ILLINOIS AGRICULTURAL LAND PRODUCTIVITY FORMULA[1]

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Public Law 95-87 (SMCRA) requires that prime farmland be restored to equivalent or higher levels of production as unmined prime lands in the surrounding area. The productivity formula was developed to evaluate the restoration of prime farmland on reclaimed coal mining area. Field evaluations were performed from 1980-1984. This evaluation established a close correlation between formula target yields and yields on in situ prime soil types.

INTRODUCTION

Illinois coal falls within the sequence of rocks commonly called the Pennsylvanian System which was developed 280 to 315 million years ago. These coal bearing rocks underlie 65% of the 56,400 square miles of Illinois and contain a coal resource of approximately 181 billion tons (Treworgy and Bargh, 1982). These figures made by the Illinois State Geological Survey are an estimate of total coal in the ground, much of which is not recoverable under present economics or present engineering technology.

Legislative History

On August 3, 1977, President Carter signed into law the "Surface Mining Control and Reclamation Act", Public Law 95-87. This Federal Act required most states to pass legislation that would comply with the federal statutes in order to receive primacy for enforcement of the federal law.

In 1979, Illinois, passed Public Act 81-1015 which enabled Illinois to develop, submit for approval, and receive conditional approval of the Permanent Program on June 1, 1982. With that approval, Illinois received primacy under the Federal Act for regulation of the coal mining industry.

[1]Paper presented at the American Society for Surface Mining and Reclamation, Denver, Colorado, October 8-10, 1985.

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Literature Review

The Federal Act in Sections 510(d)(1), 515(b)(19), and 519(c)(2) and the Federal Rules and Regulations (Federal Register 1979) concerned with reclamation of mined prime farmland indicate that success in revegetation shall be determined on the basis of crop production from mined areas compared to that of approved reference areas or other technical guidance procedures. State Rules and Regulations in Section 1785.17(b)(8), 1816.116(a)(3)(iii), 1817.116(a)(3)(iii), and 1823.15(2)(iii) (Illinois Register 1982) requiring proof of soil productivity has led to the initiation of considerable research to determine and evaluate methods of reclaiming mined prime farmland.

Hoffman, Ries, and Lorenz (1981) studied both vegetative production and animal performance on mined land and obtained results similar to those from undisturbed soil. However, Nielsen, and Miller (1980) reported that corn yields on mined soil were 4 to 90 percent less than adjacent native soils, depending upon topsoil applications and age. Grandt (1978) found that corn yields decreased over a 3 year period when corn was grown on a graded spoil, but yields were relatively constant where topsoil had been replaced. Most of the published research has been concerned with methodology of reclaimed mined soils for crop productivity and some results are often reflected in rules and regulations concerned with mined land reclamation.

A major difficulty in predicting crop yields at either a reclaimed or unmined site is the variability in weather and its effects on crop yields. Considerable research has been conducted evaluating relationships between crop yield and weather variables (Runge and Odell, 1958; Runge, 1968; and Thompson, 1975), and crop yields, weather variables, and soil parameters (Robbins and Domingo, 1953; Leeper, Runge, and Walker, 1974; and Nelson and McCracken, 1962). However, applications of specific parameters in this research to individual sites for purposes of calculating a yield standard would not be appropriate since agronomic management factors are likely to be

Proceedings America Society of Mining and Reclamation, 1985 pp 24-
DOI: 10.21000/JASMR85010024

https://doi.org/10.21000/JASMR85010024

different from those used in the cited studies. For example, recommended crop varieties, plant populations, herbicides and fertilizer rates change over time and these factors would affect crop yield based on current management practices. Variable weather conditions affect crop productivity as well as affecting parameters used to predict crop yield. Thus, yield equations developed from research data would have limited value in predicting individual site yields.

The Federal Act (PL 95-87) requires that prime farmland must be reclaimed to equivalent or higher yield levels compare to non-mined prime farmland in the surrounding area (Jansen, 1981). Researchers indicate that reconstruction of mine soils is site specific (Schuman and Power, 1981) and, thus, productivity comparisons might be expected to be site specific. This would minimize difference in yields that might be attributed to factors other than those studies.

The research methodology for evaluation of the productivity of reconstructed soil is such that comparisons are made with unmined adjacent soil at specific sites. Federal and State rules and regulations suggest similar methodology or other technical guidance procedures. The methodology proposed in the Agricultural Land Productivity Formula (ALPF) developed by the Illinois Department of Agriculture (IDOA) would be categorized as "other technical guidance procedures," as the number of sites to be evaluated and the limited resources available for site evaluation make it prohibitive to use the research approach. Therefore, the purpose of the ALPF is to provide a calculated standard yield to be used as a comparison to determine if productivity has been restored to mined land.

The ALPF has advantages as a method for determining a yield standard. Calculating a yield standard is much less expensive than managing a comparable research plot on undisturbed soil and it does provide for seasonal adjustment in the yield standard based on the use of the USDA Crop Reporting Service county estimated average yield per acre. It also utilizes computation of estimated soil productivity at a high level of management (Fehrenbacher et al., 1978) as well as the "average" management of crops reflected by the county yield that is reported.

The calculated yield standard produced by the ALPF is not site specific, the importance of which was emphasized by Schuman and Power (1981). Variations in weather during the growing season such as drought, rain, or hail storms can be site specific and quite detrimental to site yield even though the county average is not greatly affected. It appears that some adjustment in yield may be necessary when "abnormal" weather occurs at specific sites within a county.

Little or no research has been published that provided suitable methodology or parameters for predicting yield from constructed soil or even unmined soil at a specific site at some future point in time. As has been suggested previously, agronomic management factors change over time and published research showing yield prediction equations are generally not suitable beyond the conditions specific in the research.

Computations in the ALPF integrate both county weather and management practices during a given year as well as the use of expected high level management yields (Fehrenbacher et al., 1978) by soil type to reflect recognized productivity differences in soils. Thus, it might be concluded that the yield standard calculated by the Department of Agriculture's productivity formula is more current relative to weather and county management practices than some alternative choices (i.e., published yield equations, published farm yields, etc.)

The problem of major weather disasters at a given site relative to a standard yield will need some adjustment. For example, corn is relatively sensitive to moisture stress at flowering (Denmead and Shaw, 1963; Robbins and Domingo, 1953) and differences in moisture stress at flowering may result in relatively large differences in yield at harvest. It is entirely possible that one part of a county can be severely deficient in moisture while the remainder of the county has a relatively normal growing season. Provisions have been made to make adjustments for "largely abnormal" growing conditions at a test site where yields are to be compared against a county-wide standard. An abnormal growing condition might include drought, flood, hail, etc. Crop adjusters certified to perform adjustments by the Federal Crop Insurance Corporation will be utilized on a site specific basis to evaluate reported crop losses.

AGRICULTURAL LAND PRODUCTIVITY FORMULA METHODOLOGY

Initial development of the ALPF began in June 1979, after the publication of the Federal Permanent Regulatory Program Rules and Regulations (30 CFR 700 etc.) The Rules and Regulations requires that cropland productivity on post-mined cropland must be proven in order to obtain bond release. Because previous discussions and considerations indicated that operating reference crop productivity areas would be both very costly and time consuming, it was decided that an alternative methodology should be devised to replace the "reference area concept" of proving productivity.

A number of alternate methodologies were studied by the IDOA during the development phase of the ALPF. A brief discussion of the alternative methodologies reviewed is given below.

One methodology reviewed was the use of county average yields as established by the United States Department of Agriculture (USDA), Agricultural Stabilization and Conservation Service (ASCS). IDOA rejected the use of these county yields as they are established by the USDA with regard to the various "farm programs" currently being administered. We also found that these yields are assigned to each farm by the county ASCS committee based upon an established yield by the state ASCS committee for that county.

During further review of the ASCS county yields we noted that established yields could only be changed when the land owner or operator appealed those yields and provided adequate proof of productivity for the last five years. With little or no incentive provided by Federal "farm programs" for Illinois farmers to certify crop yields annually, the reliability of site specific yield figures would be unacceptable. Our review indicated that many of these farm yields had not been appealed or significantly changed for a number of years. In addition, the divergent soil types which occur in many counties would further reduce reliability of these yields for site specific evaluation. Therefore, the rejection of using these yields was further justified.

A second method studied used the Illinois Cooperative Crop Reporting Service county average yield as a "target yield". Again we rejected this yield as not being site specific for mined soils, areas, or management. However, we were impressed with the possible use of this data because the Crop Reporting Service yield is done independently of the ASCS yield and is established each year for every county. In addition a number of crops are reported using "objective surveys"[3] as data for those yields.

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[3] Illinois Cooperative Crop Reporting Service uses Objective Yield Surveys to forecast and establish yields of major crops. Fields to be sampled are selected from a June Enumerative Survey each year and are drawn so the probability of any field being chosen is proportional to the size of the field. Estimates using objective yield procedures are based on actual counts and measurements made in the same fields by trained enumerators. Two components of yield--weight of the fruit and number of the fruit (pods, ears, etc.) are forecasted separately and then combined to give a biological yield. Reports of these yields are then published by the USDA.

Another methodology studied and rejected was the use of assigning the soil productivity index as established in Circular 1156 (Fehrenbacher, 1978) to unmined soils and then reevaluating those same soils and soil mixes after mining "through a new soil survey" to see if the reclaimed soil had the same or better soil index. Since soil productivity ratings are just beginning to be developed for reclaimed soils, IDOA felt this approach would not be feasible at this time.

To further justify the development of the ALPF, IDOA studied the "reference area concept" which is allowed under the rules and regulations. As contemplated the reference area would pose a number of problems which have to be addressed by the Regulatory Authority before it would meet the standards for proof of productivity. A few of the problems the Illinois Department of Agriculture envisioned are listed below:

a) Where will the reference area be located? Is it readily accessible?

b) What are the present and past farming practices of the reference area?

c) Are the soil types of the reference area the same or similar to the pre-mined soils of the mined area?

d) Has livestock been raised on the reference area?

e) Who will farm the reference area? A neighboring farmer? A union or nonunion company employee? A custom farmer?

f) Who will supervise the day to day operations of the reference area? What are his or her qualifications?

g) Is the reference area fenced to prevent vandalism?

h) How many replications will be needed for adequate demonstrations of yield?

i) How much manpower will be needed to monitor and collect data from the reference area?

j) How will the collected data be evaluated for proof of productivity?

The various problems with the reference areas and the other methodologies spurred IDOA to develop the ALPF. It eliminates many of the problems associated with the reference areas and allows for various local factors to adjust the yield requirement for successful reclamation.

Table A. Percentage adjustments in yields under high management for common slope groups and various erosion conditions.

Favorable Subsoil			
Slope Group	(1) Uneroded	(2) Moderate Erosion	(3) Severe Erosion
		%	
A (0 - 2%)	100	97	90
B (2 - 5%)	99	96	89
C (5 - 10%)	98	95	88
D (10 - 15%)	95	92	85
E (15 - 20%)	90	87	80
F (20 - 25%)	80	77	70
G (25% +)	71	68	61

Unfavorable Subsoil			
Slope Group	(1) Uneroded	(2) Moderate Erosion	(3) Severe Erosion
		%	
A (0 - 2%)	100	95	80
B (2 - 5%)	99	94	79
C (5 - 10%)	97	92	77
D (10 - 15%)	93	89	73
E (15 - 20%)	88	83	68
F (20 - 25%)	78	73	58
G (25% +)	69	64	49

Table B. Soil variance codes.

Variance Code	Meaning
1	Soil Wet (Reduce yield by 30%)
2	Urbanized Soil (Reduce yield to zero)
3	Flooded Soil (Reduce Yield by 50%)
4	Ponded Soil (Yield Reduction Varies by County)
5	Sink Hole (Yield Reduction Varies by County)
6	Soil Variant (Yield Reduction Varies by County)
7	Mine Dump (Reduce yield to zero)
8	Quarry (Reduce yield to zero)
9	Sewage Lagoon (Reduce yield to zero)
10	Water (Reduce yield to zero)
11	Borrow Pit (Reduce yield to zero)
12	Strip Mine (Reduce yield to zero)
13	Sand Quarry/Pits (Reduce yield to zero)
14	Gravel Pit (Reduce yield to zero)
15	Made Land (Reduce yield to zero)
16	Miscellaneous non-cropped (Reduce yield to zero)

AGRICULTURAL LAND PRODUCTIVITY FORMULA CALCULATIONS

Soil Master File

The first step in development of the ALPF was to compile a comprehensive list of the soil mapping units currently recorded in Illinois. The main part of the Soil Master File (SMF) was taken from Table 2 of the University of Illinois, College of Agriculture, Cooperative Extension Service Circular 1156 entitled "Soil Productivity in Illinois."

Circular 1156 provided over 400 soils for the SMF along with their soil mapping unit number, common name, and the high level of management yields for corn, soybeans, wheat, oats, and mixed hay. Table 1 of the Circular also provided a percentage reduction for crop yields based upon slope and erosion, and whether the soil contained a favorable or unfavorable subsoil.

From Circular 1156 each soil mapping unit number was expanded to indicate whether the soil had a favorable or unfavorable subsoil, whether it was found only in certain counties and at what slope and erosion levels. This expanded number also indicated if a soil had a yield which varied from the listed high management yield due to special circumstances unique to a county.

Example 1. County cropped acreage file.

Soil Mapping Unit	Soil Name	Total* Acres	SWCD % Cropped	Total Cropped Acres
2A1	Cisne Silt Loam	6,542	100.0	6,542
3B2	Hoyleton Silt Loam	4,891	90.0	4,401
122B1	Colp Silt Loam	127	10.0	12
214D3	Hosmer Silt Loam	2,222	75.0	1,666
533A1	Urbanized Land	400	0.0	---
567C1	Elkhart Silt Loam	2,685	85.0	2,282

* Detailed Soil Survey or Bulletin 735 in absence of detailed Soil Survey.

county. This information is calculated in two steps which are explained below.

The first step is to establish the total acreage of each known soil mapping unit for a county. This information is taken from a detailed soil survey[4] or from the University of Illinois College of Agriculture, Agricultural Experimental Station Bulletin 735 entitled "Soil Types Acreages for Illinois" for each county. The use of the detailed soil survey is the preferred choice for this data; however, only 49 of the counties have a modern soil survey, therefore, the need to use Bulletin 735 in some counties.

Bulletin 735 lists the soils and acreages of each mapping unit based upon the National Conservation Needs Inventory conducted in the nineteen-sixties by the USDA, Soil Conservation Service (SCS) in cooperation with the University of Illinois. This inventory represents an approximate 2% sample of the total acreage within the county. The accuracy of the estimated acreage of each soil mapping unit increased as the percentage and acreages of the soil mapping unit increased. Acreages of the major soils are reliably estimated. However, some of the minor and less extensive soils are less accurately estimated (Runge et al., 1969). As soils lists and mapping unit acreages from Bulletin 735 are updated by SCS, the updated information will be accepted for incorporation into the formula.

After a listing of the soils is obtained, all soils are checked to see if they are on the Soil Master File (SMF) discussed previously. If the given soils are found on the SMF then no additional action is needed. If a county soil is not found on the SMF, then the questioned soil must be investigated and the necessary information on yield, slope, erosion, name, etc. must be obtained and entered into the SMF. This information is obtained from the University of Illinois soil scientists.

Step two of determining the County Cropped Acreage File requires IDOA to obtain from the county Soil and Water Conservation District (SWCD) an estimate of the percentage (%) of acres cropped for each of the listed soil mapping units obtained in step 1 above. This adjustment to the total number of acres of a soil allow for local input and estimate of the actual acres of soils that are farmed or cropped in a county.

IDOA chose to have the local SWCD Board make this adjustment because they: 1) are of local origin and should have knowledge of their soils and farming practices, 2) cooperate with the USDA, SCS and have a District Conservationist available for advice, 3) are elected by their peers and should be representative of the agriculture sector; and 4) are a recognized local government authority established by Illinois Statute. Adjustments made to the percentage of acres cropped for each of the listed soil mapping units will be certified by the District Board and maintained on file at the district office for public viewing. A copy of each such certified adjustment will be forwarded annually by August 15 to the Illinois Department of Agriculture, Division of Natural Resources for incorporation in the Agricultural Land Productivity Formula.

After obtaining the percentage (%) of each soil mapping unit cropped from the county SWCD this percentage is computer programmed along with the list of the soil mapping units and a total cropped acreage figure is given for each soil mapping unit (see Example 1 for details).

The figures used in the example demonstrate how the computer program will write and store the information. The "Total Cropped Acres" figures are carried forward to the next calculation in the ALPF.

[4] A "detailed soil survey" is defined as a soil survey according to the standards of the National Cooperative Soil Survey and in accordance with the procedures set forth in the U.S. Department of Agriculture Handbook 435 (Soil Taxonomy, 1975) and 18 (Soil Survey Manual, 1951).

Table C. Assigned county numbers for the Agricultural Land Productivity Formula.

County Number	County	County Number	County	County Number	County
1	Adams	69	Hardin	137	Morgan
3	Alexander	71	Henderson	139	Moultrie
5	Bond	73	Henry	141	Ogle
7	Boone	75	Iroquois	143	Peoria
9	Brown	77	Jackson	145	Perry
11	Bureau	79	Jasper	147	Piatt
13	Calhoun	81	Jefferson	149	Pike
15	Carroll	83	Jersey	151	Pope
17	Cass	85	Jo Daviess	153	Pulaski
19	Champaign	87	Johnson	155	Putnam
21	Christian	89	Kane	157	Randolph
23	Clark	91	Kankakee	159	Richland
25	Clay	93	Kendall	161	Rock Island
27	Clinton	95	Knox	163	St. Clair
29	Coles	97	Lake	165	Saline
31	Cook	99	LaSalle	167	Sangamon
33	Crawford	101	Lawrence	169	Schuyler
35	Cumberland	103	Lee	171	Scott
37	DeKalb	105	Livingston	173	Shelby
39	DeWitt	107	Logan	175	Stark
41	Douglas	109	McDonough	177	Stephenson
43	DuPage	111	McHenry	179	Tazewell
45	Edgar	113	McLean	181	Union
47	Edwards	115	Macon	183	Vermilion
49	Effingham	117	Macoupin	185	Wabash
51	Fayette	119	Madison	187	Warren
53	Ford	121	Marion	189	Washington
55	Franklin	123	Marshall	191	Wayne
57	Fulton	125	Mason	193	White
59	Gallatin	127	Massac	195	Whiteside
61	Greene	129	Menard	197	Will
63	Grundy	131	Mercer	199	Williamson
65	Hamilton	133	Monroe	201	Winnebago
67	Hancock	135	Montgomery	203	Woodford

In creating the SMF the high management yields for each soil was adjusted according to its subsoil, slope and erosion. Table A indicates the percentage adjustments made to the high management yield.

It was also determined that "variance codes" would be needed to disclose when a soil, under a high level of management, was not performing in some areas as listed in Circular 1156. These variance codes indicate a "special soil" that needs to be treated differently in the SMF. Table B outlines the variance codes and what they mean.

Two other unique situations also were discovered and solved in developing the SMF. One problem was that some particular soils at a given slope and/or erosion level become either a new soil, a complex soil or went from favorable to unfavorable subsoil. To solve this problem a "switch code" was added to each soil where needed. The switch code merely tells the computer at which point it should look for a new yield based upon the switch in characteristics of the soil.

The other situation occurs where soils are unique to a county, or the soil name is the same as another soil in another county but with different soil properties and yields. To eliminate any confusions between these situations it was necessary to identify these soils with a county number. The number assigned to each county is listed in Table C for any soil that fits this situation.

All of this information results in a Soil Master File containing the estimated high management yield for each soil. Because of the method of assigning code numbers that so completely describe a soil, it is easy to add new soils to this master file. For each new soil that was not included in the Circular 1156 list, an estimated high management crop yield will be obtained by IDOA from the University of Illinois soil scientists.

County Cropped Acreage File

The Agricultural Land Productivity Formula requires that the number of cropped acres by soil mapping unit be calculated for each

Table D. County crop yields by soil mapping unit.

Column A Soil Mapping Unit	Column B County Cropped Acreage	Column C % County in Soil Mapping Unit	Column D* Grain Acres by Soil Mapping Unit	Column E Adjusted High Mgt. Yield	Column F High Mgt. Production	Column G County Yield by Soil Mapping Unit
2A1	6,542	38.78				
3B2	4,891	28.99				
122B1	127	.01				
214D3	2,222	13.17				
533A1	400	.02				
567C1	2,685	19.00				
	16,867	100.00	Total		Total	

* County Acres in Corn ______
Soybeans ______
Wheat ______
Oats ______
Mixed Hay ______
Total Acres ______

County Average Yield File

The next step in developing the ALPF is to equate the USDA, Illinois Cooperative Crop Reporting Service annual yield data to the soils derived in the "County Cropped Acreage File". To derive this estimated crop yield for each soil mapping unit, Table D and the following paragraphs summarize the procedure.

Column A is the information received from the County Cropped Acreage File for each soil mapping unit. Also included in this section, but not shown, would be the variance number, switch code, subsoil condition, and common name.

Column B is the number of acres cropped in a county as determined by the County Cropped Acreage File. These figures are then added together to give a total for Column B.

Column C is the % of the acreage represented by each soil type when compared with the total in Column B (Column B = Total acres in soil mapping unit x % of acres cropped in county by mapping unit).

Column D is calculated by multiplying the % of each soil mapping unit in the county (Column C) by the total acres in the county harvested for corn, soybeans, wheat, oats, and mixed hay (see asterisk, Table D). These county harvested acreages are derived from the USDA, Illinois Cooperative Crop Reporting Service data for the year in which the yield standard is being calculated. The purpose of this calculation is to estimate the number of acres harvested from each of the particular soil mapping units. It is not recommended that only "corn acres," "soybean acres," "wheat acres," "oat acres," or "mixed hay acres," be used because it is difficult to assume that if a soil mapping unit represents 25% of the land in the county - that 25% of the crop being determined was planted on that soil mapping unit. It is assumed that 25% of the total corn, soybean, wheat, oat, and mixed hay acreage was planted on that particular soil mapping unit. Therefore, the "grain acres" are distributed on the soil mapping units based upon the percent of acres in each soil mapping unit.

Column E is the yield information for each crop which comes from the Soil Master File.

Column F is a derived high management production (Table D) obtained by multiplying Column D times Column E. This production will normally exceed actual production because the high management yield is used. The purpose of using the high management production is to derive a weighted average high management yield; which is, the total high management production (Column F) divided by the total grain acres in the county (Column D). The weighted high management yield figure will be used to derive a "factor" as described below:

$$\text{Factor} = \frac{\text{Official County Crop Yield}}{\text{Weighted High Management Yield}}$$ [5]

[5] Official County Crop Yield is determined by the USDA, Illinois Cooperative Crop Reporting Service for each crop, county and year. This is published annually and made available to the public.

Example 2. Perry County corn, 1983.

SOIL SERIES AND TYPE		PROJECTED YIELD	ACRES IN MAPPING UNIT	% OF UNIT	WEIGHTED FINAL YIELD
Cisne	2A	52	108	31.30	16.28
Bonnie	108A	51	63	18.26	9.31
Belknap	382A	56	59	17.10	9.58
Hosmer	214B	48	64	18.55	8.90
Stoy	164B	50	12	3.48	1.74
Ava	14B	44	22	6.38	2.81
Bluford	13B2	45	17	4.93	2.22
		Total Prime Acres	345	Total 100.00	Total Yield 50.84 bu/ac

In Example 2, 51 bu/acre corn is the projected yield requirement for the permit area for a specific crop.

Column G results when the above factor is multiplied by the high level management yield of each soil mapping unit (Column E). The result is a yield which represents the actual average yield in the county for that year and crop.

After completing calculations for the projected yield of the test year in question, a yield standard for each permit area must be calculated. These calculations will be performed in the following manner, and are also applicable to high capability land standards.

The acres for the individual prime farmland soil mapping units will be divided by the total prime farmland acres to obtain a **weighted proportion** for each soil type. The percentage of each prime farmland soil mapping unit in the permit area, relative to the total prime farmland acres will be multiplied times the projected yield for the pre-mining soil types. This **weighted yield** figure will be summed for all soil types to arrive at a final yield for the permit area (see Example 2).

AGRICULTURAL LAND PRODUCTIVITY FORMULA SAMPLING METHOD

The next step in implementing the Agricultural Land Productivity Formula is to describe a sampling methodology that will allow the Illinois Department of Agriculture or the Illinois Department of Mines and Minerals (IDMM) to adequately gather the data needed to determine if productivity has been returned to reclaimed mine land. The following paragraphs summarize this methodology for corn, soybeans, wheat, oats, sorghum, and mixed hay.

This sampling methodology requires an operator to submit by February 15, of each year, a scale drawing or aerial photo delineating specific field boundaries and type of crop to be sampled for proof of productivity for the current crop year. Each scale drawing and photo submitted shall include a field numbering scheme and the total acreage for each field on which sampling is being requested. In addition, the scaled drawing shall be no less than 1 inch equals 500 feet (1:500) or greater than 1 inch equals 100 feet (1:100). The February 15 annual submittal may be amended by the operator until July 15. Each amendment shall contain a written explanation of changes from the original submittal and an aerial photgraph or scaled drawing reflecting the corrected sampling submittal.

The determination of sample points within a specific field will be made on the basis of a grid overlay scheme with sample points generated at random by computer. An intentional bias of fifty ft (50') will be introduced to all field boundaries to remove the potential that sampling points may fall in turn around areas or areas where contiguous soil reconstruction may cause field boundaries to not be indicative of whole field productivity. In the event that field conditions make the location of computer generated random sampling points impractical, an alternate method will be utilized. A random numbers table will be provided to field enumerators to allow for the establishment of sample point locations under field conditions.

The minimum acceptable number of samples to be taken relative to field size is shown in Table E, with fields of four acres or less to

Table E. Sample points per crop acre.

CORN

Size of Bond Release Field	Minimum Number Of Samples
40 acres or less	8
40 - 279 acres	12
280 - 639 acres	16
640 acres or more	28

SOYBEANS

Size of Bond Release Field	Minimum Number Of Samples
40 acres or less	10
40 - 279 acres	12
280 - 639 acres	16
640 acres or more	26

WHEAT - OATS

Size of Bond Release Field	Minimum Number Of Samples
40 acres or less	6
40 - 279 acres	8
280 - 639 acres	10
640 acres or more	14

SORGHUM

Size of Bond Release Field	Minimum Number Of Samples
40 acres or less	10
40 - 279 acres	16
280 - 639 acres	28
640 acres or more	40

MIXED HAY

Size of Bond Release Field	Minimum Number Of Samples
40 acres or less	5
40 - 279 acres	10
280 - 639 acres	20
640 acres or more requires one (1) sample for each additional 35 acres	

The preceeding information regarding the minimum number of samples to be taken relative to field size for mixed hay has been derived from U.S. Department of Agriculture, Federal Crop Insurance Corporation, Forage Production Handbook.

be sampled in their entirety, and with yields determined by harvest weight. Table E is based upon information received from the USDA, Illinois Cooperative Crop Reporting Service's statistical surveys and research.

The Illinois Department of Agriculture may elect to increase the minimum number of acceptable sample points per field acres. This increase will occur only after a statistical analysis of sample variability indicates the need for additional sample points. At the option of the Department, the operator may be required to harvest specific fields in their entirety to verify yields obtained by random point sampling. In each such case, the certified harvest yield adjusted to optimum moisture content will become the comparison yield for the ALPF target yield.

A sampling technique for sorghum is included as a reference; although at the time of printing, sorghum is not intended to be used in the ALPF as an alternative crop. Circular 1156 does not address yield information for any soil series in sorghum production. If an operator requests to prove productivity by growing sorghum it will be necessary to implement a reference area concept. Sample selections will take place using the following guidelines.

Corn Sampling Technique

Step 1 - Mark the starting corner of the field to be sampled with a large stake and attach a ribbon or flag to it.

Step 2 - Pace off predetermined sample point coordinates in a sequential fashion to determine individual sample locations.

Step 3 - After taking the last of the required paces to the first sampling point, place a stake immediately adjacent to the closest corn stalk to the toe of your shoe. Measure 15 ft of the corn row starting at the first stake and placing a second stake at the 15 ft mark. Move to the next adjacent corn row, measure and stake a second 15 ft section in the same manner as the first row. One sample unit will equal two 15 ft corn row sections.

Step 4 - Determine the 3rd and 4th ears of the first row starting with the first stalk of corn. Tag these ears with a rubber band. If there are less than four ears in the first row, the last ear and the next to last ear should be tagged. In the case where a stalk has more than one ear, count the top ear first. [Note: An ear of corn is defined as a cob having at least one kernel.] The tagged ears will be used to determine the moisture content, and at least 250g of grain are needed. If if does not appear that the 3rd and 4th ear will supply sufficient grain for a moisture test, then the 5th, 6th, etc., ear(s) should be included until a sufficient weight (g) is collected.

Step 5 - Husk all ears in row 1 within the fifteen foot segment of the sample. Husk the ears and snap the shank off as cleanly as possible. Be sure to include any ears tagged for moisture testing.

Step 6 - Weigh the husked ears using a balance scale - obtain field weight in pounds.

Step 7 - After weighing, put any ears tagged for moisture testing into sealed polyethylene bags. Mark the bag with the appropriate field number (as supplied by the mine operator), and sample identification number.

Step 8 - Measure on a perpendicular line from the stalks in row one (1) to the stalks in row five (5). Divide this measured distance by four (4) to determine the average row width.

Step 9 - Repeat Steps 3 through 8 for each additional random sampling point coordinate.

Step 10 - Send or deliver to the IDOA any grain sample collected for moisture content analysis. (Note: If any single sample requires more than one bag, additional bags should be identified sequentially such as 1A, 1B, 1C).

The following method will be used for determination of gross yield of corn samples. Gross yield is determined by deducting the adjustment for moisture content of shelled corn from the harvest weight. Moisture content determinations will be made by the Illinois Crop Reporting Service.

Gross Yield = Harvest weight adjusted for moisture content.

Included below for reference is the Gross Yield formula and an explanation of its components.

Gross Yield/Acre (bu/acre) = [ABC/D]/E(56 lb/bu)

where:

A = Field weight (lb) of husked ears of corn from 15 ft of row x 2 (2 rows x 15 ft);

B = Weight of shelled grain (g) at time of moisture test;

C = Percent moisture in grain corrected to 15.5%
[1.0-(% moisture in shelled corn/100%)] /.845;

D = Weight of ears (lb) of corn used for moisture determination;

E = Row factor

Area or percent of acre sampled with 30 ft of row (2 rows x 15 ft)	30" = 0.001722
	36" = 0.002066
	38" = 0.002181
	40" = 0.002295

and .845 = The standard conversion factor moisture content for corn per bushel (1.0 - .155).

After calculation of the gross yield, the harvest loss as calculated by Illinois Cooperative Crop Reporting Service will be subtracted from the gross yield to obtain a net yield per sample. The net yield determinations for each sample will be averaged together to obtain a yield figure for the entire field being evaluated for proof of productivity.

Soybean Sampling Technique

Step 1 - Mark the starting corner of the field to be sampled with a large stake and attach a ribbon or flag to it.

Step 2 - Pace off predetermined sample point coordinates in a sequential fashion to determine individual sample locations.

Step 3 - After taking the last of the required paces to the first sampling point, lay down a sampling frame so that it touchea the toe of your shoe, crossing the crop rows at a right angle. Mark the two ends of the sampling frame with stakes just inside the 3 ft sampling tines. Continue to lay out the sample area in the direction of travel from where the last pace was counted. Rotate the sampling frame so that it is perpendicular to one corner of the stake (previously marked), and at a right angle to the original frame position. (Note: If at any time the point of a tine is restricted by a soybean plant, slide the soybean frame toward the starting point far enough for the point of the tine to clear the plant). Repeat this procedure to lay out the other two sides of the sampling square, using the opposite corner of the original frame position to find the other two sides.

Step 4 - Strip all the soybean pods from all the plants in the 9 sq ft sampling area. Pick up any loose pods or beans found on the ground. Deposit all the pods, beans and blank pods, into a paper sack. Mark the sack with the appropriate field number (as provided by the mine operator), and sample identification number. Secure the sample sack to prevent any sample loss. (Note: If sample weight is too small for the moisture test, sufficient **grain of known moisture content** will be added to the sample so that moisture tests can be made).

Step 5 - Repeat steps 3 and 4 for each additional random sampling point coordinate.

Step 6 - Send or deliver to the IDOA any grain sample collected for moisture content analysis. (Note: If any single sample requires more than one bag, additional bags should be identified sequentially such as 1A, 1B, 1C).

The following method will be used for determination of gross yield of soybean samples. Gross yield is determined by deducting the adjustment for moisture content of the soybean sample from the harvest weight. Moisture content determinations will be made by the Illinois Cooperative Crop Reporting Service.

Gross Yield = Harvest weight adjusted for moisture content.

Included below for reference is the Gross Yield formula and an explanation of its components.

Gross Yield/Acre (bu/acre) = ABC

where:

A = Total wt (g) of all beans in 9 sq ft grid;

B = (43560 sq ft/acre)/[453.6 g/lb) (60 lb/bu)(9 sq ft)] = 0.1778 bu/g/acre;

C = Percent moisture in grain corrected to 12.5%
= [1.0-(% moisture in shelled beans/100%)] /.875;

and .875 = The standard moisture content conversion factor of soybeans per bushel [1.0 - .125].

After calculation of the gross yield, the harvest loss as calculated by Illinois Cooperative Crop Reporting Service will be subtracted from the gross yield to obtain a net yield per sample. The net yield determinations for each sample will be averaged together to obtain a yield figure for the entire field being evaluated for proof of productivity.

Wheat Sampling Technique

Step 1 - Mark the starting corner of the field to be sampled with a large stake and attach a ribbon or flag to it.

Step 2 - Pace off predetermined sample point coordinates in a sequential fashion to determine individual sample location.

Step 3 - After taking the last of the required paces to the first sampling point, lay down a sampling frame so that it touches the toe of your shoe, crossing the crop rows at a right angle. Mark the two ends of the sampling frame with stakes just inside the 1.8 ft sampling tines. Continue to lay out the sample area in the direction of travel from where the last pace was counted. Rotate the sampling frame so that it is perpendicular to one corner of the stake (previously marked) and at a right angle to the original frame position. Repeat this procedure to lay out the other two sides of the sampling square using the opposite corner of the original frame position to find the other two sides.

Step 4 - Clip all wheat heads from within the square outlined by the sampling frame. The wheat heads should be clipped approximately 1/2 inch below the bottom of the head.

Deposit all the collected wheat heads into a paper sample sack. Mark the sack with the appropriate field number (as supplied by the mine operator), and sample identification number. Secure the sample sack to prevent any sample loss. (Note:

If sample weight is too small for the moisture test, sufficient **grain of known moisture content** will be added to the sample so that moisture tests can be made).

Step 5 - Repeat steps 3 and 4 for each additional random sampling point coordinate.

Step 6 - Send or deliver to the IDOA any grain sample collected for moisture content analysis. (Note: If any single sample requires more than one bag, additional bags should be identified sequentially such as 1A, 1B, 1C).

The following method will be used for determination of gross yield of wheat samples. Gross yield is determined by deducting the adjustment for moisture content of the wheat sample from the harvest weight. Moisture content determinations will be made by the Illinois Cooperative Crop Reporting Service.

Gross Yield = Harvest weight adjusted for moisture content.

Included below for reference is the Gross Yield formula and an explanation of its components.

Gross Yield/Acre (bu/acre) = ABC

where:

A = Sample wt (g) of wheat;

B = (43560 sq ft/acre)/[(453.6 g/lb) (60 lb/bu)(3.24 sq ft)] = 0.4940 bu/g/acre

C = Percent moisture in grain corrected to 12% [1.0-(% moisture in harvested wheat/100%)] /.88;

and .88 = The standard conversion factor moisture content for wheat per bushel [1.0 - .12].

After calculation of the gross yield, the harvest loss as calculated by Illinois Cooperative Crop Reporting Service will be subtracted from the gross yield to obtain a net yield per sample. The net yield determinations for each sample will be averaged together to obtain a yield figure for the entire field being evaluated for proof of productivity.

Oats Sampling Technique

Step 1 - Mark the starting corner of the field to be sampled with a large stake and attach a ribbon or flag to it.

Step 2 - Pace off predetermined sample point coordinates in a sequential fashion to determine individual sample location.

Step 3 - After taking the last of the required paces to the first sampling point, lay down a sampling frame so that it touches the toe of your shoe, crossing the crop rows at a right angle. Mark the two ends of the sampling frame with stakes just inside the 1.8 ft sampling tines. Continue to lay out the sample area in the direction of travel from where the last pace was counted. Rotate the sampling frame so that it is perpendicular to one corner of the stake (previously marked) and at a right angle to the original frame position. Repeat this procedure to lay out the other two sides of the sampling square using the opposite corner of the original frame position to find the other two sides.

Step 4 - Clip all oat heads from within the square outlined by the sampling frame. The oat heads should be clipped approximately 1/2 inch below the bottom of the head.

Deposit all the collected oat heads into a paper sample sack. Mark the sack with the appropriate field number (as supplied by the mine operator), and sample identification number. Secure the sample sack to prevent any sample loss. (Note: If sample weight is too small for the moisture test, sufficient **grain of known moisture content** will be added to the sample so that moisture tests can be made).

Step 5 - Repeat steps 3 and 4 for each additional random sampling point coordinate.

Step 6 - Send or deliver to the IDOA any grain sample collected for moisture content analysis. (Note: If any single sample requires more than one bag, additional bags should be identified sequentially such as 1A, 1B, 1C).

The following method will be used for determination of gross yield of oat samples. Gross yield is determined by deducting the adjustment for moisture content of the oat sample from the harvest weight. Moisture content determinations will be made by the Illinois Cooperative Crop Reporting Service.

Gross Yield = Harvest weight adjusted for moisture content.

Included below for reference is the Gross Yield formula and an explanation of its components.

Gross Yield/Acre (bu/acre) = ABC

where:
A = Sample wt (g) of oats;

B = (43560 sq ft/acre)/[(453.6 g/lb)(32 lb/bu)(3.24 sq ft)]
= 0.9262 bu/g/acre;

C = Percent moisture in grain corrected to 15%;
[1.0-(% moisture in harvested oats/100%)]/.85;

and .85 = The standard conversion factor moisture content for oats per bushel [1.0 - .15].

After calculation of the gross yield, the harvest loss as calculated by Illinois Cooperative Crop Reporting Service will be subtracted from the gross yield to obtain a net yield per sample. The net yield determinations for each sample will be averaged together to obtain a yield figure for the entire field being evaluated for proof of productivity.

Sorghum Sampling Technique

Step 1 - Mark the starting corner of the field to be sampled with a large stake and attach a ribbon or flag to it.

Step 2 - Pace off predetermined sample point coordinates in a sequential fashion to determine individual sample locations.

Step 3 - After taking the last of the required paces to the first sampling point, place a stake immediately adjacent to the closest sorghum plant to the toe of your shoe. Measure ten (10) ft of the plant row starting at the first stake and placing a second stake at the ten (10) ft mark. Move to the next adjacent plant row, measure and stake a second ten (10) ft section in the same manner as the first row. One sample unit will equal two (10) ten ft sorghum row sections.

Step 4 - Clip all grain heads in row 1 within the ten (10) ft segment of the sample unit.

Step 5 - Weigh the clipped grain heads using a balance scale - obtain field weight to the nearest tenth (0.1) of a pound.

Step 6 - Clip the first five grain heads and the last five grain heads in Row 2 to be used for moisture determination. Place any grain heads collected for moisture determination into sealed polyethylene bags. Mark the bags with the appropriate field number (as supplied by the mine operator), and sample identification number.

Step 7 - Measure on a perpendicular line from the plants in row one (1) to the plants in row five (5). Divide this measured distance by four (4) to determine the average row width.

Step 8 - Repeat Steps 3 through 7 for each additional random sampling point coordinate.

Step 9 - Send or deliver to the IDOA any grain sample collected for moisture content analysis. (Note: If any single sample requires more than one bag, additional bags should be identified sequentially such as 1A, 1B, 1C).

The following method will be used for determination of gross yield of sorghum samples. Gross yield is determined by deducting the adjustment for moisture content of the threshed grain from the harvest weight. Moisture content determinations will be made by the Illinois Cooperative Crop Reporting Service.

Gross Yield = Harvest weight adjusted for moisture content.

Included below for reference is the Gross Yield formula and an explanation of its components.

Gross Yield/Acre (bu/acre) = (ABC/D)/E(56 lb/bu)

where:
A = Field weight (lb) of grain heads of sorghum from ten (10) ft of row x 2 (2 rows x 10 ft);

B = Weight of threshed grain (g) at time of moisture test;

C = Percent moisture in grain corrected to 13%
= [1.0-(% moisture in threshed sorghum/100%]/.87;

D = Weight of grain seeds (g) used for moisture determination;

E = Row factor
Area or percent of acre sampled with 20 ft of row (2 rows x 10 ft)

28"	= .001070
30"	= .001148
36"	= .001377
38"	= .001455
40"	= .001529

and .870 = The standard conversion factor moisture content for sorghum per bushel (1.0-.13).

After calculation of the gross yield, the harvest loss as calculated by Illinois Cooperative Crop Reporting Service will be subtracted from the gross yield to obtain a net yield per sample. The net yield determinations for each sample will be averaged together to obtain a yield figure for the entire field being evaluated for proof of productivity.

Mixed Hay Sampling Technique

Step 1 - Mark the starting corner of the field to be sampled with a large stake and attach a ribbon or flag to it.

Step 2 - Pace off predetermined sample point coordinate in a sequential fashion to determine individual sample locations.

Step 3 - After taking the last of the required paces to the first sampling point, lay down a sampling frame perpendicular to the toe of your shoe, where applicable, crossing crop rows at a right angle. Mark the two ends of the sampling frame with stakes just inside the 3 ft sampling tines. Continue to lay out the sample area in the direction of travel from where the last pace was counted. Rotate the sampling frame so that it is perpendicular to one corner of the stake (previously marked) and at a right angle to the original frame position. Repeat this procedure to lay out the other two sides of the sampling square using the opposite corner of the original frame position to locate the other two sides. In all cases, the layout of the sample area shall be consistent for each randomly identified sample point.

Step 4 - Clip all hay stems from within the square outlined by the sampling frame. The hay stems should be uniformly clipped to an approximate height of two (2) inches above ground level.

Step 5 - Deposit all of the collected hay sample into a suitable sample sack/ container. Mark the sack/container with the appropriate field number (as supplied by the mine operator), and sample identification number. Secure the sample sack/container to prevent any sample loss. (Note: If the sample weight is too large for handling by lab personnel, the sample may be quartered until an adequate representative sample for moisture testing is obtained.)

Step 6 - Repeat Steps 3 and 4 for each additional random sampling point coordinate.

Step 7 - Send or deliver to the IDOA any hay sample collected for moisture analysis. (Note: If any single sample requires more than one bag, additional bags should be identified sequentially such as 1A, 1B, 1C).

* If a field moisture meter is used, steps 5 and 7 shall be eliminated and the following explanations for item A and D will be substituted.

A. Dry matter weight = harvest weight - percent moisture content determined by field moisture tests.

D. Percent moisture in hay at time of harvest determined by field moisture test.

The following method will be used for determination of gross yield of mixed hay samples. Gross yield is determined by deducting the adjustment for moisture content of the mixed hay sample from the harvest weight. Moisture content determinations will be made by the Illinois Cooperative Crop Reporting Service.

Gross Yield = Harvest weight adjusted for moisture content

Gross Yield/Acre (tons/acre) = A/BCF

where:
A = Oven dry wt of harvested hay;

B = Sample size (sq ft)/43560 sq ft/acre
= 0.0002066 acres;

C = Conversion factor from lb harvested to tons
(i.e., 1 ton = 2000 lb);

D = Percent moisture in hay at time of harvest
= 100 [(wet wt - oven dry wt)/oven dry wt]

*E = Approximate % moisture in baled mixed hay
= 15%

F = D/E.

The net yield determinations for each sample will be averaged together to obtain a yield figure for the entire field being evaluated for proof of productivity. The annual harvest will be determined by the cumulative yields of each cutting.

* Subject to annual adjustment at the option of the IDOA.

Special Problems in Sample Layout

1. It is possible for a sample grid coordinate to fall on areas within the field boundary which were not planted to crops (i.e., grass waterway, roadway, etc.) When this situation occurs, stop the pace count at the start of such an area and resume the count on the other side of the area.

2. If a blank area is crossed which was planted to crops, the pace count should be continued through this area. Usually

such areas are due to poor germination, insects, standing water, etc. (if the sample area falls in this planted area which is blank, then a zero yield is established).

3. If a sample coordinate falls partly in a blank area which was not planted for harvest, move the sample area ahead until it is wholly on acreage planted to the crop being sampled. The sample point should begin one pace from the edge of the blank area.

ACKNOWLEDGEMENT

The Illinois Department of Agriculture wishes to thank Brenda Wanless for her untiring effort as the single typist during project development and completion.

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