreme site. This tree was approximately 18 feet tall and 6½ inches in diameter two feet above the ground. (In Palasades-Kepler State Park, Summer, 1969)

(2) Cross-section cut at ground level, from base of the tree shown in (1), 247 growth rings present

(3) Cross-section cut at 4½ feet above ground level, from base of tree shown in (1), 215 rings present


3
1


2

Presettlement Distribution

The locations of red-cedar trees in Iowa prior to 1886 were obtained from (1) original land survey records and plats, (2) written accounts by early settlers and (3) interviews with local residents.

The method used in surveying the land into 36-square-mile areas (townships) and subsequently into 36 1-square-mile areas (sections) is pertinent to a study of distribution patterns of early forest species (Dick-Peddie, 1955). A post was established in the middle of each section line (quarter section corner). Two trees at each section corner and quarter section corner were designated by common name; their diameters, bearings and distances from the corner were recorded in the original land survey field notes. These witness or bearing trees were required to be alive and healthy and not less than five inches in diameter at breast height. The field notes were supposed to have included a list of timber species and undergrowth in the order of their abundance; however, this was often omitted or obviously incomplete.

Limitations of this method are obvious. Many trees would not be encountered which were present in the center of the section. Actually a very small proportion of trees were designated, but because of the standard procedure, there is little reason to doubt the validity of the observations. The validity of using these records for determining presettlement plant distribution is attested to by many scientists (Sears, 1921; Lutz, 1930; Kenoyer, 1933; Transeau, 1935; Dick, 1936; Gordon, 1940; Fassett, 1944; Ellarson, 1949; Potzger and Potzger, 1950; Dick-Peddie, 1955; Kilburn, 1959; Jones and Patton, 1966). Bourdo (1956) in his review of the use of the general land survey records for quantitative

studies of former forests stated that because the choice of species adjacent to the section corner was usually limited, preferences by the surveyor for certain witness trees was not an important source of bias. It is well supported by Steyermark (1959):

> "The most direct and best documentary data for a comparison of areas today with those a century or more ago are the data of field notes of the original land surveys. Although it cannot be expected that the men who made the surveys and marked the witness trees were botanists, they were sufficiently informed to be able to distinguish the main kinds of trees, and many of the shrubs. . . In other words, their field notes furnish us with the best evidence available in the specific area in which they worked."

The scarcity of evergreens in Iowa was reported in early botanical literature (Adams, 1867; Shimek, 1896; Pammel, 1902; Bourdo, 1956). Cedar trees were reported as witness trees in only three of the 160 townships examined in the original land survey field notes. This means that no healthy red-cedar trees five or more inches in diameter were present at section or quarter section corners in most of the townships. One of the cedar trees which was marked as a witness tree was only four inches in diameter, and none of the trees was more than eight inches in diameter... If larger cedar trees had been present they would probably have been selected. The presence of other trees near the witness trees is not recorded in the field notes. The presence of red-cedar was reported in 11 township summaries out of the 160 township survey records.

Interviews with old settlers and local residents have been useful in conjunction with the early botanical records and data from the original land survey field notes (Gordon, 1940). Some of the oldest inhabitants recall that when the various parts of Iowa were first occupied by pioneers many of the hills which are now covered with red-cedar did not have

trees[4,6] (Figure 28). Statements from early residents of Grant Township, O'Brien County, indicated that very large red-cedar trees once grew on the bank of Waterman Creek[7,8]. A growth ring count of 280, heartwood primarily, from a stump found on a steep slope along Waterman Creek verified this statement and the antiquity of these red-cedar trees (Figure 29). The tree had been cut for approximately 60 years and most of the sapwood had been worn away[8]. Thus the tree dates back to approximately 1629.

A red-cedar pole on the property of Henry Follett was discovered through interviews with residents of Pleasant Valley Township, Fayette County[9] (Figure 30). This pole, reported dead when cut in 1866 from Turkey Ridge, Fayette County, had retained 150 growth rings in the remaining heartwood when sampled by increment boring[10]. This tree dates back to 1716 at the latest.

The oldest naturally established red-cedar trees observed in Iowa for this study, were growing on limestone bluffs along rivers (Figure 31). A red-cedar growing on the limestone bluffs above the Cedar River in the

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[4]Brockway, Barry. ibid

[6]Ask, Leonard. 1964. Red-cedar distribution notes. Section 19, Glenwood Township, Winneshiek County, Iowa. Personal interview.

[7]Martin, Horace. 1969. Red-cedar distribution notes. Sutherland, Iowa. Personal interview.

[8]Noethe, Mathias. 1969. Red-cedar distribution notes. Sutherland, Iowa. Personal interview.

[9]Olson, Jesse. 1969. Red-cedar distribution notes., Section 31, Clermont Township, Fayette County, Iowa. Personal interview.

[10]Follett, Henry. 1969. Red-cedar distribution notes. Section 1, Pleasant Valley Township, Fayette County, Iowa. Personal interview.

Figure 28. A hill which was called "Old Baldy" by early residents

No red-cedar trees were growing on this hill fifty years ago, according to local residents, April, 1964.

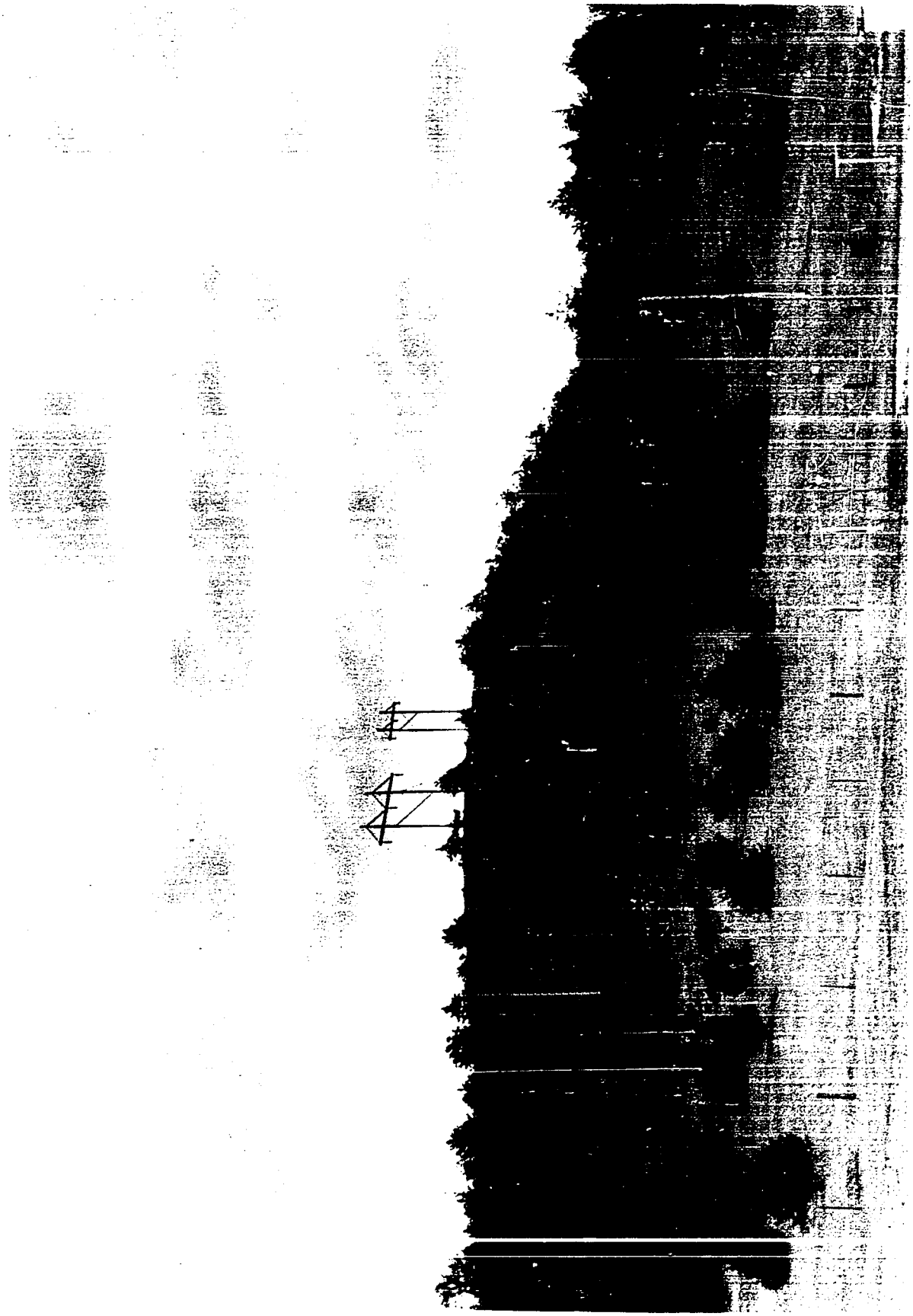


Figure 29. (top) A stump of red-cedar cut approximately 60 years ago found on a steep slope above Waterman Creek, Section 26, Grant Township, O'Brien County on "Cedar Cliff Farm", Summer, 1969

(bottom) Cross section of the lower portion of old red-cedar stump shown above with 280 growth rings

1

2

Figure 30. Red-cedar pole used as a dinner bell pole at residence of Henry Follett, was cut on Turkey Ridge and set in this yard in 1866; 150 growth rings were counted on an increment boring of the heartwood remaining (Section 1, Pleasant Valley Township, Fayette County)

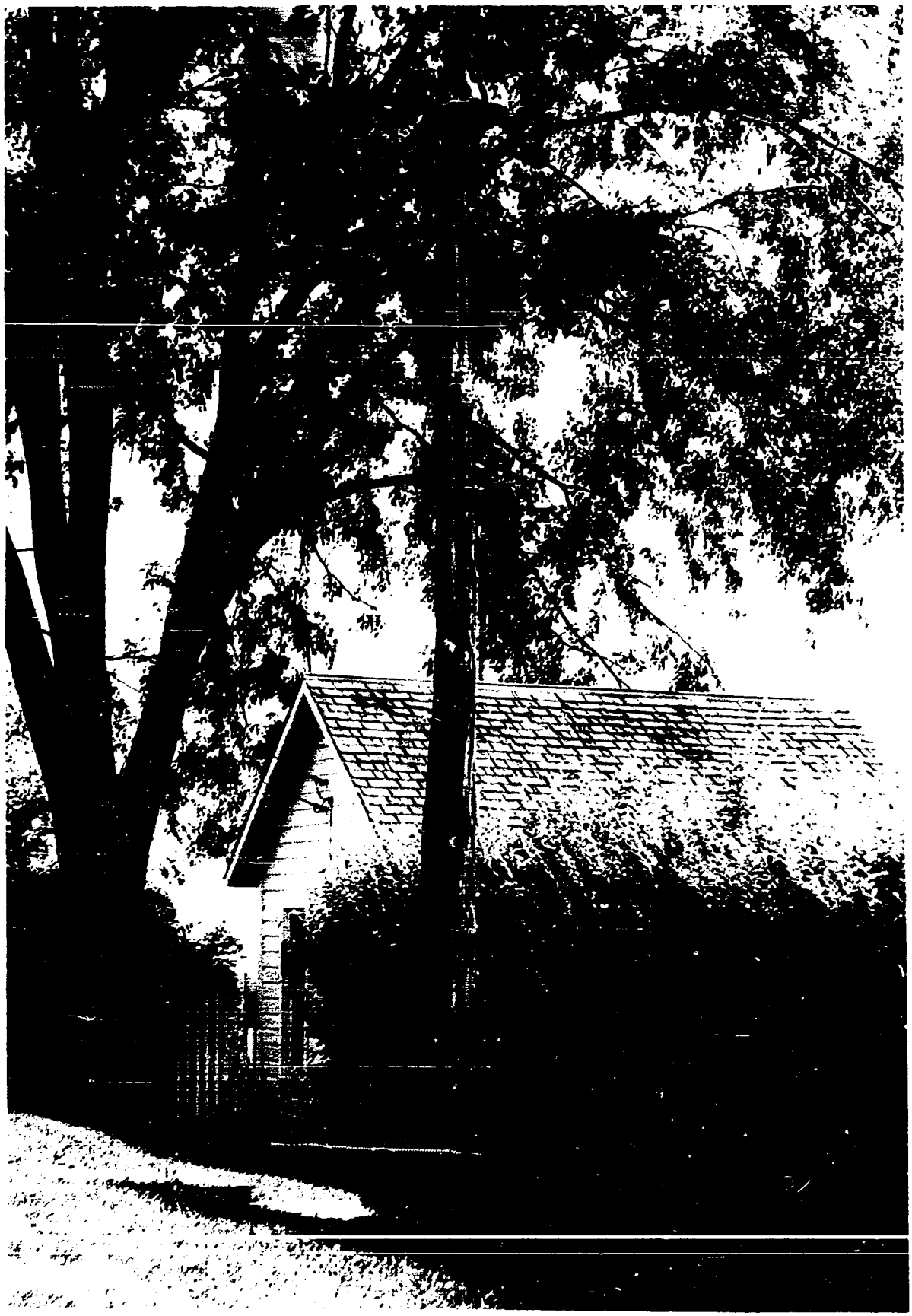
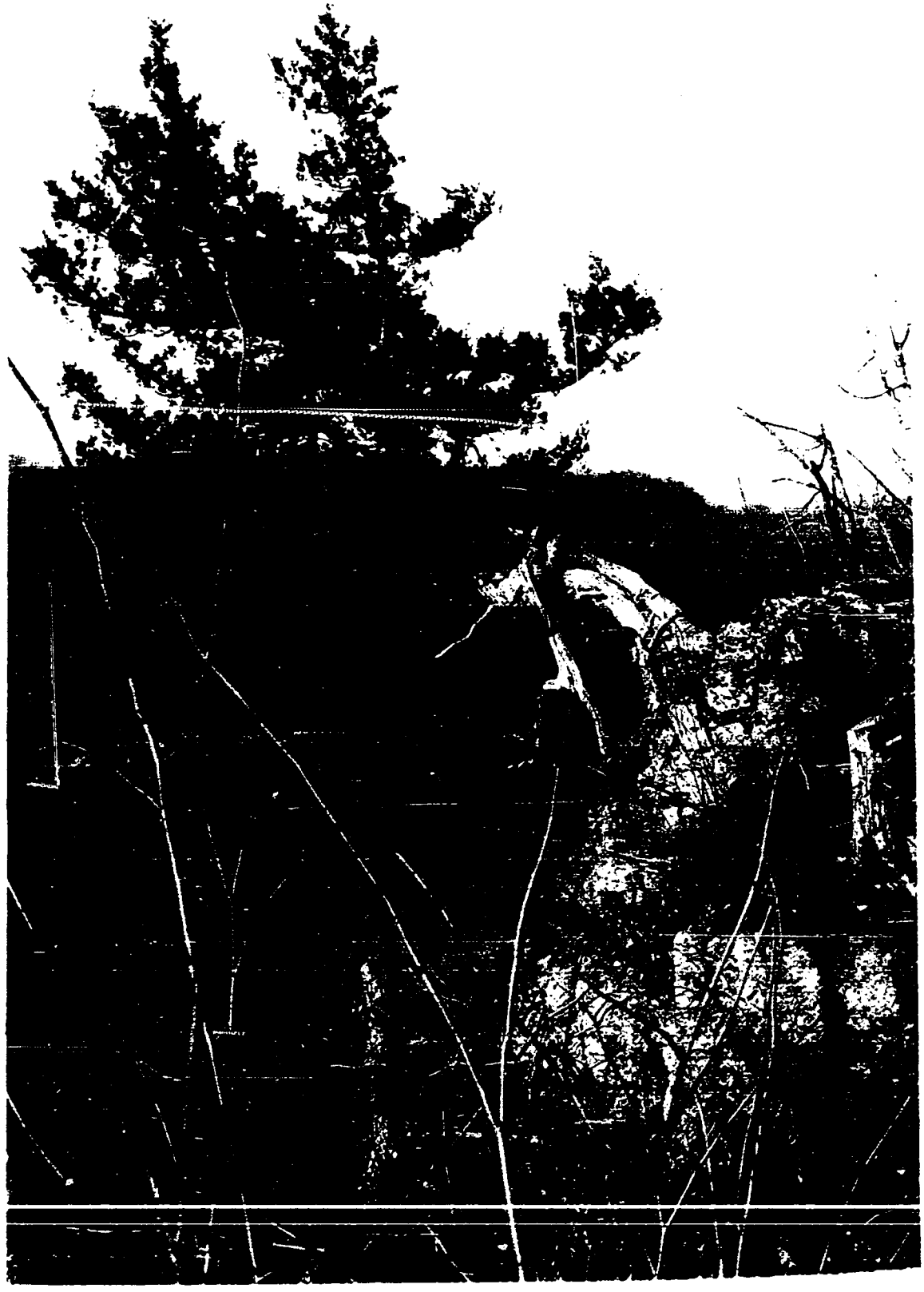


Figure 31. Old red-cedar tree on limestone bluff overhanging the Cedar River (Palisade-Kepler State Park)

The oldest living red-cedar trees in Iowa were observed on river bluffs.



Palisades State Park had 379 growth rings, determined from an increment boring.

Dates of known events in relation to red-cedar are summarized in Table 5. These dates are based on the assumption that each growth ring is one annual ring.

Table 5. Summary of early records of red-cedar in Iowa

Date of origin	Location	Source of information
1590	Cedar River, Palisades-Kepler State Park	Increment boring of naturally established tree
1629	Waterman Creek, Grant Township, O'Brien County	Cross-section of stump, mainly heartwood
1716	Section 1, Pleasant Valley Township Fayette County, Henry Follett farm	Increment boring from bell-pole, mainly heartwood
1810	Cedar cross on grave of Julien Dubuque	Written account, Negus, 1864)
1832-1859	(Sites listed in Table 8, Appendix B)	Territorial Land Survey Records
1839	Section 29, Jackson Township, Henry County, Robert Frary farm	Increment borings of planted trees

All of the cedar trees which were recorded as witness or bearing trees in the township land survey field notes were located along rivers or creeks. All evidence seems to indicate that only a few presettlement red-cedar trees were present, these along rivers and streams, presumably on bluffs or open slopes. These presettlement red-cedar trees may have functioned as seed sources in localized areas of the state, but it was not until plantings were made at many homesteads that the present pattern

developed. Red-cedar has been more or less restricted to the river edges by fire or forest competition. It spread out more extensively with the planting and management practices of pastures and woodlots.

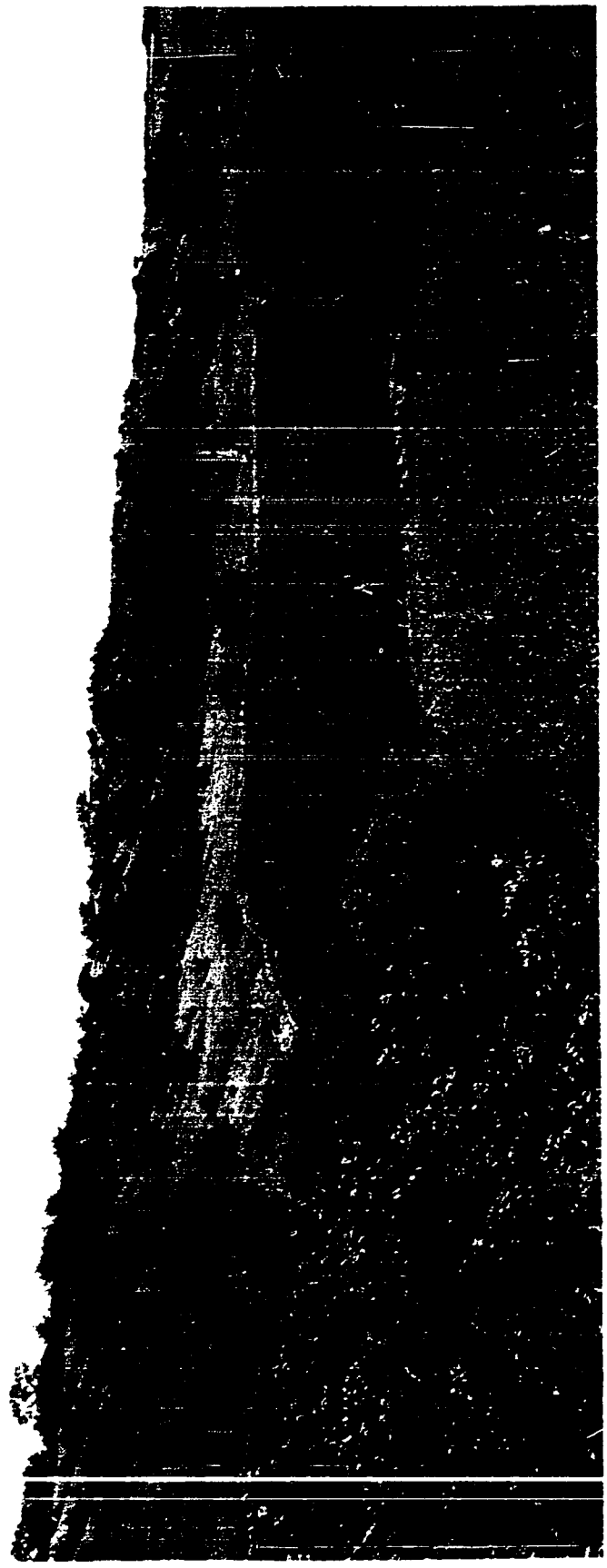
The original pattern of distribution of red-cedar becomes more difficult to read as original seed sources are removed. The razing of homesteads and even entire towns has removed former seed sources.

Striking evidence of recent invasion of red-cedar into pastures, roadsides and fence lines was observed in all sixteen townships (Figures 19, 32, 33), except Floyd, Caledonia and Hartley Townships in O'Brien County. Forty years ago there were 12-15 small red-cedar trees on the hillsides (Figure 33). This can be attributed to the reduced burning of grassland that accompanied an increase in the population (Gaskill, 1905; Beilman and Brenner, 1951; Kucera, Ehrenreich and Brown, 1963). The increased abandonment of old fields in recent years is also a factor in red-cedar invasion (Steyermark, 1959).

The lack of naturally established red-cedar trees in areas where red-cedar trees have been planted may be explained by one or more reasons: (1) there is no suitable habitat available because of close mowing of ditches and fence lines, newly constructed roads or fences, or extensive cultivation of all available land; (2) the planted trees have failed to produce seed; (3) seed dispersal to a suitable habitat has not occurred; (4) establishment may have occurred and the individuals were removed by local residents or (5) establishment occurred and the trees were not observed by the author because of limitations in the sampling method. The lack of suitable habitat is true in Floyd, Caledonia and Hartley Townships in O'Brien County.

Figure 32. Recent invasion of roadsides and woodland in Jackson Township, Henry County with planted seed source approximately one-fourth mile from this site, Winter, 1967

Figure 33. Dense stand of red-cedar trees developed in the past forty years on old pasture in Waterman Township, O'Brien County, Summer, 1969



Red-cedar has the characteristics of a pioneer species in Iowa (Collins, 1931; Fowells, 1965), spreading rapidly into open disturbed areas, increasing in density, and finally being suppressed by deciduous species after sixty years or so in other regions (Bard, 1952). Pure stands of eastern red-cedar occur when there has been no thinning of trees (United States Department of Agriculture Check List, 1927). Often these stands last indefinitely on severe limestone outcroppings where other species cannot replace them in a successful sequence. It appears that the only stands persisting to recent times were those of rock outcrops along rivers and creeks. With settlement and the great influence of man on the landscape, abundant areas became available for invasion by eastern red-cedar.

Periodic cutting, close mowing or repeated burning are effective management practices for removing naturally established trees or for preventing the invasion of red-cedar. Red-cedar is easily killed by various methods: cutting and mowing are effective because red-cedar trees do not sprout; burning is effective because red-cedar trees are very easily killed by fire (Arend, 1950; MacBride, 1895; Munns, 1938; Kucera, Ehrenreich and Brown, 1963).

In order to explain more completely the reason for the present distribution pattern of red-cedar, more intensive research into the method of dispersal of seed is needed. The observation of much excreta, largely consisting of partially digested red-cedar fruit, beneath and around seed-bearing trees indicates that further studies should be conducted on the length of time that it takes for a seed to pass through a bird. Short retention time of red-cedar seed might partially explain why seeds are

seldom carried more than one-half mile from a seed source. An accurate, efficient method of sampling clumped forest populations is needed for research into distribution patterns of individual species. The specific requirements for germination and establishment should also be studied.

SUMMARY

The present distribution pattern of eastern red-cedar in Iowa was studied in a general highway survey of the four corner townships in Fayette, Henry, Montgomery and O'Brien Counties. A total of approximately 1066 miles in the four counties was included in this survey.

Thirty-four percent of the homesteads and cemeteries in the four county study areas had planted red-cedar. Twenty-two percent of the potential sites for plantings had only trees over 40 years of age. The number of plantings over 40 years of age, under 40 and both age classes and the number of potential sites with and without planted red-cedar differ significantly among the four counties.

It was observed that the predominantly rough topography which provides suitable habitat for red-cedar and the abundant seed sources in the township study areas make extensive establishment of red-cedar possible. Much suitable habitat is provided in the hilly Fayette, Henry and Montgomery County study areas. No naturally established red-cedar trees were observed on the flat land of Floyd, Hartley and Caledonia townships in O'Brien County where suitable habitat is restricted to fence lines and roadsides.

Twenty percent of the potential sites for red-cedar plantings have nearby naturally established red-cedar trees. The planted red-cedar trees at presently occupied homesteads, deserted homesteads, and cemeteries were observed to be the seed source for most of the naturally established trees. Usually the naturally established red-cedars were not more than one-half mile from the planted seed-bearing trees. This relationship of planted trees to naturally established trees is more difficult to observe where

many homesteads have been razed and new centers of naturally established distribution have developed.

The locations of presettlement red-cedar trees in the sixteen townships and along the Mississippi, Missouri, Big Sioux and Cedar Rivers were obtained from the original land survey records, written accounts by early travelers and settlers, interviews with local residents and field evidence. Evidence of presettlement trees was only found in 14 of the 160 townships along rivers or creeks. Three red-cedar witness trees were present in the land survey records of 18,068 section corners and quarter section corners in the 160 townships.

The oldest naturally established red-cedar tree was 379 years old, on a limestone bluff of the Cedar River, and the oldest planted red-cedar tree, in the yard of a farmstead in Henry County, was 130 years old. Ages were based on numerous increment borings and cross-sections.

It is concluded that the presettlement trees have functioned as seed sources localized along rivers and creeks; however, the numerous planted trees throughout the state have been responsible for the present widespread distribution.

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APPENDIX A

Table 6 Age determinations from cross-sections of naturally established red-cedar trees in Henry County, Iowa, Fall, 1967

Ground level			1' up		2' up		3' up		4' up	
Height	Growth Rings	cm. Diam.	Growth Rings	cm =Diam.	Growth Rings	cm. Diam.	Growth Rings	cm. Diam.	Growth Rings	cm. Diam.
				Jackson Township Section 32						
				West slope - upland pasture						
7½'	10	5.0	8	3.5	7	3.2	6	2.5	5	1.8
7	9	4.8	7	3.2	6	3.0	5	2.2	4	1.4
6	7	4.2	6	3.0	5	2.6	4	1.6	4	0.9
5	7	3.2	6	2.2	6	2.0	5	1.6	4	1.0
5½	8	5.0	5	3.5	5	3.0	4	2.0	2	1.2
6	9	6.2	8	5.0	6	4.0	5	2.2	3	1.3
5	7	4.5	5	3.5	4	2.3	3	1.5	2	0.9
7	9	4.0	7	2.7	6	2.6	5	1.7	3	1.0
6	9	4.1	6	2.8	5	2.3	4	1.8	3	1.0
6	7	3.8	6	3.0	5	2.5	4	1.2	3	0.9
				Salem Township Section 23						
				Top of knoll - pasture						
5½	11	4.0	7	3.0	6	2.3	5	1.6	3	0.9
6	8	4.5	7	3.5	5	2.5	4	1.7	3	0.8
6½	9	3.5	8	2.5	6	2.3	5	2.0	4	1.5
7	10	3.7	8	2.5	6	1.8	5	1.6	3	1.2
4	8	3.0	6	2.0	5	1.5	3	1.0	2	0.4
6	6	4.5	5	3.2	4	2.3	3	1.7	2	1.0
7½	9	4.1	8	3.3	7	2.8	6	2.4	5	2.0
5	6	2.8	5	2.3	4	2.7	3	1.0	2	0.5
6½	10	4.8	7	3.0	7	2.3	6	1.8	4	1.5
	9	4.4	7	3.2	6	2.8	5	2.3	3	1.5
				Tippecanoe Township Section 26						
				East slope on highway cut - limestone outcropping						
6	8	3.0	7	2.7	6	2.2	5	1.8	4	1.2
6	7	3.8	6	3.0	5	2.6	4	1.8	3	1.2
7½	7	3.5	6	2.8	6	2.5	5	2.2	4	1.3
6	8	4.0	6	3.0	5	2.0	3	1.5	2	0.9
7	8	4.5	6	3.0	5	2.5	4	2.0	3	1.3
6½	7	4.2	6	3.0	5	2.5	4	2.0	3	1.3
6	8	4.0	6	3.0	4	2.6	4	2.0	3	1.0
6½	8	4.2	6	3.0	5	2.3	4	2.7	3	1.0
6½	6	2.4	5	2.0	4	1.7	4	1.5	3	1.3
7	8	3.0	6	2.4	5	2.0	4	1.7	3	1.1

Table 7 Growth ring counts based on increment borings from mature eastern red-cedar trees in Iowa.*

Date	Site	Diam. (cm)	Growth rings	Planted or Natural
	Palisades - Kepler State Park (Cedar River)			
1964	Limestone bluff	46	379	N
	Limestone bluff	23	264	N
	Limestone bluff	39	277	N
	Limestone bluff	41	65	N
	Limestone bluff	23	135	N
	Limestone bluff	28	265	N
	Limestone bluff	14	106	N
	Limestone bluff	13	69	N
	Limestone bluff	17	66	N
	Limestone bluff	13	159	N
	Limestone bluff	8	86	N
	Limestone bluff	33	194	N
	Limestone bluff	14	206	N
	Limestone bluff	10	64	N
	Limestone bluff	13	134	N
	Limestone bluff	23	232	N
	Limestone bluff	8	245	N
	Limestone bluff	41	56	N
	Limestone bluff	10	96	N
	Limestone bluff	14	238	N
	Limestone bluff	33	226	N
	Limestone bluff	13	191	N
	Limestone bluff	9	128	N
	Limestone bluff	16	97	N
	Limestone bluff	13	101	N
	Limestone bluff	13	138	N
	Limestone bluff	28	297	N
	Limestone bluff	23	108	N
	Limestone bluff	23	162	N
	Limestone bluff	15	64	N
	Limestone bluff	18	102	N
	Rock ledge	19	70	N
1965	In yard	25	67	P
	In yard	26	58	P
1966	In caretaker's yard	25	33	P
	In caretaker's yard	18	37	P
	In caretaker's yard	15	56	P

*Increment borings were taken approximately 4 feet above ground level.

Table 7 (continued)

Date	Site	Diam.(cm)	Growth rings	Planted or Natural
		Iowa Falls (Iowa River)		
1965	Friends Cemetery	40	88	P
	Friends Cemetery	41	76	P
	Friends Cemetery	41	56	P
	Limestone bluffs	11	77	N
	Limestone bluffs	no center	127	N
	Limestone bluffs	20	118	N
	Limestone bluffs	6	100	N
	Vacant lot	66	no center	P
	Vacant lot	38	80	P
	Vacant lot		86	P
	Vacant lot		80	P
	Old abandoned farm	36	71	P
	Old abandoned farm	38	73	P
	Old abandoned farm	30	77	P
	Old abandoned farm	30	81	P
1969	In yard	29	92	P
	Yard, windbreak	25	57	P
		Guttenberg (Mississippi River)		
1969	Large rock crevice	27	60	N
	Rocky limestone ledge	29	59	N
	Rocky limestone ledge	27	92	N
	Rocky limestone ledge	29	91	N
	Rocky limestone ledge	18	79	N
	Rocky limestone ledge	8	135	N
	Rocky bluff	19	47	N
	Rocky bluff	8	103	N
		Bentonsport (Des Moines River)		
1969	Church yard	38	73	P
	Church yard	38	83	P
	Church yard	38	66	P

Table 7 (continued)

Date	Site	Diam.(cm)	Growth rings	Planted or Natural
	Henry County			
	Jackson Township (Watts farm)			
1965	Fence row, prairie	23	67	N
	Old meadow, good soil	15	33	N
	Old pasture	30	42	N
	Old pasture	28	41	N
	Pasture	22	51	N
	Pasture	30	51	N
	Pasture	15	42	N
	Tippecanoe Township (Wright farm)			
1965	Pasture	30	51	N
	Pasture	22	51	N
	Fayette County (Turkey River)			
1969	Valley bluff	27	228	N
	River bank, limestone bluff	27	102	N
	Limestone bluff	24	158	N
	Limestone bluff	25	107	N
	Pasture	20	81	N
	Pasture	24	52	N
	Open pasture	36	75	P
	Open pasture	40	88	P
	Rough pasture	25	41	N
	In shade of oak-hickory	23	67	N
	In yard	24	61	P
	In yard	38	75	P
	Vacant yard	53	94	P
	O'Brien County			
	Waterman Township (Horace Martin farm)			
1969	South slope	20	39	N
	South slope	33	54	N
	South slope	23	46	N
	South slope	36	48	N
	South slope	20	45	N
	South slope	33	55	N

APPENDIX B

Table 8. Exact locations of presettlement red-cedar trees

Description	Coordinates	Location	Source of Data
Witness tree			
Between Sections 33 & 34	T87N R11W	Cedar River	Land Survey
Between Sections 14 & 23	T87N R12W	Cedar River	Land Survey
Between Sections 29 & 32	T95N R7W	Turkey River	Land Survey
Corner Post			
	T99N R47W and T100N R48W	Big Sioux River	Land Survey
	T99N R48W and T100N R49W	Big Sioux River	Land Survey
Stump or post			
Section 1	T94N R7W	Homestead near Turkey River	Frank Nims,Jr.
Section 26	T95N R39W	Waterman Creek	"Cedar Cliff Farm"
Stand of trees			
	T67N R4W	Mississippi River	Land Survey
Section 18	T70N R4W	Big Cedar Creek	Land Survey
Between Sections 34 & 35	T77N R1W	Mississippi River	Land Survey
	T80N R3W	Mississippi River	Land Survey
East side of Section 13	T80N R4W	Mississippi River	Land Survey
Palisades-Kepler St. Pk.	T82N R6W	Cedar River	Recent studies
Between Sections 14 & 23	T87N R12W	Cedar River	Land Survey
Iowa Falls, Iowa	T89N R20W	Iowa River	Recent studies
Iowa Falls, Iowa	T89N R21W	Iowa River	Recent studies
	T90N R48W	Big Sioux River	Land Survey
Between Sections 23 & 24	T91N R14W	Cedar River	Land Survey
Between Sections 16 & 17	T93N R3W	Mississippi River	Land Survey
Between Sections 16 & 21	T93N R3W	Mississippi River	Land Survey
Between Sections 7 & 12	T98N R2W	Mississippi River	Land Survey