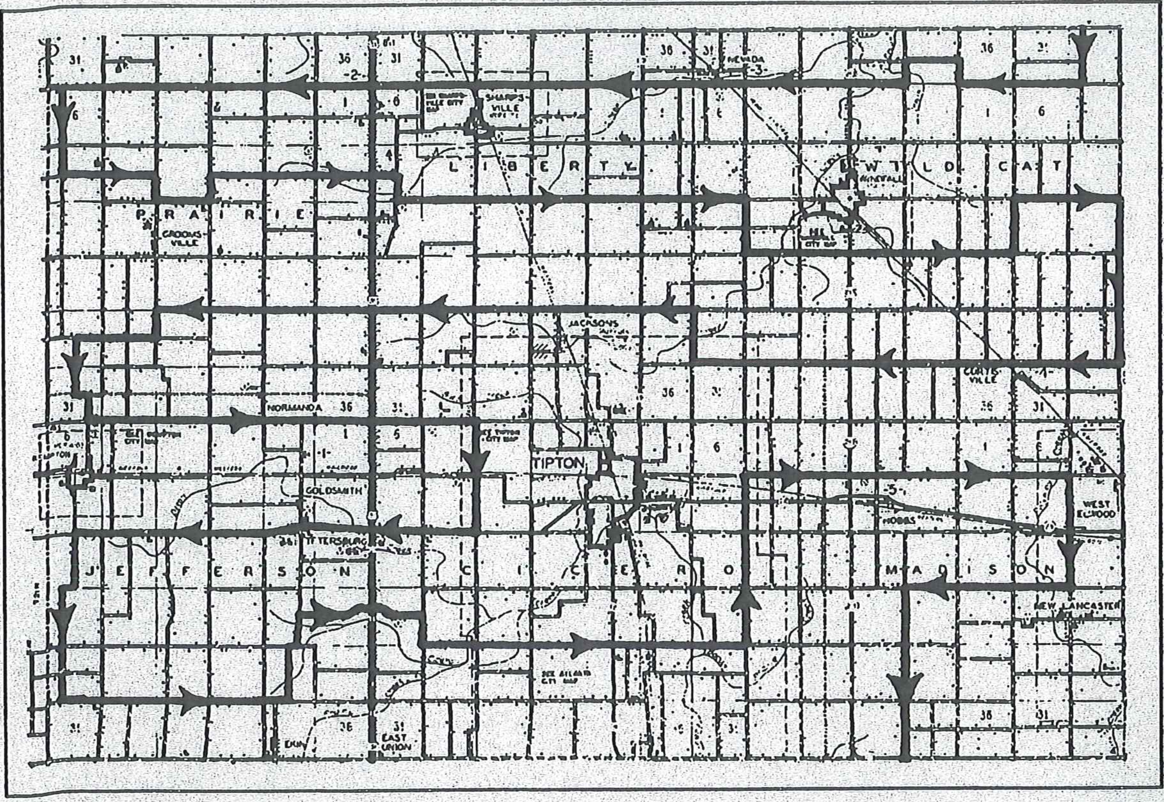
Kenneth Eck
Purdue Agronomy Dept.
6/17/14

AGRY-96-03

A Roadside Survey Method for Obtaining Reliable County- and Watershed-Level Tillage, Crop Residue, and Soil Loss Data

Procedures for Cropland Transect Surveys



Indiana's T-by-2000 Soil Conservation Education Program

Department of Agronomy

Purdue University

West Lafayette, Indiana

AGRY-96-03

A Roadside Survey Method for Obtaining Reliable County- and Watershed-Level Tillage, Crop Residue, and Soil Loss Data

Procedures for Cropland Transect Surveys

Peter R. Hill
Coordinator, Indiana's T-by-2000 Education Program
Purdue University Agronomy Department

This publication was developed as an educational resource by Indiana's T-by-2000 Soil Conservation Education Program. The Education program is funded through the Division of Soil Conservation, Indiana Department of Natural Resources.

Indiana's T-by-2000 Program is a comprehensive program aimed at significantly reducing soil erosion and resulting sedimentation throughout the state by the year 2000. In addition to the education program, T-by-2000 also offers technical assistance in both agricultural and urban areas as well as administrative assistance to all 92 of Indiana's Soil & Water Conservation Districts.

Table of Contents

About the Cover

Shown on the cover is a typical Indiana county transect route. The route is randomly drawn by someone unfamiliar with the county. A crew of 3 or 4 people then drive the route and systematically collect data approximately every one-half mile. Data categories include crop rotation, tillage system, residue cover, soil loss factors, and watershed location. After a survey is completed, the statistically reliable data can then be analyzed by the Transect computer program. In addition to Indiana, several states use the transect procedure including Illinois, Minnesota, Ohio, Pennslyvania and Wisconsin.

Introduction

Since 1989, Indiana's T-by-2000 soil conservation education program has assisted all 92 counties in conducting county road transect surveys. The surveys are designed to gather information on various agricultural practices, primarily tillage and crop residue management systems. Several counties repeat the survey annually; however, all counties are surveyed every three years.

This bulletin is intended as a guide for individuals and organizations who are interested in conducting cropland surveys. It includes the following: (1) a review of existing cropland surveys and how Indiana's survey method was developed, (2) procedures on how to conduct a county road transect survey, and (3) detailed information on survey design and data analyses.

Background

Begun in 1988, Indiana's T-by-2000 program seeks to significantly reduce soil erosion and sedimentation throughout the state by the year 2000. A major component of the program is educational assistance provided through a statewide coordinator and five regional specialists. The coordinator and specialists work primarily with the state's 92 Soil and Water Conservation Districts (SWCDs) to increase farmer adoption of conservation tillage systems, particularly on highly erodible cropland.

As T-by-2000 educational efforts progressed, it became apparent that a survey method was needed to assess their impact on producers and consequently the rate of adoption of conservation tillage systems.

Cropland surveys designed to estimate the amount of conservation tillage being used on the land are a relatively new concept. The Conservation Technology Information Center (CTIC) began surveying all states in 1982, collecting acreage information on 13 crops and five tillage systems at the county level. The data are reported by Natural Resources Conservation Service (NRCS) field office personnel in each county across the state, with assistance provided by county extension agents, agribusiness, local farm organizations, and other interested parties. They are most often "best estimates" based on personal knowledge and not actual physical surveys of cropland. This is usually necessitated by a lack of time and personnel available to conduct such surveys.

Another survey conducted on a national basis is the five-year NRCS National Resources Inventory (NRI). These data are collected on some 22 parameters, including physical characteristics of the land and the effects of agronomic practices on soil erosion. The NRI is a "point" survey method, where points correspond to random locations within a field. The first NRI in 1977 contained limited data on conservation tillage systems, as did subsequent surveys in 1982, 1987, and 1992.

Use of the NRI to estimate accurate acreage of conservation tillage or to document annual cropland trends is greatly limited by its survey interval of five years. The NRI has proven valuable, however, in development of national resource policies.

A third type of survey which has been used by the NRCS in Iowa (Iowa NRCS, 1989) and by the Ohio Department of Natural Resources (Kush and Crawford, 1987) is the county road or transect survey. Random road routes are selected so that data collected will represent all of the agricultural practices found within a county.

In Iowa, routes traverse at least six miles in every township, and tillage systems data (corresponding to CTIC survey needs) are collected on every field adjacent to the roads. Miles traveled for each survey corresponds directly to the number of townships. For example, if a county has 16 townships, then the transect route will be at least 96 miles long (16 x 6 mi.). In most cases, surveys are completed in one day with over 1,000 fields included in the data.

Ohio DNR's survey method is similar but more refined in that the survey sample size is based on statistical sampling techniques. Designed for surveying an 11-county watershed, data are collected on approximately 500 fields in each county. This number of fields yields a 90 percent accuracy level (± 5 percent) for any averages obtained from the data. Data are collected for several parameters, including present and previous crops grown, tillage systems, and residue cover. Consequently, one to two days are usually required to complete the survey. Typical county routes traverse every township and are approximately 110 miles long.

Cropland Transect Surveys

For Indiana, the Ohio road transect survey method was modified to allow more extensive surveying of cropland within a county. The purpose of the transect is three-fold: (1) to evaluate progress achieved in reaching statewide T-by-2000 goals when transects are repeated every three to five years, (2) to provide information that can be used by individual SWCDs in establishing priorities for soil conservation educational programs, and (3) to provide accurate data on tillage systems and crop residue cover that would supplement the CTIC survey.

In 1989, pilot transects were performed in 11 counties to test methodology and to make refinements in the procedures. All 92 counties were then surveyed in 1990 and again in 1993. Most transect surveys were completed in two days with assistance from personnel of NRCS, SWCDs, Indiana Department of Natural Resources, Consolidated Farm Services (CFS), and Purdue University Cooperative Extension Service. Data were summarized by the TRANSECT microcomputer program (Hess, 1990), which increased the efficiency of data processing significantly. An interval of three years was established for subsequent transect surveys.

In 1994, Illinois' NRCS and Department of Agriculture contracted with Indiana's T-by-2000 education program to conduct transect surveys statewide. They further modified the data collection form to include data categories that would allow the calculation of soil loss estimates for every field included in the survey. The Transect computer program was subsequently modified to generate soil loss estimates using the Universal Soil Loss Equation.

Survey Method

Step 1 - Establishing and Marking the Route

The first step in conducting a tillage and crop residue cover survey is to establish a driving route. The person who establishes the route should not be familiar with the county's agricultural practices, particularly areas where a high concentration of conservation tillage systems is known to exist.

Using a county highway map and a published soil survey, draw a route that passes through all soil regions that are heavily used for crop production. Avoid large urbanized areas and heavily traveled federal and state highways when possible. Orientation or direction of the route (east to west or north to south) is not significant; however, it should be at least 110 miles long. Routes for counties with more than 300,000 cropland acres should pass through townships at least twice, particularly in areas where the land is heavily used for crop production. This avoids large gaps between passes through a county even though the mileage traveled is considerably longer. Routes typically traverse east to west through a county five to eight times (see Figure 1). Traveling east and west results in less handling of the soil survey atlas sheets as compared to traveling north and south.

When the route is completed, transfer it to the soil survey map sheets (or individual atlas sheets if the soil survey is not published) using a highlight marker. Since the route will extend through several map sheets, it might be helpful to use a lettering/numbering system. For example, if a route leaves Sheet 1 and continues on Sheet 2, mark the letter "A" at the border where the route leaves and enters the sheets to ensure that the route is being followed correctly. Similarly, when it leaves Sheet 2 and enters Sheet 3, put a "B" on the borders of the sheets.

Step 2 - Establishing the Survey Date and Team

Once the route is established and marked, schedule a date for surveying the county. It should be after the majority of corn, soybeans, and other main crops have been planted (usually late May to early June for Indiana) but before the first row cultivation takes place or the crop canopy closes. Conducting the survey at this time allows for easy "windshield observations" without stopping at each field.

Since the dates for conducting the county survey will depend upon local spring planting progress, flexibility in scheduling is recommended. For example, the northern half of a county may have had more rain than the southern half; therefore, a local team may survey the southern half of the county one week and finish the northern half the following week.

Also assemble a survey team. Ideally, it should consist of: the county Extension agriculture agent, the NRCS (Natural Resources Conservation Service) district conservationist, the CFS (Consolidated Farm Services) county director, and a fourth person (perhaps SWCD employee, supervisor, cooperator, or newspaper reporter) who can assist in making observations. When conducting the

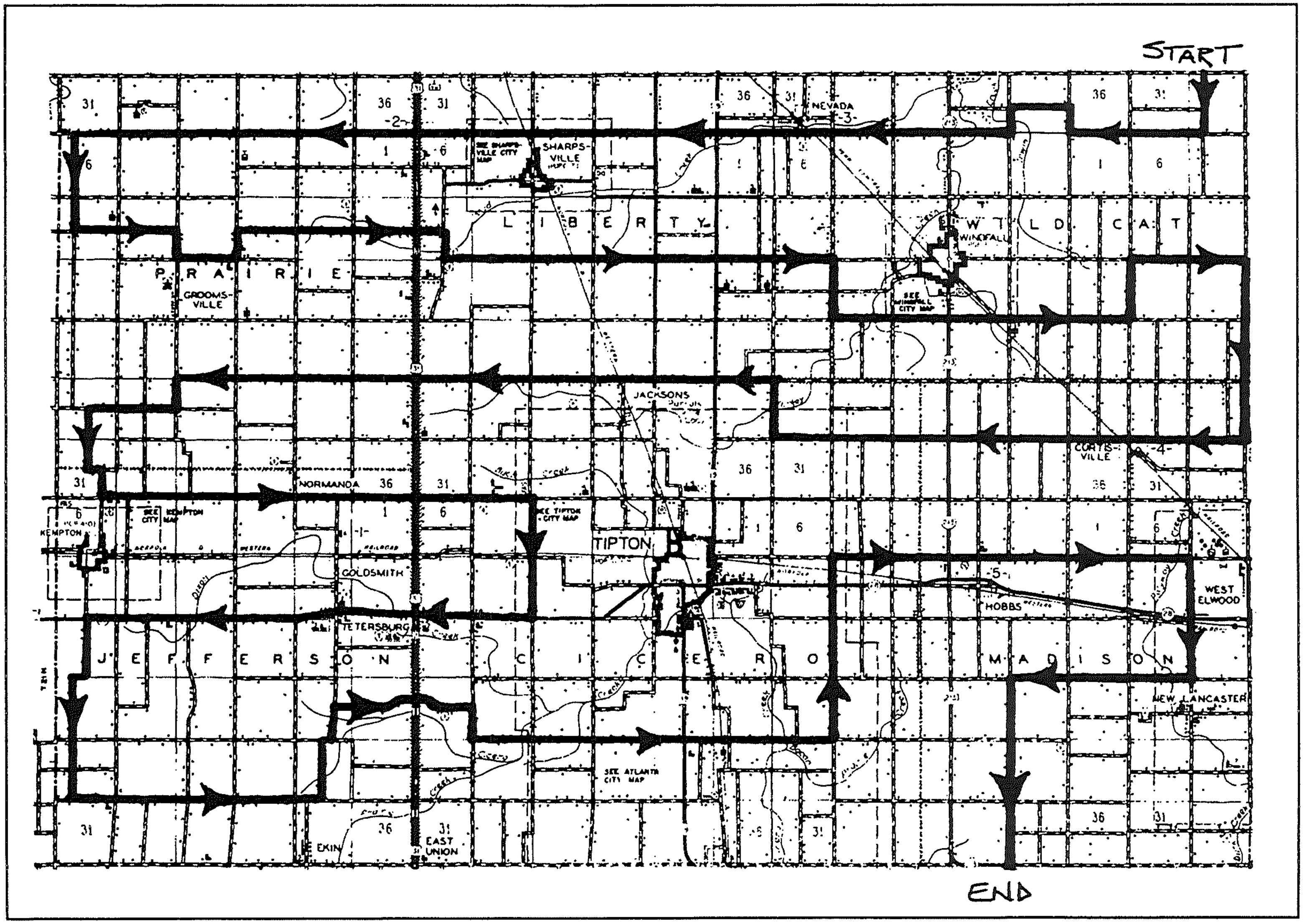


Figure 1. Sample county road transect route for Tipton County, Indiana. Note how the route bypasses towns (e.g. Tipton, Indiana located in the center of the county).

survey, one person drives, another follows the route and marks data collection points on the soil survey map sheets, the third person records data, and the fourth person makes other desired field verifications (i.e. actually walking out into the field to verify residue cover, previous crop, etc.).

By getting a variety of people involved, the ability to assemble a full team for each day of surveying is greatly increased. Even if a SWCD supervisor or volunteer can only devote a half-day collecting data, it would increase their understanding of the process while making a valuable contribution to the survey.

Step 3 - Collecting the Survey Data

In preparing to conduct the survey, plan to take both the county highway and soil survey maps. The highway map will aid navigation across the county, especially if there are detours or road changes that have occurred since publication of the soil survey. Also take at least 50 pre-printed data collection scan sheets. Data will typically be collected for the following categories: present crop, previous crop, tillage system, residue cover, soil loss factors, and watershed location.

Data will be collected at one-half mile intervals, as indicated by the vehicle odometer. To obtain a statistically reliable data set, approximately 460 cropland sites will need to be observed along the route. (For information on how the number of the data points is determined, see the Appendix.) For counties that have more than 300,000 cropland acres, a one-mile interval is recommended.

Beginning at the start of the route, travel exactly one-half mile and stop. Observe fields on both sides, and record the appropriate information on the first data sheet. The field on the left will be "1L" (one-left) and the field on the right will be "1R" (one-right). After the data are collected, mark "1L" and "1R" on the soil survey map sheet as close as possible to where the observations were taken. Repeat the procedure at half mile intervals until the route is completed.

Important:

(A) If no cropland field is encountered at the half mile interval on one side of the road, only record data for the side with cropland. Although no data are collected for the side with no cropland, note the landuse in the "comment" section of the data sheet.

(B) If no cropland field is encountered at the half mile interval on either side of the road, continue driving until cropland is observed on at least one side of the road. Record data and then proceed at half mile intervals from that point.

As the transect survey continues, the survey team should stop and check field conditions on a regular basis to insure correct estimates are being made for different crop, tillage, and residue conditions. Once the team has calibrated their visual estimates to match actual field conditions, stops can then be made less frequently. However, the team should plan to re-calibrate their visual estimates especially when entering a region of the county with different soil surface conditions due to changes in moisture, organic matter levels, stoniness, or crops grown.

Crop residue cover levels will be the most important data category to confirm with field measurements. Therefore, use the line-transect method (Eck et al., 1994 and Laflen et al., 1981) for confirming percent residue cover. Confirm visual estimates with field measurements in borderline cases. *But remember, never use end rows for field measurements*!

At the end of the route, count the number of cropland sites at which data were recorded. If less than 460, randomly extend the route and record data at half mile intervals until this number is met. *Do not count fields twice if a transect crosses over its previous route.* Be sure to mark the extended route on both the county highway map and the soil survey.

In counties that are highly urbanized, wooded, etc., collecting data on 460 cropland sites may not be feasible. In this case, collect as much data as possible.

Step 4 - Compiling and Analyzing the Data

After completion of the survey, the survey team should review the data entry sheets to correct entry mistakes, fill in missing data, etc. before having the data scanned for analysis. The data can be analyzed manually (as in Examples 1 and 2) or by using the Transect computer program, which converts scanned data to an easily compiled format (this assumes that the data sheets can be scanned with the data ouputted to a suitable file format).

Manual Analysis

The following examples illustrate how the data can be compiled manually.

Example 1: "How many acres of mulch-till soybeans (with at least 30% residue cover) are in my county?"

<u>Given:</u> 100,000 acres are estimated to be in soybeans (CFS or Ag-Census information).

<u>Transect Results:</u> 110 sites were planted to soybeans (found by adding the number of locations or stops marked for soybeans in the "present crop" section). Twenty-five of those sites were in mulch-till with greater than 30 percent residue cover.

Solution: The percentage of sites of mulch-till soybeans with greater than 30 percent residue over is 25 divided by 110 which equals 0.23 or 23 percent. This number multiplied by 100,000 acres yields 23,000 acres of mulch-till soybeans.

Example 2: "How many acres of ridge-till corn are in my county?"

Given: 50,000 acres are estimated to be in corn (CFS or Ag-Census information).

Transect Results: No sites (0) planted to ridge-till corn were recorded on the survey sheets.

Fact: The survey team members know that Farmer Brown has planted 500 acres in ridge-till corn that has greater than 30% residue cover.

Solution: Given the 10 percent error range of the transect survey when data on 460 fields are included, it is reasonable to expect survey routes to miss areas of small acreages of certain cropping systems. This is particularly true when these systems make up less than 10 percent of the total acreage. Therefore, instead of recording zero acres for ridge-till corn, use the knowledge of the survey team and add the 500 acres to your estimates of ridge-till corn. Remember, however, to reduce the total acreage figure of 50,000 by subtracting 500 (total ridge-till acres) to obtain a new base of 49,500 acres for calculating the other conservation tillage systems. This is necessary since ridge-till information was not included in the data.

Computer Analysis

Collecting the transect data on scannable forms allows for efficient proccessing and subsequent analyses of the data (as compared to anaylzing the data manually). After the forms are scanned, the data is then converted for use by the Transect computer program. The program allows for tabular summaries using any data category included on the scannable forms. For example, a report showing the percentage of the "present crops" (corn soybeans, wheat, etc.) that are planted by the different tillage systems can be generated. The program can also produce summaries by watershed and NRCS regions as well by state (when several counties conduct surveys in a given year). Tables 1 and 2 include examples of tabular summaries.

Summaries by county can also be generated for completing the annual CTIC survey data form. This summary only includes the major crops such as corn, soybeans, and wheat. Other crops are omitted since acreage is small and may not be included in the actual survey. *Remember, however, CTIC requires that no-till systems have 30% residue cover or greater — this is not a requirement when collecting data during cropland transect surveys* (see CTIC definitions in Figure 2).

Table 1. Average soil loss by crop and tillage system for Indiana (1995).

Planted Crop	Conven.	Mulch-till	No-till	Ridge-till	Average
	Tillage System [1]				
	tons per acre				
Corn	4.4	3.9	2.3	2.4	3.8
Soybeans	3.9	2.7	1.2	1.4	2.3
Small Grains	1.1	2.3	1.3	*	1.5
Forages	0.3	0.8	0.3	*	0.6
Idle/Other	0.3	0.3	0.3	*	0.3
Average	4.0	3.2	1.5	1.9	2.6

[1] Conventional tillage consists of any tillage/planting system that leaves less than 30% residue cover. Mulch-till is any system other than no-till and ridge-till that leaves more than 30% residue cover.

* Insufficient data collected.

Table 2. Percent no-till and associated soil loss for each watershed (11-digit) in the larger Eel River watershed (8-digit), 1995.

Watershed [1] (11-digit)	No-till (% of fields)	Soil Loss (tons/acre)
05120104010	52	2.2
05120104020	45	1.5
05120104030	34	1.5
05120104040	35	3.5
05120104050	19	2.0
05120104060	18	2.3
Average [2]	32	2.1

[1] Each number identifies an 11-digit watershed (hydrologic unit area) where boundaries have been identified by the Natural Resources Conservation Service. Together, these 11-digit watersheds form a larger 8-digit watershed. Consequently, summaries can also be generated for 8-digit watersheds.

[2] An interesting observation for the Eel River watershed is that percent of land farmed with no-till systems drops off significantly with each watershed (note 52% for the first watershed and 18% for the last). Orientation of the above watersheds is from the "top" of the Eel River watershed to the "bottom" of the Eel River watershed.

Conservation Technology Information Center's Definitions and Types of Systems

The following set of definitions was established by CTIC and is recognized as a standard. They are used nationwide by many USDA agencies including the Natural Resources Conservation Service.

Conservation Tillage - Any tillage or planting system that maintains at least 30% of the soil surface covered by residue after planting to reduce soil erosion by water; or where soil erosion by wind is the primary concern, maintains at least 1,000 pounds of flat, small grain residue equivalent on the surface during the critical wind erosion period.

1. No-till

The soil is left undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaner, disc openers, in-row chisels or roto-tillers. Weed control is accomplished primarily with herbicides. Cultivation may be used for emergency weed control.

2. Ridge-till

The soil is left undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges with sweeps, disc openers, coulters, row clean ers. Residue is left on the surface between ridges. Weed control is accomplished with herbi cides and/or cultivation. Ridges are rebuilt during cultivation.

3. Mulch-till

The soil is disturbed prior to planting. Tillage tools such as chisels, field cultivators, discs, sweeps or blades are used. Weed control is accomplished with herbicides and/or cultivation.

Other Tillage Types - Tillage and planting systems that may meet erosion control goals with or without other supporting conservation practices (i.e. strip cropping, contouring, etc.)

4. Reduced-till (15-30% residue cover)

Tillage types that leave 15-30% residue cover after planting or 500 to 1,000 pounds of small grain residue equivalent during the critical wind erosion period.

5. Conventional-till (less than 15% residue cover)

Tillage types that leave less than 15% residue cover after planting, or less than 500 pounds of small grain residue equivalent during the critical wind erosion period. Generally involves plowing or intensive tillage.

Figure 2. CTIC tillage definitions (1995) used for conducting their annual national survey of crop residue management practices.

References Cited

CTIC. 1994. 1994 National Crop Residue Management Survey. Conservation Technology Information Center, West Lafayette, IN.

Eck, K.J., P.R. Hill, and J.R. Wilcox. 1994. Estimating corn and soybean residue cover. Purdue University Cooperative Extension Service. Agronomy Guide AY-269. West Lafayette, IN.

Hess, P.J., D.T. Cooper, and P.R. Hill. 1990. TRANSECT: A microcomputer program for managing conservation tillage survey data. Agron. Abst. Am. Soc. Agron., Madison, Wisc. p. 71.

Iowa NRCS. 1989. Conservation tillage report. Iowa Natural Resources Conservation Service (formerly Soil Conservation Service). Iowa Bulletin No. IA190-9-10. Des Moines, IA.

Krieger, K.A. 1986. Simulated surveys of crops and tillage practices in the Honey Creek Watershed using fixed-interval and random points methods. Report for Division of Soil and Water Conservation, Ohio Department of Natural Resource, Columbus, OH.

Kush, D.M., and E.B. Crawford. 1987. Tillage and residue cover transect survey in eleven northwest Ohio counties, 1986. Report for US Environmental Protection Agency, Region V, Chicago, IL. Ohio Department of Natural Resources, Columbus, OH.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics. 2nd edition. McGraw-Hill, Inc., New York.

Tortora, R.D. 1978. A note on sample size estimation for multinomial populations. The American Statistician, Vol 32, No. 3, pp. 100-102.

APPENDIX

Survey Sample Size

The reliability of the survey to provide representative and accurate data largely depends on two factors: route layout and sample size. Layout of the route was discussed under STEP 1 of the "Survey Method" section. Determination of sample size, however, requires some understanding of how the data are distributed and collected.

The concept of a "multinomial population" is the statistical foundation of the transect survey method. A multinomial population is said to exist when an element is assigned to one and only one of two or more categories. (For example, an estimate of residue cover is an "element" and can fall into one of five categories.) The number of categories within the primary population of interest greatly determines how large a sample needs to be in order to have a high level of confidence in reaching conclusions.

For transect surveys, crop residue cover is the most important data collected. Therefore, as we determine the sample size in the following discussion, the number of categories will be six (0-15%, 15-30%, 30-50%, 50-75%,75-100% residue cover, and "/" or doesn't apply). If present crop is the primary population of interest, then the number of categories is seven (Figure 2). *Remember, the primary goal in the design of the survey method is to achieve the highest level of confidence with a reasonable sample size.*

Tortora (1978) gives the following equation to determine the sample size assuming a multinomial distribution:

$$n = X^2_{(1,\ 1-a/k)}\ q\,(1-q) / d^2$$

where:

- n = survey sample size.
- $X^2_{(1,\ 1-a/k)}$ = Chi-square value for one degree of freedom and the value (1-a/k) substituted for (1-a).
- a = *alpha* = (1-p)
- p = confidence level or degree of confidence we want in the proportions arrived at for each category.
- k = number of categories.
- q = *apriori* estimate (estimate from prior knowledge of the proportions of the category). The proportion closest to 50 percent is used. If no a priori estimate is available, use 50 percent (0.50) since this yields the largest value for n.
- d = allowable error in the proportions (e.g. plus or minus 5 percent) expressed as a decimal.

For example, if a goal of 90 percent confidence with an allowable error of five percent is desired, then $p = 0.90$, $a = (1 - p) = 0.10$, $k = 5$, $(1-a/k) = 0.98$, and $d = 0.05$. It is known from prior CTIC surveys that at least 70 percent of the fields are expected to fall in the 0-15% cover category. Of the five categories, it is determined that 70% is the closest to 50%; therefore, we select $q = 0.70$ and $(1 - q) = 0.30$. A Chi-square table (found in any statistical methods book; e.g. Steel and Torrie, 1980) lists a value of approximately 5.50 (interpolated) for $X^2_{(1,\ 0.98)}$. Solving the equation for n yields a value of 460. Consequently, a minimum of 460 fields would have to be included in the data set. If no prior knowledge had existed, then q and $(1 - q)$ would equal 0.50. These values would give the largest sample size of 550.

NOTE:

The number of cropland acres within a county and the interval between data points have no effect on sample size; thus they are not included in the equation. Whether a county has 300,000 cropland acres or 5,000, or whether the survey interval is 0.2 or 2.0 miles, statistical accuracy of the survey is always based on the type of data being collected and the desired level of accuracy. For example, Krieger (1986) found little difference in data accuracy between 0.2, 0.4 and 0.6 mile intervals. It was discussed, however, that for smaller geographic areas, shorter intervals would be needed to obtain the desired number of data points. *In counties with small cropland acreage (approximately 50,000 acres or less), choosing shorter intervals might be more efficient than driving additional miles. Similarly, in large counties with cropland acreage greater than 300,000 acres, choosing longer intervals will prevent collecting an excessive number of data points.*

Once the survey is completed, new *a priori* figures are available for determining the sample size of the next survey. Depending on these figures, more or fewer samples (fields) will be needed to achieve the same reliability. *Remember, the percentage of fields for the category that is closest to 50 percent or 0.50 is used in the equation for determining sample size.* For example, suppose a county was surveyed for the first time in 1990. With prior knowledge similar to that of the above example, a sample size of 460 was used. After conducting the survey, the following results were obtained:

Residue Cover (%) Category	Percentage of Fields
0 - 15	65
15 - 30	13
30 - 50	2
50 - 75	8
75 - 100	12
/, doesn't apply	0

Sixty-five percent of the fields fell into the 0 - 15% category. Compared to the other percentages, 65 is closest to 50 and is used in determining the sample size for the next survey. Substituting 0.65 into the equation yields n = 500. Therefore, the sample size is larger for 1991! Had the percentage of fields been equal to 80 (which is still the closest estimate to 50), the sample size would have decreased to 352.

Although the use of *a priori* estimates can refine future sample size, increasing survey accuracy can always be improved by increasing sample sizes.

For More Information

Peter Hill
Purdue University Agronomy Department
1150 Lily Hall of Life Sciences
West Lafayette, IN 47907

PHONE: (317) 494-4795
FAX: (317) 496-1368
E-MAIL: phill@dept.agry.purdue.edu