PHASE III
REVEGETATION SUCCESS STANDARDS FOR PASTURE AND PREVIOUSLY MINED AREAS

Arkansas Department of Environmental Quality
Surface Mining and Reclamation Division
P. O. Box 8913
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Effective Date:

PASTURE AND PREVIOUSLY MINED AREAS

Appendices

I. Introduction

This policy describes the criteria and procedures for determining Phase III ground cover and production success for areas being restored to pasture and previously mined areas.

Pursuant to the Arkansas Surface Coal Mining and Code (ASCMRC) Section 816.116(b)(1), ground cover and production success on pasture must be determined on the basis of the following conditions:

- **S** general revegetation requirements of the approved permit;
- **S** ground cover density; and
- **S** production.

The permittee is responsible for determining and measuring ground cover and production and submitting this data to the Director for evaluation. Procedures for making these determinations are described in this document.

Any previously mined land, that was remined or redisturbed and reclaimed to a land use of pasture, must achieve the same success standard for cover, as land that was not previously disturbed by mining. However, if the area is not reclaimed to the requirements of ASCMRC Section 816.116(b)(4), the vegetative cover shall not be less than the ground cover existing before redisturbance and shall be adequate to control erosion. This ground cover standard must have been determined and incorporated into the permit prior to disturbance. There is no productivity standard.

II. General Revegetation Requirements

The general requirements for revegetation, as stated under ASCMRC Section 816.111 shall be considered satisfied upon the determination by the Director that:

A. The permittee has established on regraded areas and all other disturbed areas, except water areas, surface areas of roads and areas around buildings that are approved as part of the postmining land use, a vegetative cover that is in accordance with the reclamation plan in the approved permit and that is:

   1. diverse, effective, and permanent;

   2. comprised of species native to the area, or of

introduced species which are desirable and allowable under ASCMRC Section 816.112, and necessary to achieve the postmining land use and approved by the regulatory authority;

3. at least equal in extent of cover to the natural vegetation of the area; and

4. capable of stabilizing the soil surface from erosion.

B. The Director must also make the determination that the reestablished plant species are:

1. compatible with the approved postmining land use;

2. of the same seasonal characteristics of growth as the original vegetation;

3. capable of self-regeneration and plant succession;

4. compatible with the plant and animal species of the area; and

5. allowed for planting under applicable State and Federal laws and regulations which control the growth of poisonous and noxious plants and introduced species.

III. Success Standards and Measurement Frequency

A. Ground Cover

1. Ground cover shall be considered acceptable if it is at least ninety percent (90%) of the approved success standard at a ninety percent (90%) statistical confidence level for any two (2)of the last four years of the five (5) year responsibility period. The success standard for ground cover shall be ninety percent (90%) density. Other approved success standards could be other areas that are representative of unmined lands in the area being reclaimed or through the use of technical guidance procedures published by the United States Department of Agriculture (USDA) or United States Department of Interior (USDI) for assessing ground cover and productivity.

Ground cover must be measured over each noncontiguous area which is proposed for release. The aggregate of areas with less than 90 percent ground cover must not exceed 5 percent of the release area. These areas must not be larger than 1 acre and must be completely surrounded by desirable vegetation which has a ground cover of 90 percent. Areas void of desirable vegetation may not be larger than 1/4 acre and must be surrounded by desirable vegetation which has a ground cover of 90 percent. Refer to sampling technique for ground cover IV. B. 1.

2. Ground cover shall consist of the species mixture which has been approved in the original permit or an approved acceptable species mixture as recommended by the United States Department of Agriculture/Natural Resources Conservation Service (NRCS) for use in that area. No more than fifteen percent (15%) of the stand can be approved species not listed in the permit. There can be no more than forty percent (40%) deviation from the approved seeding mixture in the stand. If the area was previously mined, thirty-five percent (35%) can be approved species not listed in the permit. Examples of some acceptable plant species are listed in Appendix L.

3. The sampling techniques for measuring success shall use a 90 percent statistical confidence interval (i.e., one sided test with a .10 alpha error). Whenever ground cover is equal to or exceeds the success standard, the statistical confidence interval test does not have to be determined.

4. Ground cover success and forage production success need not be met during the same year.

5. Ground cover shall be sampled twice during any two of the last four years of the five-year responsibility period to verify cover data.

B. Forage Production

1. The success standard for production of hay on pasture land shall be 90 percent of an approved reference area, if reference areas are established, or 90 percent of a <u>current</u> NRCS high management

target yield. This target yield is determined by the NRCS using current yield records of representative local farms in the surrounding area. If the permittee proposes to use the NRCS standard, it must be preapproved by the Director.

2. Production shall be sampled twice during two separate years. The permittee may select any two of the last four years of the five-year responsibility period.

C. Reference Area Requirements

1. Reference areas must be representative of soils, slope, aspect, and vegetation in the premined permit area. However, in cases where differences exist because of mixing of several soil series on the reclaimed area or unavailability of a reference area as herein described, yields must be adjusted as outlined in Appendix K.

REFERENCE AREA PASTURE MUST BE UNDER THE SAME MANAGEMENT AS PASTURE IN THE RECLAIMED AREA.

This means:

a. They must consist of similar plant species and diversity as approved in the permit;

b. be currently managed under the same land use designation as the proposed mined release area;

c. consist of soils in the same land capability class;

d. be located in the general vicinity to the mined test area to minimize weather fluctuations;

e. the same fertilizer and pest management techniques shall be used;

f. fertilizer rates shall be based on the same yield goal;

g. that, if the reference plot was mowed prior to sampling, the reclaimed area must also have been mowed at the same time to the same

height;

h. identical harvest dates, row spacing, and plant populations shall be used; and
i. any other commonly used management techniques not listed above such as adequate weed and insect control may be used provided the pasture area and the reference plot are treated identically.

Reference areas shall consist of a singleplot (whole plot) at least four (4) acres in size. Either statistically adequate subsampling or whole plot harvesting may be used to determine yields.

Reference plot crop yields must be at a level which is reasonably comparable to the county average for the given crop. Reference plot yields which are less than eighty percent (80%) of the county average are highly suspect and may be rejected.

Reference areas may be used as a standard for several mines or bond release areas in the vicinity, with prior approval of the Director. Reference areas may be located on undisturbed acreage within permitted areas. If not so located, the permittee must obtain from the landowner(s) a written agreement allowing use of the property as a reference area and allowing right of entry for regulatory personnel.

1. When release areas and reference plots fall on different soil series, adjustments must be made to compensate for the productivity difference. The NRCS county soil productivity figures shall be used for this purpose. For ease of calculation, this adjustment shall always be made to the reference area yield. EACH REFERENCE PLOT SAMPLING FRAME OR WHOLE FIELD REFERENCE PLOT YIELD MUST BE ADJUSTED BEFORE YIELD COMPARISON OR T-TEST STATISTICS CAN BE CALCULATED. See Appendices C, D, and K.

IV. Sampling Procedures

A. Random Sampling

1. To assure that the samples truly represent the vegetative characteristics of the whole release or reference area, the permittee must use methods that

will provide:

a) a random selection of sampling sites,

b) a sampling technique unaffected by the sampler's preference, and

c) sufficient samples to represent the true mean of the vegetation characteristics.

2. Sampling points shall be randomly located by using a grid overlay on a map of the release or reference area and by choosing horizontal and vertical coordinates as described in Appendix A. Each sample point must fall within the release or reference area boundaries and be within an area having the vegetative cover type being measured. Additionally, at least one ground cover sample point must be measured in each noncontiguous unit, if the release area does not consist of a single unit.

3. The permittee shall notify the Department ten (10) days prior to conducting sampling or other harvesting operations to allow a representative from the state an opportunity to monitor the sampling procedures.

B. Sampling Techniques

1. Line Point Transect (Ground Cover)

A line point transect shall be a series of 100 points spaced 1 foot apart along a straight line. The permittee shall establish a transect at each of the randomly selected sampling points. The direction of the transect shall also be determined randomly. This can be done as easily as spinning a pencil on a clipboard or throwing it in the air and using the direction where it points.

Ground cover shall be measured as the area covered by the combined aerial parts of the accepted plant species and the leaf litter that is produced naturally onsite, expressed as a percentage of the total area of measurement.

The permittee shall classify the ground cover by species at each 1-foot interval along the entire length of the

transect (starting at 1 foot from the random point). The area of measurement shall be a line projected downward and perpendicular to the ground at each 1-foot interval (100 in total).

At each point along the transect, ground cover shall be classified by species as acceptable or unacceptable as follows:

Acceptable	Unacceptable
Vegetation approved in permit	Vegetation not approved in permit
Dead vegetation or litter from from acceptable species	Rock or bare ground
Acceptable-not approved in permit	

All data gathered from the line point transects shall be recorded in the format shown in Appendix B.

2. Sampling Frames (Productivity)

A sampling frame can be square, rectangular, or circular enclosure measuring at least two feet square capable of enclosing the sample location. A sample location shall be established at each of the randomly chosen sites, such that the center of the sampling frame is the random point. The permittee shall clip the biomass 2" above ground level within the frame. The biomass to be clipped shall be from all plant species growth whose base lies within the sampling frame. This biomass shall then be weighed and recorded. As each frame is clipped and weighed, the biomass shall be put into a bag for oven drying. Samples shall be oven dried to a constant weight and reweighed to determine dried weight. The weight of each oven-dried sample can be increased by 12% to account for the extra moisture removed during the process of oven drying. All data collected from the clippings within the sampling frame shall be recorded in the format presented in Appendix C.

3. Whole Area Harvesting (Productivity)

If whole release area harvesting is chosen as the method for data collection, the entire area or representative test plots shall be harvested and the system as outlined in Appendices D, J, and K shall be used for data analysis. 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 ten (10) percent, or fifteen (15) large round bales, whichever is greater; or ten (10) percent or fifteen (15) small round bales whichever is greater and converted to lbs/ac by taking their average weight and multiplying that figure times the total number of bales, divided by the number of acres harvested.

To determine which bales to weigh, randomly select a number from one to ten then count and weigh every tenth (10th) 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, either advance one bale or select the immediate bale previous to the last bale produced.

C. Sample Adequacy

1. For Ground Cover Data

The permittee shall collect data from transects using a multi-staged sampling procedure. During the first stage, the permittee shall take an initial group of transects (minimum of ten). By using these initial transects and by applying the formula below, the permittee shall determine the actual number of transects needed:

$$n = \frac{(t^2)(s^2)}{(0.1x)^2}$$

Where n = the minimum number of samples needed

t^2 = squared t-value from the table in Appendix D

s^2 = initial estimate of the variance of the release (or reference) area

$(0.1x)^2$ = the level of accuracy expressed as 10% of the average cover. Note that this term is squared.

Example uses of the formula are shown in Appendix F.

If the formula reveals that the required number of samples is equal to or less than ten, the initial sampling will satisfy the sampling requirements. If the

number of samples needed is greater than ten, the permittee must take the balance of additional samples (Stage Two Sampling), as specified by the formula, and recalculate n. This process shall be repeated until sample adequacy is met.

2. For Sample Frame Data (See Appendix G)

The permittee shall collect hay cuttings using a multi-staged sampling procedure. During the first stage, the permittee shall take an initial group of sample frame cuttings (minimum of ten). By using these initial samples and by applying the formula below, the permittee shall determine the actual number of samples needed:

$$n = \frac{(t^2)(s^2)}{(0.1x)^2}$$

The variance (s^2) must be based on oven-dry weight

Where n = the minimum number of samples needed

t^2 = squared t-value from the table in Appendix D

s^2 = initial estimate of the variance of the release (or release (or reference) area

$(0.1x)^2$ = the level of accuracy expressed as 10% of the average weight. Note that this term is squared.

Example uses of the formula are shown in Appendix G.

If the formula reveals that the required number of samples is equal to or less than ten, the initial sampling will satisfy the sampling requirements. If the number of samples needed is greater than ten, the permittee must take the balance of additional samples (Stage Two Sampling), as specified by the formula, and recalculate n. This process shall be repeated until sample adequacy is met.

V. Data Analysis

If the data shows that revegetation success has been met, the permittee shall submit the data to the Director for review in the format shown in Appendices B, C, and D.

When the data indicates that the average ground cover and average forage production was insufficient, but close to the standards, the permittee may submit the data to the Director

to determine if the production was acceptable when statistically compared to the standards using a t-test at a 90-percent statistical confidence interval. See Appendices C, D, and J.

Raw yield data from reclaimed (mined) areas and raw data from reference (unmined) areas must first be oven dried to remove moisture, then adjusted by the established moisture content standard, Appendix K. This must be done before statistical comparisons can be made.

VI. Maps

A. Whenever a new Phase III plan is submitted to the Department, it must be accompanied by maps showing:

1. the location of the area covered by the plan (i.e., the area proposed for release);

2. the location of test and reference plots; and

3. all permit boundaries.

A. Whenever data from a previously approved plan is submitted to the Department, it must be accompanied by maps showing:

1. the location of test and reference plots;

2. the location of <u>each transect and sample frame point</u>;

3. the area covered by the sampling; and

4. all permit boundaries.

VII. Mitigation Plan

Ground cover and forage productivity must equal or exceed (pass) the standards for Phase III liability release for at least two sampling years during the second through the fourth years following completion of the last augmented seeding. If productivity is not achieved by these dates, the permittee must submit a mitigation plan to the Director which includes the following:

A. a statement outlining the problem;

B. a discussion of what practices, beyond normal farming

practices, the operator intends to use to enable the area to finally meet the release standards; and

C. a new Phase III liability release plan.

If renovation, soil substitution or any other practice which constitutes augmentation is employed, the five year responsibility period shall restart after the mitigation plan is approved and the practices are completed.

APPENDIX A

Selection of Random Sampling Sites

The permittee shall use X and Y grid coordinates in establishing the location of sampling sites on the reclaimed area (and on the reference area, if a reference area standard is used).

A grid shall be placed or drawn on the map containing the areas to be sampled. The grid must be large enough so that all of the release or reference area is covered by the grid (see drawing in Figure 1). Also, the grid pattern shall be such that the axes are 200 feet apart or closer. The X and Y axes shall be numbered in consecutive order beginning at the extreme lower left point of the grid (this point being 1).

The permittee shall generate random number pairs for each X and Y axis combination needed. For example, if five (5) sampling locations are to be established, the permittee must generate five (5) random number pairs.

The random numbers table shown in Table 1 may be used to choose the numbers needed. The table is used as follows:

Step 1) Choose an axis to work on (X or Y).

Step 2) Flip a coin twice to determine a column on which to start (refer to coin flip combinations at the head of each column).

Step 3) By beginning at the top of the column selected, begin reviewing the numbers until a number that falls within the range of those on the chosen grid axis is found. If the range of numbers on the axis is less than 10, then you will only review the last digit of the numbers in the column. If the range of numbers is more than 10 but less than 100, then the last <u>two</u> digits will be reviewed.

Step 4) Record the first number found.

Step 5) Beginning after the last number found, continue down the column until another number is located within the given range. Record this number and continue following the above procedure until the required amount of numbers is found and recorded. If you reach the bottom of the column before you locate enough numbers, proceed to one of the adjacent columns, starting again at the top. When all columns have been used, begin again with the first

column used, except review only the first (instead of the last) one or two digits of the numbers in the column.

Step 6) After enough numbers are generated for the first axis chosen, restart the process at Step 1 for the other axis.

After enough random number pairs have been generated for each axis, locate the sample points on the grid. If a point(s) falls outside the release or reference area, a new point(s) must be chosen as explained above.

APPENDIX A

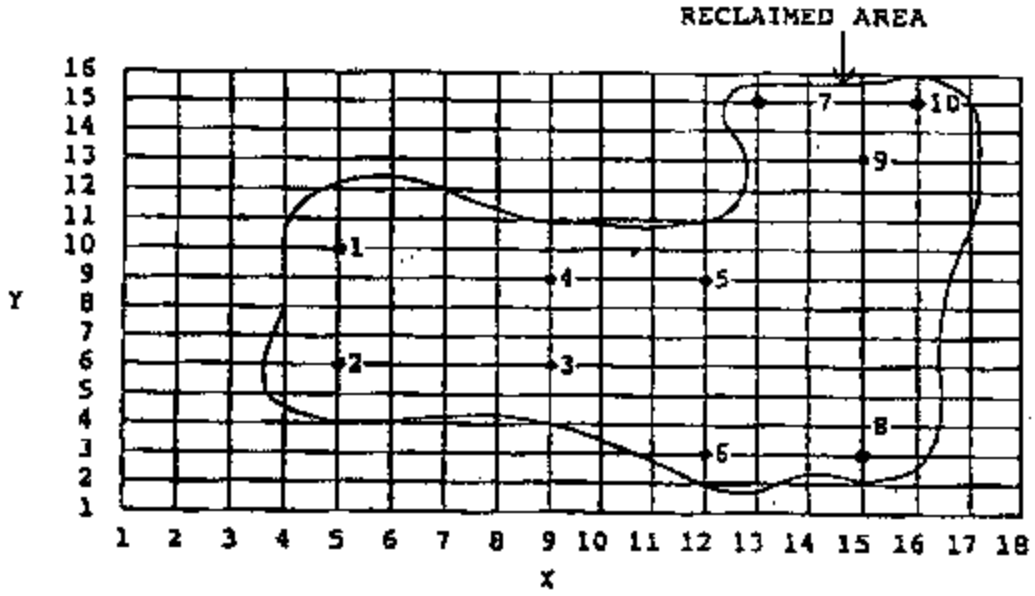
Table 1
A Set of Random Numbers

Heads/Heads Column 1	Tails/Tails Column 2	Heads/Tails Column 3	Tails/Heads Column 4
6327	0983	3798	4679
2167	6484	9467	9058
3939	0407	1804	8827
4672	3865	5689	9878
8071	5185	5514	5008
9509	0603	7461	8550
6615	2588	3558	3349
4833	2422	9790	1183
5594	1809	6931	6571
9441	1699	3947	7702
7922	9812	7229	5252
9419	6494	8179	8065
6178	3556	2466	2495
2647	3961	7546	4799
0474	1839	6926	6534
9814	1577	8293	0301
0104	4579	0627	8667
1608	9470	4131	5345
9722	1557	0471	5498
4189	3582	3675	9461
9855	8088	9006	6897
5791	8234	1472	3421
0872	3310	0510	9046
8953	9809	8037	8376
2895	4319	6544	8953
0609	5248	8734	2498
0795	2464	6170	1063
1572	7371	7936	2841
4307	0294	6060	5194
4857	0197	2401	7005
1632	7189	6463	9830
0745	8034	7882	7152
0736	5110	5165	6571
8168	7924	5876	1407
7468	5313	2736	9010
6044	5420	3077	9070
6716	0059	3001	8871
9342	0169	6880	7986
5809	6048	9051	1151
1532	9715	7081	0109
5506	5812	5917	4415
4045	1751	2817	9958
5966	9930	6437	7279
6062	3296	5093	2503
4097	8379	5670	0614
6793	3999	4645	5143
7960	4853	0583	1920
1321	4067	8503	1604

APPENDIX A
FIGURE 1

RANDOM PLOT LOCATIONS GRID OVERLAY

Random Plot	Random Numbers	
	X	Y
1	5	10
2	5	6
3	9	6
4	9	9
5	12	9
6	12	3
7	13	15
8	15	3
9	15	13
10	16	15



APPENDIX B, PART 1

(Example of format for summarizing line point transect data.)

SUMMARY DATA FORM FOR LINE-POINT TRANSECTS

Page ___ of ___

Company Name _____

Check One: ~ Reclaimed Area ~ Reference Area

Permit No. _____ (If reference area, indicate permit to which data will be compared)

Land Use _____

Acres in Sampling Release Area _____

No. of Transects Used (n) _____

Date of Sampling _____

Transect No. (n)	Acceptable Points Found (Out of 100) (X)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	

3n = _____ 3X_____

Mean O = 3X/3n = _____

APPENDIX B, PART 2

Example of Format for Recording Line Point Transect Information:

LINE POINT TRANSECT SHEET

Page _____ of _____
Company Name _____
Permit No. _____
Land Use _____
Date of Sampling _____
Line Point Transect # _____

Point #	Accept or Unaccept	Point #	Accept or Unaccept	Point #	Accept or Unaccept	Point #	Accept or Unaccept
1		26		51		76	
2		27		52		77	
3		28		53		78	
4		29		54		79	
5		30		55		80	
6		31		56		81	
7		32		57		82	
8		33		58		83	
9		34		59		84	
10		35		60		85	
11		36		61		86	
12		37		62		87	
13		38		63		88	
14		39		64		89	
15		40		65		90	
16		41		66		91	
17		42		67		92	
18		43		68		93	
19		44		69		94	
20		45		70		95	
21		46		71		96	
22		47		72		97	
23		48		73		98	
24		49		74		99	
25		50		75		100	

Species % Stand

$$\% \text{ Cover} = \frac{3 \text{ Accept}}{100} = \_\_\_\_\_$$

$$\% \text{ Accept/not approved} = \frac{3 \text{ ANA}}{100} = \_\_\_\_\_$$

APPENDIX C

(Example of format for summarizing sampling frame data.)

SUMMARY DATA FORM FOR SAMPLING FRAMES

Page ___ of ___

Company Name _____

Check One: ~ Reclaimed Area ~ Reference Area

Permit No. _____ (If reference area, indicate permit to which data will be compared)

Land Use _____

Acres in Sampling Area (A) _____

Number of Samples Taken (n) _____

Date of Sampling _____

NRCS Productivity Adjustment Up/Down (Appendix K) _____

Sampling Number	Wet Weight in Grams	(Reclaimed Area) Oven Dry Weight in Grams (DW)	(For Reference Plots) Productivity Adjusted Weight/In Grams (ADW)
_____	_____	_____	_____
n		3DW	3ADW

Reclaimed Area Mean O = $\frac{3DW}{n}$ = _____

or

Reference Area Mean O = $\frac{3ADW}{n}$ = _____

APPENDIX D

Data Form for Forage Crop Production Data Harvested as Baled Hay

Page___ of ___

Company Name: _____

Reference Area: ~ Test Area: ~

Permit: _____ (If reference area, indicate permit to which data will be compared)

Land Use: _____

Acres in Harvested Area: _____ Plot or Area Number:_____

Number of Bales Harvested (B): _____ Number of Bales Weighed (n): ___

NRCS Productivity Adjustment Up/Down (Appendix K): _____

Bale Weight (x)	Bale Weight (x)	Bale Weight (x)	Bale Weight (x)

Mean (O)= $\frac{\Sigma x}{n}$ = _____

Test-area production per acre = $\frac{BO}{A}$ = _____

Reference-area production per acre = $\frac{(\text{NRCS PI})BO}{A}$ = _____

If the test area production per acre is equal to or greater than the reference production per acre, the test passes. If the test area production is less than the reference, the statistical analysis needs to be run. Refer to Appendix H.

APPENDIX E

d.f.	t.100
1	3.078
2	1.886
3	1.638
4	1.533
5	1.476
6	1.440
7	1.415
8	1.397
9	1.383
10	1.372
11	1.363
12	1.356
13	1.350
14	1.345
15	1.341
16	1.337
17	1.333
18	1.330
19	1.328
20	1.325
21	1.323
22	1.321
23	1.319
24	1.318
25	1.316
26	1.315
27	1.314
28	1.313
29	1.311
inf.	1.282

Note: for the sample adequacy calculations and 1 tail productivity comparisons, use column t.100.

From "Table of Percentage Points of the t.Distribution." Biometrika, Vol. 32 (1941), p.300. Reproduced by permission of the Biometrika Trustees.

APPENDIX F

Example Use of Sample Adequacy Formula for Ground Cover Measurements

In this example, the permittee has taken an initial group of samples from ten (10) randomly located point-line transects. The results of his sampling are as follows:

1) Calculating the variance:

Transect No. (n)	Acceptable Points (Out of 100) X	X^2
1	86	7,396
2	90	8,100
3	76	5,776
4	82	6,724
5	40	1,600
6	76	5,776
7	40	1,600
8	82	6,724
9	86	7,396
10	90	8,100
	$3X = 748$	$3X^2 = 59,192$

Now we need to calculate the variance, S^2:
Number of transects taken (n) = 10.

$$S^2 = \frac{3X^2 - \frac{(3X)^2}{n}}{n-1}$$

or, put into words:

$$S^2 = \frac{\text{Sum of all Squared Values} - \frac{\text{Square of Sum of All Values}}{\text{\# of Values}}}{(\text{Number of Values} - 1)}$$

From the data in the above example, we calculate:

$$S^2 = \frac{59,192 - \frac{(748)^2}{10}}{9} = 360.18$$

Appendix F
Page 2

2) Determining sample adequacy:

From the t table, we find t for a sample size of 10.

3n-1 = degrees of freedom

10-1 = 9 degrees of freedom for our example

From the t table, locate the t statistic for 9 degrees of freedom = 1.383

$$\text{Mean } O = \frac{3x}{n}$$

The sample adequacy formula is:

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

Plugging these values into the sample adequacy formula, we get:

$$N = \frac{(1.383^2)(360.18)}{(7.48)^2} = \frac{688.91}{55.95} = 12.31 \text{ or } 13$$

Since we already have taken 10 samples and the sample adequacy formula tells us we need only 13, we need to take an <u>additional</u> three (3) transects (13 - 10 = 3).

Now, when those 3 additional transects have been taken, a new variance must be calculated and the sample adequacy formula recalculated. This is to ascertain that the 3 additional transects didn't somehow increase the variance and therefore require still more transects. If this happens, the additional transects must be taken and the variance recalculated to determine sample adequacy.

The sample adequacy requirements must be fulfilled before a comparison to the standard can be made.

APPENDIX G

Example Use of Sample Adequacy Formula for Hay Production Measurements

In this example, the permittee has taken an initial group of ten (10) randomly located sampling frames. The results of the sampling are as follows:

Frame No. (n)	Oven Dry Weight per Sampling Frame X	X^2
1	72.2	5,212.84
2	80.0	6,400.00
3	22.0	484.00
4	96.5	9,312.25
5	100.2	10,040.04
6	25.0	625.00
7	81.0	6,561.00
8	96.0	9,216.00
9	100.9	10,180.81
10	51.0	2,601.00
n=10	$'X = 724.8$	$'X^2 = 60,632.94$

Now we need to calculate the variance, S^2:
Number of Sampling Frames (n) = 10.

$$S^2 = \frac{'X^2 - \frac{('X)^2}{n}}{n-1}$$

or, put into words:

$$\text{Variance} = \frac{\text{Sum of All SQUARED Values} - \frac{\text{Square of SUM of All Values}}{\text{\# of Frames}}}{\text{(Number of Frames - 1)}}$$

APPENDIX G
Page 2

From the data in the above example, we calculate:

$$S^2 = \frac{60{,}632.94 - \frac{(724.8)^2}{10}}{9} = 899.94$$

2) Determining sample adequacy:

From the t table, we find t for a sample size of 10.

n-1 = degrees of freedom

10-1 = 9 degrees of freedom for our example

From the t table, locate the t statistic for 9 degrees of freedom = 1.383

The sample adequacy formula is : $n = \frac{(t^2)(s^2)}{(0.1x)^2}$

Where:

$(0.1X)^2$ = 10% of mean squared. 10% of 72.48 = 7.248, so $(7.248)^2$ = 52.53

Mean $O = \frac{'x}{n}$

N = the number of samples which will need to be taken

t^2 = t table value, squared (See Appendix D)

S^2 = variance

Plugging these values into the sample adequacy formula, we get:

$$N = \frac{(1.383^2)(899.94)}{52.53} = 32.76 = 33 \text{ samples needed}$$

Since we already have taken 10 samples and the sample adequacy formula tells us we need a total of 33, an additional 23 samples will need to be taken.

Now, when the 23 additional samples have been taken, a new variance must be calculated and the sample adequacy formula recalculated. This is to ascertain that the additional samples didn't somehow increase the variance and therefore require still more samples. If this happens, the additional samples must be taken and the variance recalculated to determine sample adequacy.

APPENDIX H

Statistical Analysis on Ground Cover Measurements

In performing statistical comparisons for groundcover, results of randomly assigned line-point transects will be compared to the success standard ninety percent (90%) ground cover at a ninety percent (90%) confidence statistical interval as illustrated in the following example:

Null hypothesis: Ground cover on release area $\geq$ 90% ground cover

Alternate hypothesis: Ground cover on release area < 90% ground cover

	Release Area Sample Results (x)	x^2	Ground Cover Standard
Assume that it took 10 samples to achieve sample adequacy	41%	1681	90%
	72%	5184	
	89%	7921	
	42%	1764	
	69%	4761	
	80%	6400	
	42%	1764	
	57%	3249	
	77%	5929	
	89%	7921	
	$3x = 658\%$	$3x^2 = 46,574$	

$$\text{Ground Cover Mean (O)} = \frac{3x}{n} = \frac{658}{10} = 65.8$$

$$\text{Standard Deviation (s)} = \sqrt{\frac{3x^2 - \frac{(SX)^2}{Sn}}{3n-1}} = \sqrt{\frac{46574 - \frac{432,964}{10}}{9}} =$$

$$\sqrt{\frac{46574 - 43296.4}{9}} = \sqrt{\frac{3277.6}{9}} = \sqrt{364.178} = 19.08$$

Number of Samples (n) = 10

t table 0.10 a df (10-1) = 1.38

$$t \text{ calculated} = \frac{|\text{Ground Cover Mean of Release Area} - \text{Target Ground Cover}|}{s/\sqrt{n}}$$

$$= \frac{|65.8-90|}{19.08/\sqrt{10}} = \frac{24.2}{6.03} = 4.01$$

Since 4.01> 1.38, the null hypothesis is rejected; and it cannot be accepted that the ground cover on the release area is greater than or equal to the target ground cover.

APPENDIX I

Statistical Analysis on Sampling Frame Data

In performing statistical comparisons for hay production when sample areas are harvested, harvest results of the randomly assigned sample areas will be compared using a t-test to ninety percent (90%) of the target or reference yield, using a ninety percent (90%) confidence interval. The hypotheses should be set up as follows:

Null hypothesis: Hay yield on release area $\geq$ 90% target yield

Alternate hypothesis: Hay yield on release area < 90% of target yield

If NRCS target yield is used as a standard, the tonnage of forage produced must be divided by 22,687.5 to convert it to sample frame weights.

APPENDIX J

Statistical Analysis on Whole Release Area Harvesting

In performing statistical comparisons for hay production when a whole field is harvested, the weights of either ten (10) percent or fifteen (15) small bales, whichever is greater; or ten (10) percent or fifteen (15) round bales whichever is greater; are converted to lbs./ac. and compared to ninety (90) percent of the reference or target yield, using a ninety (90) percent or greater statistical confidence level as approved by the Director in consultation with the NRCS follows:

Null hypothesis: Hay yield on release area > 90% reference or target yield

Alternate hypothesis: Hay yield on release area < 90% reference or target yield

Example: Size of release area: 40 acres
Number of bales harvested: 125
Number of bales weighed: 15

Release Area Harvest Data

Adjusted* Weight Per Round Bale (x) -lbs-	x^2	90% Reference Area or Target Yield
1,100	1,210,000	
1,000	1,000,000	3,200 lbs/ac
975	950,625	
900	810,000	
1,000	1,000,000	
1,100	1,210,000	
1,000	1,000,000	
900	810,000	
1,025	1,050,625	
1,000	1,000,000	
875	765,625	
975	950,625	
1,000	1,000,000	
1,100	1,210,000	
1,150	1,322,500	
$3x = 15,100$	$3x^2 = 15,290,000$	

$$\text{Mean } (O) = \frac{3n}{n} = \frac{15,100}{15} = 1006.7 \times 125 \div 40 \text{ acres} = 3145.9 = \underline{3146}$$

*See Appendix K.

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$$\text{Standard Deviation (s)} = \sqrt{\frac{3X^2 - \frac{(3x)^2}{3n}}{n-1}}$$

$$= \sqrt{\frac{15{,}290{,}000 - \frac{228{,}010{,}000}{15{,}100}}{14}}$$

$$= \sqrt{\frac{190{,}000}{14}} = \sqrt{13{,}351.4} = 116.5$$

To determine the t-value, refer to Appendix D.

The degree of freedom is the number of samples minus "1".

We had 15 samples, subtracting 1 = 14.

Fourteen (14) degrees of freedom = 1.345 from column t.100.

Therefore, the formula to calculate t value from the harvest data is:

$$\frac{|O_1 - O_2|}{\sqrt{\frac{S^2}{sn}}} = \frac{|3{,}146 - 3{,}200|}{\frac{116.5}{s15}} = 1.79$$

Since 1.79 > 1.345, the null hypothesis is accepted. Crop yield data from the test area is not different from the yield from the reference area.

APPENDIX K

Yield Adjustments for Release Areas Due to
Differing Soil Series

When test plots and reference plots fall on different soil series, adjustments must be made to compensate for the productivity difference. The soil productivity shall be established by the NRCS from a site-specific investigation, or derived from established improved management yields for the type soil(s) in the appropriate Soil Conservation Service (NRCS) County Soil Survey. For ease of calculation, this adjustment shall always be made to the reference area yield.

Example: Bermudagrass pastureland

Consider a case in which there are three soil types (or complexes) on a permit site covering 100 acres in Johnson County. The soils types are Cane fine sandy loam (abbreviated CaB), which covers 40 acres; Leadvale silt loam (LeB), which covers 20 acres; and Leesburg-Enders Association (LBD), which covers 40 acres. The appropriate bermudagrass improved management yields from the soil survey manual are:

Soil Series	Yield in A.U.M.*
CaB	6.0
LeB	6.5
LBD	No yield provided

*A.U.M. - Animal unit months. According to the Range Handbook (1997),one A.U.M. is equal to 790 air-dried pounds of grass per acre.

In those cases such as the LBD soils when no yield figures are available, the potential range production for normal years can be used as a substitute production figure. The LBD is an example of a soil complex composed of two different soils with different range yield potentials. The Leesburg portion has a normal potential range yield of 4,345 pounds per acre while the Enders portion has a normal potential range yield of 3,950 pounds per acre. Since these make up roughly equivalent proportions of the soil complex, the two figures can be averaged to make a yield for the soil as a whole.

Using the information provided above, the soil types can be assumed to have the following bermudagrass productivities and weighting factors based on the percentage of area of the site.

Soil Series	Productivity	Weighting Factor
CaB	4,740 lbs/acre	0.40
LeB	5,135 lbs/acre	0.20
LBD	4,148 lbs/acre	0.40

The technical productivity standard is as follows:

(4,740)(0.40) + (5,135)(0.20) + (4,148)(0.40) =
1,896 + 1,027 + 1,659 = 4,582 pounds per acre

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The reference area for this permit is located on a Cane fine sandy loam with a productivity of 4,740 lbs./acre. In this situation, the test plot has a productivity that is 3.3% lower than the reference plot; therefore, the reference plot yield is adjusted downward by 3.3%.

If the reference area is on the Leeburg-Enders Association, the productivity is 4,148 lbs./acre. In this situation, the test plot has a productivity that is 10.5% higher than the reference plot; therefore, the reference plot yield is adjusted upward by 10.5%.

APPENDIX L

Grasses of acceptable plant species* for permanent ground cover on agricultural areas.

Warm Season Grasses		Cool Season Grasses	
Bahiagrass	Paspalpum notatum	Bluegrass	Poa pratensis Poa compressa
Bermudagrass	Cynodon dactylon	Redtop	Agrostis gigantea
Bluestems	Andropogon L. Schizachyrium scoparium	Orchardgrass	Dactylis glomerata
Buffalograss	Buchloe dactyloades	Fescues	Festuca arundinacea Festuca pratensis
Dallisgrass	Paspalpum dilatatum	Ryegrass	Lolium perenne
Gramagrass	Bouteloua gracilis Bouteloua curtipenula	Wheatgrass	Agropylon smithii
Indiangrass	Sorghastrum nutans	**Legumes**	
Lovegrass	Eragrostis curvula	Bird’s Foot Trefoil	Lotus corniculatus
Panicgrass	Panic virgatum	Clovers	Trifolium pratense Trifolium repens Trifolium hyubridum
		Lespedezas	Lespedeza cuneata
		Vetch	Coronilla varia Astragalus cicer

*At any time during the planning, reclamation and sampling phases, the permittee may make a written request that the Surface Mining and Reclamation Division accept plant species not listed here.

APPENDIX M

References

Bonham, Charles D., 1989. Measurements for Terrestial Vegetation. Wiley, New York, 338 pages.

Chambers, Jeanne C., and Ray W. Brown. 1983. Methods for Vegetation Sampling and Analysis on Revegetated Mined Lands. U. S. Forest Service, Intermountain Forest and Range Experiment Station, Odgen,Utah. General Technical Report INT-151.