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Estimate of Slope Classes by Counties in Iowa[1]

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Abstract. The proportion of land in given slope classes has been estimated for Iowa counties from a randomly selected sample. The sample, approximately 2 percent of the land area of the state, consists of about 4,500 individual tracts, each about 160 acres in size. A detailed soil map was made of each tract, using a 4-inch-to-the-mile aerial photograph as a base map, thus providing the basic information for a physical land-condition inventory. The data from the soil maps were projected to give estimates of physical land conditions by counties and for the state as a whole. On a state basis, nearly 60 percent of the state has slopes of less than 5 percent gradient, and almost 75 percent of the state has slopes of less than about 9 percent gradient. Summarized estimates of percent land in the 0-1, 2-4, 5-8, 9-13, 14-17, 18-24, and 24 plus percent slope classes are given for all counties of the state, and for the state.

Qualitative and quantitative measurements of land slopes have been made and interpreted in Iowa for many years. Many descriptions of topography (Kay and Apfel, 1944) indicate a correspondence of slope and geologic materials, notably the Pleistocene drifts and eolian deposits. Slope gradient has been used as an aid in interpretation of drift topographies (Ruhe, 1950). The importance of land slopes and soils as being among the limiting factors of land use and crop production in southern Iowa has been noted (Riecken *et al.*, 1959). The general relationships between soils and topography in Iowa have received special attention in a publication, "Understanding Iowa Soils" (Simonson *et al.*, 1952).

In 1947 the Soil Conservation Service and the Iowa Agricultural Experiment Station initiated a program of work to prepare an estimate of physical land conditions in Iowa. This inventory is based on a randomly selected sample consisting of three one-quarter sections of land per township and constitutes approximately a 2 percent sample of the total land area. The Statistical Laboratory at Iowa State University drew the samples, and the quarter-sections were soil mapped by Soil Conservation Service soil scientists. Four-

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inch-to-the-mile aerial photographs were used as base maps for the field work.

About 4,500 individual tracts, totaling slightly more than 730,000 acres, comprise the 2 percent statistical sample. The soil mapping was completed during 1959, and the resultant measurements and expansion of the data for each county also have been completed. The land percentages in each county do not total 100 percent because large urban areas, bodies of water, and some minor miscellaneous areas were excluded from the expansion of the data.

Methods of Mapping Samples

Every quarter-section has been traversed on foot by the soil scientists. The recorded information includes soil types and their slope and erosion phases, which were mapped more or less according to standard procedures. In addition, the current land use, such as cropland, permanent pasture, idle, and forest land, was recorded.

The slope classes reported are those established by the soil survey in Iowa which have, in general, been found to be significant for most agricultural practices in the state. Slopes reported as percent correspond to given differences of vertical height for every 100 feet of horizontal distance. For example the slope class 2 to 4 percent represents a vertical rise or fall of 2 to 4 feet for each 100 feet in horizontal distance. Slope of the land in each sample area was determined by measurement of slope gradients with an Abney level in the field. Any given slope class, such as the 2 to 4 percent class, when assigned to a specific area of the soil map, may contain small inclusions of lesser or stronger slopes; however, most of the area is required to have slope gradients within the limits of the class.

Compilation and Summarization of the Soil Map Information

The acreage of every soil mapping unit, i.e., the soil type plus slope and erosion phase, in each land use category was measured for each tract. The sample measurements were totaled for each county, and the percent of the county sample in each mapping area was calculated.

The proportion of the sample size to the county size provided a factor for expanding the data for each county. The county summaries which contain information about land use, soil types, erosion, and land slopes are the basis of the state summary reported here. A previous estimate of land slopes in Iowa, based on a study of published county soil survey reports (Simonson *et al.*, 1952), is in close agreement with results of the present study.

Discussion of the Slope-Class Data

A summary of the percentages of land within specific slope classes, determined from the 2 percent sample, is given by counties in Table 1. As certain non-soil segments were not included in the expansion of the data, the county totals do not always equal 100 percent. The excluded areas consist of large urban areas, rivers and large bodies of water, quarries, gravel pits, mine dumps, and areas of man-made land.

Direct comparisons of the relative proportion of land within the slope classes in the counties are easily made from Table 1. If the counties are nearly equal in size, then direct areal comparisons in addition to proportionality are quite valid. An example is that of Calhoun and Carroll counties which differ in size by less than 3,000 acres. In Calhoun County 61 percent of the land has a slope less than 2 percent, and 93 percent less than 5 percent, but in Carroll County only 15 percent of the land has slopes less than 2 percent, and 55 percent less than 5 percent. It is evident that Calhoun County has a much greater acreage of level (0-1 percent slope) and nearly level (2-4 percent slope) land than does Carroll County.

Estimates of variance of the data (Taylor, 1958) show that the randomly selected sample provides highly accurate figures for the state and reasonably accurate figures for the individual counties. The accuracy of the estimate of percent land area in each slope class increases with increasing acreage within the class. Most of the percentages reported for the state as a whole have an error of only about 1 part in 90, with a chance of being wrong only 1 time in 20.

Each soil association area of Iowa (Figure 1) has its own general slope characteristics. Some of the areas have similar topography, but others differ widely from each other. At present the data are summarized by counties and not by natural land subdivisions; however, sub-samples of the original sample which are representative of the different soil association areas are currently under investigation.

The distribution of land in the various slope classes for three selected counties is compared with the state totals in Figure 2. Hamilton County is in the Clarion-Webster Soil Association; Cass County lies principally in the Marshall Soil Association; and Clayton County lies principally in the Tama-Downs and Fayette-Dubuque-Stony Land Soil Association areas. Differences in land use in these counties appear to be, in part, a reflection of the slope differences.

The various slope classes represent the relative steepness of the

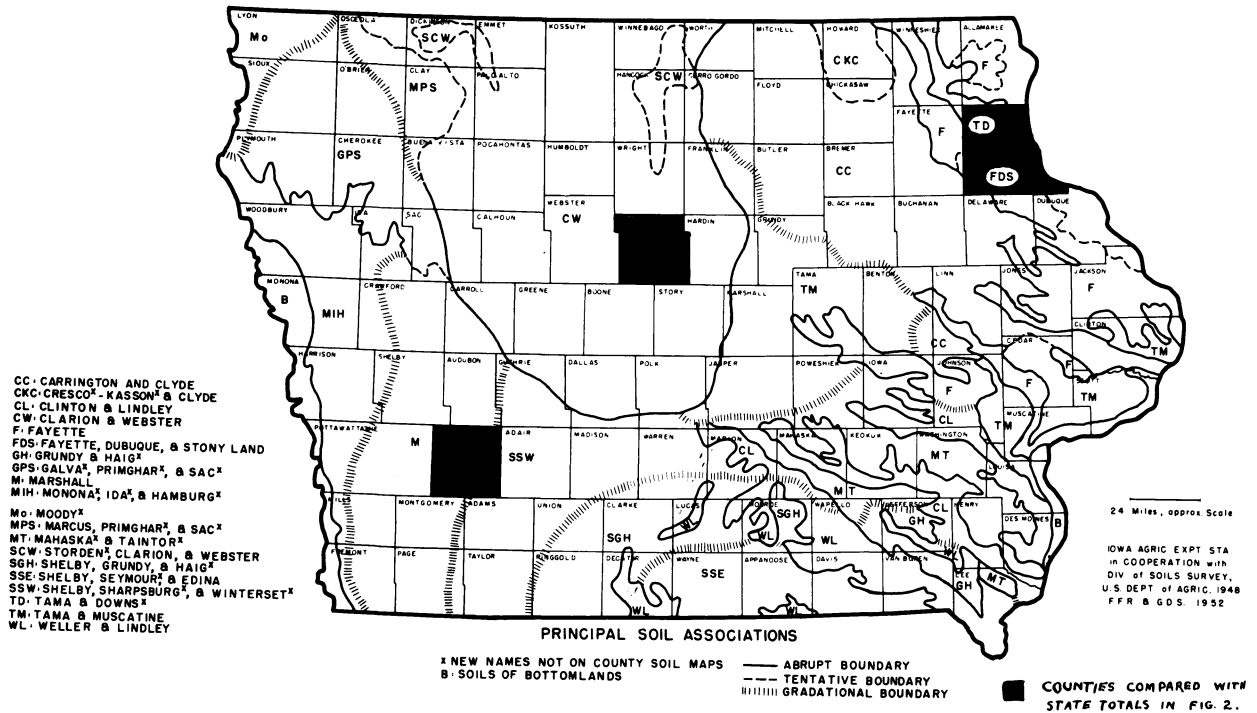

Figure 1. Principal Soil Associations.

land surface, and slope of land is, of course, only one factor affecting land use and crop production. Therefore, conclusions concerning the nature of the soils, the kinds of geological materials present, or the land use suitability and crop yielding capacity should not be made from the slope data alone. The slope data presented here obviously do not give direct information about the slope of any given piece of land within a county. This kind of information must be obtained from county-wide modern soil maps (e.g., Monona County).

Appraisal and review of soil conservation programs should include an evaluation of land slope (Heady, 1960). For example, runoff and erosion are a greater problem in counties with a high percentage of steep land (9 to 24 percent slopes) than in counties with a high percentage of level (0-1 percent slope) and nearly level land (2-4 percent slope).

Slope is also an important consideration in the study of sustained or increased crop production. Areas of level land used for crop production, unless very sandy or underlain by rapidly permeable materials at shallow depths, commonly have drainage problems caused by high water tables. Some general interpretations might be made from the slope class data pertaining to the ease of operation of large farm machinery, or relative suitability for terracing, as slope of land is an important factor in each case.

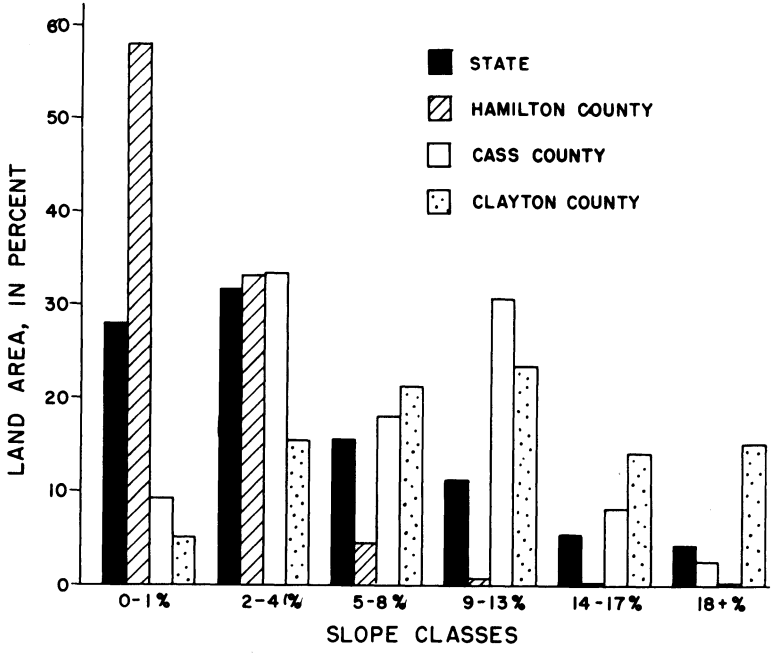

Figure 2. Distribution of land by slope classes in Hamilton, Cass, and Clayton counties, and the state as a whole.

Table 1
Estimated Percent of Land in Given Slope Classes for Iowa counties

County Name	Acres[a]	Slope gradient classes[b] 0-1 %	2-4 %	5-8 %	9-13 %	14-17 %	18-24 %	25 %+
		Percent of county[c]						
Adair	364,166	8.8	24.6	22.6	30.9	7.8	2.6	–
Adams	272,641	17.7	26.6	20.4	23.1	7.0	2.2	0.8
Allamakee	423,681	9.0	7.9	17.1	31.9	1.0	1.0	28.8
Appanoose	334,720	13.0	21.0	21.6	15.7	15.7	7.0	6.0
Audubon	286,721	6.4	26.3	16.2	34.3	10.7	4.8	0.2
Benton	459,522	9.4	53.2	19.8	6.4	3.8	2.2	0.6
Black Hawk	363,519	36.2	42.6	13.0	0.5	0.1	0.1	0.1
Boone	366,725	33.0	48.3	10.0	1.6	0.6	–	3.4
Bremer	280,962	48.0	43.6	3.6	0.8	0.2	0.5	0.2
Buchanan	364,160	27.4	59.8	7.7	0.4	0.5	–	0.3
Buena Vista	369,917	45.0	42.0	7.5	1.3	0.8	0.4	3.0
Butler	372,480	44.1	37.2	10.1	3.7	0.5	0.5	0.2
Calhoun	366,720	61.3	31.8	2.9	0.3	0.3	0.3	0.3
Carroll	367,360	15.3	40.2	21.1	14.8	3.3	0.8	0.7
Cass	357,666	9.0	33.5	18.0	31.0	8.2	0.3	–
Cedar	374,401	16.6	40.6	22.0	9.9	4.9	2.1	–
Cerro Gordo	368,640	45.7	34.9	6.9	2.7	1.6	1.6	0.6
Cherokee	366,720	16.3	46.3	22.1	2.9	1.6	1.5	4.3
Chickasaw	323,200	37.9	52.7	5.4	0.1	–	–	–
Clarke	274,563	13.2	18.0	25.0	14.3	16.4	6.7	2.2
Clay	367,356	54.0	36.0	7.2	2.0	0.4	–	0.6
Clayton	509,440	5.1	15.5	21.7	23.4	13.7	6.3	8.9
Clinton	444,800	30.5	27.6	14.4	10.9	5.2	5.4	1.0
Crawford	458,245	8.7	19.2	21.0	29.9	11.2	5.4	1.7
Dallas	382,083	27.3	43.1	10.2	6.2	5.1	2.6	3.1
Davis	325,760	22.9	22.3	20.0	16.0	9.2	4.6	1.6
Decatur	339,196	11.9	17.6	20.7	18.9	20.4	6.6	1.4
Delaware	366,720	18.2	46.6	15.9	6.7	4.0	1.7	3.4
Des Moines	270,723	32.9	26.8	16.9	6.8	4.4	2.5	3.9
Dickinson	255,806	32.8	38.4	15.9	3.6	2.3	0.8	0.4
Dubuque	398,083	3.5	12.2	18.1	31.5	18.0	4.7	6.3
Emmet	280,253	36.2	31.5	19.6	6.0	1.8	3.8	0.1
Fayette	465,924	12.9	53.6	13.5	6.6	6.1	2.9	3.2
Floyd	321,920	48.0	42.8	4.3	0.4	0.5	0.1	–
Franklin	375,040	41.2	42.3	10.7	2.3	0.5	0.4	–
Fremont	333,440	38.7	19.3	9.5	20.6	2.9	2.5	2.2
Greene	364,160	42.7	41.6	7.2	1.3	0.7	–	2.4
Grundy	320,631	35.0	48.8	13.1	0.8	0.1	–	–
Guthrie	381,441	19.1	26.7	18.5	17.3	9.7	2.6	3.9
Hamilton	369,882	58.5	33.5	4.4	1.1	0.4	0.4	2.3
Hancock	366,106	59.2	27.2	8.3	1.8	1.4	0.4	0.4
Hardin	367,360	37.4	38.3	14.9	3.2	0.7	0.6	0.1
Harrison	447,376	33.1	13.4	13.6	11.3	10.7	7.6	8.2
Henry	281,604	25.8	26.8	23.5	10.0	6.0	2.7	0.6
Howard	301,438	36.1	53.7	6.5	0.8	0.2	–	–
Humboldt	278,404	53.8	39.8	3.5	0.6	0.6	–	0.8

Table 1 (Continued)

County Name	Acres	Slope gradient classes 0-1 %	2-4 %	5-8 %	9-13 %	14-17 %	18-24 %	25 %+
		Percent of county						
Ida	276,542	5.4	33.3	29.2	24.4	5.5	1.8	0.3
Iowa	373,760	23.7	20.6	15.1	21.0	10.4	3.9	2.5
Jackson	414,120	8.2	8.7	14.8	29.9	18.0	8.2	11.9
Jasper	471,040	20.3	25.7	20.8	20.7	9.1	2.2	0.3
Jefferson	279,044	25.0	22.2	25.0	9.9	9.4	5.0	0.2
Johnson	396,800	23.0	25.4	16.1	15.0	6.6	2.2	2.2
Jones	375,308	12.4	33.3	21.4	12.9	6.7	7.5	2.2
Keokuk	370,580	25.6	29.7	22.2	18.0	3.7	0.8	–
Kossuth	626,557	35.4	50.5	8.5	0.9	0.3	0.5	0.2
Lee	348,800	19.3	33.3	15.8	8.5	2.9	2.7	8.4
Linn	458,883	15.0	42.8	21.3	4.3	2.4	1.4	1.6
Louisa	267,521	38.3	26.2	11.4	5.4	5.5	5.3	3.5
Lucas	276,963	21.4	23.1	21.2	8.4	18.4	7.3	–
Lyon	376,326	24.4	51.6	17.1	2.8	0.6	0.5	2.0
Madison	361,596	24.3	19.8	22.2	10.5	7.1	7.5	2.2
Mahaska	366,073	16.9	26.3	27.4	19.9	3.8	1.1	–
Marion	364,806	15.9	20.7	27.1	21.4	7.3	2.1	0.2
Marshall	367,341	22.6	29.5	29.6	14.1	3.8	0.4	0.1
Mills	285,440	18.0	25.1	18.4	20.2	8.6	3.8	1.6
Mitchell	298,880	61.0	30.4	2.3	1.2	0.4	0.4	0.4
Monona	454,398	46.9	8.5	7.8	7.9	11.7	5.3	9.7
Monroe	278,402	10.8	18.4	24.2	18.4	11.0	10.4	4.5
Montgomery	270,080	19.2	31.7	12.9	28.6	2.1	0.9	0.5
Muscatine	287,964	42.5	32.2	12.4	5.9	3.0	1.4	2.6
O'Brien	368,260	30.8	62.6	4.0	0.8	0.1	0.6	1.0
Osceola	254,705	38.7	47.8	8.9	1.6	0.7	0.5	–
Page	342,400	21.8	25.4	15.7	30.0	2.1	0.3	0.4
Palo Alto	362,875	51.5	34.6	10.9	2.2	0.5	0.2	–
Plymouth	552,345	12.0	32.0	35.0	11.4	4.0	3.0	2.3
Pocahontas	371,843	67.1	25.0	5.0	0.8	0.3	0.3	0.3
Polk	380,155	30.1	34.3	12.0	5.7	3.2	–	1.8
E. Pottawattamie	399,520	13.7	33.7	12.6	29.2	5.7	1.5	0.9
W. Pottawattamie	330,240	23.2	23.6	11.2	17.9	10.7	4.1	2.0
Poweshiek	376,960	16.9	27.7	22.0	16.8	9.4	2.9	0.2
Ringgold	344,320	5.3	23.3	30.3	24.2	11.5	1.1	–
Sac	371,033	29.0	50.3	14.2	4.1	1.3	0.5	0.6
Scott	289,920	23.3	34.5	17.5	6.2	3.5	4.0	1.5
Shelby	375,683	10.0	30.7	7.8	35.0	11.3	2.3	0.3
Sioux	484,790	19.7	49.1	22.3	4.3	0.3	0.1	1.0
Story	363,500	39.0	38.3	9.4	3.2	1.9	1.7	0.4
Tama	460,800	43.9	31.3	–	10.2	6.3	5.6	–
Taylor	337,919	21.6	22.4	22.6	27.3	2.1	0.7	3.1
Union	272,640	12.0	26.0	25.9	19.9	7.3	3.0	1.1
Van Buren	313,597	17.5	16.3	18.4	12.3	10.5	15.9	6.2
Wapello	280,327	25.3	27.4	20.7	10.6	6.7	3.8	3.3
Warren	360,750	19.0	28.0	24.0	15.0	8.2	5.3	0.5

Table 1 (Continued)

County Name	Acres	Slope gradient classes 0-1 %	2-4 %	5-8 %	9-13 %	14-17 %	18-24 %	25 %+
		Percent of county						
Washington	363,493	31.0	28.0	22.0	15.0	3.1	0.9	–
Wayne	340,477	11.2	27.7	29.2	18.3	10.5	0.6	–
Webster	459,520	47.5	41.5	2.9	0.7	0.7	0.7	2.6
Winnebago	257,280	44.5	33.2	16.5	5.1	1.6	–	–
Winneshiek	440,284	5.6	28.0	26.4	20.7	7.8	5.1	6.4
Woodbury	561,291	28.2	10.1	18.1	20.8	13.3	3.2	1.4
Worth	256,640	63.9	23.5	5.6	1.7	1.3	0.1	–
Wright	369,280	55.6	31.4	5.8	1.6	0.9	0.2	0.1
Total or Average	36,021,764	27.7	31.9	15.6	11.7	5.3	2.5	2.0

[a]The acres listed are those of the county Soil Conservation Districts which exclude incorporated villages.
[b]Slopes are given in percent. For example, the slope class 2-4% represents a range of slopes having vertical fall between 2 and 4 feet per 100-foot distance.
[c]The county percents often do not total 100 as urban areas, rivers, large bodies of water, quarries, and similar areas have been excluded in this summary.

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