An Analysis of Irregularity of Surveyed Sections in Indiana

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Introduction

The Congressional Land Survey System, commonly called either the Section, Township, and Range or the rectangular land system, is frequently used to make accurate descriptions of geographic location. The extent to which sections are not square and do not have sides of exactly one mile can affect the complexity and accuracy of the location description. It was possible to measure the lengths of all section sides in Indiana to an accuracy of about ± 25 feet using data collected for a computer mapping system. Using the length of each section side made it possible to assign a degree of irregularity to each section in the state. The computer mapping system, coupled with a Calcomp plotter, has drawn maps locating the sections with varying degrees of irregularity as well as a map of the most nearly perfect sections. The maps illustrate some of the systematic error in the original land surveys and point out some errors or differences that are not easily explained.

The locations of all the section corners in Indiana were digitized by the staffs of the Illinois and Indiana Geological Surveys from 7½ minute topograhic quadrangles published by the United States Geological Survey. The computer mapping system was designed at the Illinois Geological Survey. This system is designed to handle sections only and not locations, military donations, surveys, reservations, or other non-Congressional surveying units. All of these extraneous units are here considered irregular, and were not considered pertinent to the current study. Their presence did not significantly affect the results of this study. The analysis of section irregularity was conducted at the Indiana Geological Survey with the encouragement and assistance of Dr. Robert F. Blakely.

The Congressional Land System

The Congressional Land System was enacted by the Continental Congress on May 20, 1785. Townships and sections were to be surveyed on the ground with the accompanying legal records of land ownership for most of the usable lands west of the Allegheny Mountains. Several schemes of systematic rectangular surveys were attempted in the State of Ohio. These prototype surveys were more useful than the highly irregular metes and bounds system of land survey used in Ohio and other states at that time. The present plan of townships, 6 miles to a side, subdivided into 36 sections, each one mile square, was adopted in western Ohio and southwestern Indiana by an Act of Congress on May 18, 1796 (3). Other minor instructions governing the Congressional Land Survey System were enacted by Congress on March 26, 1804.

The first lands surveyed by any system in Indiana were probably the French farmlands in the vicinity of Vincennes. The first rectangular survey in Indiana, although a non-Congressional plan, was the Illinois Grant, also called Clark's Grant, mostly in Clark County. The lands were donated by the Virginia General Assembly in 1781 to General George Rogers Clark and his regiment and surveyed by William Clark in 1795 or 1796. Other Military Donation Lands were established in Knox

County by Congress in 1891. Other lands in the vicinity were surveyed as Locations and Surveys to relocate those disposed from the Military Donations (2).

Various survey lines were established in the Northwest Territory and later Indiana between 1802 and about 1846, some into adjacent states, to establish the boundaries of a series of concessions of lands resulting from treaties with various Indians. About 20 separate treaties were made for lands now in Indiana and some irregular tracts remain as Indian Reserves.

The first Congressional Land System survey in Indiana was initiated in southwestern Ohio as a result of the Greenville Treaty of 1795. Lands were surveyed as townships east and west of a meridian extending north from the mouth of the Miami River, later established as the First Principal Meridian, and the Ohio—Indiana State Line in 1810. A somewhat triangular area was laid out in townships and sections from 1799 to 1805. Treaties at Fort Wayne in 1803, Vincennes in 1804, and Grouseland in 1805 acquired the southern fourth of the present state.

The initial point for the Second Principal Meridian and Base Line was established astronomically by Jared Mansfield in 1804, within about two miles of Latitude 38° 30' North and Longitude 86° 30' West. Ebenezer Buckingham surveyed the Base Line in 1804 and subsequently lands within the Vincennes Tract were surveyed in accordance with the Congressional System from 1804 to 1806, excepting the Military Donations, Locations, Surveys, etc. previously granted by Congress. The township and section surveys proceeded southward in 1805 to 1806, eastward in 1806, then northward to the Michigan line by about 1829-1830, generally soon after each land concession by Indians (1). A few Indian concessions were not surveyed until as late as 1840.

Township and Section Surveying Procedure

Simply stated, range lines were laid out as true north-south meridians at six mile intervals east and west of the Second Principal Meridian and township lines were established as parallels extending east-west at right angles to the range lines at six mile intervals from the base line. Section and quarter section monuments were set at half mile intervals along these lines as they were surveyed. The range lines noticeably converge poleward such that standard parallels or correction lines were established as new base lines every 24 miles or every four townships, starting anew with a full 24 mile width from each correction line.

The survey of mile square sections with quarter section markers within each township was to proceed from the southeast corner of the township. The eastern most row of sections was surveyed first, from south to north, then the next row of sections on the west, from south to north, to establish five rows of sections. The westernmost row was surveyed last. Each section was intended to contain 640 acres, but the Land Office was aware of the imperfections of surveying, as well as the faults of some surveyors, perhaps, and expected some errors in addition to those caused by convergence of the meridians. Error from south to north was to be reconciled within the northern half section of the northern tier of sections (Sections 1 through 6). Deviation from a perfect section east to west, particularly that caused by convergence, was to be within the western half of the western row of sections (Sections 6, 7, 18, 19, 30, and 31). Sections within these two rows that contain appreciably more or less than 640 acres are called fractional sections. Theoretically, sections not in these two rows should be perfect sections of 640 acres each. Such is not the case.

Anyone with even limited experience in determining exact locations using footages within the quarter, quarter, quarter parts of conventional sections quickly becomes aware of the minor imperfections within the system. The exact distribution and amount of deviation of fractional sections has until now been unavailable, although many such errors had been noted, such as slivers of some sections less than a quarter mile wide north-south (northeastern Posey County) and elongated sections more than a mile and a half long (southeastern Washington County). Initially, this study was based on the assumption that of the 36 sections in a township 25 should be essentially perfect and that 11 were fractional sections with most of the error occuring in the northern tier and western row of sections. The amount of deviation of the fractional sections was to be used as a measure of the imperfection of any so-called perfect sections, or, overall, a maximum of about 30 percent of the sections should be considered irregular, the remaining 70 percent, more or less, should be regular by definition, or at least up to federal standards.

Method of Analysis

All the section corners in Indiana were digitized from standard 7½ minute topographic maps in longitude and latitude using a Summagraphics digitizer. The digitizing equipment was accurate to 0.005 inches. The determination of section corner location could be made accurate to half the mapped road width which is about 25 feet on the maps used. Section side length was calculated as the arc length between the appropriate section corners. Where sections were bounded by a river, the river side of the section was calculated as the arc distance between the endpoints and not as the length of the river between them (FIGURE 1e).

The degree of irregularity of each section was calculated as the maximum absolute difference of any of its sides from 1.00 mile. The calculated irregularities of some sections are shown in FIGURE 1. Sections which were so irregular as to have

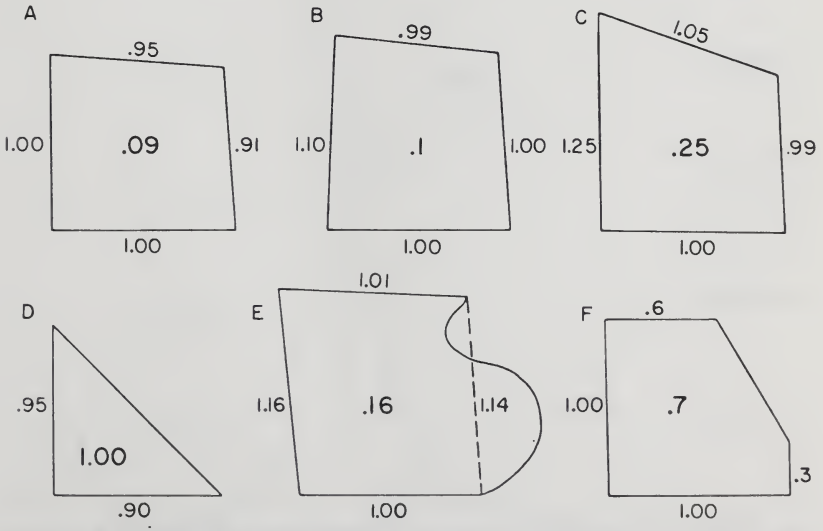

FIGURE 1. *Schematic representation of possible irregularities of sections. Sections (a), (b), and (c) are nearly square. Sections (d) and (f) have been terminated along an Indian treaty line. Section (e) has one side along a river on a state boundary.*

only three sides have an irregularity of 1.00 mile (FIGURE 1d). For this analysis, section lines are considered to cross county lines, but not to cross state lines.

The deviation of each side from true north-south or east-west was also computed. This irregularity was computed as the difference in latitude of the appropriate section corners for east-west section lines and as the difference in longitude for north-south lines. Sections which were irregular due to an angular irregularity always were irregular due to a length irregularity. So to simplify the analysis, only the irregularity in length was used to assign the degree of irregularity to each section.

Results

A histogram showing the distribution of actual section irregularity is shown in FIGURE 2. This distribution has a mean of 0.03 miles, a median of 0.04 miles, a mode

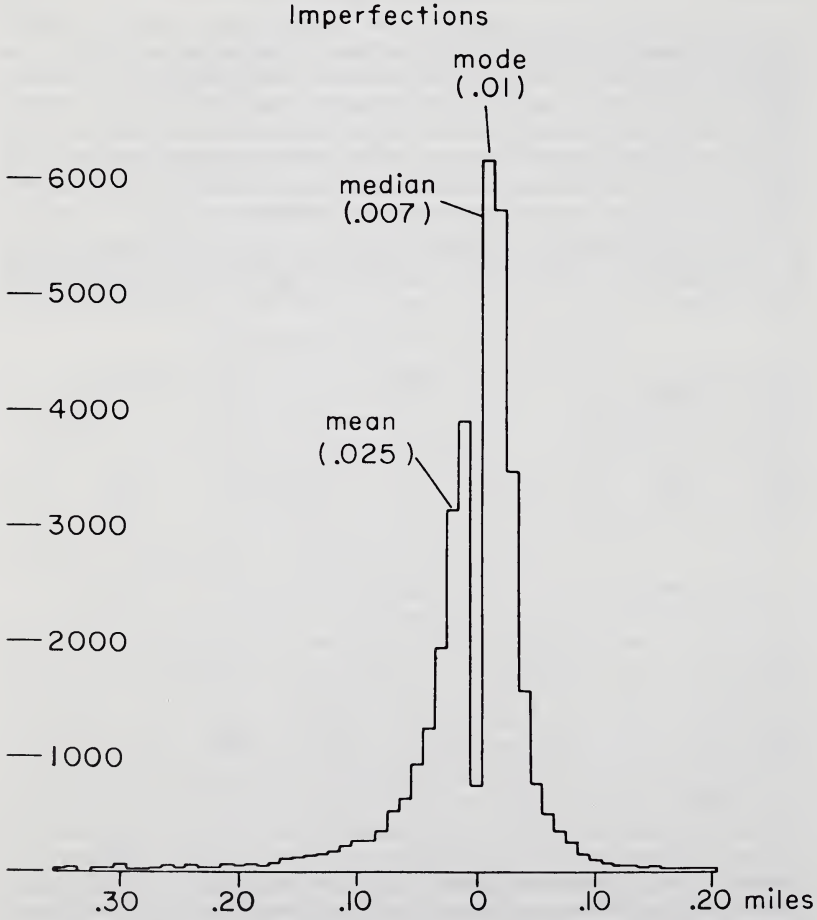

FIGURE 2. *Histogram of irregularity for 36,698 sections in Indiana. This is the maximum difference of any section side from 1.00 mile.*

of 0.01 miles, and a range of – 1.00 to 1.10 miles for a total of 36,678 sections. Because this is clearly not a normal distribution, no further statistical analysis would be meaningful nor would it be meaningful to try to establish a statistical basis for section irregularity. FIGURE 3 shows a histogram of the distribution of the section side lengths. This distribution has a mean of 0.99 miles, a median of 1.00 miles, a mode of 1.00 miles, and a range of 0.00 to 2.81 miles. Again this is not a normal distribution and no further statistical analysis would be meaningful. The sharpness of the peak of this distribution shows the accuracy of the section surveys. Sixty-two per cent of the section sides are correct to within .01 miles (53 feet). The percentage of sections accurate to this limit, 29 percent, is much lower because whole section accuracy is measured by its worst side.

A criterion for section irregularity is suggested by the method by which the surveying was done. Because all townships were surveyed from southeast to northwest, most of the surveying error is expected to accumulate in the northern and western tiers of sections within each township. A township diagram showing the percentage of imperfect vs. perfect sections is shown in FIGURE 4. Most of the imperfect sections are clearly in the northern and western tiers while most of the

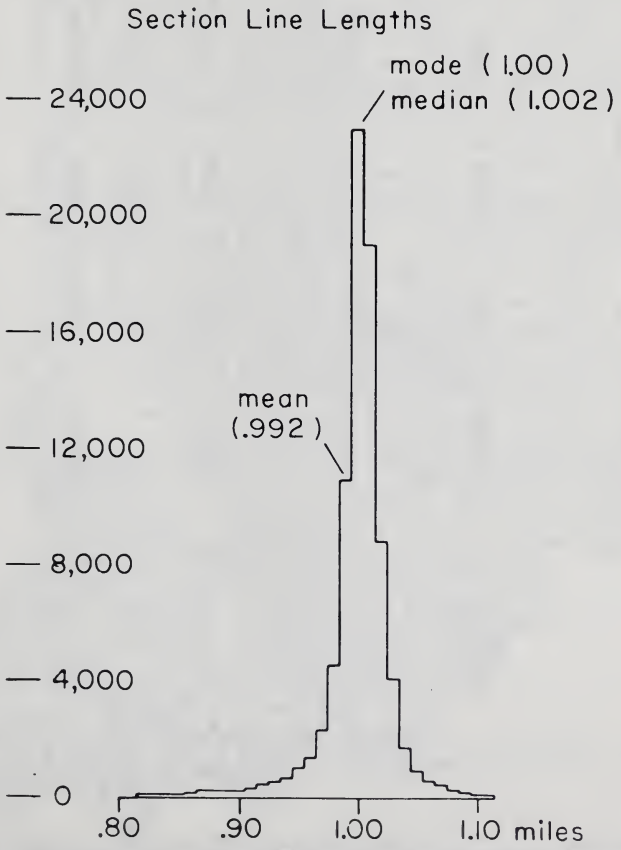

FIGURE 3. *Histogram of lengths of 85,316 section lines in Indiana. As expected the mode is 1.00 mile.*

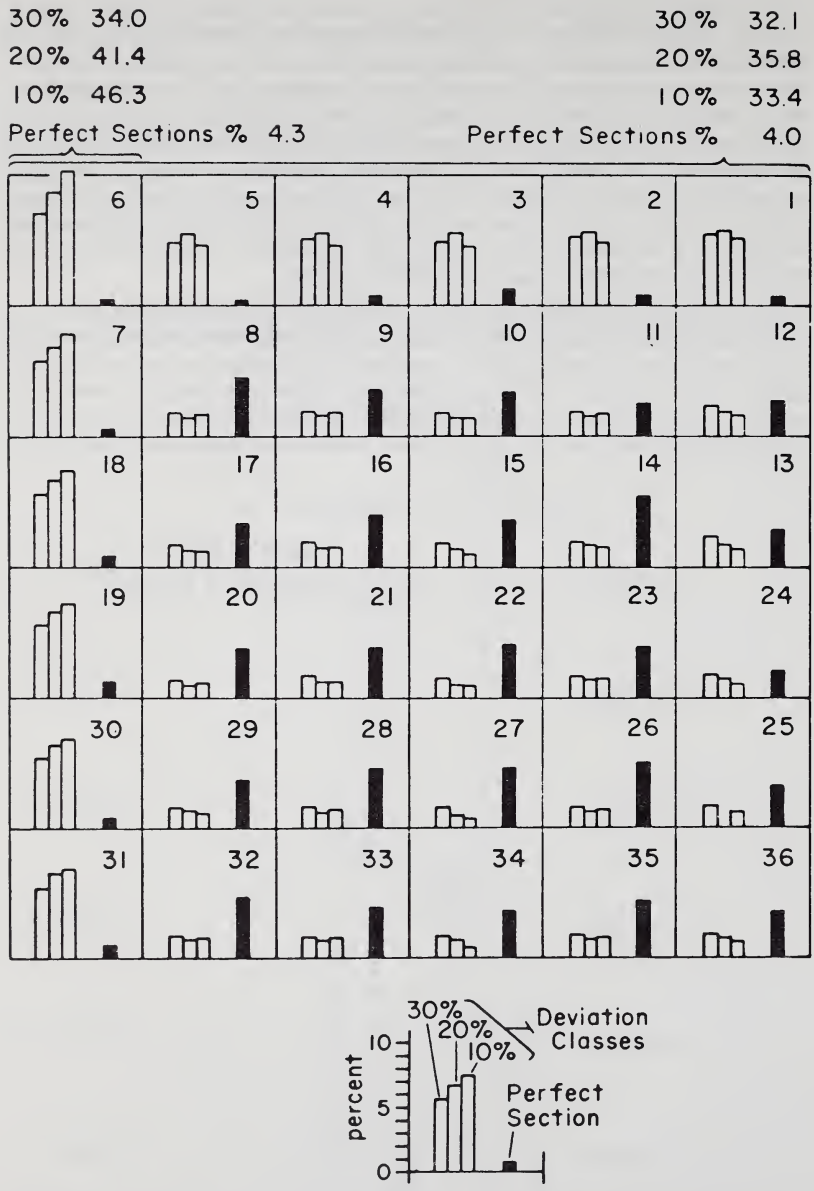

FIGURE 4. *Schematic representation of the sections in a township showing the percentages of imperfect and perfect sections by section number.*

perfect sections are not (59 percent of the imperfect sections vs. 8 percent of the perfect sections). The sections in these two tiers include 11 of the 36 sections in a township or 30.5 percent. Assuming 30 percent as the cutoff for irregularity, sec-

tions which vary from 1.00 mile by 0.03 miles (158 feet) are considered irregular. A computer generated map showing the locations of this 30 percent is shown in FIGURE 5.

FIGURE 5. *Locations of the 30 percent worst sections in Indiana. These sections have at least one side varying from 1.00 mile by ± 0.035 mile (185 feet).*

Discussion

The map in FIGURE 5 shows that irregular sections do tend to be on the north and west sides of townships, but that is not always the case. Other less obvious fac-

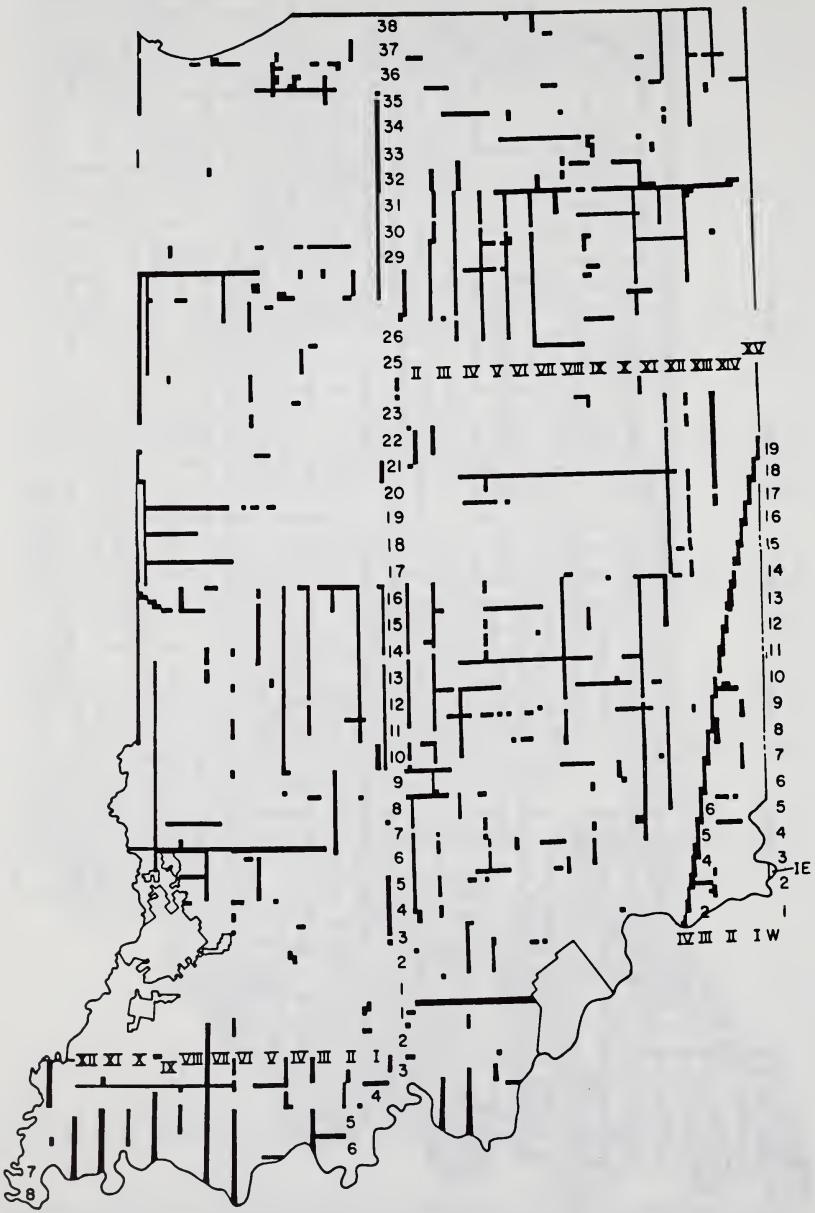

FIGURE 6. *Locations of the 10 percent worst sections in Indiana. These sections have at least one side varying from 1.00 mile by ± 0.10 mile (528 feet).*

tors such as the presence of wide rivers, rough terrain, or swamps certainly affected the accuracy of surveys. For comparison FIGURE 6 shows the worst 10 per-

FIGURE 7. *The best 2 percent of sections in Indiana. These 746 sections vary from 1.00 mile by less than the error of measurement, ± 25 feet.*

cent sections. These clearly have a much stronger tendency to be in the northern and western tiers of sections than on the 30 percent map. The map of "perfect" sections (FIGURE 7) shows no particular pattern to the locations of these best sections. This map shows all the sections with all sides equal to 1.000 ± 0.005 miles; 0.005 miles being the inherent error in the section corner location measurement. The diagram in FIGURE 4 has shown them to not be in the northern and western tiers within each township. These sections are fairly evenly distributed across the state, with a tendency to be more common in the north than the south. This is probably due to the presence of the Knox and Clark county irregular surveys and the large number of wide rivers in the south.

Any concept of perfection within the Section, Township and Range (Congressional Land) Survey System is unfounded inasmuch as there is an average of less than one perfect section per township in Indiana. This analysis for Indiana has shown that 30.7 percent of the sections have at least one side varying more than 3 percent (158 feet), 20.7 percent varying more than 5 percent (264 feet), and 9.9 percent varying more than 10 percent (528 feet or .10 mile). Fractional sections on the western row and northern tier of sections account for 69 percent of the sections that vary more than .10 mile much as planned by Congress in 1796. Much of the remaining 31 percent is accounted for by sections which terminate along the Ohio and Wabash Rivers and so cannot be whole sections. Yet some errors greater than .10 mile as well as smaller yet significant errors occur in places where gross survey error is their cause.

Several reasons for various errors of greater or lessor magnitude appear obvious. Generally, the amount and number of errors, aside from the normal occurrence of fractional sections, seem to diminish northward in Indiana as the surveys progressed with time. Assuming this to be true, the better surveys may be credited to: 1) flatter topography in a northerly direction, 2) development of better survey instruments, 3) better instructions, and 4) more quality control by the government. Some surveyors conducted relatively shoddy surveys. On the other hand, topographic features alone may account for many errors, even in northern Indiana, considering the non-traversable obstacles such as lakes, swamps, and some rivers present at the time of the surveys.

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