# Kansas Department of Health & Environment Bureau of Environmental Remediation Surface Mining Section

# GUIDANCE DOCUMENT-REVEGETATION

**Revegetation Standards for Success and Statistically Valid Sampling Techniques for Measuring Revegetation Success**

**Issued**
**2006**

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## Preface

This guidance document discusses revegetation standards for success and statistically valid sampling techniques which are used by the Coal Mining Industry and enforced by the Kansas Department of Health and Environment - Surface Mining Section (SMS). This guidance document is used for the permitting and revegetation requirements of bond release. This guidance document concentrates primarily on the geographic region of eastern Kansas which is actively mined for coal (Cherokee, Labette, Crawford, Bourbon, and Linn Counties). The regulations covered are K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111 and 816.116; K.A.R. 47-9-1 (d)(35) and (38) adopting by reference 30 CFR 817.111and 817.116; K.A.R. 47-9-1(f)(5), adopting by reference 30 CFR 823.15; and portions of K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40.

All vegetation data collected prior to this document is subject to the previously approved 2002, 'Revegetation Standards for Success and Statistically Valid Sampling Techniques for Measuring Revegetation Success'. The 2006 Revegetation Guideline will be a replacement document to the 2002 document. The 2006 document incorporates revisions to the established technical success standards for forage ground cover of several land uses, as well as revisions to the definition of which types of vegetation can be counted in determining the percentage of forage ground cover. It also includes updated productivity databases based on the Natural Resource Conservation Service Soil Data Mart.

This document is a guideline to be used to fulfill the requirements of State regulations pertaining to revegetation. It is therefore recommended that the Permittee consult with the SMS before implementing any sampling plan in the pre-mine data gathering stage and the post-mine revegetation/Bond Release stage of the mining and reclamation process.

## Introduction

The Kansas Department of Health and Environment, Surface Mining Section (SMS) is mandated by K.A.R. 47-9-1(c)(42), adopting by reference 30 CFR 816.116(a)(1); and K.A.R. 47-9-1(d)(35) and (38), adopting by reference 30 CFR 817.111 and 817.116(a)(1) to select standards for success and statistically valid sampling techniques for measuring success which must be included in the approved regulatory program. This revegetation guideline is a guidance document which will serve as the revegetation standards for success and the statistically valid sampling techniques for the State of Kansas as part of the approved regulatory program. This guidance document is applicable to all land uses as described by K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111(a), 816.111(d) and 816.116(b); and K.A.R. 47-9-1(d)(35) and (38), adopting by reference 30 CFR 817.111(a), 817.111(d) and 817.116(b).

The land use of prime farmland cropland is additionally covered by K.A.R. 47-9-1(f)(5), adopting by reference 30 CFR 823.15, which requires that the operator use a reference crop for a standard and a statistically valid sampling technique at a 90% or greater statistical confidence as approved by the SMS in consultation with the United States Department of Agriculture, (USDA) Natural Resource Conservation Service, (NRCS).

## Definitions

A.U.M.: Animal Unit Month, the monthly average pounds of forage needed to support each 1,000 pounds of cattle. (Defined in Kansas as 760# for cool season grasses.)

Cropland: Land used for the production of adapted crops for harvest, alone or in rotation with grasses and legumes that include row crops, small grain crops, hay crops, nursery crops, orchard crops, and other similar crops.

Desirable: Any species of plant not listed in Appendix A as 'Unacceptable'.

Developed Water Resources:
Land used for storing water for beneficial uses, such as stockponds, irrigation, fire protection, flood control, and water supply.

Diverse: Sufficiently varied amounts and types of vegetation to achieve ground cover and support the postmining land uses. This includes different grasses, forbs, shrubs, trees, etc., depending on the land use.

Effective: The planted species must be both productive and control erosion.

Fish and Wildlife Habitat:
Land dedicated wholly or partially to the production, protection, or management of species of fish or wildlife.

Forage: Plants used for feeding livestock either by grazing, or cutting and baling for future use.

Forestry: Land used or managed for the long-term production of wood, wood fiber, or wood derived products.

Grazingland: Land used for grasslands and forest lands where the indigenous vegetation is actively managed for grazing, browsing, or occasional hay production.

GPS: Global Positioning System.

Historically used for cropland:
(a) lands that have been used for cropland for any 5 years or more out of the 10 years immediately preceding the acquisition, including purchase, lease, or option, of the land for the purpose of conducting or allowing through resale, lease or option the conduct of surface coal mining and reclamation operations;
(b) lands that the regulatory authority determines, on the basis of additional cropland history of the surrounding lands and the lands under consideration, that the permit area is clearly cropland but falls outside the specific 5-years-in-10 criterion, in which case the regulations for prime farmland may be applied to include more years of cropland history only to increase the prime farmland acreage to be preserved; or

(c) lands that would likely have been used as cropland for any 5 out of the last 10 years, immediately preceding such acquisition but for the same fact of ownership or control of the land unrelated to the productivity of the land.

Industrial/Commercial:

Land used for-

(1) Extraction or transformation of materials for fabrication of products, wholesaling of products, or long-term storage of products. This includes all heavy and light manufacturing facilities.

(2) retail or trade of goods or services, including hotels, motels, stores, restaurants, and other commercial establishments.

KDWP: Kansas Department of Wildlife and Parks.

KSU: Kansas State University.

NRCS: United States Department of Agriculture; Natural Resource Conservation Service

Pastureland: Land used primarily for the long-term production of adapted, domesticated forage plants to be grazed by livestock or occasionally cut and cured for livestock feed.

Permanent: The plant community as a whole must be capable of propagating and providing erosion control through natural plant succession.

Previously Mined:

Land affected by surface coal mining operations prior to August 3, 1977, that has not been reclaimed to the standards of Kansas Administrative Regulation Article 47. Also referred to as "No Topsoil" in this document.

Prime Farmland:

Lands historically used for cropland defined by the Secretary of Agriculture in 7 CFR part 657.

Recreation: Land used for public or private leisure-time activities, including developed recreation facilities such as parks, camps, and amusement areas, as well as areas for less intensive uses such as hiking, canoeing, and other undeveloped recreational uses.

Residential: Land used for single- and multiple-family housing, mobile home parks, or other residential lodgings.

SMS: Kansas Department of Health and Environment; Surface Mining Section.

Total Cover: Ground covered by the combined low growing parts of the vegetation, the aerial parts of the vegetation, and a percent of the litter that is produced naturally on site.

**TABLE 1: Revegetation Requirements for Pastureland and Grazingland Bond Release**

No Revegetation Data Required for Phase I Bond Release

| **Land Use** | **PHASE II** | | **PHASE III** | |
|---|---|---|---|---|
| **Pastureland** | Productivity | Cover | Productivity | Cover |
| With Topsoil | One year forage, at a 90% Success Standard from either: 1) Reference areas, 2) Weighted average based on soil type. | One year ground cover at 90% or greater of the 100% standard.* | One additional year forage, at a 90% Success Standard from either: 1) Reference areas, 2) Weighted average based on soil type. | One additional year ground cover at 90% or greater of the 100% standard.* |
| No Topsoil | NA | One year ground cover, at 90% of the Premine cover, and adequate to control erosion. | NA | One additional year ground cover, at 90% of the premine cover, and control erosion. |
| **Grazingland** | | | | |
| With Topsoil | One year forage, at a 90% Success Standard from either: 1) Reference areas, 2) Weighted average based on soil type. | One year ground cover at 90% or greater of the 90% standard.** | One additional year forage, at a 90% Success Standard from either: 1) Reference areas, 2) Weighted average based on soil type. | One additional year ground cover at 90% or greater of the 90% standard.** |
| No Topsoil | NA | One year ground cover, at 90% of the Premine cover, and adequate to control erosion. | NA | One additional year ground cover, at 90% of the premine cover, and control erosion. |

* 100% Standard based on high production capabilities of the soils in eastern KS under high management. Lower Technical Standard must be demonstrated and justified by the Permittee, approved by the SMS, and incorporated into the approved permit.

** 90% Standard based on the growth characteristics of warm season native grasses.

**TABLE 2: Revegetation Requirements for Fish And Wildlife Habitat, Recreation, Shelter Belts, And Forest Products, And Industrial, Commercial, or Residential Bond Release**

No Revegetation Data Required for Phase I Bond Release *

| Land Use | PHASE III | |
|---|---|---|
| | Productivity | Cover |
| **Industrial, Commercial, or Residential** These land uses must be developed within two years after regrading or the land use must be changed. | | |
| With Topsoil | NA | Ground cover must meet 90% of the established technical success standard during the growing season of the last year of the period of operator responsibility [a]. The minimum technical success standard shall be 70%. |
| No Topsoil | NA | Ground cover must meet 90% of the established technical success standard during the growing season of the last year of the period of operator responsibility [a]. The minimum technical success standard shall be 70%. |
| **Wildlife Habitat, Recreation, Shelter Belts, & Forest Products** | | |
| With Topsoil | Trees and Shrubs must meet 90% of the success standard as approved by the permit. | Ground cover must meet 90% of the established technical success standard during the growing season of the last year of the period of operator responsibility [a]. The minimum technical success standard shall be 70%. |
| No Topsoil | NA | Ground cover must meet 90% of the established technical success standard during the growing season of the last year of the period of operator responsibility [a]. The minimum technical success standard shall be 70%. |

[a] The period of operator responsibility is five full years in areas with more than 26.0 inches of annual precipitation. The period of operator responsibility continues each year until final bond is release.

* At phase II, the operator must show that the area has been seeded, and planted with trees and shrubs, according to the approved reclamation plan. Since there is no regulatory requirement for a Phase II release, the policy of the SMS will be to maintain full bond coverage for acres in these land uses throughout the entire period of operator responsibility.

**TABLE 3: Revegetation Requirements for Cropland Prime Farmland Bond Release**
Three crop years

No Revegetation Data Required For Phase I Bond Release

| PHASE II | | PHASE III | |
|---|---|---|---|
| Productivity [a] | Cover | Productivity [b] | Cover |
| * One year from a deep rooted row crop [a] using:<br><br>(a) Test Plots: Adjacent forage areas must also be sampled<br><br>(b) Whole Field Sampling: No ground cover sampling required. | Ground cover at 90% of the Technical Success Standard of 100%. | * Two additional years from either [b]:<br><br>1) Row Crop, using:<br><br>(a) Test Plots: Adjacent forage must also be sampled<br><br>(b) Whole Field Sampling. No ground cover sampling required. | Ground cover at 90% of the Technical Success Standard of 100%. |
| Forage, using:<br><br>(a) Reference areas<br><br>(b) Weighted Averages based on soil type. | Ground cover at 90% of the Technical Success Standard of 100% | Forage, using:<br><br>(a) Reference areas<br><br>(b) Weighted Averages based on soil type. | Ground cover at 90% of the Technical Success Standard of 100%. |

* Results must meet 100% of the production success standard established in the permit or 100% of the production of the approved reference area. *If test plots are used then*, ground cover must meet 90% of the cover standard of 100% *for the areas in forage.*

[a] Soybeans, corn, or grain sorghum must be used for a Phase II release.

[b] The row crops of soybeans, grain sorghum, wheat, or corn may be used to achieve Phase III release.

Two of the three crops years may be forage.

**TABLE 4: Revegetation Requirements for Cropland Bond Release**
Two crop years

No Revegetation Data Required For Phase I Bond Release

| PHASE II | | PHASE III | |
|---|---|---|---|
| Productivity [a] | Cover | Productivity [a] | Cover |
| One year from either [b]<br><br>1) a Row Crop, using:<br><br>(a) Test Plots: Adjacent forage must also be sampled<br><br>(b) Whole Field Sampling. No ground cover sampling required. | Ground cover at 90% of the Technical Success Standard. [c] | One additional year from either [b]<br><br>1) Row Crop, using:<br><br>(a) Test Plots: Adjacent forage must also be sampled<br><br>(b) Whole Field Sampling. No ground cover sampling required. | Ground cover at 90% of the Technical Success Standard. [c] |
| 2) Forage, using:<br><br>(a) Reference areas<br><br>(b) Weighted Averages based on soil type. | Ground cover at 90% of the Technical Success Standard. [c] | 2) Forage, using:<br><br>(a) Reference areas<br><br>(b) Weighted Averages based on soil type. | Ground cover at 90% of the Technical Success Standard. [c] |

[a] If the premine cropping was row crops, then the deep rooted row crops of soybeans, corn, or grain sorghum must be used for Phase II proof of productivity success. If the premine cropping was forage, then forage can be used for both years of productivity data of Phase II and Phase III.

[b] Results must meet 90% of the Success Standard. *If test plots are used then*, ground cover must meet 90% of the cover standard of 100% *for the areas in forage.*

[c] Technical Success Standard is 100% unless another Standard is approved in the Permit by premine sampling.

# I. Ground Cover Success Standard

Ground cover is defined as the area of ground covered by the combined aerial parts of the vegetation and the litter that is produced naturally on a site, and is expressed as a percentage of the total area of measurement. Ground cover must demonstrate the general requirements of diversity, effectiveness, and permanence as stated in K.A.R. 47-9-1(c)(39), adopting by reference 30 CFR 816.111, and shall consist of the species mixture which has been approved in the original permit, approved permit amendments, or volunteer species allowed by land use as listed in Appendix A.

The technical success standard for ground cover has been established for each land use and is defined below. For any land use, this technical success standard for ground cover may be approved at a lower value by proposing a premine ground cover study to establish a standard. The permittee must demonstrate and justify why the site cannot achieve the established technical success standard for ground cover, under a high level of management. This would include high level of management history records (i.e., fertility, liming, mowing, haying and pest control). The justification must include site specific physical and/or chemical characteristics which cannot be eliminated under a high level of management. The permittee's demonstration, justification and proposed premine standard, must be approved by the SMS, on a permit specific basis, and included in the approved permit.

## A. Technical Success Standard for Ground Cover - Prime Farmland Cropland

Ground cover on prime farmland cropland is measured on forage areas only. Areas in active row crop or small grain crop production, in the premine or postmine state, are not subject to ground cover sampling requirements. This section is applicable to areas where forage is the established premine cover or the intended postmine cover, and/or used in conjunction with row crop test plots. When test plots are used to prove row crop productivity, the forage area outside the test plot must meet forage ground cover requirements, however success is not required to be achieved in the same year due to the seasonal variations between row crops and forage crops.

The technical success standard is 100% ground cover when the land use is at a high level of management. This standard is based on the high production capabilities of the soils in eastern Kansas.

At phase II revegetation bond release, the applicant must meet 90% of the premine ground cover success standard for one growing season, excluding the first season. Prime farmland revegetation establishment must be demonstrated per K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111(a) and (b), and 816.116(a); K.A.R. 47-9-1-(d)(35) and (38), adopting by reference 30 CFR 817.111(a) and (b), and 817.116(a); and K.A.R. 47-9-1 (f)(5), adopting by reference 30 CFR 823.15(a). At phase III revegetation bond release, the applicant must meet 90% of the premine ground cover success standard for two additional growing seasons.

## B. Technical Success Standard for Ground Cover - Cropland

Ground cover on cropland is measured on forage areas only. Areas in active row crop or small grain crop production, in the premine or postmine state are not subject to ground cover sampling requirements. This section is applicable to areas where forage is the established premine cover or the intended postmine cover, used in conjunction with row crop test plots. When test plots are used to prove row crop productivity, the forage area outside the test plot must meet forage ground cover requirements, however success is not required to be achieved in the same year due to the seasonal variations between row crops and forage crops.

The technical success standard is 100% ground cover when the land use is at a high level of management. This standard is based on the high production capabilities of the soils in eastern Kansas.

At phase II revegetation bond release, the applicant must meet 90% of the premine ground cover success standard for one growing season, excluding the first season. Cropland revegetation establishment must be demonstrated per K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111(a) and (b), and 816.116(a); K.A.R. 47-9-1-(d)(35) and (38), adopting by reference 30 CFR 817.111(a) and (b), and 817.116(a). At phase III revegetation bond release, the applicant must meet 90% of the premine ground cover success standard for one additional growing season.

## C. Technical Success Standard for Ground Cover - Pastureland and Grazingland

Pastureland consists of land used for the long-term production of adapted, domesticated forage plants to be grazed by livestock or occasionally cut and cured for livestock feed. Grazingland consists of land used for grasslands or forest lands where the indigenous vegetation is actively managed for grazing, browsing, or occasional hay production.

The technical success standard for Pastureland is 100% ground cover when the land use is at a high level of management. This standard is based on the high production capabilities of the soils in eastern Kansas.

The technical success standard for Grazingland is 90% ground cover when the land use is at a high level of management. This standard is based on the growth characteristics of the reintroduced indigenous grass species.

At phase II revegetation bond release, the applicant must meet 90% of the premine ground cover success standard for one growing season, excluding the first season. Pastureland and Grazingland revegetation establishment must be demonstrated per K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111(a) and (b), and 816.116(a); K.A.R. 47-9-1-(d)(35) and (38), adopting by reference 30 CFR 817.111(a) and (b), and 817.116(a). At phase III revegetation bond release, the applicant must meet 90% of the premine ground cover success standard for one additional growing season.

D. Technical Success Standard for Ground Cover - Pastureland and Grazingland-No Topsoil

For areas previously disturbed by mining that were not reclaimed to the requirements of the regulations and that are remined or otherwise disturbed by surface coal mining operations, as a minimum, the vegetative ground cover shall be not less than the ground cover existing before redisturbance and shall be adequate to control erosion.

The technical success standard for Pastureland or Grazingland established on previously mined areas is 90% of the premine ground cover or at a minimum control erosion. The minimum technical success standard shall be 70%.

At phase II revegetation bond release, the applicant must meet 90% of the premine ground cover success standard for one growing season, excluding the first season. Revegetation establishment on Pastureland and Grazingland without topsoil must be demonstrated per K.A.R. 47-9-1(c)(42), adopting by reference 30 CFR 816.116(b)(5); K.A.R. 47-9-1-(d)(38), adopting by reference 30 CFR 817.116(b)(5). At phase III revegetation bond release, the applicant must meet 90% of the premine ground cover success standard for one additional growing season.

E. Technical Success Standard for Ground Cover - Fish and Wildlife Habitat, Recreation, Shelter Belts, and Forest Products Land Uses

The ground cover success standards for Fish and Wildlife Habitat, Recreation, Shelter Belts and Forest Products land uses will be the greater of either the premine ground cover, or the ground cover value needed to meet the approved postmining land use. The ground cover value needed to meet the approved postmining land use will be determined by specific land use requirements stipulated in the reclamation plan and at a minimum capable of controlling erosion.

For Fish and Wildlife Habitat, Recreation, Shelter Belts, and Forest Products land, the technical success standard is 90% of the premine ground cover. The minimum technical success standard shall be 70%.

In accordance with K.A.R. 47-9-1(c)(42), adopting by reference 30 CFR 816.116(b)(3) and K.A.R. 47-9-1(d)(38), adopting by reference 30 CFR 817.116(b)(3), all areas must meet 90% of the success standard. At phase III revegetation bond release, the applicant must meet or exceed 90% of the applicable technical success standard during the growing season of the last year of the responsibility period.

F. Technical Success Standard for Ground Cover - Fish and Wildlife Habitat, Recreation, Shelter Belts, and Forest Products Land Uses-No Topsoil

The ground cover success standards for Fish and Wildlife Habitat, Recreation, Shelter Belts and Forest Products land uses will be the greater of either the premine ground cover, or the ground cover value needed to meet the approved postmining land use. The ground cover value needed to meet the approved postmining land use will be determined by specific land use requirements stipulated in the reclamation plan and at a minimum shall not be less than the ground cover existing before redisturbance and shall be adequate to control erosion.

For areas without topsoil, the technical success standard is 90% of the premine ground cover. The minimum technical success standard shall be 70%.

In accordance with K.A.R. 47-9-1(c)(42), adopting by reference 30 CFR 816.116(c)(2) and K.A.R. 47-9-1(d)(38), adopting by reference 30 CFR 817.116(c)(2), all areas must meet 90% of the success standard. At phase III revegetation bond release, the applicant must meet or exceed 90% of the applicable technical success standard during the growing season of the last year of the responsibility period.

G. Technical Success Standard for Ground Cover - Industrial, Commercial, or Residential with or without Topsoil

In accordance with K.A.R. 47-9-1(c)(42), adopting by reference 30 CFR 816.116(b)(4) and K.A.R. 47-9-1(d)(38), adopting by reference 30 CFR 817.116(b)(4), the ground cover success standard for land use designated for industrial, commercial, or residential less than two years after regrading the area shall not be less than that required to control erosion. The ground cover value sufficient to control erosion must be stipulated in the approved permit and shall not be less than 70%. The development plans in the approved permit must be valid at bond release. The operator must conduct ground cover studies and make the bond release findings that the ground cover is sufficient to control erosion. Active erosion will be grounds for bond release denial. The requirement is the same for areas without topsoil.

## II. Ground Cover Sampling

### A. Premine Ground Cover Sampling Criteria and Techniques

A detailed analysis of the premine ground cover will be required and must consider the premine quality of each land use. The analysis may be conducted based on the species identification collected during ground cover measurements by the permittee. The ground cover success standard may be approved at a lower value by proposing a premine reference ground cover success standard. The permittee must demonstrate and justify why the site cannot achieve the established technical success standard under a high level of management. This would include high level of management history records (i.e., fertility, liming, mowing, haying and pest control) and justification why the site cannot achieve the established technical success standard. The justification must site specific physical and/or chemical characteristics which cannot be eliminated under a high level of management. The permittee's demonstration, justification and proposed premine reference ground cover success standard must be approved by the SMS, on a permit specific basis, and be included in the approved permit.

The point intercept technique of ground cover sampling has been discussed by many authors and is well documented and utilized (Chambers & Brown 1983). It is appropriate for collecting the premine ground cover data on all land uses outlined here.

#### Premine Ground Cover Sampling Criteria

1. The vegetative ground cover study must be stratified before sampling. Stratification must be developed in consultation with, and approved by the SMS. Some of the types of stratification would be invading shrubs and grasses, cool season grassland and weeds, warm season grassland and weeds, tree invading shrub land, upland forest, bottom land forest, and grassland mosaic. The stratified sample areas will have at a minimum one random sample point per 5 acres.

2. Each stratified sampling area will have a minimum of 15 transects that are 10 to 50 feet in length, with first hit recording conducted on a minimum of one foot intervals. The overall first hit points for a stratified sample area must be a minimum of 150.

3. Report weather conditions (i.e., temperature, humidity, precipitation, wind, etc.). Sampling must only be done on calm days (i.e., 0-5 mph wind).

4. All sample pins are projected from a fixed point at a 45° angle from the transect line.

5. All sampling pins will be 0.10 to 0.20 of an inch in diameter and ground to a fine point on the sampling end.

6. Canopy cover will be measured and recorded at each first hit point by projecting an imaginary vertical line from the first hit point to the canopy cover intercepted

or no canopy. Notes regarding the canopy covers ability to control erosion are recorded and utilized in the final ground cover success standard.

7. All ground cover sampling for setting the ground cover success standard will be conducted from April 1 to November 1.

Premine Ground Cover Sampling Technique

1. Mark the starting corner of the stratified sample area with a large stake identifying the stratified sample area number. This stake will remain until the data has been reviewed and field verified by the SMS.

2. Locate the random transect points for each stratified sample area. All random sampling points will be located in relation to the stake marked in step one. The locations of the sample points will be determined from a set of random coordinates. All sample point numbers, used in the stratified sample area, are listed in relation to the specific coordinates which are reported with each stratified sample area. Field locating of the sample points will be conducted by the use of a measuring tape, pacing which has been calibrated to a 100-foot measuring tape, or a Global Positioning System (GPS) for each stratified sampling area.

3. The transect line is laid out utilizing a tape measure. A predetermined length from 10 to 50 feet is laid out in a predetermined compass direction. The compass direction must be the same for all sample points in each stratified sampling area. The transect length must remain constant for each stratified sample area.

4. The predetermined first hit transect length is measured on the tape measure laid out in step three. At a minimum this must be 1 foot in length. The pin is projected from the top of the vegetation at a 45° angle from the transect line. The projection side must remain constant for each stratified sample area. The first hit is recorded by plant species, bare ground or litter. Continue this process until the first hits have been collected and recorded for the entire transect.

5. Canopy cover will be measured and recorded at each first hit point by projecting an imaginary vertical line from the first hit point to the canopy cover intercepted or no canopy.

6. The total percent ground cover is calculated as follows:

$$TPGCT = \frac{TNSLFH}{TNFH} \times 100$$

TPGCT = Total Percent Ground Cover by Transect

TNSLFH = Total Number Species & Litter by First Hit

TNFH = Total Number of First Hits

7. Repeat steps two through six until the 15 or more transacts have been collected and analyzed for the stratified sample area. The following equation will then be used to determine sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{X^2 \times 0.1^2}$$

Nmin = The number of sample transacts required to meet the statistical confidence of the mean

t = Students t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the TPGCT

X = Mean of the TPGCT

0.1 = The precision required of the sample population mean

Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points, if the result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2 - 7 until the resultant is zero or a negative number.

Sample Number Test

Areas requiring more than 30 sample transect points must be further stratified. The stratified sampling area will have to be further stratified by plant vigor and sampling conducted within the stratified areas until sample adequacy is met.

8. The canopy cover is added together as a separate cover component as follows:

$$TCCT = \frac{TNCCFH}{TNFH} \times 100$$

TCCT = Total Canopy Cover by Transect

TNCCFH = Total Number Canopy Cover by First Hit

TNFH = Total Number of First Hits

When the total canopy cover by transect is greater than 50%, a portion of the canopy cover must be added to the total percent ground cover. The following table is used to determine the amount to add to the total percent ground cover.

| Percent Canopy Cover | Add Value |
|---|---|
| 50% or less | 0% |
| 51% to 60% | 5% |
| 61% to 70% | 10% |
| 71% to 80% | 15% |
| 81% to 90% | 20% |
| 91% to 100% | 25% |

9. The total percent ground cover for the stratified sampling area is calculated by the following equation:

$$TPGC = \frac{STPGCT}{TNST} (+ AV)$$

TPGC = Total Percent Ground Cover

STPGCT = The sum of the TPGCT's

TNST = Total Number of Sample Transects Taken

AV = Add Value from step 8. This value is added only when the TPGC is less than 100%. When the TPGC is less than 100%, the AV is added to increase the TPGC up to 100%.

10. The total percent ground cover value is the premine ground cover success standard. At a minimum the permittee must meet 90% of the total percent ground cover success standard, and control erosion.

11. A copy of the field data collection sheets, sample adequacy calculations, and total percent ground cover calculations will be included with all vegetation studies for each stratified sample area.

B. Postmine Ground Cover Sampling Criteria and Techniques

The ground cover measurements are utilized to determine if the permit areas qualify for revegetation bond release. For the land uses of Pastureland, Grazingland, Cropland and Prime Farmland Cropland, at the phase II revegetation bond release, the applicant must demonstrate successful revegetation establishment, as per K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40(c)(2). Successful revegetation establishment is attained when the revegetation success standards are achieved for one growing season in accordance with the requirements in K.A.R. 47-9-1(c)(38) and (42), adopting by reference 30 CFR 816.111(a) and (b), and

816.116(b); and K.A.R. 47-9-1(d)(35) and (38), adopting by reference 30 CFR 817.111 (a) and (b) and 817.116(b).

At the phase III revegetation bond release, the applicant must use the additional growing season data sets, which meet the success standards, in accordance with the requirements of K.A.R. 47-9-1(c)(42), adopting by reference 30 CFR 816.111(a) and (b), 816.116(b) and (c); and K.A.R. 47-9-1(d)(35), adopting by reference 30 CFR 817.111(a) and (b), 817.116(b) and (c), to demonstrate that the operator has completed successfully all surface coal mining and reclamation activities, as per K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40(c)(3).

The sampling techniques for measuring success shall use a 90 percent statistical confidence interval (i.e., a one-sided test with a 0.10 alpha error). The permittee must meet 90 percent of the premine ground cover success standard.

The point intercept technique of ground cover sampling has been discussed by many authors and is well documented and utilized (Chambers & Brown 1983). The point intercept technique is appropriate for collecting the postmine ground cover data on all land uses outlined here.

Postmine Ground Cover Sampling Criteria

1. The vegetation ground cover study must be divided into stratified sample areas. Stratification will be conducted based on vegetative ground cover diversity accounted for by traversing the study area. Areas lacking vegetative ground cover, having sparse vegetation and/or active erosion will not be included in the sample areas. Active erosion is defined by K.A.R. 47-9-1(c)(30), adopting by reference 30 CFR 816.95. All stratified sample areas must have vegetation that is either, permanent or self propagating, according to the approved permit before sampling can begin. The stratified sample area will have at a minimum one random sample point per five acres.

2. Each stratified sample area will have a minimum of 15 transects that are 10 to 50 feet in length, with first hit recording conducted on a minimum of one foot intervals. The overall first hit points for a stratified sample area must be a minimum of 150.

3. Report weather conditions (i.e., temperature, humidity, precipitation, wind, etc.). Sampling may only be conducted on calm days (i.e., 0-5 mph wind).

4. All sample pins are projected from a fixed point at a 45° angle from the transect line.

5. All sampling pins will be 0.10 - 0.20 of an inch in diameter and ground to a fine point on the sampling end.

6. All ground cover sampling will be conducted during the time frames specified by the following schedule:

a. Cool season grasses - April 1 to November 1

b. Native grasses - June 1 to November 1

**Note: These dates will be the only times of the year that the SMS will accept and evaluate revegetation data.**

Postmine Ground Cover Sampling Technique

1. Mark the starting corner of the stratified sample area with a large stake identifying the area number, or by GPS coordinates. This stake will remain until the data has been reviewed and field verified by the SMS.

2. Locate the random transect points for each stratified sample area. All random sampling points will be located in relation to the stake marked in step one. The locations of the sample points will be determined from a set of random coordinates. All sample point numbers are listed in relation to the specific coordinates reported with each stratified sample area. Field locating of the sample points will be conducted by the use of a measuring tape, pacing which has been calibrated to a 100-foot measuring tape for each stratified sampling area, or by GPS coordinates.

3. The transect line is laid out utilizing a tape measure. A predetermined length from 10 to 50 feet is laid out in a predetermined compass direction. The compass direction must be the same for all sample points in each stratified sampling area. The transect length must remain constant for each stratified sample area.

4. Only the current season's growth is sampled. If the area has not had the forage removed (mowing, baling, grazing, etc.) since the last sampling then sampling must not be conducted until the vegetation has been removed and regrowth has taken place.

5. The predetermined first hit transect length is measured on the tape measure laid out in step three. At a minimum this must be 1 foot in length. The pin is projected from the top of the vegetation at a 45° angle from the transect line. The projection side must remain constant for each stratified sample area. The first hit is recorded by plant species, bare ground or litter. Continue this process until the first hits have been collected and recorded for the entire transect.

6. The total acceptable percent ground cover is made up of the first hits on:

   a. Approved permanent grass species in the permit or approved permit amendments.

   b. A portion of other plant species allowed by land use as listed in Appendix A. For the purposes of the ground cover study, a portion is defined as:

(1) Up to 10 percent other approved grass species, counted as a percentage of the total cover,

(2) Up to 10 percent desirable annual/biennial forbs or legumes, counted on any transect.

c. Up to 10 percent litter on any transect as defined by volunteer plant species allowed by land use as listed in Appendix A.

d. Where Pastureland or Grazingland is being enhanced for wildlife based on species existing in the premine state, up to 5 percent of forb and legume species approved for wildlife only in Appendix A may be counted on any transect point.

The total acceptable percent ground cover by transect is calculated as follows:

$$TAPGCT = \frac{TNAGFH}{TNFH} \times 100$$

TAPGCT = Total Acceptable Percent Ground Cover by Transect

TNAGFH = Total Number of Acceptable Ground Cover data as First Hits

TNFH = Total Number of First Hits

7. Repeat steps two through six until enough transects have been collected and analyzed for the stratified sample area to achieve sample adequacy. The following equation will be used to determine sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{X^2 \times 0.1^2}$$

Nmin = The number of sample transects required to meet the statistical confidence of the mean

t = Students t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the TAPGCT

X = Mean of the TAPGCT

0.1 = The precision required of the sample population mean

## Sample Adequacy Test

Take the Nmin value minus the number of transect points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2 - 7 until the resultant is zero or a negative number.

## Sample Number Test

Areas requiring more than 30 sample transect points must be further stratified. The stratified sampling area will have to be further stratified by plant vigor and sampling conducted within the stratified areas until sample adequacy is met.

8. The total percent ground cover for the stratified sampling area is calculated by the following equation:

$$TPGC = \frac{STAPGCT}{TNST}$$

TPGC = Total Percent Ground Cover

STAPGCT = The sum of the TAPGCT's

TNST = Total number of sample transects taken

9. Data developed from ground cover measurements, in addition to a visual scan during the optimal growing season, will be used to determine if each stratified sample area meets the following criteria for the intended land use:

   a. Fish and Wildlife Habitat, Recreation, Shelter Belts, and Forest Products:
      The sample area must reflect a minimum of five grass species and three forb species in the approved plant list for the intended land use (Appendix A).

   b. Pastureland or Grazingland
      The sample area must reflect the establishment and persistence of the seeded species approved in the permit for the intended land use (Appendix A).

   c. Industrial, Commercial, Residential Land.
      If the area is not developed for residential use within two years of regrading, the land use designation must be changed. Otherwise, the sample area must reflect the establishment of the seeded species approved in the permit for the intended land use (Appendix A).

d. Prime Farmland and Cropland.

The sample area must reflect the establishment and persistence of the seeded species approved in the permit for the intended land use (Appendix A).

10. The total ground cover value for the stratified sample area, for the growing season sampled, will have met the ground cover success standards when:

a. the ground cover value is greater than or equal to 90% of the reference area ground cover value or technical ground cover success standards;

b. statistical sample adequacy has been achieved;

c. all general revegetation requirements have been met. Ground cover values less than the 90% of the reference area ground cover value or technical ground cover success standards will not be accepted for the purposes of bond release.

11. The permittee must additionally meet erosion control. The erosion control will be monitored through the SMS inspections. History of erosion in the inspection reports and field verification will determine the erosion control of the site. Active erosion will be grounds for bond release denial. The following values are offered as general guidance for erosion control based on percent slope and percent ground cover:

| % SLOPE | % GROUND COVER |
|---|---|
| 0 - 1% | 70% |
| 1 - 3% | 80% |
| 3 - 6% | 85% |
| 6 - 15% | 90% |
| 15 - 45% | > 90% |

**Note: Active erosion will be grounds for bond release denial.**

12. A copy of the field data collection sheets, sample adequacy calculations, and total percent ground cover calculations will be included with all vegetation studies for each stratified sample area. In addition to percent ground cover, data collected should reflect diversity, effectiveness, and permanence as per K.A.R. 47-9-1 (c)(39), adopting by reference 30 CFR 816.111, and more specifically defined in the definitions portion of this document.

## III. Production Success Standard-Forage

### A. Forage Productivity Standard Databases

Forage crops are common crops in Linn, Bourbon, Crawford, Cherokee, and Labette counties, as established in the county soil surveys. Forage production success standards are set utilizing the United States Department of Agriculture, Natural Resources Conservation Service, USDA-NRCS, crop yield databases. These databases have been available for years within the published county soil surveys and associated NRCS Technical Guide Notices. The best available source of county and soil mapping unit forage production data currently available can now be found in the NRCS Soil Data Mart which is located on their website at http://soildatamart.nrcs.usda.gov/.

Yield numbers in the Soil Data Mart are listed by county and soil mapping units. Where a yield number has not been established for a particular crop in a particular soil mapping unit, the operator may, in conjunction with the SMS and NRCS, establish a yield target based on the previously published county soil surveys, information from adjacent counties with similar soil types, or the USDA-NRCS database in Technical Guide Notice KS-145.

For native grass seed mixtures, the Rangeland Productivity database is used (See example in Appendix C). For tall fescue, the Nonirrigated Yields by Map Unit database is used (See example in Appendix C). These databases are used in all permanent program permits issued, midterm review updates, and renewed permits by the SMS. As part of the approved permit application package, the operator will be required to submit a printout of the yield data generated for the permit, including the date the information was accessed. There are no forage production standards for areas reclaimed without topsoil.

An alternative forage production success standard may be set utilizing a Reference Area as discussed in Appendix E.

#### 1. Productivity Standards for Prime Farmland Cropland Forage Crops

The permittee may use forage crops for up to two years of the three years required to grow crops for phase III bond release. Forage crops cannot be used for a phase II bond release as per K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40(c)(2). The permittee must meet 100% of the forage productivity standard in accordance with K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111(a) and(b), and 816.116(a); K.A.R. 47-9-1(d)(35) and (38), adopting by reference 30 CFR 817.111(a) and (b), and 817.116(a); and K.A.R. 47-9-1(f)(5), adopting by reference 30 CFR 823.15 (a) and (b).

#### 2. Productivity Standards for Cropland Forage Crops

The permittee may use forage crops for the two years required to grow crops for both Phase II and Phase III bond release if the premine cropping history was forage. However, if premine cropping was row crops, then a deep-rooted row crop must be used for Phase II productivity data. The permittee must meet 90% of the forage productivity standard in accordance with K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111(a) and (b), and 816.116 (b); and K.A.R. 47-9-1(d)(35) and (38), adopting by reference 30 CFR 817.111 (a) and (b)and 817.116

(b). At Phase III bond release, the operator must use the additional growing season data sets to demonstrate that all surface coal mining and reclamation activities have been successfully completed as per K.A.R. 47-8-9 (a)(13), adopting by reference 30 CFR 800.40 (c).

### 3. Productivity Standards for Pastureland & Grazingland

The forage productivity measurements for Pastureland and Grazingland are utilized to determine if the permit areas qualify for revegetation bond release. At the phase II and phase III revegetation bond release, the applicant must demonstrate successful revegetation establishment, as per K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40(c)(2) and (c)(3). At Phase II, successful revegetation establishment is attained when the revegetation success standards are achieved for one growing season in accordance with the requirements in K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111 (a) and (b), and 816.116(b) and (c); and K.A.R. 47-9-1(d)(35) and (38), adopting by reference 30 CFR 817.111(a) and (b), and 817.116(b) and (c).

At the phase III bond release, the applicant must use the additional growing season data set to demonstrate that all surface coal mining and reclamation activities have been successfully completed as per K.A.R. 47-8-9 (a)(13), adopting by reference 30 CFR 800.40(c)(3), and in accordance with K.A.R. 47-9-1(c)(42), adopting by reference 30 CFR 816.116(a)(2); and K.A.R. 47-9-1(d)(38), adopting by reference 30 CFR 817.116(a)(2), all areas must meet 90% of the success standard. The sampling techniques for measuring success shall use a 90 percent statistical confidence interval (i.e., a one-sided test with a 0.10 alpha error).

## B. Method of Calculation

The Animal Unit Month (A.U.M.) values listed in the NRCS Nonirrigated Yields by Map Unit database are converted to lbs./acre of dry forage per growing season. A conversion factor of 760 lbs. of dry forage per A.U.M. is used (Appendix B). The acreage within the permit area of the soil mapping units is accounted. Each soil mapping unit is given a weighted factor based on the total acreage of the soil, negatively determined prime soil, or prime soil mapping units. This factor is then multiplied by the forage production for that soil map unit. The summation of the results is the final productivity standard that the reclaimed land use must achieve for the revegetation requirements of bond release. The tables in Appendix B describe two methods of calculation for various forage production scenarios.

The A.U.M values listed as tall fescue are considered cool season grass production data applicable to all cool season grass seed mixtures. For native grasses, the Rangeland Productivity database is applicable to all native grass seed mixtures. The total dry weight production for a Normal Year will be set as the success standard for native grass seed mixtures.

The success standards for forage production are set in each permit for the designated land use. The quantities of fertilizer amendments must be determined by soil nutrient testing and recommendations based on the success standards for the forage yields to be achieved. The information on fertilizer rates must be supplied in the planting reports (Appendix D). When cool season grasses are planted, the spring and fall forage production results for the same growing season may be added together for meeting the forage production success standard.

The total forage production value for the stratified sample area, for the growing season sampled, will have met the forage production success standards when:

1. statistical sample adequacy has been achieved;

2. the forage production is greater than or equal to 90% (Pastureland, Grazingland, and Cropland), or 100% (Prime Farmland Cropland), of the reference area forage production or calculated forage production success standards; and

3. all general revegetation requirements have been met.

Forage production values less than 90% (Pastureland, Grazingland, and Cropland), or 100% (Prime Farmland Cropland) of the reference area forage production or calculated forage production success standards will not be accepted for the purposes of bond release.

## C. Methods for Data Collection

The permittee may choose to collect forage production data through a sampling program or through whole field harvest. If a sampling program is used, the permittee may choose to use representative areas with test plots, or to sample the entire area. When a representative area with test plots is chosen to assess forage productivity, the permittee must meet the definition and criteria in Appendix F - *Representative Sample Field Area Definition and Test Plot Criteria*. If the permittee plants the entire area into forage, then the entire area will be sampled by forage methods, and management will be validated on the entire reclaimed area. The sampling for both representative areas with test plots and entire areas will be conducted using the forage sampling criteria and techniques described here.

If a reference area is used (Appendix E), the reclaimed areas are sampled at the same time and in the same manner as the reference area. The reference area must be harvested as a separate entity. For this method to result in statistically valid and adequate data, the permittee will need to harvest the crop and reference area in a consistent manner.

### 1. Whole Field Harvest - Bale Sampling Methods:

A. Whole field harvest may be used to provide forage production data. If whole field harvest is selected as the sampling method, the SMS will require the following:

1. The SMS must be notified 14 days prior to beginning the harvest;

2. The SMS may require that a representative be present during the harvesting operation;

3. The permittee must weigh all hay bales from the area, and submit all signed scale tickets showing weight of each bale.

4. The total number of bales harvested from each area will be counted, field numbered and recorded with an accurate determination of the acreage harvested to calculate production on a per acre basis.

5. A statistically adequate number of hay bales (generally 10-15) must be sampled for moisture and adjusted to a 14% moisture condition prior to determining statistical adequacy of the sample. To select the bales to be sampled, a random number table will be used, with the number generated corresponding to the field number of the bale. The first and last bale of any noncontiguous field or site should not be weighed.

B. Or, the permittee may sample a statistically adequate sample of bales. This entails counting all bales produced on the harvested areas and multiplying this number by the average weight of a randomly selected number of bales. The number of bales to count and weigh for any site would consist of 10% or 15 bales, whichever is greater and convert this to lbs./acre by taking their average weight and multiplying that figure times the total number of bales, divided by the number of acres harvested. If this method is selected as the sampling method, the SMS will require the following:

1. The SMS must be notified 14 days prior to beginning the harvest;

2. The SMS may require that a representative be present during the harvesting operation;

3. When a hay field has been harvested and baled, count all of the bales and multiply this number by the average weight of a randomly selected number of bales.

4. The bales must be sampled for moisture and adjusted to a 14% moisture condition prior to determining statistical adequacy of the sample.

5. To determine which bales to weigh and sample for moisture, randomly select a number from one to ten, then count and weigh every tenth bale thereafter until the minimum number, or 10% of the bales have been weighed. The first and last bale of any noncontiguous field or site should not be weighed. The bales shall be counted, but if the random number falls on either of the two bales mentioned, then either advance one bale or select the immediate bale previous to the last bale produced.

The following equation will then be used to determine sample adequacy on either collection method.

$$Nmin = \frac{t^2 \times S^2}{X^2 \times 0.1^2}$$

Nmin = The number of sample bales required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of sampled bales

X = Mean weight of sampled bales

0.1 = The precision required of the sample population mean

Sample Adequacy Test

Take the Nmin value minus the number of bales sampled for the stratified sample. If the result is positive, take that number of additional sample bales. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2(c) - 2(e) until the resultant is zero or a negative number.

2. Sampling Program - Forage Production Study

The forage production study must be stratified into sampling areas. The stratification of the areas will be based on factors such as last augmented seeding, vegetation type, aspect, slope, erosion, and other factors which would account for sample variability. Areas lacking vegetative ground cover, having sparse vegetation and/or active erosion will not be included in the sampling areas. Active erosion is defined by K.A.R. 47-9-1(c)(30), adopting by reference 30 CFR 816.95. All sample areas must have permanent vegetation according to the approved permit before sampling can begin. Each operator is required to submit to the SMS, the plan for stratification prior to the initiation of sampling.

All forage production sampling will be conducted during the time frames specified by the following schedule:

a. Cool season grasses - April 1 to November 1

b. Native grasses - June 1 to November 1.

**Note: These dates will be the only times of the year that the SMS will accept and evaluate revegetation data.**

A minimum number of random sample points will be used to determine productivity for each stratified sample area. This will insure an adequate number of samples when dry weight sample adequacy determinations are conducted. Table 4 lists suggested minimum number of samples of forage per number of acres. However, sufficient samples must be taken to meet sample adequacy.

## Productivity Sampling Technique

1. Mark the starting corner of the stratified sampling area with a large stake identifying the stratified sample area, or with GPS coordinates. This stake will remain until the data has been reviewed and field verified by the SMS.

2. Locate the random sample points for each stratified sample area. All random sampling points will be located in relation to the stake marked in step one. The locations of the sample points will be determined from a set of random coordinates. All sample point numbers, used in the stratified sample area, are listed in relation to the specific coordinates which are reported with each stratified sample area. Field locating of the sample points will be conducted by the use of a measuring tape and/or pacing which has been calibrated to a 100-foot measuring tape for each stratified sampling area.

3. The sampling frame is placed on the ground at each of the random sampling points. The sample frame used for each sample plot area must be 0.96 $ft^2$ to 2.4 $ft^2$ in size. The frame size must remain constant for each stratified sample area. The forage on the edge of the frame must be moved in or out of the frame based on the basal position of the vegetation in question. Only the vegetation that has basal area originating from inside the frame is sampled.

4. Only the current season's growth is sampled. If the area has not had the forage removed (mowing, baling, grazing etc.) since the last sampling, then sampling must not be conducted until the vegetation has been removed and regrowth has taken place. Litter and other attached non green matter is not included in the sample. Only acceptable plant species allowed by land use as listed in Appendix A are included. Any unacceptable plant species must be discarded from the sample.

5. The acceptable forage within the sampling frame is then clipped using hand shears or clippers. All samples must be clipped between a minimum height of 1.5 inches and a maximum height of 3 inches from the ground surface.

6. Weigh the acceptable clipped forage to obtain a field weight to the nearest five grams (.01 lbs.). Record this data by the stratified sample area number and sample number. This wet weight will be used to determine field sample adequacy.

7. Store the acceptable forage for each sample in a suitable container. Permanently mark on the container the stratified sample area number and sample number.

8. Repeat steps two through seven for the 15 or more sample points for each stratified sampling area. The following equation will be used to determine field sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{X^2 \times 0.1^2}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the clipped forage

X = Mean weight of the clipped forage

0.1 = The precision required of the sample population mean

Field Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2 - 8 until the resultant is zero or a negative number.

9. The forage samples collected and marked in step seven are oven dried at 140° to 158° F until a constant dry weight is obtained. Weighing will be performed immediately after oven drying to avoid absorption of water from humid air. This constant dry weight will equal 0 percent moisture. All samples will be adjusted to 14 percent moisture based on the respective dry weights by the following equation:

CFW = DFW x 1.163

CFW = Corrected Forage Weight

DFW = Dry Forage Weight

10. The dry weights of all collected samples will be used to determine dry weight sample adequacy. The following equation will be used to determine dry weight sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{X^2 \times 0.1^2}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the dried forage

X = Mean weight of the dried forage

0.1 = The precision required of the sample population mean

Dry Weight Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then dry weight sample adequacy has been met. Repeat steps 2 - 10 until the resultant is zero or a negative number.

11. The CFW in grams is converted to pounds per acre of forage by using the following conversions:

| If Sample frame size is: | Multiply the gram weight by: | If Sample frame size is: | Multiply the gram weight by: |
|---|---|---|---|
| 0.96 $ft^2$ | 100.04 | 1.80 $ft^2$ | 53.35 |
| 1.00 $ft^2$ | 96.03 | 1.90 $ft^2$ | 50.54 |
| 1.10 $ft^2$ | 87.30 | 1.92 $ft^2$ | 50.02 |
| 1.20 $ft^2$ | 80.03 | 2.00 $ft^2$ | 48.02 |
| 1.30 $ft^2$ | 73.87 | 2.10 $ft^2$ | 45.73 |
| 1.40 $ft^2$ | 68.60 | 2.20 $ft^2$ | 43.65 |
| 1.50 $ft^2$ | 64.02 | 2.30 $ft^2$ | 41.75 |
| 1.60 $ft^2$ | 60.02 | 2.40 $ft^2$ | 40.01 |
| 1.70 $ft^2$ | 56.49 | | |

12. The total production for the stratified sampling area is calculated by the following equation:

$$TFP = \frac{SCCFW}{TNSP}$$

TFP = Total Forage Production

SCCFW = The sum of the converted CFW's

TNSP = Total number of sample points

13. Forage production values for prime farmland less than100% of the success standards will not be accepted for the purposes of bond release. Forage production values for cropland less than 90% of the success standards will not be accepted for the purposes of bond release.

**Note: Active erosion will be grounds for bond release denial.**

14. A copy of the field data collection sheets, sample adequacy calculations, and total forage production calculations will be included with all vegetation studies for each stratified sampling area.

## IV. Production Success Standard-Row Crops

The row crop productivity standards are based on the USDA-NRCS, crop yield databases. These databases have been available for years within the published county soil surveys and associated NRCS Technical Guide Notices. The best available source of county and soil mapping unit forage production data currently available can now be found on the NRCS website at http://soildatamart.nrcs.usda.gov/. Yields are listed by county and soil mapping units. Where a yield number has not been established for a particular crop in a particular soil mapping unit, in conjunction with the SMS, the operator may establish a yield target based on the previously published county soil surveys and the USDA-NRCS database in Technical Guide Notice KS-145. As part of the approved permit application package, the operator will be required to submit a printout of the yield data generated for the permit, including the date the information was accessed.

Adjustments of a crop yield, for prime farmland, as per K.A.R. 47-9-1(f)(5), adopting by reference 30 CFR 823.15(b)(8), will be made on a case by case basis by the SMS in consultation with the USDA-NRCS. Reference areas may be used for productivity standards if approved in the permit. See Appendix E for a discussion on 'Reference Areas'.

### A. Acceptable Row Crops for Productivity

The most common row crops grown in Linn, Bourbon, Crawford, Cherokee, and Labette counties are soybeans, grain sorghum (milo), corn, and wheat. This is based on historical data from the Kansas State Board of Agriculture - USDA Statistical Reporting Service Database.

The most common row crop requiring the greatest rooting depth cannot be practically determined on a state wide basis. The counties of Linn, Bourbon, Crawford, Cherokee and Labette consist of many types of cropland soils, including prime farmland. These soils, encountered on the economically recoverable coal seams, are mainly derived from weathered shales and alluvium. The texture commonly found in the soil surface layer is a silt loam with clay increasing to the subsurface which has a clay texture. The subsurface texture (clay) is a dominant factor in the productive capabilities of these soils. The most common row crops with the greatest rooting depths regardless of soil physical barriers are soybeans, corn, and grain sorghum (Grecu).

The land use of prime farmland means those lands which are defined by the Secretary of Agriculture in 7 CFR part 657.5 (a), and which have historically been used for cropland for any five years or more out of the ten years immediately preceding the acquisition.

The land use of cropland as described, as per K.A.R. 47-9-1(c)(42), adopting by reference 30 CFR 816.116(b)(2) must meet the requirements of crop production. The crop production on this land use may be row crops or forage crops in the premine state. The postmine requirements are dependent on the premine cropping land use history. If the area is historically used for row crops in the premine state, then the operator must use one year of row crops for the phase II revegetation bond release. The selection of the row crop and the analysis of production will be the same as for prime farmland cropland. The main difference between cropland and prime farmland cropland is that the operator must meet 90% of the success standard for cropland, rather than greater than or equal to the success standard, as for prime farmland. The other crop growing season may be a

forage crop. If the cropland is historically used for forage crop production in the premining state, then the revegetation bond release requirements will be forage crops for phase II and III revegetation bond release. For general purposes of revegetation bond release, a combination of all techniques and criteria, for both row crops and forage crops, will probably be utilized by the operator.

1. For prime farmland, the row crops of soybeans or grain sorghum must be utilized to achieve phase II bond release. The crops of wheat, grain sorghum, corn or soybeans may be utilized for the phase III bond release requirements, and two of the three required crop years may be forage crops. Corn may be used, but is not required as the deep-rooted crop due to the unpredictability of the weather patterns in southeast Kansas which greatly limit the frequency of corn production.

2. For cropland requiring row crops, soybeans or grain sorghum must be utilized to achieve phase II bond release. The crops of wheat, grain sorghum, corn or soybeans may be utilized for the phase III bond release, and one of the two required crop years may be a forage crop.

3. Waterways located in prime farmland cropland or cropland should be included as part of the sample area if the entire area is in forage and a sampling program is utilized. Waterways are not subject to production sampling when the remaining area is in row crop production. In all cases, waterways must meet the ground cover standards of the associated land use and the engineering design criteria under which they were constructed.

### B. Method of Row Crop Production Success Standard Calculation

The row crop standard is set for each permit based on the acreage of the prime farmland and cropland soil mapping units being cropped before mining. These acreages are used as weighting factors to develop overall standards. The tables in Appendix B describe two methods of calculation for various crop production scenarios.

### C. Row Crop Sampling Criteria

The permittee must utilize row crops planted in rows to prove row crop productivity. The row crop variety must be one of the most common utilized in the county as described in the previous year by the Kansas State Board of Agriculture. The quantities of fertilizer amendments must be determined by soil nutrient testing and recommendations for the row crop success standard to be achieved. This information must be supplied in the planting reports (Appendix D).

### D. Methods for Data Collection

The permittee may choose to use representative areas, with test plots, or whole field sampling, or whole field harvest to assess row crop productivity.

1. Representative Area Test Plots

When the permittee uses representative areas with row crop test plots, they must also assess the productivity and ground cover of the remaining farmland forage areas outside of the row crop test plots. The production data and ground cover data will be utilized to support that the permittee is managing the entire reclaimed permit areas under a high level of management and that the area will support a productive land use after row crop productivity has been proven in the test plots. The permittee must meet the definition and criteria in Appendix F 'Representative Sample Field Area Definitions and Test Plot Criteria'.

2. Whole Field Harvest

Whole field harvest may be used to provide row crop production data. The permittee may use the county standard as provided for by the NRCS. If a reference area is used, the reclaimed whole field is harvested at the same time and in the same manner as the reference area. The reference area must be harvested as a separate entity. For this method to result in statistically valid and statistically adequate data, the permittee will need to harvest the crop in a very consistent manner. If whole field harvest is selected as the sampling method, the SMS will require the following:

1. The whole field harvest must include the whole field and the entire reference area;

2. The SMS must be notified 14 days prior to beginning the harvest;

3. The SMS may require that a representative be present during the harvesting operation;

4. The grain production will be weighed on a scale licensed for trade. The moisture content will be determined by a licensed grain dealer and will be adjusted to the marketable condition weight of 13% moisture;

5. The foreign material content will be determined by a licensed grain dealer and the weight will be shrunk to marketable condition weight with a foreign material allowance of 1%;

6. The signed scale tickets showing weight and grade will be submitted;

7. There will be no allowances for harvest and handling loses;

8. The data will be recorded and submitted within 30 days of harvest.

9. The total row crop production value for the growing season will have been met when; the row crop production is greater than or equal to the reference area row crop production or calculated row crop production success

standards for prime farmland and greater than or equal to 90% of the success standard for cropland. Row crop production values less than the reference area row crop production or calculated row crop production success standards will not be accepted for the purposes of bond release of Prime Farmland and values less than 90% of the success standard will not be accepted for cropland.

E. Productivity Sampling Criteria for Prime Farmland Row Crops

The row crop productivity measurement for prime farmland cropland is utilized to determine if the permit areas qualify for revegetation bond release. At the phase II revegetation bond release, the applicant must demonstrate that soil productivity for prime farmlands has returned to the equivalent yield as the unmined land of the same soil type, in the surrounding area under equivalent management practices, as determined from the soil survey performed pursuant to section K.A.R. 47-9-1 (f), and K.S.A. 49-407 (c) of the Act in accordance with K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40(c)(2). The operator must equal or exceed the calculated row crop success standard, as per K.A.R. 47-9-1(f)(5), adopting by reference 30 CFR 823.15(b)(5). Row crops must be grown one out of the three required crop years as per K.A.R. 47-9-1(f)(5), adopting by reference 30 CFR 823.15(b)(3) and (6). This required year of row crops must meet the calculated row crop success standard, or meet or exceed a reference area, to obtain a phase II bond release as per K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40(c)(2).

At the phase III revegetation bond release, the applicant must use the required two additional growing season data sets. These three growing season data sets, may be averaged together to meet the success standards, as per the requirements of K.A.R. 47-9-1(f)(5), adopting by reference 30 CFR 823.15(b), to demonstrate that the operator has completed successfully all surface coal mining and reclamation activities, as per K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40(c)(3). A statistically valid sampling technique at a 90% or greater statistical confidence level shall be used as approved by the SMS in consultation with the USDA-NRCS.

F. Productivity Sampling Criteria for Cropland Row Crops

The row crop productivity measurement for cropland is utilized to determine if the permit areas qualify for revegetation bond release. At the phase II revegetation bond release, the applicant must demonstrate successful revegetation establishment, as per K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40(c)(2). Successful revegetation establishment is attained when the revegetation success standards for row crops are achieved for one growing season in accordance with the requirements in K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111 (a) and (b), and 816.116(b); and K.A.R. 47-9-1(d)(35) and (38), adopting by reference 30 CFR 817.111(a) and (b), and 817.116(b).

At the phase III revegetation bond release, the applicant must use the additional growing season data sets, which meet the success standards, in accordance with the requirements of K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111(a) and (b), 816.116(b) and 816.116(c); and K.A.R. 47-9-1(d)(35) and (38), adopting by reference 30 CFR 817.111(a) and (b), and 817.116(b) and (c), to demonstrate that the operator has completed successfully all surface coal mining and reclamation activities, as per K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR

800.40(c)(3). In accordance with K.A.R. 47-9-1(c)(42), adopting by reference 30 CFR 816.116(a)(2); and K.A.R. 47-9-1(d)(38), adopting by reference 30 CFR 817.116(a)(2), all areas must meet 90% of the success standard. The sampling techniques for measuring success shall use a 90 percent statistical confidence interval (i.e., a one-sided test with a 0.10 alpha error).

## G. Row Crop Sampling Techniques

The row crop sampling techniques for the crops of grain sorghum, wheat, soybeans and corn are described below. For each crop, the methodology used is applicable whether a field or a test plot is being sampled.

### Special Problems in Row Crop Sampling

It is possible that a sample point's coordinates will fall on areas within the test plot or field boundaries which were not planted to crops (i.e., grass waterways, roadways, etc.). When this occurs, do not use these coordinates as a sample point. Select a new random coordinate that can be sampled.

### Grain Sorghum (Milo) Sampling Technique - Test Plots and Whole Field Sampling

1. Mark the starting corner of the test plot or field to be sampled with a large stake identifying the test plot or field number. This stake will remain until the data has been reviewed and field verified by the SMS.

2. The SMS suggests a minimum number of 15 sample points be used to determine productivity for each test plot or field. More or less random sample points may be needed based upon the sample adequacy test for each test plot or field.

3. All random sampling points will be located in relation to the field or test plot stake marked in step one. The locations of the sample points will be determined from a set of random coordinates. The random coordinates will be listed in relation to the specific sample points. All random coordinates used will be reported with the study. Field locating of the sample points will be conducted by the use of a measuring tape, or GPS coordinates. Mark each sampling point with a stake or flag. Place the marker immediately adjacent to the sorghum plant closest to the toe of your shoe.

4. Measure on a perpendicular line from the closest marked sorghum plant to the plants located five rows from the marked row. The closest marked sorghum plant is contained in row one. Divide this measured distance by four to determine the average row width for this sample unit. Record this value, in feet, for each sample unit, as Average Row Width (ARW).

5. Starting from the closest sorghum plant previously marked measure 10 feet of the row and mark the closest sorghum plant at 10 feet or less. Always traverse the ten-foot segment in the same compass direction for each sample point.

6. Clip all the sorghum grain heads approximately ½ inches below the grain head in a uniform fashion within the marked 10 feet of row segment of each sample unit.

7. Weigh the clipped sorghum grain heads to obtain a field weight to the nearest five grams (.01 lbs.). Record this data by field number and sample number. This weight will be used to determine sample adequacy.

8. Store the clipped grain heads for each sample unit in a suitable container. Permanently mark on each container the field or test plot number, sample number, and field weight.

9. Repeat steps four through eight for each of the sample units. The following equation will be used to determine sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{x^2 \times 0.1^2}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the clipped grain heads

x = Mean weight of the clipped grain heads

0.1 = The precision required of the sample population mean

Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2-9 until the resultant is zero or a negative number.

10. When sample adequacy has been met and all samples have been collected and marked, then the grain will be thrashed for each sample unit. Immediately after the grain is thrashed and collected, it must be weighed to the nearest five grams (.01 lbs.) and then be measured for moisture content. Moisture must be determined using a standard agricultural grain moisture tester calibrated by a primary method (Appendix G).

11. Correct the measured grain weight to 13 percent moisture for each sample unit. This will be accomplished by the following equation:

$$CGW = \frac{(100 - MM)}{(100 - 13.0)} \times GW$$

CGW = Corrected Grain Weight

MM = Measured Moisture

GW = Grain Weight

12. Repeat steps two through 11 until corrected weight sample adequacy has been met. The following equation will be used to determine sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{x^2 \times 0.1^2}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Students t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the corrected grain weight

x = Mean weight of the corrected grain heads

0.1 = The precision required of the sample population mean

Corrected Weight Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2 - 12 until the resultant is zero or a negative number.

13. Use the following equation to determine sorghum grain production for each sample unit:

$$SUP = \frac{(CGW \times 0.002205 \text{ Lbs./Gram}) / 56 \text{ Lbs./Bushel}}{(10 \text{ ft.} \times ARW \text{ ft.}) / 43560 \text{ ft.}^2\text{/Acre}}$$

SUP = Sample Unit Production

CGW = Corrected Grain Weight

ARW = Average Row Width

14. The total production for the field or test plot is calculated by the following equation:

$$TP = \frac{TSUP}{TNSU}$$

TP = Total Production

TSUP = Total of all sample unit production

TNSU = Total number of sample units

15. The total row crop production value for the individual test plot or whole field area, for the growing season sampled, will have met the row crop production success standards when:

    a. the row crop production from the averaged test plots or the whole field area is greater than or equal to the reference area row crop production or calculated row crop production success standards for prime farmland and greater than or equal to 90% for cropland;

    b. statistical sample adequacy has been achieved; and

    c. all the sampling and analysis criteria have been met.

Row crop production values less than the reference area row crop production or calculated row crop production success standards will not be accepted for the purposes of bond release of prime farmland and values less than 90% will not be accepted for cropland.

Wheat Sampling Technique - Test Plots and Whole Field Sampling

1. Mark the starting corner of the test plot or field to be sampled with a large stake identifying the test plot or field number. This stake will remain until the data has been reviewed and field verified by the SMS.

2. The SMS suggests a minimum number of 15 sample points be used to determine productivity for each test plot or field. More or less random sample points may be needed based upon the sample adequacy test for each test plot or field.

3. All random sampling points will be located in relation to the field or test plot stake marked in step one. The locations of the sample points will be determined from a set of random coordinates. The random coordinates will be listed in relation to the specific sample points. All random coordinates used will be reported with the study. Field locating of the sample points will be conducted by the use of a measuring tape. Mark each sampling point with a stake or flag. Place the marker

immediately adjacent to the wheat plant closest to the toe of your shoe. Project a line perpendicular to the marked wheat row across the two adjacent rows on both sides of the marked row and mark the closest wheat plants to the projected line. This will be the five marked rows to be sampled.

4. Measure on a perpendicular line from the marked wheat plants of the five rows from last marked rows (row one to row five). Divide this measured distance by four to determine the average row width for this sample unit. Record this value, in feet for each sample unit, as Average Row Width (ARW).

5. Starting from the five marked wheat plants, measure five feet of the row and mark the closest wheat plant at 5 feet or less. Always traverse the 5-foot segment in the same compass direction for each row and sample point.

6. Clip all the wheat grain heads approximately ½ inches below the grain head in a uniform fashion within the marked 5 feet of the row segment for each of the five rows.

7. Weigh the clipped wheat grain heads to obtain a field weight to the nearest five grams (.01 lbs.). Record this data by field number and sample number. This weight will be used to determine sample adequacy.

8. Store the clipped grain heads for each sample unit in a suitable container. Permanently mark on each container the field or test plot number, sample number, and field weight.

9. Repeat steps four through eight for each of the sample units. The following equation will be used to determine sample adequacy:

$$Nmin = \frac{(t^2)\ (S^2)}{(x^2)\ (0.1^2)}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the clipped grain heads

x = Mean weight of the clipped grain heads

0.1 = The precision required of the sample population mean

## Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2 - 9 until the resultant is zero or a negative number.

10. When sample adequacy has been met and all samples have been collected and marked, then the grain will be thrashed for each sample unit. Immediately after the grain is thrashed and collected it must be weighed to the nearest five grams (.01 lbs.) and then be measured for moisture content. Moisture must be determined using a standard agricultural grain moisture tester calibrated by a primary method.

11. Correct the measured grain weight to 13 percent moisture for each sample unit. This will be accomplished by the following equation:

$$CGW = \frac{(100 - MM)}{(100 - 13.0)} \times GW$$

CGW = Corrected Grain Weight

MM = Measured Moisture

GW = Grain Weight

12. Repeat steps 2 through 11 until corrected weight sample adequacy has been met. The following equation will be used to determine sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{x^2 \times 0.1^2}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the corrected grain weight

x = Mean weight of the corrected grain heads

0.1 = The precision required of the sample population mean

Corrected Weight Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2 - 12 until the resultant is zero or a negative number.

13. Use the following equation to determine wheat grain production:

$$SUP = \frac{(CGW \times 0.002205 \text{ Lbs./Gram}) / 60 \text{ Lbs./Bushel}}{(25 \text{ ft.} \times ARW \text{ ft.}) / 43560 \text{ ft.}^2/\text{Acre}}$$

SUP = Sample Unit Production

GW = Corrected Grain Weight

ARW = Average Row Width

14. The total production for the field or test plot is calculated by the following equation:

$$TP = \frac{TSUP}{TNSU}$$

TP = Total Production

TSUP = Total of all sample unit production

TNSU = Total number of sample units

15. The total row crop production value for the individual test plots or whole field areas, for the growing season sampled, will have met the row crop production success standards when:

    a. the row crop production from the averaged test plots or the whole field area is greater than or equal to the reference area row crop production or calculated row crop production success standards for prime farmland and greater than or equal to 90% for cropland;

    b. statistical sample adequacy has been achieved; and

    c. all the sampling and analysis criteria have been met.

    Row crop production values less than the reference area row crop production or calculated row crop production success standards will not be accepted for the

purposes of bond release of prime farmland and values less than 90% will not be accepted for cropland.

Soybean Sampling Technique - Test Plots and Whole Field Sampling

1. Mark the starting corner of the test plot or field to be sampled with a large stake identifying the test plot or field number. This stake will remain until the data has been reviewed and field verified by the SMS.

2. The SMS suggests a minimum number of 15 sample points be used to determine productivity for each test plot or field. More or less random sample points may be needed based upon the sample adequacy test for each test plot or field.

3. All random sampling points will be located in relation to the field or test plot stake marked in step one. The locations of the sample points will be determined from a set of random coordinates. The random coordinates will be listed in relation to the specific sample points. All random coordinates used will be reported with the study. Field locating of the sample points will be conducted by the use of a measuring tape or GPS coordinates. Mark each sampling point with a stake or flag. Place the marker immediately adjacent to the soybean plant closest to the toe of your shoe. Project a line perpendicular to the marked soybean row across the two adjacent rows on both sides of the marked row and mark the closest soybean plants to the projected line. This will be the five marked rows to be sampled.

4. Measure on a perpendicular line from the marked soybean plants of the five rows from last marked row (row one to row five). Divide this measured distance by four to determine the average row width for this sample unit. Record this value, in feet, for each sample unit, as Average Row Width (ARW).

5. Starting from the five marked soybean plants measure five feet of the row and mark the closest soybean plant at 5 feet or less. Always traverse the 5-foot segment in the same compass direction for each row and sample point.

6. Collect all the soybean pods from within the marked 5-foot row segments for each of the five rows.

7. Weigh the soybean pods to obtain a field weight to the nearest five grams (.01 lbs.). Record this data by field number and sample number. This weight will be used to determine sample adequacy.

8. Store the soybean pods for each sample unit in a suitable container. Permanently mark on each container the field or test plot number, sample number, and field weight.

9. Repeat steps four through eight for each sample units. The following equation will be used to determine sample adequacy:

$$Nmin = \frac{(t^2)\,(S^2)}{(x^2)\,(0.1^2)}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the soybean pods

x = Mean weight of the collected soybean pods

0.1 = The precision required of the sample population mean

Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2 -9 until the resultant is zero or a negative number.

10. When sample adequacy has been met and all samples have been collected and marked, then the pods will be thrashed for each sample unit. Immediately after the pods are thrashed and beans collected, they must be weighed to the nearest five grams (.01 lbs.) and then be measured for moisture content. Moisture must be determined using a standard agricultural grain moisture tester calibrated by a primary method.

11. Correct the measured bean weight to 13 percent moisture for each sample unit. This will be accomplished by the following equation:

$$CGW = \frac{(100 - MM)}{(100 - 13.0)} \times GW$$

CGW = Corrected Grain Weight

MM = Measured Moisture

GW = Grain Weight

12. Repeat steps two through 11 until corrected weight sample adequacy has been met. The following equation will be used to determine sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{x^2 \times 0.1^2}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the corrected grain weight

x = Mean weight of the corrected grain heads

0.1 = The precision required of the sample population mean

Corrected Weight Sample Adequacy Test

Take the Nmin value minus the number of points. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then corrected sample adequacy has been met. Repeat steps 2 - 12 until the resultant is zero or a negative number.

13. Use the following equation to determine soybean production for each sample unit:

$$SUP = \frac{(CGW \times 0.002205 \text{ Lbs./Gram}) / 60 \text{ Lbs./Bushel}}{(25 \text{ ft.} \times ARW \text{ ft.}) / 43560 \text{ ft.}^2/\text{Acre}}$$

SUP = Sample Unit Production

CGW = Corrected Grain Weight

ARW = Average Row Width

14. The total production for the field or test plot is calculated by the following equation:

$$TP = \frac{TSUP}{TNSU}$$

TP = Total Production

TSUP = Total of all sample unit production

TNSU = Total number of sample units

15. The total row crop production value for the test plots or field area, for the growing season sampled, will have met the row crop production success standards when:

    a. the row crop production from the averaged test plots or the whole field area is greater than, or equal to, the reference area row crop production or calculated row crop production success standards for prime farmland and greater than, or equal to, 90% for cropland;

    b. statistical sample adequacy has been achieved; and

    c. all the sampling and analysis criteria have been met.

    Row crop production values less than the reference area row crop production or calculated row crop production success standards will not be accepted for the purposes of bond release of prime farmland and values less than 90% will not be accepted for cropland.

Corn Sampling Technique - Test Plots and Whole Field Sampling

1. Mark the starting corner of the test plot or field to be sampled with a large stake identifying the test plot or field number. This stake will remain until the data has been reviewed and field verified by the SMS.

2. The SMS suggests a minimum number of 15 sample points be used to determine productivity for each test plot or field. More or less random sample points may be needed based upon the sample adequacy test for each test plot or field.

3. All random sampling points will be located in relation to the field or test plot stake marked in step one. The locations of the sample points will be determined from a set of random coordinates. The random coordinates will be listed in relation to the specific sample points. All random coordinates used will be reported with the study. Field locating of the sample points will be conducted by the use of a measuring tape. Mark each sampling point with a stake or flag. Place the marker immediately adjacent to the corn plant closest to the toe of your shoe.

4. Measure on a perpendicular line from the closest marked corn plant to the plants located five rows from the marked row. The closest marked corn plant is contained in row one. Divide this measured distance by four to determine the average row width for this sample unit. Record this value, in feet, for each sample unit, as Average Row Width (ARW).

5. Starting from the closest corn plant previously marked measure 10 feet of the row and mark the closest corn plant at 10 feet or less. Always traverse the ten-foot segment in the same compass direction for each sample point.

6. Harvest corn ears (Note: an ear of corn is defined as a cob having at least one kernel) within the marked 10 feet of row segment of each sample unit. Husk the ears and snap the shank off as cleanly as possible.

7. Weigh the husked ears to obtain a field weight to the nearest five grams (.01 lbs.). Record this data be field number and sample number. This weight will be used to determine sample adequacy.

8. Store the husked ears for each sample unit in a suitable container. Permanently mark on each container the field or test plot number, sample number, and field weight.

9. Repeat steps four through eight for each of the sample units. The following equation will be used to determine sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{x^2 \times 0.1^2}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the husked ears

x = Mean weight of the husked ears

0.1 = The precision required of the sample populations mean

Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2-9 until the resultant is zero or a negative number.

10. When sample adequacy has been met and all samples have been collected and marked then the ears will be shelled for each sample unit. Immediately after the ears are shelled and collected the sample must be weighed to the nearest five grams (.01 lbs.) and then be measured for moisture content. Moisture must be determined using a standard agricultural grain moisture tester calibrated by a primary method (see Appendix G).

11. Correct the measured kernel weight to 13 percent moisture for each sample unit. This will be accomplished by the following equation:

$$CKW = \frac{(100 - MM)}{(100 - 13.0)} \times KW$$

CKW = Corrected Kernel Weight

MM = Measured Moisture

KW = Kernel Weight

12. Repeat steps two through 11 until corrected weight sample adequacy has been met. The following equation will be used to determine sample adequacy:

$$Nmin = \frac{t^2 \times S^2}{x^2 \times 0.1^2}$$

Nmin = The number of samples required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the corrected kernel weight

x = Mean weight of the corrected kernels

0.1 = The precision required of the sample population mean

Corrected Weight Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive, take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2 - 12 until the resultant is zero or a negative number.

13. Use the following equation to determine corn grain production for each sample unit:

$$SUP = \frac{(CKW \times 0.002205 \text{ Lbs./Gram}) / 56 \text{ Lbs./Bushel}}{(10 \text{ ft.} \times ARW \text{ ft.}) / 43560 \text{ ft.}^2/\text{Acre}}$$

SUP = Sample Unit Production

CKW = Corrected Kernel Weight

ARW = Average Row Width

14. The total production for the field or test plot is calculated by the following equation:

$$TP = \frac{TSUP}{TNSU}$$

TP = Total Production

TSUP = Total of all sample unit production

TNSU = Total number of sample units

15. The total row crop production value for the individual test plot or whole field area, for the growing season sampled, will have met the row crop production success standards when:

a. the row crop production from the averaged test plots or whole field area is greater than, or equal to, the reference area row crop production or calculated row crop production success standards for prime farmland and greater than, or equal to, 90% for cropland;

b. statistical sample adequacy has been achieved; and

c. all the sampling and analysis criteria have been met.

Row crop production values less than the reference area row crop production or calculated row crop production success standards will not be accepted for the purposes of bond release of prime farmland and values less than 90% will not be accepted for cropland.

## V. Stem Density

### A. Fish and Wildlife Habitat, Recreation, Shelter Belts, and Forest Products Land Uses

The success standards are developed in joint cooperation between the Kansas Department of Wildlife and Parks (KDWP), Farm Service Agency-Natural Resource Conservation Service (FSA-NRCS), Kansas State University - Forestry Extension (KSU), the Operator and the SMS. The Fish and Wildlife Habitat, Recreation, Shelter Belts, and Forest Products Reclamation plans are reviewed by the KDWP and the KSU State Forester. The review comments are addressed and considered before the final reclamation plans are approved. The final plans, on a permit specific basis, are approved by the appropriate state agencies responsible for the administration of forestry (KSU) and wildlife (KDWP). The final reclamation plan includes requirements such as minimum stocking and planting arrangements, the ground cover value needed to meet the approved postmining land use, plant species diversity ("in-kind replacement"), specific fish and wildlife shelter development, forestry goals, and specific plant species for food requirements. Evaluation of the approved reclamation plan, other than ground cover, will be stipulated in the approved permit on a permit specific basis.

### B. Productivity Success Standard

The productivity success is determined by the success of the trees and shrubs. The minimum stocking and planting arrangements of the trees and shrubs are evaluated in the field during the phase III bond release. At the phase III revegetation bond release, the applicant must demonstrate successful revegetation establishment, as per K.A.R. 47-8-9(a)(13), adopting by reference 30 CFR 800.40(c)(3); K.A.R. 47-9-1(c)(39) and (42), adopting by reference 30 CFR 816.111 and 816.116; and K.A.R. 47-9-1(d)(35) and (38), adopting by reference 30 CFR 817.111 and 817.116. The applicant must prove that the stem density is equal to at least 90 percent of the approved success rate, and at least 80 percent of the stems used to determine success have been in place for at least three years or 60 percent of the responsibility period. Stems counted in determining such success shall be healthy and have been in place for not less than two growing seasons.

### C. Productivity Sampling Criteria

The 100% counts of all plantings, or the 1/50 acre sampling circle, are utilized to determine if the permit areas qualify for revegetation bond release. The permittee must utilize those species approved in the permit and for the land use intended. The information must be supplied in the planting reports (see Appendix D).

### D. Stem Density Sampling Techniques

The Permittee will be required to utilize one of two sampling techniques: 100 percent count or 1/50 acre sampling circles. All data must be collected in a statistically valid manner. Where the stocking density for the permit has been set at less than 450 stems per acre and less than 10 acres, a 100% stem count is required. Where the stocking density exceeds 450 stems per acre on 10 acres or more, a 1/50 acre sampling circle may be used.

The sampling circle will be a round area, one-fiftieth (1/50) acre in size (16.7 feet in radius). The Permittee will establish a sampling circle at each of the randomly selected sampling points, such that the center of the sampling circle is the random point.

The stem density data are collected as follows:

1. The sampling circle may be drawn by attaching a 16.7 foot string to a stake fixed at the random point and then sweeping the end of the string (tightly stretched) in a circle around the stake;

2. All living trees and shrubs within each of the sampling circles are counted and recorded by species. Shrubs or trees rooted within the sampling circle are counted; those rooted outside of the sampling circle are not included in the sample. To count as living, the tree or shrub must be alive, healthy, and have been in place for the required time.

3. Continue sampling randomly selected points until sample adequacy is met. Individual sampling circle values summarized by species are used for statistical analysis.

4. The total stem density per acre is calculated as follows:

$$D = \frac{S}{N} \times 50$$

D = Total Stem Density per Acre

S = Total Number of Stems Counted

N = Total Number of Sample Points

5. Repeat steps one through four and use the following equation to determine when sample adequacy is met:

$$Nmin = \frac{t^2 \times S^2}{X^2 \times 0.1^2}$$

Nmin = The number of sample transects required to meet the statistical confidence of the mean

t = Student's t value for a one-sided 0.10 alpha with N - 1 degrees of freedom

S = Standard deviation of the D

X = Mean of the D

0.1 = The precision required of the sample population mean

Sample Adequacy Test

Take the Nmin value minus the number of points sampled for the stratified sample area. If the result is positive take that number of additional sample points. If this result is negative or equal to zero, then field sample adequacy has been met. Repeat steps 2 - 5 until the resultant is zero or a negative number.

6. Only trees and shrubs that are healthy and have been in place for not less than two growing seasons may be counted in determining stocking success. For phase III bond release, at a minimum the permittee must meet 90% of the approved standard for trees and shrub live stems and at least 80% of those stems must have been in place for three years.

E. Fish and Wildlife Habitat, Recreation, Shelter Belts, and Forest Products Land Uses - Previously Mined Land

For previously mined areas, reclaimed to these land uses, the operator must meet the premine ground cover success standards and at a minimum erosion control. All other specifications in the reclamation plans for these land uses will be reviewed through normal inspections and the bond release inspections. Evaluation of the approved reclamation plan, other than ground cover, will be stipulated in the approved permit on a permit specific basis for previously mined areas.

# APPENDIX A

## Plant Species List

Un-acceptable Plant Species For All Land Uses

**Note:** All plants species listed are acceptable for the fish and wildlife habitat land use except where indicated by (*).

| Scientific Name | Common Name |
|---|---|
| **EQUISETACEAE** | *Scouring Rush Family* |
| *Equisetum arvense* | Horsetail |
| *Equisetum* | Scouring rush |
| **ALISMATACEA** | *Waterplantain Family* |
| *Sagittaria latifolia* | Arrowhead |
| **TYPHACEAE** | *Cattail* |
| *Typha latifolia* | Cattail |
| **POTAMOGETONACEAE** | *Pondweed Family* |
| *Potamogeton spp* | Pondweeds |
| *Zannichellia palustris* | Pondweed |
| **LILIACEAE** | *Lily Family* |
| *Allium canadense* | Wild onion, meadow garlic |
| *Allium porrum* | Leek |
| *Allium vineale* | Wild onion, wild garlic |
| *Yucca glauca* | Yucca, soapweed |
| *Zygadenus nuttallii* | Zygadenus, death camas |
| **COMMELINACEAE** | *Dayflower Family* |
| *Commelina spp* | Dayflower |
| **UNCACEAE** | *Rush Family* |
| *Juncus torreyi* | Torrey rush |
| *Juncus macer* | Slender yardrush |
| **CYPERACEAE** | *Sedge Family* |
| *Carex gravida* | Heavy sedge |
| *Carex vulpinoidea* | Fox sedge |
| *Cyperus esculentus* | Yellow nutrush |
| *Eleocharis macrostachya* | Spikerush |
| **POACEAE** | *Grass Family* |
| *Aegilops cylindrica* | (*) Goatgrass |
| *Agropyron repens* | (*) Quackgrass-Noxious in KS |
| *Agrostis hyemalis* | (*) Ticklegrass |
| *Alopecurus carolinianus* | (*) Foxtail |
| *Andropogon virginicus* | (*) Broomsedge |
| *Aristida longiseta* | (*) Dogtown grass |

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|---|---|
| *Aristida oligantha* | (*) Prairie triple awn |
| *Bromus japonicus* | (*) Japanese bromegrass |
| *Bromus secalinus* | (*) Cheat |
| *Bromus tetorum* | (*) Downy bromegrass |
| *Cenchrus pauciflorus* | (*) Sandbur |
| *Chloris verticillata* | (*) Windmill grass |
| *Digitaria sanguinalis* | (*) Crabgrass |
| *Digitaria filiformis* | (*) Slender crabgrass |
| *Distichlis stricta* | (*) Saltgrass |
| *Echinochloa crugalli amd var* | (*) Barnyard grass |
| *Eleusine indica* | Goosegrass |
| *Elymus spp* | Wildrye |
| *Eragrostic cilianensis* | (*) Stinkgrass |
| *Eragrostic pectinacea* | (*) Pursh lovegrass |
| *Eragrostic spectabilis* | Purple lovegrass |
| *Eriochloa contracta* | Prairie cupgrass |
| *Hordeum jubatum* | Squirreltail grass |
| *Hordeum pusilum* | (*) Little barley |
| *Muhlenbergia mexicana* | Wirestem muhly |
| *Muhlenbergia racemosa* | Marsh muhly |
| *Muhlenbergia sobolifera* | Muhly |
| *Muhlenbergia schreiberi* | Muhly |
| *Panicum capillare* | Witchgrass |
| *Panicum dichotomiflorum* | Fall panicum |
| *Paspalum stramineum* | Straw paspalum |
| *Poa annua* | (*) Annual bluegrass |
| *Setaria lutescens* | (*) Foxtail |
| *Setaria viridis* | (*) Foxtail |
| *Sitaion hystrix* | (*) Squirreltail |
| *Sorghum halepense* | (*) Johnsongrass-Noxious in KS |
| *Sporobolus neglectus* | Dropseed |
| *Stipa spartea* | (*) Porcupine grass |
| *Triodia flava* | False redtop |
| **RANUNCULACEAE** | *Buttercup or Crowfoot family* |
| *Ranunculus acris* | Tall buttercup |
| *Ranunculus sceleratus* | Cursed crowfoot |
| **MALVACEAE** | *Mallow family* |
| *Abutilon theophrasti* | (*) Velvetleaf |
| *Hibiscus trionum* | (*) Flower-or-the-hour |
| *Malva neglecta* | Mallow, cheeses |
| *Malva rotundifolia* | Cheeses |
| *Sida spionosa* | Prickly sida |
| **MORACEAE** | *Mulberry family* |
| *Cannabis sativa* | (*) Indian hemp, marihuana |

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|---|---|
| **URTICACEAE** | *Nettle family* |
| *Pilea pumila* | Clearweed |
| *Parietaria pennsylvania* | Pennsylvania pellitory |
| *Urtica procera* | Slender nettle |
| **GERANIACEAE** | *Geranium family* |
| *Erodium Cicutarium* | Alfilaria |
| *Geranium carolinianum* | Carolina cranesbill |
| **OXALIDACEAE** | *Oxalis family* |
| *Oxalis europaea* | Yellow wood sorrel |
| *Oxalis europaca bushii* | Bush yellow wood sorrel |
| *Oxalis stricta* | Wood sorrel |
| *Oxalis violacea* | Violet wood sorrel |
| **ZYGOPHYLLACEAE** | *Caltrop family* |
| *Tribulus terrestris* | (*) Puncture vine |
| **EUPHORBIACEAE** | *Spurge family* |
| *Acalypha gracilens* | 3-seeded mercury |
| *Acalypha ostrlyaefolia* | 3-seeded mercury |
| *Acalypha virginica* | 3-seeded mercury |
| *Croton capitatus* | (*) Woolly croton |
| *Croton monanthogynus* | (*) Croton |
| *Croton texensis* | (*) Texas croton |
| *Euphorbia corollata* | (*) Flowering spurge |
| *Euphorbia dentata* | (*) Toothed spurge |
| *Euphorbia escula* | (*) Leafy spurge-Noxious in KS |
| *Euphorbia glyptosperma* | (*) Mat spurge |
| *Euphorbia heterophylla* | (*) Spurge |
| *Euphorbia hexagona* | (*) Spurge |
| *Euphorbia hyssopifolia (E. Proslii)* | (*) Upright spurge |
| *Euphorbia lucida* | (*) Spurge |
| *Euphorbia maculata* | (*) Spotted spurge |
| *Euphorbia marginata* | (*) Snow-on-the-mountain |
| *Euphorbia serpens* | (*) Spurge |
| *Euphorbia stictospora* | (*) Mat spurge |
| **VIOLACEAE** | *Violet family* |
| *Viola rafinesquii* | Johnny-jump-up |
| **PAPAVERACEAE** | *Poppy family* |
| *Argemone intermedia* | (*) Prickly poppy |
| *Corydalis aurea occidentalis* | Corydalis |
| **CAPPARIDACEAE** | *Caper family* |
| *Cleome serrulata* | Rocky mountain bee plant |
| *Polanisia trachysperma* | Clammyweed |

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|---|---|
| **BRASSICACEAE** | *Mustard family* |
| *Alliaria officinalis* | Garlic mustard |
| *Barbarea vulgaris* | (*) Winter cress |
| *Berteroa incana* | (*) Hoary alyssum |
| *Brassica campestris* | (*) Rutabaga |
| *Brassica juncea* | (*) Indian mustard |
| *Brassica kaber (B. aravensis)* | Charlock |
| *Brassica nigra* | Black mustard |
| *Camelina microcarpa* | False flax |
| *Capsella bursapastoris* | Shepards purse |
| *Conringia orientalis* | Hare's-ear mustard |
| *Descurainia intermedia* | (*) Tansy mustard |
| *Descurainia sophia* | Flixweed |
| *Erysium asperum* | Wallflower |
| *Erysium repandum* | Treacie mustard |
| *Hesperis matronalis* | Dame's rocket |
| *Lepidium campestre* | Field peppergrass |
| *Lepidium densiflorum* | Peppergrass |
| *Lepidium draba* | (*) Hoary cress-Noxious in KS |
| *Lepidium perfoliatum* | Clasping-leaved peppergrass |
| *Lepidium ramosissimum* | Bushy peppergrass |
| *Lepidium virginianum* | Peppergrass |
| *Rorippa sessiliflora* | Yellow cress |
| *Rorippa sinuata* | Yellow cress |
| *Sisymbrium altissimum* | Hedge mustard |
| *Sisymbrium officinale* | Hedge mustard |
| *Thlaspi arvense* | Pennycress |
| **CARYOPHYLLACEAE** | *Pink family* |
| *Agrostemma githago* | (*) Corn cockle |
| *Cerastium vulgatum* | Mouse-ear chickweed |
| *Saponaria officinalis* | Soapwort, Bouncing bet |
| *Silene antirrhina* | Sleepy catchfly |
| *Silene noctiflora* | Nightflowering catchfly |
| *Stellaria media* | Chickweed |
| *Vaccaria vulgaris* | Cowcockle |
| **PORTULCACEAE** | *Portulaca family* |
| *Portulaca oleracea* | (*) Purslane, pursely |
| **AIZOACEAE** | *Carpetweed family* |
| *Mollugo verticillata* | Carpetweed |
| **PHYTOLACCACEAE** | *Pokeweed family* |
| *Phytolacca decandra* | Pokeweed |
| **AMARANTHACEAE** | *Amaranth family* |
| *Acnida tamariscina* | Water hemp |

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|---|---|
| *Amaranthus bhtoides* | (*) Prostrate pigweed |
| *Amaranthus graecizans* | (*) Tumblweed |
| *Amaranthus hybridus* | (*) Green amaranth |
| *Amaranthus retroflexus* | (*) Green pigweed, redroot |
| *Amaranthus spinosus* | Spiny amaranth |
| *Froelichia campestris* | Froelichia |
| *Froelichia gracilie* | Froelichia |
| *Tidestromia lanuginosa* | None |
| | |
| **CHENOPODIACEAE** | *Goosefoot family* |
| *Atriplex argentea* | Saltbush, Orache |
| *Atriplex hastata* | Saltbush, Orache |
| *Chenopodium album* | (*) Lamb's quarters |
| *Chenopodium ambrosioides* | Mexican tea |
| *Chenopodium boscianum* | Goosefoot |
| *Chenopodium gigantospermum* | Maple-leaved goosefoot |
| *Chenopodium leptophyllum* | Narrow-leaved goosefoot |
| *Corispermum hyssopifolium* | Bugseed |
| *Cycloloma atriplicifolium* | (*) Winged pigweed |
| *Kochia scoparia* | Mexican fireweed, burning bush |
| *Monolepis nuttalliana* | (*) Poverty weed |
| *Salsola pestifer* | (*) Russian thistle |
| | |
| **POLYGONACEAE** | *Smartweed Family* |
| *Eriogonum annuum* | Annual eriogonum |
| *Polygonum aviculare* | Prostrat knotweed |
| *Polygonum aviculare angustissimum* | Knotweed |
| *Polygonum buxiforme* | Knotweed |
| *Polygonum coccineum pratincolum* | Swamp smartweed |
| *Polygonum convolvulus* | Wild buckwheat |
| *Polygonum erectum* | Erect knotweed |
| *Polygonum hydropiper* | Water pepper |
| *Polygonum hydropiperoides* | Mild water pepper |
| *Polygonum lapathifolium* | Pale Smartweed |
| *Polygonum longistylum* | Longstyled smartweed |
| *Polygonum pennsylvanicum* | Pennsylvania smartweed |
| *Polygonum persicaria* | Lady's smartweed |
| *Polygonum punctatum* | Water smartweed |
| *Polygonum ramosissimum* | Tall knotweed |
| *Polygonum scandens* | Climbing false buckwheat |
| *Rumex acetosella* | (*) Sheep sorrel dock |
| *Rumex altissimus* | (*) Tall or pale dock |
| *Rumex crispus* | (*) Curly dock |
| *Rumex obtusifolius* | (*) Broad-leaved dock |
| *Rumex patientia* | (*) Patience dock |
| *Rumex venosus* | (*) Veined dock |

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|---|---|
| **NYCTAGINACEAE** | *Four-o'clock family* |
| *Mirabilis lineuris* | Wild four-o'clock |
| *Mirabilis nyctaginea and var* | Wild four-o'clock |
| | |
| **PLANTAGINACEAE** | *Plantain family* |
| *Plantago aristata* | (*) Bracted plantain |
| *Plantago lanceolata* | (*) Ribbed or buckhorn plantain |
| *Plantago major* | English plantain |
| *Plantago purshii* | Pursh or woolly plantain |
| *Plantago rugelii* | Rugel plantain |
| *Plantago virginica* | Virginia plantain |
| *Plantago rhodosperma* | Red-seeded plantain |
| | |
| **CONVOLVULACEAE** | *Morning glory family* |
| *Convolvulus sepium* | (*) Hedge bindweed |
| *Convolvulus arvensis* | (*) Field bindweed-Noxious in KS |
| *Convolvulus interior* | (*) Hairy bindweed |
| *Convolvulus japonicus* | (*) Japanese morning-glory |
| *Cuscuta pentagona* | Dodder |
| *Cuscuta polygonorum* | Dodder |
| *Ipomoea hederacea* | Ivy-leaved morning-glory |
| *Ipomoea leptophylla* | Bush morning-glory |
| *Ipomoea pandurata* | (*) Wild potato vine |
| *Ipomoea purpurea* | Wild morning-glory |
| *Quamoclit coccinea* | Red morning-glory |
| | |
| **HYDROPHYLLACEAE** | *Waterleaf family* |
| *Ellisia nyctelea* | Ellisia |
| | |
| **BORAGINACEAE** | *Borage family* |
| *Cynoglossum officinale* | Houndstung |
| *Echium vulgare* | Vipers bugloss |
| *Heliotropium convolvulaceum* | Wild heliotrope |
| *Lappula echinata* | Sticktight |
| *Lappula occidentalis* | Western stickseed |
| *Lappula virginiana* | Virginia stickseed, beggar-lice |
| *Lithospermum arvense* | Field gromwell |
| | |
| **SOLANACEAE** | *Potato or Nightshade family* |
| *Chamaesaracha conioides* | Chamaesaracha |
| *Datura stramonium* | (*) Jimson weed |
| *Lycium halimifolium* | Matrimony vine |
| *Physalis heterophylla* | (*) Clammy ground cherry |
| *Physalis lanceolata* | Prairie ground cherry |
| *Physalis longifolia* | Ground cherry |
| *Physalis macrophysa* | Ground cherry |
| *Physalis pumila* | Low ground cherry |
| *Physalis rotundata* | Ground cherry |

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|---|---|
| *Physalis subglabrata* | Ground cherry |
| *Physalis virginiana* | Ground cherry |
| *Quincula lobata* | Ground cherry |
| *Solanum carolinense* | (*) Carolina nightshade |
| *Solanum elaeagnifolium* | (*) Silverleaf nightshade |
| *Solanum nigrum and var. Interius* | (*) Black or garden nightshade |
| *Solanum rostratum* | (*) Prickly nightshade (*) buffalo bur |
| *Solanum triflorum* | (*) Cutleaf nightshade |
| **APOCYNACEAE** | *Dogbane Family* |
| *Apocynum cannabinum* | (*) Dogbane, Indian Hemp |
| *Apocynum sibiricum* | (*) Dogbane |
| **ASCLEPIADACEAE** | *Milkweed Family* |
| *Asclepias pumila* | Low narrow-leaved milkweed |
| *Asclepias speciosa* | Showy milkweed |
| *Asclepias syriaca and kansana* | Common milkweed |
| *Asclepias tuberosa* | Orange milkweed, pleurisy root |
| *Asclepias verticillata* | Eastern narrow-leaved milkweed |
| *Asclepiodora viridis* | Green milkweed |
| *Gonolobus laevis* | Climbing milkweed |
| **SCROPHULARIACEAE** | *Figwort family* |
| *Leucospora multifida* | Leucospora |
| *Linaria vulgaris* | Butter-and-eggs |
| *Verbascum blattaria* | (*) Moth mullein |
| *Verbascum thapsus* | (*) Mullein |
| *Veronica arvensis* | Cord speedwell |
| *Veronica peregrina* | Common or purslane speedwell |
| *Veronica peregrina xalapensis* | Common or purslane speedwell |
| **BIGNONIACEAE** | *Bignonia or Trumpet Creeper family* |
| *Campsis radicans* | (*) Trumpet creeper |
| **MARTYNIACEAE** | *Unicorn Plant Family* |
| *Martynia louisianica* | Devil's claw |
| **VERRENACEAE** | *Verbena Family* |
| *Lippia cuneifolia* | Fogfruit |
| *Lippia lanceolata* | Fogfruit |
| *Verbena bipinnatifida* | Verbena |
| *Verbena bracteata* | Spreading or bracted verbena |
| *Verbena hastata* | Blue verbena |
| *Verbena simplex* | Narrow-leaved verbena |
| *Verbena stricta* | Hoary verbena |
| *Verbena urticifolia* | Nettle-leaved verbena |

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|---|---|
| **LAMIACEAE** | *Mint family* |
| *Lamium amplexicaule* | Henbit, dead nettle |
| *Leonurus cardiaca* | Motherwort |
| *Marrubium vulgare* | Horehound |
| *Monarda mollis* | Wild bergamot |
| *Nepeta cataria* | Catnep, catnip |
| *Nepeta hederacea parviflora* | Ground ivy |
| *Salvia reflexa* | Small-flowered sage |
| **ROSACEAE** | *Rose family* |
| *Potentilla norvegica hirsuta* | Norwegian cinquefoil |
| *Potentilla simplex* | Cinquefoil |
| *Rosa suffulta* | Wild or prairie rose |
| **MIMOSACEAE** | *Mimosa family* |
| *Schrankia uncinata* | Sensitive brier |
| *Desmanthus illinoensis* | Prairie mimosa |
| **CASSIACEAE** | *Cassia family* |
| *Cassia chamaecrista var. chamaecrista fasciculata* | Partridge pea, wild senna |
| *Cassia nictitans* | Sensitive pea |
| **FABACEAE** | *Pea or Bean family* |
| *Amorpha canescens* | Leadplant |
| *Astragalus mollissimus* | (*) Woolly or stemmed loco |
| *Baptisia minor* | Wild indigo |
| *Baptisia leucantha* | Wild indigo |
| *Baptisia leucophaca* | Wild indigo |
| *Crotalaria sagittalis* | Rattlebox |
| *Dalea enneandra* | Dalea |
| *Desmodium illinoense* | Tick-trefoil |
| *Glycyrrhiza lepidota* | Wild licorice |
| *Lotus americanus* | Prairie bird's foot trefoil |
| *Medicago lupulina* | Noensuch, black medic |
| *Melilotus alba* | (*) White sweet clover |
| *Melilotus officinalis* | (*) Yellow sweet clover |
| *Oxytropos lambertii* | (*) Stemless loco |
| *Psoralea argophylla* | Silvery psoralea |
| *Psoralea tenuiflora, var. floribunda* | Psoralea, wild alfalfa |
| *Strophostyles helvola* | Pea vine |
| *Strophostyles leiosperma* | Wild pea or bean vine |
| **OENOTHERACEAE** | *Evening Primrose family* |
| *Gaura biennis pitcheri* | Biennial gaura |
| *Gaura coccinea* | Scarlet gaura |
| *Gaura parviflora* | Velvety gaura |
| *Oenothera biennis* | Evening primrose |
| *Oenothera speciosa* | Evening primrose |

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|---|---|
| *Oenothera strigosa* | Evening primrose |
| *Stenosiphon linifolius* | Stenosiphon |
| | |
| **CACTACEAE** | *Cactus family* |
| *Opuntia* | Prickly pear |
| | |
| **LOASACEAE** | *Loasa family* |
| *Mentzelia decapetala* | Sand lily |
| *Mentzelia oligisperma* | Stickleaf |
| *Mentzelia stricta* | Sand lily |
| | |
| **CUCURBITACEAE** | *Gourd family* |
| *Cucurbita foetidissima* | Wild pumpkin, gourdvine |
| *Echinocystis lobata* | Wild cucumber |
| *Sicyos angulatus* | (*) Bur cucumber |
| | |
| **RHAMNACEAE** | *Buckthorn family* |
| *Ceanothus ovatus* | New jersey tea |
| | |
| **ANACARDIACEAE** | *Sumac family* |
| *Rhus copallina* | Dwarf sumac |
| *Rhus glabra* | Smooth sumac |
| *Rhus toxicodendron and var.* | (*) Poison ivy |
| | |
| **AMMIACEAE** | *Carrot family* |
| *Chaerophyllum procumbens* | Chervil |
| *Cicuta manculata* | Cieuta |
| *Conium maculatum* | Poison hemlock |
| *Daucus carota* | Wild carrot, Queen Anne's lace |
| *Falcaria vulgaris* | Falcaria |
| *Pastinaca sativa* | Wild parsnip |
| *Zizia aurea* | Golden Alexanders |
| | |
| **RABIACEAE** | *Madder family* |
| *Diodea teres* | Buttonweed |
| *Galium aparine* | Cleavers, bedstraw |
| | |
| **CAPRIFOLIACEAE** | *Honeysuckle family* |
| *Sambucus canadensis* | Elderberry |
| *Symphoricarpos occidentalis* | Snowberry |
| *Symphoricarpos orbiculatus* | Coralberry, buckbrush |
| | |
| **CAMPANULACEAE** | *Bellflower family* |
| *Specularia perfoliata* | Venus'-looking glass |
| *Specularia leptocarpa* | Venus'-looking glass |
| | |
| **COMPOSITAE** | *Composite Family* |
| *Bidens bipinnata* | Spanish needles |

| | |
|---|---|
| *Bidens frondosa* | Beggar-ticks |
| *Bidens involucrata* | Tickseed |
| *Bidens vulgata* | Beggar ticks |
| *Coreopsis tinctoria* | Coreopsis |
| *Eclipta alba* | Yerba de Tajo |
| *Galinsoga aristulata* | Galinsoga |
| *Helianthus annuus* | Common sunflower |
| *Helianthus ciliaris* | Texas blueweed |
| *Helianthus grosseserratus* | Large-toothed sunflower |
| *Helianthus petiolaris* | Plains sunflower |
| *Helianthus salicifolius* | Willow-leaved sunflower |
| *Helianthus tuberosus* | Jerusalem artichoke |
| *Parthenium hysterophorus* | Santa Maria |
| *Rudbeckia hirta* | Black-eyed Susan |
| *Rudbeckia laciniata* | Goldenglow |
| *Ximenesia encelioides* | Golden crownbeard |
| *Ambrosia bidentata* | Ragweed |
| *Ambrosia elatior* | Ragweed |
| *Ambrosia trifida* | Giant ragweed |
| *Franseria tomentosa* | (*)Bur ragweed |
| *Ambrosia grayii* | (*)Bur ragweed-Noxious in KS |
| *Iva ciliata* | Marsh elder |
| *Xanthium italicum* | (*) Cocklebur |
| *Xanthium pennsylvanicum* | (*) Cocklebur |
| *Xanthium chinense* | (*) Cocklebur |
| *Dyssodia papposa* | Fetid marigold |
| *Helenium tenuifolium* | Sneezeweed, bitterweed |
| *Gaillardia pulchella* | Blanketflower |
| *Gaillardia* | Indian blanketflower |
| *Gnaphalium obtusifolium* | Cudweed, fragrant everlasting |
| *Amphiachyris dracunculoides* | Broomweed |
| *Aster ericoides (multiflorus)* | Whiteheath aster |
| *Erigeron annuus* | (*) Annual fleabane |
| *Erigeron canadensis* | (*) Horseweed, Mare's |
| *Erigeron divaricatus* | Western fleabane |
| *Erigeron ramosus* | (*) Daisy fleabane |
| *Erigeron philadelphicus* | (*) Daisy fleabane |
| *Gutierrezia sarothrae* | Gutierrezia |
| *Heterotheca subaxillaris* | Heterotheca |
| *Grindelia squarrosa* | Gumweed, broomweed |
| *Iva xanthifolia* | Burweed march elder |
| *Machaeranthera tanacetifolia* | Tansy aster |
| *Prionopsis ciliata* | Prionopsis |
| *Solidago canadensis and var* | Goldenrod |
| *Solidago glaberrima* | Missouri goldenrod |
| *Solidago rigida* | Stiff-leaf goldenrod |
| *Solidago serotina* | Late-flowering goldenrod |
| *Vernonia fasciculata* | Ironweed |

| | |
|---|---|
| *Eupatorium altissimum* | Thoroughwort |
| *Eupatorium rugosum* | White snakeroot |
| *Kuhnia hitchcockii* | False boneset |
| *Kuhnia suaveolens* | False boneset |
| *Liatris punctata* | Blazing star |
| *Achillea millefolium* | Yarrow |
| *Achillea lanulosa* | Western yarrow |
| *Anthemis cotula* | Mayweed, dog fennel |
| *Artemisia vulgaris vars. ludoviciana, gnaphalodes* | Sage, mugwort |
| *Chrysanthemum leucanthemum* | Oxeye daisy |
| *Senecio plattensus* | Ragwort |
| *Senecio riddellii* | Riddell ragwort |
| *Centaurea picris* | (*) Russian knapweed-Noxious in KS |
| *Centaurea solstitialis* | (*) Barnaby's thistle |
| *Cirsium altissimum* | (*) Tall, field or pasture thistle |
| *Cirsium arvense* | (*) Canada thistle-Noxious in KS |
| *Cirsium lanceolatum* | (*) Bull thistle |
| *Arctium minus* | (*) Burdock |
| *Cirsium ochrocentrum* | (*) Yellow-spine thistle |
| *Cirsium undulatum* | (*) Wavy-leaved thistle |
| *Onopordum acanthium* | (*) Scotch thistle |
| *Lactuca canadensis* | (*) Canada wild lettuce |
| *Lactuca ludoviciana* | (*) Western wild lettuce |
| *Lactuca pulchella* | (*) Wild blue lettuce |
| *Lactuca scariola* | (*) Prickly lettuce |
| *Lygodesmia juncea* | Skeleton weed |
| *Pyrrhopappus carolinianus* | False dandelion |
| *Pyrrhopappus grandiflorus* | False dandelion |
| *Sonchus asper* | (*) Sow thistle |
| *Sonchus oleraceus* | (*) Sow thistle |
| *Taraxacum laevigatum* | Red-fruited dandelion |
| *Taraxacum vulgare* | Dandelion |
| *Tragopogon porrifolius* | Purple salsify, or goatsbeard |
| *Tragopogon pratensis* | Yellow salsify, or goatsbeard |

**Additional Noxious Weeds:**

| | |
|---|---|
| *Pueraria lobata* | (*) Kudzu |
| *Hoffmannseggia densiflora* | (*) Pignut |
| *Carduus nutans* | (*) Musk thistle |
| *Lespedeza cuneata* | (*) Sericea lespedeza |

Acceptable Tree Species for Fish and Wildlife Habitat
Recreation, Shelter Belts, and Forest Products Land Uses

| Scientific Name | Common Name |
|---|---|
| *Ginkgo biloba* | Ginkgo |
| *Pinus strobus* | White pine |
| *Pinus resinosa* | Red pine |
| *Pinus taeda* | Loblolly pine |
| *Pinus banksiana* | Jack pine |
| *Pinus nigra* | Austrian pine |
| *Pinus sylvestris* | Scotch pine |
| *Pinus ponderosa* | Ponderosa pine |
| *Pinus rigida* | Pitch pine |
| *Pinus virginiana* | Virginia pine |
| *Pinus echinata* | Shortleaf pine |
| *Picea abies* | Norway spruce |
| *Picea glauca* | White spruce |
| *Picea pungens* | Blue spruce |
| *Pseudotsuga taxifolia* | Douglas fir |
| *Juniperus virginiana* | Easter red cedar |
| *Taxodium distichum* | Bald cypress |
| *Liriodendron tulipifera* | Tulip tree |
| *Asimina triloba* | Pawpaw |
| *Sassagras albidum* | Sassafras |
| *Populus alba* | Silver poplar |
| *Populus nigra var. Italica* | Lombardy poplar |
| *Populus canaensis* | Carolina poplar |
| *Populus sargentii* | Plains cottonwood |
| *Populus deltoides* | Cottonwood |
| *Populus tremuloides* | Quaking aspen |
| *Celtis occidentalis* | Hackberry |
| *Celtis laevigata* | Sugarberry |
| *Celtis tenuifolia* | Dwarf hackberry |
| *Celtis reticulata* | Netleaf hackberry |
| *Corylus americana* | Hazelnut |
| *Ptelea trifoliata* | Hop tree |
| *Staphylea trifolia* | Bladdernut |
| *Rhamnus lancelata* | Buckthorn |
| *Ulmus rubra* | Slippery elm |
| *Ulmus americana* | American elm |
| *Ulmus thomasi* | Rock or Cork elm |
| *Ulmus pulmila* | Siberian elm |
| *Ulmus alta* | Winged elm |
| *Maclura pomifera* | Osage orange |
| *Morus rubra* | Red mulberry |
| *Morus alba* | White mulberry |
| *Zanthoxylum americanum* | Prickly ash |
| *Ailanthus alitissina* | Tree of heaven |

| Scientific Name | Common Name |
|---|---|
| *Fraxinus americana* | White ash |
| *Fraxinus pennsylvanica var. pennsylvanica* | Red ash |
| *Fraxinus pennsylvanica var. Subintegerrima* | Green ash |
| *Fraxinus quadrangulata* | Blue ash |
| *Forestiera acuminata* | Swamp privet |
| *Tilia americana* | Basswood |
| *Bumelia lanuginosa* | Wooly buckthorn |
| *Diospyros virginiana* | Persimmon |
| *Paulowina tomentosa* | Empress tree |
| *Catalpa speciosa* | Hardy catalpa |
| *Catalpa bignonioides* | Common catalpa |
| *Prunus americana* | Wild plum |
| *Prunus hortulana* | Wild goose plum |
| *Prunus munsoniana* | Wild goose plum |
| *Prunus angustifolia* | Chickasaw plum |
| *Prunus virginiana* | Choke cherry |
| *Prunus serotina* | Black cherry |
| *Prunus gracilis* | Oklahoma plum |
| *Prunus mahaleb* | Perfumed cherry |
| *Prunus rivularis* | Creek plum |
| *Cercis canadensis* | Redbud |
| *Eloeagnus angustifolia* | Russian olive |
| *Eloeagnua unbellata* | Autumn olive |
| *Sapindus drummondii* | Western soapberry |
| *Aesculus hippocastranum* | Horse chestnut |
| *Carya illinoensis* | Pecan |
| *Carya ovalis* | Pignut hickory |
| *Carya texana* | Black hickory |
| *Carya laciniosa* | Kingnut hickory |
| *Carya ovata* | Shagbark hickory |
| *Carya cordiformis* | Bitternut hickory |
| *Carya tomentosa* | Mockernut hickory |
| *Plantanus occidentalis* | Sycamore |
| *Juglans nigra* | Black walnut |
| *Salix amygdaloides* | Peach-leaved willow |
| *Salix nigra* | Black willow |
| *Salix caroliniana* | Carolina willow |
| *Salix babylonica* | Weeping willow |
| *Salix alba* | White willow |
| *Salix discolor* | Pussy willow |
| *Salix erocephala* | Diamond willow |
| *Salix rigida* | Willow |
| *Salix humilis* | Dwarf prairie willow |
| *Salix interior* | Sandbar willow |
| *Amelanchier arborea* | June berry |
| *Pyrus ioensis* | Wild crabapple |

| Scientific Name | Common Name |
|---|---|
| *Crataegus crus-galli* | Cockspur hawthorn |
| *Crataegus mollis* | Red haw |
| *Crataegus calpodendron* | Urn-tree hawthorn |
| *Crataegus coccinioides* | Hawthorn |
| *Crataegus lanuginosa* | Wooly hawthorn |
| *Crataegus palmeri* | Palmer's hawthorn |
| *Crataegus pruinosa* | Frosty hawthorn |
| *Crataegus punctata* | Hillside hawthorn |
| *Crataegus succulenta* | Succulent hawthorn |
| *Crataegus viridis* | Green haw |
| *Gleditsia triancanthos* | Honey locust |
| *Gymnocladus dioica* | Kentucky coffee tree |
| *Cladistis lutea* | Yellow wood |
| *Robinia pseudoacacia* | Black locust |
| *Ostrya virginiana* | Ironwood |
| *Juglans cinera* | Butternut |
| *Aesculus glabra* | Ohio buckeye |
| *Aesculus glabra var. Arguta* | Western buckeye |
| *Acer negundo* | Box elder |
| *Acer saccharum* | Sugar maple |
| *Acer nigrum* | Black maple |
| *Acer rubrum* | Red maple |
| *Quercus alba* | White oak |
| *Quercus stellata* | Post oak |
| *Quercus macrocarpa* | Bur oak |
| *Quercus palustris* | Pin oak |
| *Quercus borealis* | Red oak |
| *Quercus velutina* | Black oak |
| *Quercus marilandica* | Blackjack oak |
| *Quercus imbricaria* | Shingle oak |
| *Quercus muehlenbergii* | Chestnut oak |
| *Quercus shumardii* | Shumard's oak |
| *Quercus prinoides* | Dwarf chinkapin oak |
| *Betula nigra* | River birch |
| *Cornus florida* | Flowering dogwood |
| *Cornus drummondii* | Rough-leaved dogwood |
| *Cornus obliqua* | Swamp dogwood |
| *Viburnum lentago* | Nannyberry |
| *Viburnum prunifolium* | Black haw |
| *Viburnum rufidulum* | Southern black haw |

Acceptable Shrub and Vine Species for Fish and Wildlife Habitat, Recreation, and Shelter Belt Land Uses

| Scientific Name | Common Name |
|---|---|
| *Lindera benzoin* | Spicebush |
| *Ribes missouriennse* | Wild gooseberry |
| *Ribes odoratum* | Golden currant |
| *Rubus occidentalis* | Black raspberry |
| *Rubus flagellaris* | Dewberry |
| *Rubus ostryifolius* | Highbush blackberry |
| *Rosa setigera var. tomentosa* | Climbing Prairie rose |
| *Rosa arkansana var. suffulta* | Prairie rose |
| *Rhus glabra* | Smooth sumac |
| *Rhus copallina var. latifolia* | Winged sumac |
| *Rhus aromatic* | Aromatic sumac |
| *Rhus typhina* | Staghorn sumac |
| *Euonymus astropurpurea* | Wahoo |
| *Caelastrus scandens* | Bittersweet |
| *Ceanothus ovatus* | New Jersey tea |
| *Ampelopsis cordata* | Racoon grape |
| *Parthenocissus quinquefolia* | Virginia creeper |
| *Vitris riparia* | Riverbank grape |
| *Symphoricarpos orbiculatus* | Coralberry |
| *Sambucus canadensis* | Elderberry |

Note: The Fish and Wildlife Habitat, Recreation, and Shelter Belt land uses may have other acceptable shrub and vine species approved based on the premine vegetation survey. This will be approved on a permit by permit basis.

Acceptable Legume Species Based on Land Use
for Revegetation Productivity and Ground Cover

| Scientific Name | Common Name | Land Use |
|---|---|---|
| *Amorpha canescens* | Lead plant | all vegetative land uses |
| *Amorpha fruticosa* | False indigo | all vegetative land uses |
| *Lespedeza stipulacea* | Korean lespedeza | all vegetative land uses |
| *Lespedeza striata* | Common lespedeza | all vegetative land uses |
| *Lespedeza striata var. kobe* | Kobe lespedeza | all vegetative land uses |
| *Medicago stiva* | Alfalfa | all vegetative land uses |
| *Trifolium pratense* | Red clover | all vegetative land uses |
| *Trifolium repens* | White clover | all vegetative land uses |
| *Trifolium repens f. giganteum* | Ladino clover | all vegetative land uses |
| *Trifolium hybridum var. pratense* | Alsike clover | all vegetative land uses |
| *Lotus corniculatus* | Birdsfoot trefoil | wildlife habitat |
| *Cassia fasciculata* | Partridge pea | wildlife habitat |
| *Demanthus illinoensis* | Illinois bundleflower | wildlife habitat |
| *Coronilla varia* | Crown vetch | dams, and no-topsoil steep slopes |

Note: The Fish and Wildlife Habitat, Recreation, and Shelter Belt land uses may have other acceptable legume species approved based on the premine vegetation survey. This will be approved on a permit by permit basis.

Acceptable Grass Species Based on Land Use
for Revegetation Productivity and Ground Cover

| Scientific Name | Common Name | Land Use |
|---|---|---|
| **TRIBE 2- FESTUCEAE** | | |
| *Bromus biebersteinii* | Meadow Brome | pasture, hayland, dams, waterways, diversions |
| *Bromus inermis* | Smooth Brome | pasture, hayland, dams, waterways, diversions |
| *Bromus latiglumis* | | wildlife (woodland) |
| *Bromus latiglumis f. incanus* | | |
| *Cynodon dactylon* | Bermuda grass | Pasture, hayland |
| *Festuca arundinacea* | Tall Fescue | pasture, hayland, dams, waterways, diversions |
| *Festuca elatior* | Meadow Fescue | pasture, hayland, dams, waterways, diversions |
| *Festuca paradoxa* | | wildlife (woodland) |
| *Poa compressa* | Canada Bluegrass | pasture |
| *Poa pratensis* | Kentucky Bluegrass | pasture, hayland, dams, waterways, diversions |
| *Eragrostis curvula* | Weeping Lovegrass | pasture, hayland, dams, waterways, diversions |
| *Eragrostis intermedia* | Plains Lovegrass | wildlife (prairie) |
| *Eragrostis trichodes* | | wildlife (sand prairie) |
| *Eragrostis spectabilis* | Purple Lovegrass | wildlife (sand prairie) |
| *Diarrhena americana* | | wildlife (woodland) |
| *Uniola latifolia* | Broadleaf Uniola | wildlife (woodland) |
| *Dactylis glomerata* | Orchard Grass | pasture, hayland, dams, waterways, diversions |
| *Triodia stricta* | Triodia wildlife | (bottomland woodland) |
| **TRIBE 3-HORDEAE** | | |
| *Elymus villosus* | Wild Rye | wildlife (woodland) |
| *Elymus villosus arkansanus* | Wild Rye | wildlife (woodland) |
| *Elymus canadensia* | Canada Wild Rye | wildlife (prairie and shrubland) |
| *Elymus canadensis robustus* | Wild Rye | wildlife (prairie and shrubland) |
| *Elymus canadensis brachystachys* | Wild Rye | wildlife (woodland) |
| *Elymus virginicus* | Virginia Wild Rye | wildlife (bottomland woodland) |
| *Elymus virginicus glabriflorus* | Wild Rye | wildlife ( open woodland) |
| *Elymus virginicus submuticus* | Wild Rye | wildlife (shrubland) |
| *Elymus virginicus intermedius* | Wild Rye | wildlife (woodland) |
| *Hystrix patula* | Bottlebrush | wildlife (woodland) |
| *Lolium perenne* | Perennial Ryegrass | pasture, hayland, dams, waterways, diversions |
| Pascopyrum smithii | Western Wheatgrass | wildlife (prairie), dams, waterways diversions |

| | | |
|---|---|---|
| **TRIBE 4- AVENEAE** | | |
| *Koeleria cristata* | Junegrass | wildlife (prairie) and grazingland |
| *Sphenopholis obtusata* | Prairie Wedgegrass | wildlife (prairie) and grazingland |
| *Sphenopholis intermedia* | Slender Wedgegrass | wildlife (prairie) and grazingland |
| **TRIBE 5 - AGROSTIDEAE** | | |
| *Agrostis alba* | Redtop | pasture, hayland, dams, waterways, diversions |
| *Cinna arundinacea* | Stout Woodreed | wildlife (woodland) |
| *Phleum pratense* | Timothy | pasture, hayland, dams, waterways, diversions |
| *Sporobolus asper* | Dropseed | wildlife (sand prairie) |
| *Sporobolus clandestinus* | Dropseed | wildlife (prairie) |
| *Sporobolus heterolepis* | Prairie Dropseed | wildlife (sand prairie) |
| *Sporobolus cryptandrus* | Sand Dropseed | wildlife (woodland) |
| *Brachyelytrum erectum* | | wildlife (woodland) |
| *Aristida purpurascens* | Arrow Feather | grazingland |
| **TRIBE 7 - CHLORIDEAE** | | |
| *Spartina pectinata* | Prairie Cordgrass | wildlife (wetlands) |
| *Gymnopogon ambiguus* | | wildlife (woodland) |
| *Chloris verticillata* | Windmill Grass | wildlife (prairie) |
| *Bouteloua curtipendula* | Sideoats Grama | wildlife (prairie), pasture, hayland, dams, waterways, diversions |
| *Buchloe dactyloides* | Buffalo Grass | wildlife (prairie) and grazingland |
| **TRIBE 8 - PHALARIDEAE** | | |
| *Phalaris arundinacea* | Reed Canary Grass | waterways, wet areas as approved by the SMS |
| **TRIBE 9 - ORYZEAE** | | |
| Leersia oryzoides | Rice Cutgrass | wildlife (wetlands) |
| Leersia virginica | Whitegrass | wildlife (wetlands) |
| **TRIBE 12- PANICEAE** | | |
| *Leptoloma cognatum* | Fall Witchgrass | wildlife (prairie) |
| *Paspalum repens* | Water Paspalum | wildlife (wetlands) |
| *Paspalum circulare* | Paspalum | wildlife (wetlands) |
| *Paspalum floridanum glabratum* | Paspalum | wildlife (wetlands) |
| *Panicum linearifloium* | | wildlife (woodlands) |
| *Panicum lindheimeri* | | wildlife (woodlands) |
| *Panicum huachucae* | Hairy Panicgrass | |
| *Panicum huachucae fasciculatum* | | wildlife (woodlands) |
| *Panicum tennesseense* | | wildlife (woodlands) |
| *Panicum praecocius* | | wildlife (prairie) |
| *Panicum sphaerocarpon* | | wildlife (prairie) |
| *Panicum scribnerianum* | Panicgrass | wildlife (prairie) |

| | | |
|---|---|---|
| *Panicum leibergii* | | wildlife (prairie) |
| *Panicum scoparium* | | wildlife (prairie) |
| *Panicum clandestinum* | | wildlife (prairie) |
| *Panicum latifolium* | | wildlife (woodlands) |
| *Panicum virgatum* | Switchgrass | wildlife (prairie), pasture, hayland, dams, waterways, diversions |
| *Panicum agrostoides* | Redtop Panicgrass | wildlife (prairie) |
| *Panicum anceps* | | wildlife |
| *Digitaria ciliaris* | Crabgrass | pasture, grazingland, as allowed by SMS |

**TRIBE 13 - ANDROPOGONEAE**

| | | |
|---|---|---|
| *Andropogon scoparius* | Little Bluestem | wildlife (prairie), pasture, hayland, dams, waterways, diversions |
| *Andropogon gerardi* | Big Bluestem | wildlife (prairie), pasture, hayland, dams, waterways, diversions |
| *Sorghastrum nutans* | Indian Grass | wildlife (prairie), pasture, hayland, dams, waterways, diversions |
| *Tripsacum dactyloides* | Eastern Gamagrass | wildlife (prairie), pasture, hayland |

# APPENDIX B

## Animal Unit Month - Methods of Production Success Standard Calculations

## ANIMAL UNIT MONTH

As defined in the Crawford County Soil Survey, the Animal-unit-month (A.U.M.) per acre per year is a term used to express the carrying capacity of pasture. It is the number of animal units, 1000 pounds live weight, that can be grazed on an acre of pasture each month throughout the year, without damage to the pasture.

Documentation is attached to support a forage quantity of 25 pounds/day when calculating the expected forage yield.

USDA-NRCS 25 lbs forage/day/1000# animal
State Conservationist - David Kraft

KSU Extension Service 26 lbs forage/day/1000# animal
Extension Specialist - Gary Kilgore

The SMS proposes to use 25 lbs forage/day/1000# animal; for the monthly requirement this figures:

$$\frac{\text{25 lbs forage/day/1000\# animal x 365 days/year}}{\text{12 months/year}} = \text{A.U.M.}$$

$$\frac{\text{9125 lbs forage/1000\# animal/year}}{\text{12 months/year}} = \text{A.U.M.}$$

760.4 lbs forage/1000# animal/month

Rounded to the nearest pound = 760 lbs forage in one A.U.M.

Based on the attached documentation and preceding calculations, the SMS proposes that the number to be used in calculation production requirements for forage based on Animal Unit Months be as shown below for both native and introduced species:

A.U.M. = 760 lbs forage

United States Department of Agriculture
Soil Conservation Service
2917 West Hwy 50
Emporia, Kansas
66801

May 11, 1993

Mr. Jack Hammershack
Box 1418
Surface Mining Section
Pittsburg, Kansas 66762



Dear Jack,

In speaking with you recently there was some question of how much forage constitutes an animal unit month (aum). Although some schools of thought differ on this topic I will do my best to explain the basis of how aum's are derived, and types of factors which influence them.

On the average, the amount of forage needed by a mother cow, yearling cattle, steer or heifer, replacement breeding stock, etc., averages about 2.5 pounds of forage per 100 pounds of body weight. From here we look at an average type of animal which most research uses a 1000 pound cow. Then we must determine the amount of forage needed to sustain the animals needs throughout the year. This amount of forage is determined by the month which is where the aum theory comes from. For a 1000 pound cow this would be 25 pounds of forage per day or 750 pounds of forage per month.

However this is an average. When forage quality is high an animal may eat up to 3.25% of their body weight per day. This would figure out to 32.5 pounds of forage per day or 975 pounds per month. As forage quality drops off so does intake of forage because of the increased retention time of the forage in the animal due to the lignin and fiber increase of lower quality forage. During periods of low forage quality the amount of intake may drop to 1.5% of their body weight per day which would be 15 pounds per day or 450 pounds per month.

When comparing native grass to cool season grass or more specifically fescue the time when the two differing forage types reach their optimum crude protein level will be late May to early June for native grass at a level of approximately 16% and for fescue it will be between 20-25% crude protein in late April to early May. There is however a difference in animal performance when comparing endophyte free fescue to endophyte infected fescue.

If animals are given the opportunity to select between the two types of grasses, native grass has a higher selectability than does fescue which makes it very difficult to manage the two together.

When looking at production levels of these two types of seedings they may differ somewhat. These figures are the product of many years of historical data studying stocking rates. On the average native grass seedlings which are fully established and healthy will yield somewhere between 0.5 to 1.5 aum's per acre. Whereas fescue will yield somewhere between 0.8 to 1.6 aum's per acre. Fescue can be heavily influenced by the use of nutrients. These figures may seem low when looking at some data which shows a considerably higher figure of pounds per acre on native grass and fescue. However total production yield per acre per year fails to take into account the loss of forage due to trampling and other natural means of destruction of forage.

When considering or comparing these two types of seedings, native grass seedings are more commonly recommended for critical area seedings due to the rhizomatous nature of many of the native grass species, whereas fescue is a non-rhizomatus species. This is a factor to consider when site stabilization is your first consideration.

I also asked some colleagues how the percent moisture of forage in these figures affects the pounds of forage required, and the consensus was there is little known difference.

I hope I have shed some light on this matter by giving you a fairly broad explanation of this theory. If I can be of further service please let me know.

Sincerely,

David J. Kraft

David J. Kraft
Range Conservationist

KSU
KANSAS STATE UNIVERSITY

Cooperative Extension Service

Southeast Area Extension Office
20 South Highland
Chanute, Kansas 66720
316-431-1530

April 20, 1993

Jim Bentley
Triad Environmental Services
P.O. Box 1507
Pittsburg, Kansas 66762

Dear Jim:

An animal unit month (AUM) is defined as the amount of forage a 1,000 pound cow will eat in a month. There are lots of figures available, I use the figure 26 pounds of dry matter per day or a total of 780 pounds of dry matter consumed in 30 days. It is important to use a realistic figure and stick with it throughout all calculations.

Animal unit month is designed for those folks who sit behind a desk and try to figure out what the carrying capacity of a pasture will be once they predict grass production and select type of grazing animal. One must realize that the 26 pound figure is an average over several months. In the spring the cow may consume 30-35 pounds of dry matter a day and as the grass matures, that consumption can drop to 15-18 pounds. The only thing sure in the biological world is that nothing is sure.

One must also realize that depending upon grass species, total forage production isn't utilized. Some must be left for grass health and some is lost by tramping. A pasture, cut for hay, will have the highest utilization percentage.

In my opinion, one should not have AUM's as a production goal. A realistic goal is pounds of forage produced, that's the real objective. Then, it can be utilized however the landowner wishes.

Regarding the percent cover in a fescue pasture.

First, one must define what percent cover is and when and how it is going to be measured.

To me, percent cover is the amount of soil surface covered by fescue leaves, stems or residue at the time of fescue heading. The pasture must be fertilized and all forage produced that spring left intact. Using a line transect type of measurement I would expect a 90% ground cover to be an average figure. In dry springs it could be considerable less cover.

If legumes are present, then one must reduce the nitrogen application rate. In that case, percent ground cover will decrease because of less grass production and the nature of legume growth.

Very truly yours,

Gary L. Kilgore
Extension Specialist
Crops & Soils, Southeast

GLK:pb

**CALCULATING FORAGE PRODUCTION BASED ON A.U.M. PER GIVEN SOIL TYPE**

*Forage AUM is taken from Nonirrigated Yields by Map Unit, Tall Fescue AUM and is found at http://soildatamart.nrcs.usda.gov/*

*Data current as of May 2006*

**METHOD 1**

**Cool Season Grass Seed Mix Crawford County**

| Soil Map Unit | Acreage (1) | Weighted Factor (3) | Cool AUM (4) | Conversion Lbs/acre (5) | Weighted Yield Lbs/acre (6) |
|---|---|---|---|---|---|
| 8679 Dennis | 15 | 0.0872 | 5.0 | 3800 | 331.40 |
| 8863 Parsons | 45 | 0.2616 | 3.7 | 2812 | 735.70 |
| 8864 Parsons | 32 | 0.1860 | 3.7 | 2812 | 523.16 |
| 8460 Cherokee | 10 | 0.0581 | 4.4 | 3344 | 194.42 |
| 8621 Bates | 12 | 0.0698 | 4.4 | 3344 | 233.30 |
| 8775 Kenoma | 7 | 0.0407 | 3.7 | 2812 | 114.44 |
| 8990 Zaar | 51 | 0.2965 | 4.4 | 3344 | 991.53 |
| **Total Acres (2)** | 172 | | | | (7) 3123.95 |

**Table of Calculations**

Sum of (1) = (2)
(1)/(2) = (3)
(4) x 760 = (5)
(5) x (3) = (6)
Sum of (6) = (7)

**Success Standard (7) = 3123.95**

**METHOD 2**

**Cool Season Grass Seed Mix Crawford County**

| Soil Map Unit | Acreage (1) | Cool AUM (3) | Conversion Lbs/acre (4) | Weighted Yield Lbs/acre (5) |
|---|---|---|---|---|
| 8679 Dennis | 15 | 5.0 | 3800 | 57,000 |
| 8863 Parsons | 45 | 3.7 | 2812 | 126,540 |
| 8864 Parsons | 32 | 3.7 | 2812 | 89,984 |
| 8460 Cherokee | 10 | 4.4 | 3344 | 33,440 |
| 8621 Bates | 12 | 4.4 | 3344 | 40,128 |
| 8775 Kenoma | 7 | 3.7 | 2812 | 19,684 |
| 8990 Zaar | 51 | 4.4 | 3344 | 170,544 |
| **Total Acres (2)** | 172 | | | (6) 537,320 |

**Table of Calculations**

Sum of (1) = (2)
(3) x 760 = (4)
(4) x (1) = (5)
Sum of (5) = (6)
(6)/(2) = (7)

**Success Standard (7) = 3123.95**

**CALCULATING FORAGE PRODUCTION PER GIVEN SOIL TYPE**

*Rangeland Productivity is taken from Normal Year Total dry-weight production found at http://soildatamart.nrcs.usda.gov/*

*Data current as of May 2006*

## METHOD 1

**Warm Season Grass Seed Mix Crawford County**

| Soil Map Unit | Acreage (1) | Weighted Factor (3) | Normal Year Rangeland Production (4) | Weighted Yield Lbs/acre (5) |
|---|---|---|---|---|
| 8679 Dennis | 15 | 0.0872 | 4750 | 414.24 |
| 8863 Parsons | 45 | 0.2616 | 4000 | 1046.51 |
| 8864 Parsons | 32 | 0.1860 | 4000 | 744.19 |
| 8460 Cherokee | 10 | 0.0581 | 4000 | 232.56 |
| 8621 Bates | 12 | 0.0698 | 4750 | 331.40 |
| 8775 Kenoma | 7 | 0.0407 | 4000 | 162.79 |
| 8990 Zaar | 51 | 0.2965 | 4000 | 1186.05 |
| **Total Acres (2)** | 172 | | | (6) 4117.73 |

**Table of Calculations**

Sum of (1) = (2)
(1)/(2) = (3)
(4) x (3) = (5)
Sum of (5) = (6)

**Success Standard (6) = 4117.73**

## METHOD 2

**Warm Season Grass Seed Mix Crawford County**

| Soil Map Unit | Acreage (1) | Normal Year Rangeland Production (3) | Weighted Yield Lbs/acre (4) |
|---|---|---|---|
| 8679 Dennis | 15 | 4750 | 71,250 |
| 8863 Parsons | 45 | 4000 | 180,000 |
| 8864 Parsons | 32 | 4000 | 128,000 |
| 8460 Cherokee | 10 | 4000 | 40,000 |
| 8621 Bates | 12 | 4750 | 57,000 |
| 8775 Kenoma | 7 | 4000 | 28,000 |
| 8990 Zaar | 51 | 4000 | 204,000 |
| **Total Acres (2)** | 172 | | (5) 708,250 |

**Table of Calculations**

Sum of (1) = (2)
Rangeland Production = (3)
(3) x (1) = (4)
Sum of (4) = (5)
(5)/(2) = (6)

**Success Standard (6) = 4117.73**

**CALCULATING CROP PRODUCTION PER GIVEN SOIL TYPE**

*Crop productivity is found at http://soildatamart.nrcs.usda.gov/*
*Data current as of May 2006*

## METHOD 1

**Grain Sorghum Row Crop Crawford County**

| Soil Map Unit | Acreage (1) | Weighted Factor (3) | Grain Sorghum Bu/acre (4) | Weighted Yield Bu/acre (5) |
|---|---|---|---|---|
| 8679 Dennis | 15 | 0.0872 | 67 | 5.84 |
| 8863 Parsons | 45 | 0.2616 | 64 | 16.74 |
| 8864 Parsons | 32 | 0.1860 | 58 | 10.79 |
| 8460 Cherokee | 10 | 0.0581 | 64 | 3.72 |
| 8621 Bates | 12 | 0.0698 | 59 | 4.12 |
| 8775 Kenoma | 7 | 0.0407 | 62 | 2.52 |
| 8990 Zaar | 51 | 0.2965 | 56 | 16.60 |
| **Total Acres (2)** | 172 | | | (6) 60.34 |

**Table of Calculations**

Sum of (1) = (2)
(1)/(2) = (3)
(4) x (3) = (5)
Sum of (5) = (6)

**Success Standard (6) = 60.34**

## METHOD 2

**Grain Sorghum Row Crop Crawford County**

| Soil Map Unit | Acreage (1) | Grain Sorghum Bu/acre (3) | Weighted Yield Lbs/acre (4) |
|---|---|---|---|
| 8679 Dennis | 15 | 67 | 1,005 |
| 8863 Parsons | 45 | 64 | 2,880 |
| 8864 Parsons | 32 | 58 | 1,856 |
| 8460 Cherokee | 10 | 64 | 640 |
| 8621 Bates | 12 | 59 | 708 |
| 8775 Kenoma | 7 | 62 | 434 |
| 8990 Zaar | 51 | 56 | 2,856 |
| **Total Acres (2)** | 172 | | (5) 10,379 |

**Table of Calculations**

Sum of (1) = (2)
Grain Sorghum Prod. = (3)
(3) x (1) = (4)
Sum of (4) = (5)
(5)/(2) = (6)

**Success Standard (6) = 60.34**

**CALCULATING CROP PRODUCTION PER GIVEN SOIL TYPE**

*Crop productivity is found at http://soildatamart.nrcs.usda.gov/*

*Data current as of May 2006*

## METHOD 1

### Soybean Row Crop Crawford County

| Soil Map Unit | Acreage (1) | Weighted Factor (3) | Soybean Bu/acre (4) | Weighted Yield Bu/acre (5) |
|---|---|---|---|---|
| 8679 Dennis | 15 | 0.0872 | 21 | 1.83 |
| 8863 Parsons | 45 | 0.2616 | 20 | 5.23 |
| 8864 Parsons | 32 | 0.1860 | 18 | 3.35 |
| 8460 Cherokee | 10 | 0.0581 | 20 | 1.16 |
| 8621 Bates | 12 | 0.0698 | 20 | 1.40 |
| 8775 Kenoma | 7 | 0.0407 | 22 | 0.90 |
| 8990 Zaar | 51 | 0.2965 | 19 | 5.63 |
| **Total Acres (2)** | 172 | | | 19.50 |

**Table of Calculations**

Sum of (1) = (2)
(1)/(2) = (3)
(4) x (3) = (5)
Sum of (5) = (6)

**Success Standard (6) = 19.50**

## METHOD 2

### Soybean Row Crop Crawford County

| Soil Map Unit | Acreage (1) | Soybean Bu/acre (3) | Weighted Yield Lbs/acre (4) |
|---|---|---|---|
| 8679 Dennis | 15 | 21 | 315 |
| 8863 Parsons | 45 | 20 | 900 |
| 8864 Parsons | 32 | 18 | 576 |
| 8460 Cherokee | 10 | 20 | 200 |
| 8621 Bates | 12 | 20 | 240 |
| 8775 Kenoma | 7 | 22 | 154 |
| 8990 Zaar | 51 | 19 | 969 |
| **Total Acres (2)** | 172 | | (5) 3354 |

**Table of Calculations**

Sum of (1) = (2)
Soybean Production = (3)
(3) x (1) = (4)
Sum of (4) = (5)
(5)/(2) = (6)

**Success Standard (6) = 19.50**

# APPENDIX C

## Production Data

*Disclaimer: The productivity data presented here is subject to change based on information made available from the NRCS. Production target requirements will be set on a case-by-case basis at the time of permit issuance.*

# Rangeland Productivity

Bourbon County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8151: | | | | |
| Lanton | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8160: | | | | |
| Leanna | CLAY LOWLAND (PE35-42) | 8,750 | 6,250 | 4,500 |
| 8203: | | | | |
| Osage | CLAY LOWLAND (PE35-42) | 8,750 | 6,250 | 4,500 |
| 8300: | | | | |
| Verdigris, channeled | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8301: | | | | |
| Verdigris | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8302: | | | | |
| Verdigris | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8501: | | | | |
| Mason | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8621: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8623: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8624: | | | | |
| Bates, eroded | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8643: | | | | |
| Catoosa | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8647: | | | | |
| Catoosa | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| Rock outcrop | --- | --- | --- | --- |
| 8657: | | | | |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 3,000 |
| 8663: | | | | |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 3,000 |

# Rangeland Productivity

Bourbon County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8663: | | | | |
| Rock outcrop | — | — | — | — |
| 8673: | | | | |
| Collinsville | SHALLOW SANDSTONE (PE35-42) | 2,600 | 1,850 | 1,250 |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8679: | | | | |
| Dennis | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8683: | | | | |
| Dennis | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8735: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8749: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Collinsville | SHALLOW SANDSTONE (PE35-42) | 4,000 | 3,000 | 2,000 |
| 8755: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Lebo | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8771: | | | | |
| Kanima | — | — | — | — |
| 8775: | | | | |
| Kenoma | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8843: | | | | |
| Nowata | LOAMY UPLAND (PE35-42) | 5,500 | 4,000 | 2,500 |
| 8863: | | | | |
| Parsons | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8875: | | | | |
| Ringo | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 3,000 |

# Rangeland Productivity

Bourbon County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8885: | | | | |
| Shidler | SHALLOW LIMY (PE35-42) | 3,500 | 2,500 | 1,750 |
| Catoosa | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8911: | | | | |
| Summit | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8912: | | | | |
| Summit | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8929: | | | | |
| Tamaha | SAVANNAH (PE35-42) | 5,000 | 3,500 | 2,500 |
| 8990: | | | | |
| Zaar | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8991: | | | | |
| Zaar | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8992: | | | | |
| Zaar | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 9211: | | | | |
| Bolivar | SAVANNAH (PE35-42) | 5,000 | 4,000 | 3,000 |
| Hector | SHALLOW SAVANNAH (PE35-42) | 2,600 | 1,850 | 1,250 |
| 9971: | | | | |
| Arents, earthen dam | — | — | — | — |
| 9983: | | | | |
| Pits, quarries | — | — | — | — |
| 9990: | | | | |
| Orthents | — | — | — | — |
| 9999: | | | | |
| Water | — | — | — | — |

# Nonirrigated Yields by Map Unit

Bourbon County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | Tall fescue | Winter wheat | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | *AUM* | *Bu* | |
| 8151: Lanton | 2w | 70 | — | — | 27 | |
| 8160: Leanna | 2w | 64 | — | 5.0 | 25 | |
| 8203: Osage | 3w | 62 | — | — | 19 | |
| 8300: Verdigris, channeled | 5w | — | — | 5.6 | — | |
| 8301: Verdigris | 5w | — | — | — | — | |
| 8302: Verdigris | 2w | 79 | — | — | 31 | |
| 8501: Mason | 1 | 82 | 27 | 5.6 | 33 | |
| 8621: Bates | 2e | 56 | 20 | — | 25 | |
| 8623: Bates | 3e | 51 | 18 | — | 22 | |
| 8624: Bates, eroded | 4e | 45 | 16 | — | 20 | |
| 8643: Catoosa | 2e | — | — | — | — | |
| 8647: Catoosa | 6s | — | — | — | — | |
| Rock outcrop | 8 | | | | | |
| 8657: Clareson | 6s | — | — | — | — | |
| 8663: Clareson | 6e | — | — | — | — | |
| Rock outcrop | 8 | | | | | |

# Nonirrigated Yields by Map Unit

Bourbon County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | Tall fescue | Winter wheat | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | *AUM* | *Bu* | |
| 8673: | | — | — | — | — | |
| Collinsville | 6e | | | | | |
| Bates | 6e | | | | | |
| 8679: | | 64 | 21 | — | 26 | |
| Dennis | 2e | | | | | |
| 8683: | | 53 | 19 | — | 24 | |
| Dennis | 3e | | | | | |
| 8735: | | — | — | — | — | |
| Eram | 4e | | | | | |
| 8749: | | — | — | 3.7 | — | |
| Eram | 6e | | | | | |
| Collinsville | 6e | | | | | |
| 8755: | | — | — | — | — | |
| Eram | 6e | | | | | |
| Lebo | 6e | | | | | |
| 8771: | | — | — | — | — | |
| Kanima | 7s | | | | | |
| 8775: | | 60 | 20 | — | 25 | |
| Kenoma | 3e | | | | | |
| 8843: | | 42 | 15 | — | 19 | |
| Nowata | 4e | | | | | |
| 8863: | | 61 | 20 | — | 24 | |
| Parsons | 2s | | | | | |
| 8875: | | — | — | 4.4 | — | |
| Ringo | 6e | | | | | |
| Clareson | 6s | | | | | |
| 8885: | | — | — | — | — | |
| Shidler | 6e | | | | | |
| Catoosa | 2e | | | | | |
| 8911: | | — | — | — | — | |
| Summit | 2e | | | | | |
| 8912: | | — | — | — | — | |
| Summit | 3e | | | | | |

# Nonirrigated Yields by Map Unit

Bourbon County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | Tall fescue | Winter wheat | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | *AUM* | *Bu* | |
| 8929: | | 64 | 21 | — | 26 | |
| Tamaha | 3e | | | | | |
| 8990: | | 56 | 19 | 4.4 | 22 | |
| Zaar | 3w | | | | | |
| 8991: | | 53 | 16 | 4.4 | 25 | |
| Zaar | 3e | | | | | |
| 8992: | | 45 | 15 | 4.4 | 18 | |
| Zaar | 4e | | | | | |
| 9211: | | — | — | 4.4 | — | |
| Bolivar | 6e | | | | | |
| Hector | 6e | | | | | |
| 9971: | | — | — | — | — | |
| Arents, earthen dam | 8 | | | | | |
| 9983: | | — | — | — | — | |
| Pits, quarries | — | | | | | |
| 9990: | | — | — | — | — | |
| Orthents | 6s | | | | | |
| 9999: | | — | — | — | — | |
| Water | — | | | | | |

# Rangeland Productivity

Cherokee County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8100: | | | | |
| Hepler | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8101: | | | | |
| Hepler | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8150: | | | | |
| Lanton | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8203: | | | | |
| Osage | CLAY LOWLAND (PE35-42) | 8,750 | 6,250 | 4,500 |
| 8302: | | | | |
| Verdigris | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8460: | | | | |
| Cherokee | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8621: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8623: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8627: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| Collinsville | SHALLOW SANDSTONE (PE35-42) | 4,000 | 3,000 | 2,000 |
| 8630: | | | | |
| Brazilton | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8643: | | | | |
| Catoosa | LOAMY UPLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8679: | | | | |
| Dennis | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8735: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 5,000 | 4,000 | 2,500 |
| 8761: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |

# Rangeland Productivity

Cherokee County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8761: | | | | |
| Shidler | SHALLOW LIMY (PE35-42) | 3,500 | 2,500 | 1,750 |
| 8770: | | | | |
| Kanima | — | — | — | — |
| 8771: | | | | |
| Kanima | — | — | — | — |
| 8863: | | | | |
| Parsons | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8927: | | | | |
| Taloka | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8990: | | | | |
| Zaar | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 9050: | | | | |
| Secesh | LOAMY LOWLAND (PE35-42) | — | — | — |
| 9150: | | | | |
| Secesh | LOAMY LOWLAND (PE35-42) | — | — | — |
| 9211: | | | | |
| Bolivar | SAVANNAH (PE35-42) | 5,000 | 4,000 | 3,000 |
| Hector | SHALLOW SAVANNAH (PE35-42) | 2,600 | 1,850 | 1,250 |
| 9250: | | | | |
| Clarksville | SAVANNAH (PE37-45) | 5,000 | 4,000 | 3,000 |
| 9260: | | | | |
| Gerald | — | — | — | — |
| 9270: | | | | |
| Nixa | SAVANNAH (PE37-45) | 5,000 | 4,000 | 3,000 |
| 9280: | | | | |
| Tonti | SAVANNAH (PE37-45) | 5,000 | 4,000 | 3,000 |
| 9290: | | | | |
| Waben | LOAMY UPLAND (PE37-45) | 6,250 | 4,750 | 3,250 |

# Rangeland Productivity

Cherokee County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 9975: | | | | |
| Dumps | — | — | — | — |
| 9983: | | | | |
| Quarries | — | — | — | — |
| 9986: | | | | |
| Miscellaneous water | — | — | — | — |
| 9999: | | | | |
| Water | — | — | — | — |

# Nonirrigated Yields by Map Unit

Cherokee County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | Tall fescue | Winter wheat | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | *AUM* | *Bu* | |
| 8100: | | — | — | — | — | |
| Hepler | 5w | | | | | |
| 8101: | | 84 | — | — | 34 | |
| Hepler | 2w | | | | | |
| 8150: | | 84 | — | 5.0 | 34 | |
| Lanton | 2w | | | | | |
| 8203: | | 72 | — | 5.0 | 26 | |
| Osage | 3w | | | | | |
| 8302: | | 88 | — | — | 37 | |
| Verdigris | 2w | | | | | |
| 8460: | | 71 | 20 | — | 31 | |
| Cherokee | 2s | | | | | |
| 8621: | | 65 | 20 | — | 31 | |
| Bates | 2e | | | | | |
| 8623: | | 58 | 18 | — | 28 | |
| Bates | 3e | | | | | |
| 8627: | | — | — | — | — | |
| Bates | 6e | | | | | |
| Collinsville | 6e | | | | | |
| 8630: | | 59 | 19 | — | 28 | |
| Brazilton | 3e | | | | | |
| 8643: | | 75 | 23 | — | 35 | |
| Catoosa | 2e | | | | | |
| 8679: | | 74 | 21 | — | 32 | |
| Dennis | 2e | | | | | |
| 8735: | | 52 | 16 | — | 25 | |
| Eram | 4e | | | | | |
| 8761: | | — | — | 3.7 | — | |
| Eram | 6e | | | | | |
| Shidler | 7s | | | | | |
| 8770: | | — | — | — | — | |
| Kanima | 6s | | | | | |

# Nonirrigated Yields by Map Unit

Cherokee County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | Tall fescue | Winter wheat | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | *AUM* | *Bu* | |
| 8771: | | — | — | — | — | |
| Kanima | 7s | | | | | |
| 8863: | | 71 | 20 | — | 31 | |
| Parsons | 2s | | | | | |
| 8927: | | 80 | 21 | — | 35 | |
| Taloka | 2w | | | | | |
| 8990: | | 65 | 21 | — | 28 | |
| Zaar | 3w | | | | | |
| 9050: | | — | — | — | — | |
| Secesh | 5w | | | | | |
| 9150: | | 91 | 26 | — | 40 | |
| Secesh | 2s | | | | | |
| 9211: | | — | — | — | — | |
| Bolivar | 6e | | | | | |
| Hector | 6e | | | | | |
| 9250: | | — | — | — | — | |
| Clarksville | 7s | | | | | |
| 9260: | | 68 | 19 | — | 30 | |
| Gerald | 3w | | | | | |
| 9270: | | 56 | 16 | — | 24 | |
| Nixa | 4s | | | | | |
| 9280: | | 60 | 19 | — | 29 | |
| Tonti | 4e | | | | | |
| 9290: | | 62 | 18 | — | 27 | |
| Waben | 3s | | | | | |
| 9975: | | — | — | — | — | |
| Dumps | — | | | | | |
| 9983: | | — | — | — | — | |
| Quarries | — | | | | | |
| 9986: | | — | — | — | — | |
| Miscellaneous water | — | | | | | |

# Nonirrigated Yields by Map Unit

Cherokee County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | Tall fescue | Winter wheat | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | *AUM* | *Bu* | |
| 9999: | | — | — | — | — | |
| Water | — | | | | | |

# Rangeland Productivity

Crawford County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8050: | | | | |
| Girard | CLAY LOWLAND (PE35-42) | 8,750 | 6,250 | 4,500 |
| 8100: | | | | |
| Hepler, frequently flooded | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8101: | | | | |
| Hepler | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8150: | | | | |
| Lanton | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8160: | | | | |
| Leanna | CLAY LOWLAND (PE35-42) | 8,750 | 6,250 | 4,500 |
| 8180: | | | | |
| McCune | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8200: | | | | |
| Osage | CLAY LOWLAND (PE35-42) | 8,750 | 6,250 | 4,500 |
| 8240: | | | | |
| Radley | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8241: | | | | |
| Radley | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| Hepler | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8300: | | | | |
| Verdigris, channeled | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8302: | | | | |
| Verdigris | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8460: | | | | |
| Cherokee | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8621: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8622: | | | | |
| Bates, eroded | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |

# Rangeland Productivity

Crawford County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8623: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8624: | | | | |
| Bates, eroded | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8630: | | | | |
| Brazilton | — | — | — | — |
| 8643: | | | | |
| Catoosa | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8657: | | | | |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 3,000 |
| 8670: | | | | |
| Coalvale | — | — | — | — |
| 8679: | | | | |
| Dennis | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8681: | | | | |
| Dennis, eroded | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8683: | | | | |
| Dennis | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8685: | | | | |
| Dennis, eroded | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8693: | | | | |
| Dennis, severely eroded | CLAY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8705: | | | | |
| Dennis | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| Parsons | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8733: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8735: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |

# Rangeland Productivity

Crawford County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8749: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Collinsville | SHALLOW SANDSTONE (PE35-42) | 4,000 | 3,000 | 2,000 |
| 8755: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Lebo | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8761: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Shidler | SHALLOW LIMY (PE35-42) | 3,500 | 2,500 | 1,750 |
| 8771: | | | | |
| Kanima | — | — | — | — |
| 8775: | | | | |
| Kenoma | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8797: | | | | |
| Lula | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8799: | | | | |
| Lula, eroded | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8801: | | | | |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 3,000 |
| Lula | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8863: | | | | |
| Parsons | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8864: | | | | |
| Parsons | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8865: | | | | |
| Parsons, eroded | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8870: | | | | |
| Ringo | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |

# Rangeland Productivity

Crawford County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8870: | | | | |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 3,000 |
| 8873: | | | | |
| Ringo | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8874: | | | | |
| Ringo, eroded | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8875: | | | | |
| Ringo | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 3,000 |
| 8885: | | | | |
| Shidler | SHALLOW LIMY (PE35-42) | 3,500 | 2,500 | 1,750 |
| Catoosa | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8990: | | | | |
| Zaar | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8991: | | | | |
| Zaar | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8992: | | | | |
| Zaar | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 9211: | | | | |
| Bolivar | SAVANNAH (PE35-42) | 5,000 | 4,000 | 3,000 |
| Hector | SHALLOW SAVANNAH (PE35-42) | 2,600 | 1,850 | 1,250 |
| 9971: | | | | |
| Arents, earthen dam | — | — | — | — |
| 9976: | | | | |
| Borrow pits | — | — | — | — |
| 9986: | | | | |
| Miscellaneous water | — | — | — | — |
| 9999: | | | | |
| Water | — | — | — | — |

# Nonirrigated Yields by Map Unit

Crawford County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | | | |
| 8050: | | — | — | | | |
| Girard | 5w | | | | | |
| 8100: | | — | — | | | |
| Hepler, frequently flooded | 5w | | | | | |
| 8101: | | 73 | — | | | |
| Hepler | 2w | | | | | |
| 8150: | | 84 | — | | | |
| Lanton | 2w | | | | | |
| 8160: | | 64 | — | | | |
| Leanna | 2w | | | | | |
| 8180: | | 76 | — | | | |
| McCune | 2w | | | | | |
| 8200: | | 65 | — | | | |
| Osage | 3w | | | | | |
| 8240: | | 77 | — | | | |
| Radley | 2w | | | | | |
| 8241: | | — | — | | | |
| Radley | 5w | | | | | |
| Hepler | 5w | | | | | |
| 8300: | | — | — | | | |
| Verdigris, channeled | 5w | | | | | |
| 8302: | | 88 | — | | | |
| Verdigris | 2w | | | | | |
| 8460: | | 64 | 20 | | | |
| Cherokee | 3w | | | | | |
| 8621: | | 59 | 20 | | | |
| Bates | 2e | | | | | |
| 8622: | | 53 | 18 | | | |
| Bates, eroded | 3e | | | | | |
| 8623: | | 53 | 18 | | | |
| Bates | 3e | | | | | |

# Nonirrigated Yields by Map Unit

Crawford County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | | | |
| 8624: | | 47 | 16 | | | |
| Bates, eroded | 4e | | | | | |
| 8630: | | 60 | — | | | |
| Brazilton | 3s | | | | | |
| 8643: | | — | — | | | |
| Catoosa | 2e | | | | | |
| 8657: | | — | — | | | |
| Clareson | 6s | | | | | |
| 8670: | | 60 | — | | | |
| Coalvale | 3s | | | | | |
| 8679: | | 67 | 21 | | | |
| Dennis | 2e | | | | | |
| 8681: | | 61 | 18 | | | |
| Dennis, eroded | 3e | | | | | |
| 8683: | | 63 | 19 | | | |
| Dennis | 3e | | | | | |
| 8685: | | 55 | 17 | | | |
| Dennis, eroded | 4e | | | | | |
| 8693: | | — | — | | | |
| Dennis, severely eroded | 6e | | | | | |
| 8705: | | 65 | 20 | | | |
| Dennis | 3e | | | | | |
| Parsons | 3e | | | | | |
| 8733: | | — | — | | | |
| Eram | 3e | | | | | |
| 8735: | | — | — | | | |
| Eram | 4e | | | | | |
| 8749: | | — | — | | | |
| Eram | 6e | | | | | |
| Collinsville | 6e | | | | | |

# Nonirrigated Yields by Map Unit

Crawford County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | | | |
| 8755: | | — | — | | | |
| Eram | 6e | | | | | |
| Lebo | 6e | | | | | |
| 8761: | | — | — | | | |
| Eram | 6e | | | | | |
| Shidler | 7s | | | | | |
| 8771: | | — | — | | | |
| Kanima | 7s | | | | | |
| 8775: | | 62 | 22 | | | |
| Kenoma | 3e | | | | | |
| 8797: | | 66 | 23 | | | |
| Lula | 2e | | | | | |
| 8799: | | 60 | 21 | | | |
| Lula, eroded | 3e | | | | | |
| 8801: | | — | — | | | |
| Clareson | 6s | | | | | |
| Lula | 3e | | | | | |
| 8863: | | 64 | 20 | | | |
| Parsons | 2s | | | | | |
| 8864: | | 58 | 18 | | | |
| Parsons | 3e | | | | | |
| 8865: | | 52 | 16 | | | |
| Parsons, eroded | 4e | | | | | |
| 8870: | | — | — | | | |
| Ringo | 6e | | | | | |
| Clareson | 6s | | | | | |
| 8873: | | 33 | 12 | | | |
| Ringo | 4e | | | | | |
| 8874: | | 38 | 14 | | | |
| Ringo, eroded | 4e | | | | | |
| 8875: | | — | — | | | |
| Ringo | 6e | | | | | |
| Clareson | 6s | | | | | |

# Nonirrigated Yields by Map Unit

Crawford County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | | | |
| 8885: | | — | — | | | |
| Shidler | 6e | | | | | |
| Catoosa | 2e | | | | | |
| 8990: | | 56 | 19 | | | |
| Zaar | 3w | | | | | |
| 8991: | | 53 | 16 | | | |
| Zaar | 3e | | | | | |
| 8992: | | 45 | 15 | | | |
| Zaar | 4e | | | | | |
| 9211: | | — | — | | | |
| Bolivar | 6e | | | | | |
| Hector | 6e | | | | | |
| 9971: | | — | — | | | |
| Arents, earthen dam | 8 | | | | | |
| 9976: | | — | — | | | |
| Borrow pits | — | | | | | |
| 9986: | | — | — | | | |
| Miscellaneous water | — | | | | | |
| 9999: | | — | — | | | |
| Water | — | | | | | |

# Nonirrigated Yields by Map Unit

Crawford County, Kansas

| Map symbol and soil name | Land capability | Winter wheat | Tall fescue | | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *AUM* | | | |
| 8050: | | — | — | | | |
| Girard | 5w | | | | | |
| 8100: | | — | 5.0 | | | |
| Hepler, frequently flooded | 5w | | | | | |
| 8101: | | 34 | 5.0 | | | |
| Hepler | 2w | | | | | |
| 8150: | | 34 | 5.0 | | | |
| Lanton | 2w | | | | | |
| 8160: | | 25 | 5.0 | | | |
| Leanna | 2w | | | | | |
| 8180: | | 34 | — | | | |
| McCune | 2w | | | | | |
| 8200: | | 24 | 5.0 | | | |
| Osage | 3w | | | | | |
| 8240: | | 36 | — | | | |
| Radley | 2w | | | | | |
| 8241: | | — | — | | | |
| Radley | 5w | | | | | |
| Hepler | 5w | | | | | |
| 8300: | | — | 5.6 | | | |
| Verdigris, channeled | 5w | | | | | |
| 8302: | | 33 | — | | | |
| Verdigris | 2w | | | | | |
| 8460: | | 31 | 4.4 | | | |
| Cherokee | 3w | | | | | |
| 8621: | | 31 | 4.4 | | | |
| Bates | 2e | | | | | |
| 8622: | | 28 | 4.4 | | | |
| Bates, eroded | 3e | | | | | |
| 8623: | | 28 | 4.4 | | | |
| Bates | 3e | | | | | |

# Nonirrigated Yields by Map Unit

Crawford County, Kansas

| Map symbol and soil name | Land capability | Winter wheat | Tall fescue | | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *AUM* | | | |
| 8624: | | 25 | 4.4 | | | |
| Bates, eroded | 4e | | | | | |
| 8630: | | 26 | — | | | |
| Brazilton | 3s | | | | | |
| 8643: | | — | 4.4 | | | |
| Catoosa | 2e | | | | | |
| 8657: | | — | 4.0 | | | |
| Clareson | 6s | | | | | |
| 8670: | | 26 | — | | | |
| Coalvale | 3s | | | | | |
| 8679: | | 32 | 5.0 | | | |
| Dennis | 2e | | | | | |
| 8681: | | 28 | 3.7 | | | |
| Dennis, eroded | 3e | | | | | |
| 8683: | | 29 | 3.7 | | | |
| Dennis | 3e | | | | | |
| 8685: | | 27 | 3.7 | | | |
| Dennis, eroded | 4e | | | | | |
| 8693: | | — | 3.7 | | | |
| Dennis, severely eroded | 6e | | | | | |
| 8705: | | 31 | 3.7 | | | |
| Dennis | 3e | | | | | |
| Parsons | 3e | | | | | |
| 8733: | | — | — | | | |
| Eram | 3e | | | | | |
| 8735: | | — | — | | | |
| Eram | 4e | | | | | |
| 8749: | | — | 3.7 | | | |
| Eram | 6e | | | | | |
| Collinsville | 6e | | | | | |

# Nonirrigated Yields by Map Unit

Crawford County, Kansas

| Map symbol and soil name | Land capability | Winter wheat | Tall fescue | | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *AUM* | | | |
| 8755: | | — | 3.7 | | | |
| Eram | 6e | | | | | |
| Lebo | 6e | | | | | |
| 8761: | | — | 3.7 | | | |
| Eram | 6e | | | | | |
| Shidler | 7s | | | | | |
| 8771: | | — | — | | | |
| Kanima | 7s | | | | | |
| 8775: | | 28 | 3.7 | | | |
| Kenoma | 3e | | | | | |
| 8797: | | 36 | — | | | |
| Lula | 2e | | | | | |
| 8799: | | 33 | — | | | |
| Lula, eroded | 3e | | | | | |
| 8801: | | — | — | | | |
| Clareson | 6s | | | | | |
| Lula | 3e | | | | | |
| 8863: | | 31 | 3.7 | | | |
| Parsons | 2s | | | | | |
| 8864: | | 28 | 3.7 | | | |
| Parsons | 3e | | | | | |
| 8865: | | 25 | 3.7 | | | |
| Parsons, eroded | 4e | | | | | |
| 8870: | | — | 4.4 | | | |
| Ringo | 6e | | | | | |
| Clareson | 6s | | | | | |
| 8873: | | 18 | 4.4 | | | |
| Ringo | 4e | | | | | |
| 8874: | | 21 | 4.4 | | | |
| Ringo, eroded | 4e | | | | | |
| 8875: | | — | 4.4 | | | |
| Ringo | 6e | | | | | |
| Clareson | 6s | | | | | |

# Nonirrigated Yields by Map Unit

Crawford County, Kansas

| Map symbol and soil name | Land capability | Winter wheat | Tall fescue | | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *AUM* | | | |
| 8885: | | — | — | | | |
| Shidler | 6e | | | | | |
| Catoosa | 2e | | | | | |
| 8990: | | 22 | 4.4 | | | |
| Zaar | 3w | | | | | |
| 8991: | | 25 | 4.4 | | | |
| Zaar | 3e | | | | | |
| 8992: | | 18 | 4.4 | | | |
| Zaar | 4e | | | | | |
| 9211: | | — | 4.4 | | | |
| Bolivar | 6e | | | | | |
| Hector | 6e | | | | | |
| 9971: | | — | — | | | |
| Arents, earthen dam | 8 | | | | | |
| 9976: | | — | — | | | |
| Borrow pits | — | | | | | |
| 9986: | | — | — | | | |
| Miscellaneous water | — | | | | | |
| 9999: | | — | — | | | |
| Water | — | | | | | |

# Rangeland Productivity

Labette County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8100: | | | | |
| Hepler | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8101: | | | | |
| Hepler | LOAMY LOWLAND (PE35-42) | 10,000 | 8,500 | 6,000 |
| 8150: | | | | |
| Lanton | LOAMY LOWLAND (PE35-42) | 10,000 | 7,000 | 5,500 |
| 8203: | | | | |
| Osage | CLAY LOWLAND (PE35-42) | 9,000 | 8,000 | 6,000 |
| 8301: | | | | |
| Verdigris | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8302: | | | | |
| Verdigris | LOAMY LOWLAND (PE35-42) | 10,000 | 8,500 | 6,000 |
| 8460: | | | | |
| Cherokee | CLAY UPLAND (PE35-42) | 6,000 | 4,500 | 2,500 |
| 8610: | | | | |
| Apperson | LOAMY UPLAND (PE35-42) | 6,000 | 4,300 | 3,200 |
| 8621: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,000 |
| 8623: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,000 |
| 8625: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| Collinsville | SHALLOW SANDSTONE (PE35-42) | 4,000 | 3,000 | 2,000 |
| 8627: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,000 |
| Collinsville | SHALLOW SANDSTONE (PE35-42) | 3,500 | 2,300 | 1,500 |
| 8630: | | | | |
| Brazilton | CLAY UPLAND (PE35-42) | --- | --- | --- |

# Rangeland Productivity

Labette County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8643: | | | | |
| Catoosa | LOAMY UPLAND (PE35-42) | 6,500 | 5,000 | 4,000 |
| 8679: | | | | |
| Dennis | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,000 |
| 8733: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,200 | 3,000 |
| 8735: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,200 | 3,000 |
| 8755: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Lebo | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8759: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,200 | 3,000 |
| Nowata | LOAMY UPLAND (PE35-42) | 5,500 | 4,000 | 2,500 |
| 8761: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Shidler | SHALLOW LIMY (PE35-42) | 3,500 | 2,500 | 1,750 |
| 8770: | | | | |
| Kanima | — | — | — | — |
| 8771: | | | | |
| Kanima | — | — | — | — |
| 8775: | | | | |
| Kenoma | CLAY UPLAND (PE35-42) | 6,000 | 4,500 | 2,500 |
| 8853: | | | | |
| Olpe | LOAMY UPLAND (PE35-42) | 6,000 | 4,500 | 3,000 |
| Dennis | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,000 |
| 8863: | | | | |
| Parsons | CLAY UPLAND (PE35-42) | 6,000 | 4,500 | 2,500 |

# Rangeland Productivity

Labette County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8885: | | | | |
| Shidler | SHALLOW LIMY (PE35-42) | 3,000 | 2,000 | 1,500 |
| Catoosa | LOAMY UPLAND (PE35-42) | 6,500 | 5,000 | 4,000 |
| 8990: | | | | |
| Zaar | CLAY UPLAND (PE35-42) | 6,000 | 4,500 | 2,500 |
| 9211: | | | | |
| Bolivar | SAVANNAH (PE35-42) | 5,400 | 3,000 | 2,200 |
| Hector | SHALLOW SAVANNAH (PE35-42) | 3,000 | 2,000 | 1,500 |
| 9971: | | | | |
| Arents, earthen dam | — | — | — | — |
| 9983: | | | | |
| Pits, quarries | — | — | — | — |
| 9986: | | | | |
| Miscellaneous water | — | — | — | — |
| 9989: | | | | |
| Orthents | — | — | — | — |
| 9999: | | | | |
| Water | — | — | — | — |

# Nonirrigated Yields by Map Unit

Labette County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Tall fescue | Winter wheat | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *AUM* | *Bu* | | |
| 8100: | | — | — | — | | |
| Hepler | 5w | | | | | |
| 8101: | | 78 | — | 31 | | |
| Hepler | 2w | | | | | |
| 8150: | | 75 | — | 31 | | |
| Lanton | 2w | | | | | |
| 8203: | | 67 | — | 22 | | |
| Osage | 3w | | | | | |
| 8301: | | — | — | — | | |
| Verdigris | 5w | | | | | |
| 8302: | | 85 | — | 35 | | |
| Verdigris | 2w | | | | | |
| 8460: | | 70 | — | 28 | | |
| Cherokee | 2s | | | | | |
| 8610: | | 71 | — | 28 | | |
| Apperson | 2e | | | | | |
| 8621: | | 60 | — | 28 | | |
| Bates | 2e | | | | | |
| 8623: | | 54 | — | 25 | | |
| Bates | 3e | | | | | |
| 8625: | | — | — | — | | |
| Bates | 4e | | | | | |
| Collinsville | 6e | | | | | |
| 8627: | | — | — | — | | |
| Bates | 6e | | | | | |
| Collinsville | 6e | | | | | |
| 8630: | | 60 | — | 26 | | |
| Brazilton | 3e | | | | | |
| 8643: | | 70 | — | 32 | | |
| Catoosa | 2e | | | | | |
| 8679: | | 72 | — | 29 | | |
| Dennis | 2e | | | | | |

# Nonirrigated Yields by Map Unit

Labette County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Tall fescue | Winter wheat | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *AUM* | *Bu* | | |
| 8733: | | 54 | — | 25 | | |
| Eram | 3e | | | | | |
| 8735: | | 48 | — | 23 | | |
| Eram | 4e | | | | | |
| 8755: | | — | — | — | | |
| Eram | 6e | | | | | |
| Lebo | 6e | | | | | |
| 8759: | | 53 | — | 26 | | |
| Eram | 4e | | | | | |
| Nowata | 4e | | | | | |
| 8761: | | — | 3.7 | — | | |
| Eram | 6e | | | | | |
| Shidler | 7s | | | | | |
| 8770: | | — | — | — | | |
| Kanima | 6s | | | | | |
| 8771: | | — | — | — | | |
| Kanima | 7s | | | | | |
| 8775: | | 64 | — | 28 | | |
| Kenoma | 3e | | | | | |
| 8853: | | — | — | 26 | | |
| Olpe | 4e | | | | | |
| Dennis | 4e | | | | | |
| 8863: | | 66 | — | 28 | | |
| Parsons | 2s | | | | | |
| 8885: | | — | — | — | | |
| Shidler | 6e | | | | | |
| Catoosa | 3e | | | | | |
| 8990: | | 65 | — | 27 | | |
| Zaar | 3w | | | | | |
| 9211: | | — | — | — | | |
| Bolivar | 6e | | | | | |
| Hector | 7e | | | | | |

# Nonirrigated Yields by Map Unit

Labette County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Tall fescue | Winter wheat | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *AUM* | *Bu* | | |
| 9971: | | — | — | — | | |
| Arents, earthen dam | 8 | | | | | |
| 9983: | | — | — | — | | |
| Pits, quarries | — | | | | | |
| 9986: | | — | — | — | | |
| Miscellaneous water | — | | | | | |
| 9989: | | — | — | — | | |
| Orthents | 4e | | | | | |
| 9999: | | — | — | — | | |
| Water | — | | | | | |

# Rangeland Productivity

Linn County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 7677: | | | | |
| Welda | SAVANNAH (PE35-42) | 5,500 | 4,500 | 3,500 |
| 8101: | | | | |
| Hepler | LOAMY LOWLAND (PE35-42) | 10,000 | 8,500 | 6,000 |
| 8150: | | | | |
| Lanton | LOAMY LOWLAND (PE35-42) | 10,000 | 7,000 | 5,500 |
| 8160: | | | | |
| Leanna, drained | CLAY LOWLAND (PE35-42) | 10,000 | 8,000 | 5,000 |
| 8201: | | | | |
| Osage | CLAY LOWLAND (PE35-42) | 9,000 | 8,000 | 6,000 |
| 8203: | | | | |
| Osage | CLAY LOWLAND (PE35-42) | 9,000 | 8,000 | 6,000 |
| 8301: | | | | |
| Verdigris | LOAMY LOWLAND (PE35-42) | 9,000 | 7,000 | 5,500 |
| 8302: | | | | |
| Verdigris | LOAMY LOWLAND (PE35-42) | 10,000 | 8,500 | 6,000 |
| 8501: | | | | |
| Mason | LOAMY LOWLAND (PE35-42) | 11,500 | 9,400 | 8,000 |
| 8621: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,500 |
| 8623: | | | | |
| Bates | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,500 |
| 8643: | | | | |
| Catoosa | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8645: | | | | |
| Catoosa | LOAMY UPLAND (PE35-42) | 6,500 | 5,000 | 4,000 |
| 8661: | | | | |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 2,500 |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,200 | 3,000 |

# Rangeland Productivity

Linn County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8663: | | | | |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 3,000 |
| Rock outcrop | — | — | — | — |
| 8671: | | | | |
| Collinsville | SHALLOW SANDSTONE (PE35-42) | 4,000 | 3,000 | 2,000 |
| Bates | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8679: | | | | |
| Dennis | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,500 |
| 8683: | | | | |
| Dennis | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,500 |
| 8687: | | | | |
| Dennis, eroded | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,500 |
| 8733: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,200 | 3,000 |
| 8735: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,200 | 3,000 |
| 8741: | | | | |
| Eram, eroded | CLAY UPLAND (PE35-42) | 6,000 | 4,200 | 3,000 |
| 8745: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Clareson | SHALLOW FLATS (PE35-42) | 5,000 | 4,000 | 3,000 |
| 8755: | | | | |
| Eram | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| Lebo | LOAMY UPLAND (PE35-42) | 6,250 | 4,750 | 3,250 |
| 8770: | | | | |
| Kanima | — | — | — | — |
| 8771: | | | | |
| Kanima | — | — | — | — |

# Rangeland Productivity

Linn County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 8775: | | | | |
| Kenoma | CLAY UPLAND (PE35-42) | 6,000 | 4,500 | 2,500 |
| 8789: | | | | |
| Lebo | LOAMY UPLAND (PE35-42) | 6,000 | 5,000 | 4,000 |
| 8797: | | | | |
| Lula | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,500 |
| 8837: | | | | |
| Newtonia | LOAMY UPLAND (PE35-42) | 7,000 | 4,500 | 3,200 |
| 8838: | | | | |
| Newtonia | LOAMY UPLAND (PE35-42) | 7,000 | 4,500 | 3,200 |
| 8839: | | | | |
| Newtonia | LOAMY UPLAND (PE35-42) | 7,000 | 4,500 | 3,200 |
| 8847: | | | | |
| Okemah | LOAMY UPLAND (PE35-42) | 7,000 | 5,500 | 4,500 |
| 8863: | | | | |
| Parsons | CLAY UPLAND (PE35-42) | 6,000 | 4,500 | 2,500 |
| 8909: | | | | |
| Stony land | — | — | — | — |
| Talihina | CLAY UPLAND (PE35-42) | 4,500 | 3,200 | 2,250 |
| 8911: | | | | |
| Summit | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8912: | | | | |
| Summit | CLAY UPLAND (PE35-42) | 6,000 | 4,000 | 2,500 |
| 8961: | | | | |
| Woodson | CLAY UPLAND (PE35-42) | 6,000 | 4,500 | 2,500 |
| 8962: | | | | |
| Woodson | CLAY UPLAND (PE35-42) | 6,000 | 4,500 | 2,500 |
| 9970: | | | | |
| Aquolls | — | — | — | — |

# Rangeland Productivity

Linn County, Kansas

| Map symbol and soil name | Ecological site | Total dry-weight production | | |
|---|---|---|---|---|
| | | Favorable year | Normal year | Unfavorable year |
| | | *Lb/ac* | *Lb/ac* | *Lb/ac* |
| 9971: | | | | |
| Arents, earthen dam | — | — | — | — |
| 9983: | | | | |
| Pits, quarries | — | — | — | — |
| 9986: | | | | |
| Miscellaneous water | — | — | — | — |
| 9999: | | | | |
| Water | — | — | — | — |

# Nonirrigated Yields by Map Unit

Linn County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | Winter wheat | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | *Bu* | | |
| 7677: | | — | — | — | | |
| Welda | 2e | | | | | |
| 8101: | | — | — | — | | |
| Hepler | 2w | | | | | |
| 8150: | | — | — | — | | |
| Lanton | 2w | | | | | |
| 8160: | | 85 | — | 33 | | |
| Leanna, drained | 2w | | | | | |
| 8201: | | — | — | — | | |
| Osage | 2w | | | | | |
| 8203: | | — | — | — | | |
| Osage | 3w | | | | | |
| 8301: | | — | — | — | | |
| Verdigris | 5w | | | | | |
| 8302: | | — | — | — | | |
| Verdigris | 2w | | | | | |
| 8501: | | — | — | — | | |
| Mason | 1 | | | | | |
| 8621: | | — | — | — | | |
| Bates | 2e | | | | | |
| 8623: | | — | — | — | | |
| Bates | 3e | | | | | |
| 8643: | | — | — | — | | |
| Catoosa | 2e | | | | | |
| 8645: | | — | — | — | | |
| Catoosa | 2e | | | | | |
| 8661: | | — | — | — | | |
| Clareson | 6e | | | | | |
| Eram | 6e | | | | | |
| 8663: | | — | — | — | | |
| Clareson | 6e | | | | | |
| Rock outcrop | 8 | | | | | |

# Nonirrigated Yields by Map Unit

Linn County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | Winter wheat | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | *Bu* | | |
| 8671: | | — | — | — | | |
| Collinsville | 6s | | | | | |
| Bates | 3e | | | | | |
| 8679: | | — | — | — | | |
| Dennis | 2e | | | | | |
| 8683: | | — | — | — | | |
| Dennis | 3e | | | | | |
| 8687: | | 68 | 22 | 28 | | |
| Dennis, eroded | 3e | | | | | |
| 8733: | | — | — | — | | |
| Eram | 3e | | | | | |
| 8735: | | — | — | — | | |
| Eram | 4e | | | | | |
| 8741: | | 48 | 15 | 19 | | |
| Eram, eroded | 4e | | | | | |
| 8745: | | — | — | — | | |
| Eram | 4e | | | | | |
| Clareson | 6e | | | | | |
| 8755: | | — | — | — | | |
| Eram | 6e | | | | | |
| Lebo | 6e | | | | | |
| 8770: | | — | — | — | | |
| Kanima | 6s | | | | | |
| 8771: | | — | — | — | | |
| Kanima | 7s | | | | | |
| 8775: | | — | — | — | | |
| Kenoma | 3e | | | | | |
| 8789: | | — | — | — | | |
| Lebo | 6e | | | | | |
| 8797: | | 89 | 27 | 35 | | |
| Lula | 2e | | | | | |

# Nonirrigated Yields by Map Unit

Linn County, Kansas

| Map symbol and soil name | Land capability | Grain sorghum | Soybeans | Winter wheat | | |
|---|---|---|---|---|---|---|
| | | *Bu* | *Bu* | *Bu* | | |
| 8837: | | — | — | — | | |
| Newtonia | 1 | | | | | |
| 8838: | | — | — | — | | |
| Newtonia | 2e | | | | | |
| 8839: | | — | — | — | | |
| Newtonia | 3e | | | | | |
| 8847: | | — | — | — | | |
| Okemah | 1 | | | | | |
| 8863: | | — | — | — | | |
| Parsons | 2s | | | | | |
| 8909: | | — | — | — | | |
| Stony land | 7e | | | | | |
| Talihina | 7e | | | | | |
| 8911: | | — | — | — | | |
| Summit | 2e | | | | | |
| 8912: | | — | — | — | | |
| Summit | 3e | | | | | |
| 8961: | | — | — | — | | |
| Woodson | 2s | | | | | |
| 8962: | | 68 | — | 25 | | |
| Woodson | 3e | | | | | |
| 9970: | | — | — | — | | |
| Aquolls | 5w | | | | | |
| 9971: | | — | — | — | | |
| Arents, earthen dam | 8 | | | | | |
| 9983: | | — | — | — | | |
| Pits, quarries | — | | | | | |
| 9986: | | — | — | — | | |
| Miscellaneous water | — | | | | | |
| 9999: | | — | — | — | | |
| Water | — | | | | | |

# APPENDIX D

## Planting Reports

# CROPLAND SEEDING REPORT

Operator:_____ Permit Number:_____
Field Identification Code:_____ Acres_____

## SEEDING

Crop Seeded:_____
Variety:_____
Date Seeded:_____
Method of Seeding:_____(Drilled, broadcast, etc.)
Seeding Rate:_____(Bu/acre or lbs PLS/acre)
Row Spacing:_____inches

## FERTILIZER APPLICATION

Lab Recommendation: N_____lbs/acre
P_____lbs/acre
K_____lbs/acre

Applied: N-source_____lbs/acre
P-source_____lbs/acre
K-source_____lbs/acre
Other source_____lbs/acre

Date applied:_____
Total applied:_____

## LIME APPLICATION

Recommended: (Test Results)
$CaCO_3$:_____tons/acre
Aglime:_____tons/acre/N.I.
Other:_____

Applied:
Type:_____tons/acre
Neutralization Index:_____tons/acre
Rate:_____tons/acre
Date Applied:_____

## HERBICIDE APPLICATION

Product Name:_____
Application Rate:_____
Method of Application:_____
Date(s) of Application:_____

## INSECTICIDE APPLICATION

Product Name:_____
Application Rate:_____
Method of Application:_____
Date(s) of Application:_____

Attach map or aerial photograph of the permit area showing the fields depicted by the Field Identification Code.

Use of this form complies with the requirements of K.S.A 49-413.

Comments:

_____
_____
_____
_____

Operators Signature:_____Date:_____

## FORAGE/PASTURELAND SEEDING REPORT

Operator:_____ Permit Number:_____
Field Identification Code:_____ Acres_____

## FORAGE/PASTURELAND SEEDING MIXTURE

| Mixture % | Species | Variety | lbs/acre/PLS |
|---|---|---|---|
| / | / | / | |
| / | / | / | |
| / | / | / | |
| / | / | / | |
| / | / | / | |
| / | / | / | |

Total lbs/acre/PLS:_____

## SEEDING

Date Seeded:_____
Method of Seeding:_____(Drilled, broadcast, etc.)
Row Spacing(if drilled):_____inches

## FERTILIZER APPLICATION

Lab Recommendation:
N_____lbs/acre
P_____lbs/acre
K_____lbs/acre

Applied:
N-source_____lbs/acre
P-source_____lbs/acre
K-source_____lbs/acre
Other source_____lbs/acre

Date applied:_____
Total applied:_____

## LIME APPLICATION

Recommended: (Test Results)
$CaCO_3$:_____tons/acre
Aglime:_____tons/acre/N.I.
Other:_____

Applied:
Type:_____tons/acre
Neutralization Index:_____tons/acre
Rate:_____tons/acre
Date Applied:_____

## HERBICIDE APPLICATION

Product Name:_____
Application Rate:_____
Method of Application:_____
Date(s) of Application:_____

## INSECTICIDE APPLICATION

Product Name:_____
Application Rate:_____
Method of Application:_____
Date(s) of Application:_____

Attach map or aerial photograph of the permit area showing the fields depicted by the Field Identification Code.

Use of this form complies with the requirements of K.S.A 49-413.

Comments:

_____
_____
_____
_____

Operators Signature:_____Date:_____

## WILDLIFE SEEDING REPORT

Operator:_____ Permit Number:_____
Field Identification Code:_____ Acres_____

## WILDLIFE SEEDING MIXTURE

| Mixture % | Species | Variety | lbs/acre/PLS |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Total lbs/acre/PLS:_____

## SEEDING

Date Seeded:_____
Method of Seeding:_____(Drilled, broadcast, etc.)
Row Spacing(if drilled):_____inches

## FERTILIZER APPLICATION

Lab Recommendation:
N_____lbs/acre
P_____lbs/acre
K_____lbs/acre

Applied:
N-source_____lbs/acre
P-source_____lbs/acre
K-source_____lbs/acre
Other source_____lbs/acre

Date applied:_____
Total applied:_____

## LIME APPLICATION

Recommended: (Test Results)
$CaCO_3$:_____tons/acre
Aglime:_____tons/acre/N.I.
Other:_____

Applied:
Type:_____tons/acre
Neutralization Index:_____tons/acre
Rate:_____tons/acre
Date Applied:_____

## HERBICIDE APPLICATION

Product Name:_____
Application Rate:_____
Method of Application:_____
Date(s) of Application:_____

## INSECTICIDE APPLICATION

Product Name:_____
Application Rate:_____
Method of Application:_____
Date(s) of Application:_____

Attach map or aerial photograph of the permit area showing the fields depicted by the Field Identification Code.

Use of this form complies with the requirements of K.S.A 49-413.

Comments:

_____
_____
_____
_____

Operators Signature:_____Date:_____

## WOODLAND/WILDLIFE SEEDING REPORT

Operator:_____ Permit Number:_____
Field Identification Code:_____ Acres_____

### TREES AND SHRUBS PLANTED

Species planted_____numbers_____
_____numbers_____
_____numbers_____
_____numbers_____
_____numbers_____
_____numbers_____
_____numbers_____
_____numbers_____

Date planted:_____
Method of Planting:_____(Bare root, spade, etc.)
Spacing:_____
Live Stems/acre:_____

### FERTILIZER APPLICATION

Lab Recommendation: N_____lbs/acre
P_____lbs/acre
K_____lbs/acre

Applied: N-source_____lbs/acre
P-source_____lbs/acre
K-source_____lbs/acre
Other source_____lbs/acre

Date applied:_____
Total applied:_____

### LIME APPLICATION

Recommended: (Test Results)
$CaCO_3$:_____tons/acre
Aglime:_____tons/acre/N.I.
Other:_____

Applied:
Type:_____tons/acre
Neutralization Index:_____tons/acre
Rate:_____tons/acre
Date Applied:_____

## HERBICIDE APPLICATION

Product Name:_____
Application Rate:_____
Method of Application:_____
Date(s) of Application:_____

## INSECTICIDE APPLICATION

Product Name:_____
Application Rate:_____
Method of Application:_____
Date(s) of Application:_____

Attach map or aerial photograph of the permit area showing the fields depicted by the Field Identification Code.

Use of this form complies with the requirements of K.S.A 49-413.

Comments:

_____
_____
_____
_____

Operators Signature:_____Date:_____

# APPENDIX E

## Reference Area Criteria

## Reference Areas

The use of 'reference areas' is discouraged because of the difficulty in selecting a site and the management of the site. The technical standard approach eliminates much of the uncontrollable variability which is encountered when using reference areas. When a reference area is used, the reference area will serve as the data set for establishing a technical success standard. The setting of the technical success standard, from a reference area, will utilize the sampling criteria and techniques discussed in this guidance document by the appropriate land use. The success standard will change from growing season to growing season with direct comparison of the reclaimed area to the technical success standard established from the reference area.

**Note: Management of the reference area and the reclaimed area must be identical in all aspects.**

The following are excerpts from Chambers and Brown, 1983, Methods for Vegetation Sampling and Analysis on Revegetated Mined Lands, on the selection of 'reference areas'. At a minimum the criteria discussed will be followed when selecting reference areas. The permittee should work closely with the SMS when developing reference areas.

"Reference areas serve as standards of comparison to assess whether mined land areas have been successfully revegetated. Reference areas are land units maintained under appropriate management for the purpose of measuring vegetation ground cover, productivity, and plant species diversity. Reference areas are produced naturally or by crop production methods approved by the regulatory authority. Reference areas must be representative of the geology, soils, slope, and vegetation in the permit area.

The selection of reference areas will be dependent upon (1) the proposed land use for the revegetated area (wildlife habitat, improved pasture, cropland, etc.) and (2) the approved revegetation plan for each individual mine. It is recognized that in many cases the postmining vegetation and land use may differ from the premining vegetation and land use".

"Mined and revegetated areas may differ significantly from the communities that originally occupied the site. Perhaps the most important of these, from the biological standpoint, is that the properties of the soil are often altered. The topography of the site may be changed and the composition of the vegetation may or may not be similar to that of the original site. Therefore, when comparing a revegetated area to a reference area, it will be necessary to integrate the factors that characterize the 'new site' created through revegetation and soil replacement with those of the pre-existing, established reference area. A list of the essential criteria for comparing revegetated and reference areas follows:

1. Individual site factors including elevation, precipitation, slope and aspect must be the same for both areas.

2. Both areas will comprise the same plant life forms and seasonal varieties of vegetation.

3. Although it is unlikely that the revegetated area will have the same soils as the reference area, it is important that certain edaphic characteristics be similar.

4. The reference area will have to be realistically comparable to the revegetated area, having the capability to produce a similar kind and amount of vegetation.

5. Management of the reference area will have to be consistent during the revegetation phase and the same as that proposed for the revegetated area. The condition class of the reference area (when dealing with rangeland) should be the same as that desired in the management plan for the revegetated area and should have a stable trend.

6. Seeding of the reference area will be at the same time as seeding of the revegetated area.

It is not essential that the reference area be immediately adjacent to the revegetated area as long as the above criteria are met. The two areas must not be separated by too great a distance, however, as differences in rainfall distribution patterns and other environmental factors could result in statistically different production, cover and diversity values".

Reference areas for cropland should be a minimum of 1 acre in size. Larger areas 2 to 5 acres are preferable, as they allow for variations in productivity due to differences in fertilization, topography, drainage and so forth.

When grazing is practiced, special measures will have to be taken to ensure that it has no effect on the accuracy of the production, cover, and diversity sampling on either the revegetated area or the reference area. This can be accomplished in one of two ways:

1. Exclosures could be built on both the revegetated area and the reference areas to exclude livestock grazing during the years in which sampling is to occur. Amount and number of exclosures will be decided in consultation with the SMS.

2. Grazing could be deferred or delayed on both the revegetated and reference areas until after sampling has been completed. The deferment applies only to those years during which sampling is scheduled. The proposed grazing management scheme should be adhered to during all other years."

"Special considerations are required in the selection of reference areas for mined lands that are to be revegetated as wildlife habitat areas or that are to approximate the potential natural vegetation (woodland, rangeland, or grazing land). Areas must be chosen that are consistent with the management goals or the planned future use of the area. They must also be representative of the potential natural community as described by range site or habitat type concepts. Where differences in species composition exist between the potential natural community and the revegetated area, life-form and seasonality must be similar."

# APPENDIX F

## Representative Sample Field Area Definition and Test Plot Criteria

## Representative Area Requirements

The permittee must utilize row crops planted in rows to prove row crop productivity for cropland and cropland prime farmland. The permittee may choose to use representative areas with test plots as described here to access row crop productivity. When the representative areas, with test plots, are chosen to assess row crop productivity, the permittee must develop the areas in consultation with the SMS and meet the following definition and criteria:

Representative Sample Field Area Definition and Test Plot Criteria

1. The permittee must commit to collecting productivity data in the test plots and productivity and ground cover data for the remaining areas which will be in forage.

2. The permittee must supply the SMS with the reclaimed soil characteristics and topographical features. At a minimum the permittee must supply soil probing data on 300 foot centers. The reclaimed soil resources will be classified as follows:

   A. Each reclaimed area must be probed at the minimum grid cited. Additional intensified probing on a regular grid will be required until a 20% or less coefficient of variation (COV) (i.e. COV = sample standard deviation / sample mean) is reached for each class range of the topsoil replacement depth. The reclaimed topsoil horizon depth probe data is classified into ranges based on the mean topsoil replacement depth as stipulated in the approved permit. The data will be classified into ranges as follows:

      X = Mean topsoil replacement depth in the approved permit.

      1. Thin depth range = X - (21% of X in inches) to
         X - (100% of X in inches)

         (i.e. Assume X = 12 inches
         a. 12 inches x 21% = 2.5 inches
         b. 12 inches x 100% = 12.0 inches
         c. 12 inches - 2.5 inches = 9.5 inches
         d. 12 inches - 12.0 inches = 0
         e. Thin depth range = 0.0 inches to 9.5 inches)

2. Normal depth range = X + (20% of X in inches) to
X - (20% of X in inches)

(i.e. Assume X = 12 inches
a. 12 inches x 20% = 2.4 inches
b. 12 inches + 2.4 inches = 14.4 inches
c. 12 inches - 2.4 inches = 9.6 inches
d. Normal depth range = 9.6 inches to 14.4 inches)

3. Thick depth range = X + (21% of X in inches) to
X + (100% of X in inches)

(i.e. Assume X = 12 inches
a. 12 inches x 21% = 2.5 inches
b. 12 inches x 100% = 12 inches
c. 12 inches + 2.5 inches = 14.5 inches
d. 12 inches + 12 inches = 24 inches
e. Thick depth range = 14.5 inches to 24.0 inches)

B. The permittee will supply the drainage characteristic and slope measurement of each probe location.

C. The reclaimed soil at each soil probing location must be described morphologically as follows:

1. Topsoil horizon depth and subsoil horizon depth in inches.

2. Topsoil and subsoil color utilizing a Munsell Soil Color Chart.

3. Topsoil and subsoil texture classified by USDA-NRCS using recognized field estimate methods (submit with data).

D. The soil probe locations and representative probe areas must be located on a map depicting the permit boundary area at a scale of 1" = 400' or larger (i.e. 1" = 300', 1" = 200', etc.).

3. Representative sample field areas must be defined for each reclaimed area. The probing data will be presented to the SMS based on representative sample groups. The groups are percent slope and topsoil horizon depth. When needed, the other characteristics of topsoil horizon texture and topsoil horizon color may be utilized to additionally sub-group the slope data.

Representative sample field areas must be equal to or greater than 40 acres. When initial slope groups are less than 40 acres then they will continue to be grouped as if larger than 40 acres to a minimum size of 2 acres. Areas less than or equal to 2 acres will constitute a test plot. The primary grouping of the field data will proceed as follows:

PRIMARY GROUPING:

a. Group the % slope data based on the following slope groups.

1. 0 - 3%
2. 4 - 7%

b. Sub-group each % slope group by the classified topsoil horizon depth.

X = Mean topsoil replacement depth in the approved permit.

1. Thin depth range = X - (21% of X in inches) to X - (100% of X in inches)
2. Normal depth range = X + (20% of X in inches) to X - (20% of X in inches)
3. Thick depth range = X + (21% of X in inches) to X + (100% of X in inches)

4. The test plot or plots of each representative sample field area will be at a minimum 5% of the representative area in size (i.e. 120 acre representative area could have one 6 acre test plot or at the minimum size three 2 acre test plots). The minimum plot size is 2 acres.

5. In consultation with the SMS, randomly locate the test plot or plots. This will be conducted by overlaying a grid on the representative sample field area and selecting random coordinates to locate the center of the test plot. The maximum grid size to be used is 100' by 100'. Each individual test plot will be a minimum of 2 acres in size.

6. Separate planting reports must be kept on each row crop test plot and the representative forage areas (see appendix D).

7. Sampling will be conducted on each row crop test plot as described in this section.

8. Test plots may be averaged together to meet the row crop production success standard as specified in the approved permit. Furthermore, test plots in non-contiguous fields, that represent the same soil properties and in close proximity to one another, may be averaged together to meet the row crop production success standard as specified in the approved permit.

# APPENDIX G

## Measuring Grain Moisture

AG FACTS

KSU
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Cooperative Extension Service

# Measuring Grain Moisture Content On-Farm

Joseph P. Harner
Extension Agricultural Engineer

## Introduction

Moisture content is a vital factor in harvesting and storing grain. The threshing quality and breakage of standing grain are influenced by moisture. The energy required to dry the kernels to a recommended storage level is affected by moisture content at harvest. Grain moisture is also a deciding factor in establishing grain grades and prices since trading is by a percent moisture weight basis rather than a dry matter basis. Therefore, accurate measurement of the moisture content of grain is essential to protect against losses during harvesting or storing and to guarantee receipt of fair market prices.

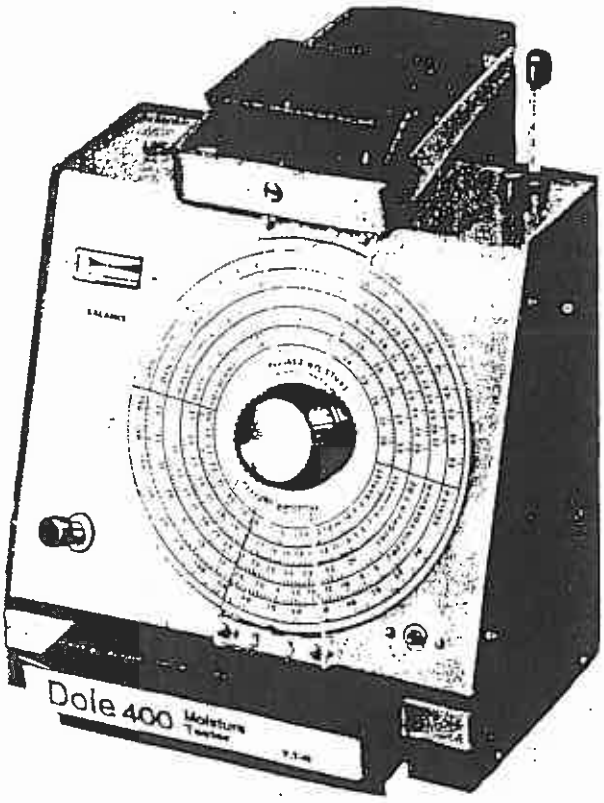
## Types of Moisture Meters

Moisture content of a grain is determined using primary (direct) or secondary (indirect) methods. A primary method removes the water in a sample and then the quantity of water is measured. Types of primary methods include the Karl Fischer Titration method, air-oven methods, and distillation methods. The air-oven and distillation methods are "official" methods recognized by the Consumer and Marketing Service in U.S.D.A. Generally, grain producers cannot justify time, equipment, or expenses necessary to determine the moisture content of a sample using a primary method. Therefore, secondary methods are used on farm. These methods measure a characteristic of the grain which is then related to moisture content. A secondary method is calibrated against a primary method for improved accuracy.

The electric meters are the best secondary methods available. The basic categories are resistance and dielectric meters. These meters may be influenced by temperature, moisture content, variety of grain, and handling of samples. However, electric meters should indicate the moisture content within ± 0.22 percent of the moisture content of a sample determined using a primary method. If properly used and calibrated in marketing grain, one should neither gain nor lose in on the basis of moisture determination with an electric meter because the errors would be expected to cancel out.

## Electric Meters

A resistance meter partially crushes seeds between contacts for a good electrical connection. The electrical resistance or conductivity of the grain varies with the distribution of the moisture in the individual seeds as well as with the moisture content. The accuracy of a resistance meter is dependent upon normal distribution of moisture within the grain kernels. Recently, dried grain will normally give low readings while freshly moistened grain will give high readings. Errors will also occur with mixing wet and dry grain. The upper limit accuracy of a resistance meter is around 23 percent since conductance is high at this level and differentials are hard to detect. Below moisture contents of seven percent resistance meter cannot measure the conductance. This will result in inaccurate moisture measurements of very dry grain.




Farm type moisture meter

Table 1. Information about commercially available moisture meters.*

| Meter Model | Manufacturer | Measurement Principle | Sample Weight Required | Method of calibration & display of results |
|---|---|---|---|---|
| Steinlite SS-250 | Stein Laboratories Inc., 121 N. 4 St. Atchison, KS | Capacitance | 250g | Straight-line, digital |
| Steinlite AUT | Stein Laboratories Inc. | Capacitance | 250g | Straight-line, revolving dial |
| Steinlite RCT | Stein Laboratories Inc. | Capacitance | 250g | Look-up charts, meter pointer |
| Burrows 700[a] | Burrows Equip. Co., Inc., 1316 Sherman Ave. Evanston, IL 60204 | Capacitance | 250g | Straight-line, digital |
| Motomco 919[b] | Motomoc, Inc. Box 300 Patterson, NJ 07510 | Capacitance | 150g or 250g[c] | Look-up charts, manually rotated dial |
| Dickey-John GAC-II | Dickey-John, Inc. P.O. Box 10 Auburn, IL 62615 | Capacitance | Internal weighing | Microprocessor, digital |

[a]Machine manufactured for Burrows by Dickey-John, Inc.
[b]Motomco meter is used exclusively by Federal Grain Inspection Service.
[c]Sample weight dependent on moisture content of sample tested.

Table 2. Companies Manufacturing Moisture Meters Suitable For Measuring Moisture Content of Corn On Farm*

| Company | Other Grain Applications | Method of Measurement With Other Grains |
|---|---|---|
| Dickey-John Corporation P.O. Box 10 Auburn, IL 62615 | Wheat, Soybeans, Barley Sorghum, Oats, Peanuts Rye, Sunflower | Conversion Charts |
| O.T. Industries, Inc. 877 Third Street, SW St. Paul, MN 55112 | Wheat, Soybeans, Barley Sorghum, Rapeseed | Change Dial Plate |
| Delmhorst Instrument Company 607 Cedar Street Boonton, NJ 07005 | Wheat, Soybeans, Barley Oats, Rye, Sorghum | Change Dial Plate |
| Froment USA 3305 Hearst Road Cedar Falls, IA 50613 | Not Mentioned | Log Charts |
| Eaton Control Products 191 East North Avenue Carol Stream, IL 60187 | Wheat, Oats, Rapeseed | Switch Dial |
| Sruttle Manufacturing Company Electronics Division Canfield, OH 44406 | Wheat | Change Dial Plate |
| Insto, Inc. P.O. Box 113 Auburn, IL 62615 | Wheat, Sorghum, Soybeans Barley, Rye and Sunflower | Conversion Charts |

Table 3. Results of the Prairie Agricultural Machinery Institute Moisture Meter Tests*

| Moisture Meter | Accuracy | | | Suitable for Field Use | Temp. Comp-Sensation | Weighing Required |
|---|---|---|---|---|---|---|
| | Wheat | Barley | Oats | | | |
| Qwik-Test | F | VG | F | Y | I | Y |
| Insto 2 | F | VG | F | Y | I | Y |
| Agtek-35 | G | VG | VG | Y | U | N |
| Farmi-35 | G | VG | VG | Y | U | N |
| Wile-35 | G | VG | VG | Y | U | N |
| Labtronics 919 | VG | VG | VG | N | U | Y |
| Motomco 919 | E | G | G | N | U | Y |
| RDS Grain-O-Meter | F | P | P | Y | U | N |
| Delmhorst G-6B | G | F | G | Y | U | N |
| Dole 400 (PB-70-11) | E | G | F | Y | U | Y |
| CAE 101-A | VG | G | VG | Y | I | N |
| Dickey-John | VG | F | VG | Y | I | N |
| Insto | VG | F | VG | Y | I | N |
| Skuttle MT2 | G | P | UN | Y | U | N |
| Protrimeter TW73 | VG | F | F | Y | U | N |

F—Fair, P—Poor, G—Good, VG—Very Good, E—Excellent, UN—Unsatisfactory
Y—Yes, N—No, I—Internal, U—User

A dielectric meter estimates moisture by measuring the capacitance or impedance of a carefully weighed sample of grain placed between two flat plates or in a circular cell. The range of these meters are 6 to 28 percent moisture content. The grain must be poured into the cell in a manner to give consistent packing. Errors may be introduced by surface moisture on the kernels or failure to compensate for temperature. **Table 1** gives a listing of some available commercial moisture meters and their manufacturers. Each of these meters determines the moisture content of a sample based on the principle of capacitance. **Table 2** gives a listing of some companies producing moisture meters suitable for on farm. Several grain moisture meters were tested by the Prairie Agricultural Machinery Institute in Canada and their results are shown in **Table 3.** Test results were based on moisture comparison with different grains, portability, and operating requirements of the meters.

## Factors Influencing Meter Accuracy

The capacitance type meters operate on the principle that the dielectric properties are largely dependent on moisture content of a grain. Research has shown that moisture meter readings may vary ± 0.8 percentage points for corn with a moisture content between 12 and 16 percent. More variability in the readings are introduced as the moisture content of grain increases past 25 percent. As the moisture content increases to 28-32 percent, the readings may vary as much as ± 3.2 percent. Therefore, it is extremely important to take multiple samples to average out possible errors when determining moisture contents of a large quantity of grain.

The accuracy of a moisture meter may also be influenced by the type of sample taken. A difference of 1.0 percent may occur when comparing moisture meter readings of hand-shelled versus combined-shelled samples taken from the same lot of grain. Generally, as the damage incurred by a sample increases, the moisture content reading of a meter decreases. This may be critical as the moisture content of the grain approaches safe storage levels. Moisture meters which are over estimating the actual moisture content may result in high moisture grain being placed into bins. This could eventually result in storage problems. The majority of grain trading occurs when the grain is at moisture contents between 14 and 16 percent, where most of the physical damage due to grain handling occurs. Therefore, a moisture meter must give reliable readings to prevent potential economic losses due to errant readings.

A meter's accuracy may be influenced by temperature, time of day, operator error, or handling of the sample. However, recent research has shown the importance of calibrating moisture meters against an official or primary method. Meters which are out of calibration result in eventual economical losses. A meter over estimating the actual moisture content of a sample results in additional energy requirements for drying, harvesting losses, and potential storage problems. A meter under estimating

the actual moisture content results in additional energy being expended during the drying process and an undue loss in weight.

Since farm type meters are less expensive and generally receive less care, they should be checked periodically against a moisture meter at the local elevator or the supplier representative. One should always beware of the correct procedures for grain sampling and be very carefully to follow manufacturer's instruction in using the instrument. This will help insure that the time, energy, and effort gone into planting, cultivating, harvesting, and drying will not be wasted due to errors in a moisture meter.

## Summary

Remember, no two moisture meters will give exactly the same readings. Even meters of the same brand may give slightly different values. Some of the features to consider when buying a meter are:

- Portability
- Accuracy over a wide range of the specific range needed
- Operating requirements and type of readout
- Cost service, and availability
- Time required to perform a test
- Usage with other grains

If you feel your meter is inaccurate, before buying a new one, you may consider:

- Checking it against local elevator meter on service representative
- Checking the batteries or power source
- Reread operator manual to insure measuring techniques are correct

After you purchase or check the calibration of a meter you can improve the accuracy during sampling. This is done by considering:

- Making sure that the sample taken is representative of the field or truck load. In the field, a mixture of complete grain heads from various locations in the field is best. Never sample off the top of a truck load, but use mixture from top to bottom of bed.
- If sample is not checked immediately, place it in a sealed plastic container or jar. If it is held more than one day, place in a refrigerator. Allow the cold sample to warm up to room temperature before opening the container and making a test. Shake the container frequently during the warmup period to reabsorb any condensed moisture and get a uniform temperature distribution in the sample.
- Follow the test procedures carefully making sure to use the correct amount of grain, meter calibration, temperature compensation, etc.
- At the beginning of the grain harvest check, the meter against a unit known to be accurate, then do not subject the meter to stresses by bouncing around in a truck.
- Take readings on at least two samples before making a decision.

Remember, the moisture content of a bin is the determining factor if the grain will store safely or spoil. You can reduce economic losses by developing sound management practices by using moisture meters during harvesting and storing of grain.

*The use of trade names does not imply endorsement by the Kansas State University Extension of the product named nor criticism of similar ones not mentioned.

KSU KANSAS STATE UNIVERSITY

COOPERATIVE EXTENSION SERVICE, MANHATTAN, KANSAS

March 1985

AF-135

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3-85—5M

File Code: Engineering 3-1