SELECTION OF GRASS AND LEGUME SPECIES AND VARIETIES FOR RECLAMATION OF MINED LANDS[1]

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Abstract.--Several species of legumes and grasses (particularly cool-season grasses) have been successfully established and maintained on western Kentucky surface-mined land. Some varieties of these species have performed better than others. Whereas, others have given good initial yields, but the stand diminished significantly after two or more years. These decreases occurred in both pure stands as well as when seeded with a companion grass or legume.

INTRODUCTION

The data to be presented here is a summary of four separate experiments and several generalizations will be made. The initial one or two years of data for three of these experiments has been presented earlier (Powell et al., 1982; Laue et al., 1982; and Powell et al., 1983). This paper will emphasize the changes and observations that have occurred over the past few years, in some cases as long as eight years .

The Surface Mining Control and Reclamation Act (SMCRA) of 1977 provided a mandate for diversity of plant materials used within reclamation programs and also included important requirements for use of introduced plant species. The initial two field studies were initiated in anticipation of the regulations associated with SMCRA, and plots were established in 1977. Both grass and legume species were evaluated for productivity on these mine spoils for the first two years, and ground cover estimations were made in 1985.

In a subsequent study on topsoiled mined land, grasses and legume species were established in 1980 and evaluated for productivity and ground cover for the next five years under two management systems, "hay-land" and "non-harvested hay-land" or a "reclamation bond release" system.

These trials were established to assist us in making recommendations for selection of both species and varieties within a species in order to meet specific reclamation goals. The objectives of these individual experiments are given below. However, data will not be presented for all of these experiments.

1. Evaluate the suitability of 33 separate cool-season grass species and/or varieties within species as a pure stand for ground cover and agricultural production.

2. Evaluate the suitability of 33 separate cool-season grass species and/or varieties within species seeded with both 'KY 31' tall fesoue and a legume mixture for ground cover and agricultural production.

3. Make all of the above evaluations from both a fall and spring establishment season.

4. Evaluate the yield potential of 25 separate legume species established as a pure stand.

5. Evaluate the yields of these same 25 entries of legumes seeded with 'KY 31' tall fescue.

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6. Make the above evaluations from both a fall and spring establishment season.

7. Evaluate 16 legume and 16 grass species on topsoiled mined land.

8. Compare the effects of harvesting these species on forage productivity and survival under a typical "hay-land" management system.

9. Compare the forage yields and survival of these species under a "reclamation bond release" management ("unmanaged") system.

METHODS AND MATERIALS

Location

The evaluation of grass and legume species on mine spoils was conducted on Peabody Coal Company's Ken Surface Mine in Ohio County, Ky. The evaluation of grass and legume species on topsoiled mined land was conducted on Peabody's Sinclair Mine in Muhlenburg County, Ky. Both of these mines are in western Kentucky and are separated by approximately 7 miles (by air), one on each side of the Green River.

Growth Media

The spoil material on which the Ken Mine studies were established was dragline spoil above the Number 9 coal from the Carbondale formation (Pennsylvanian age). The spoil was a mixture of shale, sandstone, and siltstone with shale being the dominant rock type. After grading to the approximate original contour (6.6%) slope, the spoil was limed with 17 Mg/ha with Ag lime, $CaCO_3$.

The overburden at the Sinclair Mine was a mixture of gray and acidic black shale. The shale was limed with 67 Mg/ha of $CaCO_3$ prior to placement of 20-25 cm of topsoil. The topsoil was also limed with 16 Mg/ha.

Fertility Treatments

At both sites, surface samples were collected and fertilizers applied accordingly. At Ken, phosphorus was applied as 0-46-0 at 450 kg/ha and potassium as 0-0-60 at 225 kg/ha. Nitrogen was applied at seeding and each spring with 135 kg/ha of 33-0-0. At Sinclair, essentially the same rates of phosphorus and potassium were used. All plots received 112 kg/ha of nitrogen at seeding (Spring of 1980), but only the plots that were to be harvested received additional nitrogen in the following years, applied as a topdressing in the spring. Those plots managed for continuous hay production received nitrogen at the above 112 kg/ha rate each year. Plots under the "reclamation bond release" management system received this same rate of nitrogen in 1984 and 1985.

Seedbed Preparation

Lime was disked into the growth media just prior to seeding with a heavy-duty 'John Deere' disk harrow. At Ken, grasses and legumes were seeded both in Sept. 1977 and April 1978. The fertilizer and seed were applied to a freshly-disk surface without incorporation. At Sinclair, all plots were seeded in Oct. 1980.

Experimental Design

At Ken, a split-block experimental design was used with three replications. For the grass species study, the dimensions of each replication were 15 x 132 meters. This area was divided into three main blocks 5 x 132 meters, then these strips were divided into 33 split-blocks for the fall-seeded experiment and 32 split-blooks for the spring-seeded experiment. One of the main blooks was seeded to tall fescue, another to a birdsfoot trefoil-alfalfa mixture, and the third received only the grass species in a "pure" stand. In Table 1 are listed the identifying number, common and scientific name of each grass species, variety, and seeding rate.

A similar experimental design was used for the legume study at Ken except that only 24 entries were used. Also there were only two main blooks, the legume entry seeded alone as well as seeded with tall fescue. Plots were established in both the spring and fall. In Table 2 are listed the identifying number, common and scientific name of eaoh legume species, variety, and seeding rate.

At Sinclair, a randomized, complete-block experimental design was employed for both the grass and legume species/variety study and for both management systems. In these four experiments, 16 entries were used with four replications. The individual plot size was 5 x 10 meters.

Estimation of Ground Cover

In most cases, at least two (and often four) persons made individually-derived estimations of ground cover for each plot. We made two or more observations as a part of this research study. First of all the overall ground cover was determined. This value included all living plants. Secondly, the percent bare ground was noted, and thirdly, the percent ground cover of the seeded species, or species in cases where mixtures were planted, was recorded. The ground cover made up by the seeded species was used in some cases to calculate an "adjusted" yield. For example, if the ground cover was estimated to be 50% for the entry in question, then the total biomass was divided by 2.

Table 1. Common names, scientific names, varieties and seeding rates of the grasses used in the Ken and Sinclair mine experiments.

Entry Number	Common Name	Scientific Name	Variety	Seeding Rate kg/ha
1	Kentucky Bluegrass	Poa pratensis L.	Troy	16.8
2	Kentucky Bluegrass	Poa pratensis L.	Kenblue	16.8
3	Kentucky Bluegrass	Poa pratensis L.	Parade	16.8
4	Canada Bluegrass	Poa pratensis L.	Rubens	16.8
5	Tall Fescue	Festuca arundinacea Schreb.	Ky 31	28.1
6	Tall Fescue	Festuca arundinacea Schreb.	Kenhy	28.1
7	Tall Fescue	Festuca arundinacea Schreb.	Festal	28.1
8	Hard Fescue	Festuca duriuscula (L) Kooh	Scaldis	22.4
9	Hard Fescue	Festuca duriuscula (L) Kooh	Dura	22.4
10	Meadow Fescue	Festuca pratensis Hud.	Bundy	28.1
11	Fine Fescue	Festuca ovina L.	F-1377	5.6
12	Red Fescue	Festuca rubra L.	Fortress	28.1
13	Timothy	Phleum pratensis L.	Clair	9.0
14	Orchardgrass	Dactylis glomerata L.	Boone	16.8
15	Redtop	Agrotis alba L.	Common	9.0
16	Reed Canarygrass	Phalaris arundinacea L.	Common	11.2
17	Tall Wheatgrass	Agropyron elongatum (H.) Beauv.	Common	16.8
18	Western Wheatgrass	Agropyron smithii Rydb.	Common	16.8
19	Western Wheatgrass	Agropyron smithii Rydb.	Jacklin	16.8
20	Crested Wheatgrass	Agropyron desertorum Schult	Nordon	13.5
21	Intermed. Wheatgrass	Agropyron intermedium (H.) Beauv.	Tegmar	13.5
22	Smooth Bromegrass	Bromus inermis Leyss	Common	28.1
*				
26	Fescue/P. Ryegrass Mixture		Ky 31 Common	22.4/ 6.7
27	Fescue/P. Ryegrass Mixture		Ky 31/ Common	16.8/ 13.5
28	Fescue/P. Ryegrass Mixture		Ky 31/ Common	11.2/ 20.2
29	Fescue/P. Ryegrass Mixture		Ky 31/ Common	5.6/ 26.9
30	P. Ryegrass	Lotium perenne L.	Petra	33.7
31	P. Ryegrass	Lotium perenne L.	Revielle	33.7
32	P. Ryegrass	Lotium perenne L.	Omega	33.7
33	P. Ryegrass	Lotium perenne L.	Common	33.7
34	Intermed. Wheatgrass	Agropyron intermedium (H) Beauv.	Slate	13.5
35	Western Wheatgrass	Agropyron smithii Rybd.	Barton	16.8
36	Western Wheatgrass	Agropyron trichophorum Richt.	Luna	16.8
37	Orchardgrass	Dactylis glomerata L.	Hallmark	16.8
38	Orchardgrass	Dactylis glomerata L.	Hawk	16.8
39	P. Ryegrass	Lotium perenne L.	Manhattan	33.7
40	Reed Canarygrass	Phalaris arundinacea L.	Vantage	11.2

* Identifying numbers 23-25 were not used in this report. These plots were seeded to wheat, but were not harvested

Table 2. Common names, scientific names, varieties, and seeding rates of the legumes in the Sinclair mine experiments.

Entry Number	Common Name	Scientific Name	Variety	Seeding Rate kg/ha
1	Alfalfa	Medicago sativa L.	Apollo	22.8
2	Alfalfa	Medicago sativa L.	Classic	22.8
3	Alfalfa	Medicago sativa L.	Hy-Phy	22.8
4	Alfalfa	Medicago sativa L.	Trident	22.8
5	Alfalfa	Medicago sativa L.	Phytor	22.8
6	Alfalfa	Medicago sativa L.	Vernal	22.8
7	Red Clover	Trifolium pretense L.	Redland II	21.4
8	Alfalfa	Medicago sativa L.	Weevelck.	22.8
9	Red Clover	Trifolium pretense L.	Kenstar	21.4
10	Red Clover	Trifolium pretense L.	E-688	21.4
11	Birdsfoot trefoil	Lotus corniculatus L.	Dawn	13.5
12	Birdsfoot trefoil	Lotus corniculatus L.	Viking	13.5
13	Birdsfoot trefoil	Lotus corniculatus L.	Fergus	13.5
14	White Clover	Trifolium repens L.	Ladino	6.8
15	Big Flower Vetch	Vica grandiflora L.	Common	42.8
16	Red Clover	Trifolium pretense L.	Kenland	21.4

Determination of Yield

Yield measurements were determined by removing the biomass above 7 cm from a known area. The area harvested was not always constant for at least two reasons: The plots were not the same size, and two different harvesters were used. In most cases, a 53 cm wide, 'Snapper' rotary lawn mower was used. The fresh weights were determined by weighing these clippings on a metric dairy scales to the nearest 10 grams. For the other cases, a 'Holdrup' mechanical harvester was used in which a 1.5 m wide strip was mowed off, conveyed into a bin, and weighed to the nearest 100 g.

Adjacent to these mowed strips, small representative samples of the plant species were oollected with an electric hand shears. This plant material was placed into a pre-weighed 'whirl' bag, and the fresh weight was determined in the field with an eleotric digital balance to the nearest 0.01 g.

The samples were frozen with dry ice, transported to the laboratory, and stored frozen until they could be dried at 60°C. The loss of water was used to calculate biomass yields on an oven-dry basis. The dried plant material was ground and chemical analyses performed using standard wet-ashing methods.

Statistical Analyses

Data were analyzed using Duncan's Multiple Range for comparison of means within the analyses of variance program. All statistical analysis reported here were performed using an alpha of 0.10. This alpha level was chosen becauss Federal regulations require that success of revegetation programs be judged by a confidence interval of 10 percent. The computer program used was the HASPII System LOG-EXEC, SAS.

Because of the massive amount of data collected over the duration of these experiments, essentially only yields and ground cover estimations will be given here. We also have chosen not to include the Duncan's Multiple Range designations on some of the tables; because the number of entries were large, this frequently resulted in 3 or 4 letters to be used in such designations. Some of these data are presented in a similar way in our earlier papers (Powell et al., 1982; Laue, 1982; and Powell, 1983).

RESULTS AND DISCUSSION

Evaluation of Grasses

Grasses for Mine Spoils.--As indicated earlier, this work is a part of and/or a continuation of earlier reported work (Powell et al., 1982; Laue et al., 1982). In most cases, statistical analyses are given for only the new data collected since these papers have been published.

One important aspect of selection of a grass species and/or variety is its persistence. In Table 3 are listed percent ground cover data from 1978, 1981, and 1985 observations of areas seeded to the various grass species. Since these

data are listed in the same order as appearing in Table 1, only the identifying number and variety names are given in this table. Significant changes in percent ground cover at the 90% statistical confidenoe level from one year to the next are indicated by an asterisk. For this report, we have chosen not to repeat the yield data here since all yield data collected from these plots are given in the paper by Powell et al., 1982 .

Table 3 contains ground cover data for species established in both seeding seasons for western Kentucky conditions, i.e. fall and spring. There are two values listed for 1985. One estimation was made as to total ground cover, the higher of the two values, and the other was that of only the seeded species. In one sense of the word, the differences between these two numbers would qualify as being "weeds," as these plants were not seeded, but essentially all of these are desirable "weeds" as they are the grasses (and legumes) that have moved through reseeding to adjacent plots. For the most part, the dominant grass species that have migrated include Ky bluegrass, tall fescue, and Canadian bluegrass. Whereas, birdsfoot trefoil was the legume that invaded the various blocks seeded as a pure stand. In many cases, the plot northeast contained a significant amount of tbe same grass species that was originally seeded to the southwest. The prevailing wind direction in this area is from the southwest to northeast. However, as one would expect, the same trend was not as prevalent for the legume species seeded in this general area.

There are several trends in these data that were somewhat unexpected. First of all was the excellent ground cover from plots seeded to Kentucky bluegrass. In 1981, the varieties of this species exhibited some of the best ground covers, for both plots seeded in tbe spring and the fall. By 1985 the ground cover of plots seeded to bluegrass increased in total percentage, although this inorease was primarily the result of other grasses and legumes moving into these plots. By the same token, bluegrass seed migrated (downwind) into adjacent plots. In fact, in many cases, it became the dominate species in these adjacent plots. The same can be said for Canadian bluegrass.

We reported in our 1982 paper (Powell et al., 1982) higher yields for the 'Kenblue' variety than the other bluegrass varieties, even though 'Kenblue' did not have the highest ground cover. However, in 1982 'Kenblue' had about the same ground cover as 'Troy', the best bluegrass variety in 1981.

In contrast to Ky bluegrass, perennial ryegrass varieties were the opposite. They initially had one of the best ground covers and produced the highest yields in 1979, but the stands (and yields) declined with time. In 1985, the range in total ground cover of the four varieties initially seeded to perennial ryegrass was 68.3 to 100%, yet for only the 'Petra' variety, a turf type ryegrass, was any of this species observed (10%). The ground cover was primarily birdsfoot trefoil with some tall fescue as well as several other grasses seeded in adjacent plots.

With respect to persistence of the various grasses, two entries were higher than all others, these being 'Jacklin' western wbeatgrass and a common, or an unnamed, variety of tall wheatgrass. Other grasses with greater than 50% ground cover of the originally seeded species included: 'Ky 31' tall fescue; 'Scaldis' hard fescue; a common smooth bromegrass; and 'Kenblue' Ky bluegrass.

In general, the plots seeded to species that were "weaker" in 1979-1981, and/or had a lower growing height habit, are now largely birdsfoot trefoil with some other grasses. Whereas, those that remained vigorous in 1981 remained near the top in ranking in 1985.

In addition to the perennial ryegrasses, there were a few other entries that also performed rather poorly. These grasses include: 'Nordon' crested wheatgrass, 'Bundy' meadow fescue, and 'Boone' orchard grass. One should also note that some varieties within a species performed differently in this research project on mine spoils. For example, 'Parade' Ky bluegrass had a much lower ground cover than 'Troy' or 'Kenblue' varieties. The same can be said for 'Festal' tall fescue in comparison with 'Ky 31' and 'Kenhy.'

Grasses--Topsoiled Mined Land.--Some of the same varieties and species were established on a topsoiled site on Sinclair. We chose some of the higher yielding varieties from the Ken Mine experiment, and some additional varieties of those species that gave lower than the desired values were seeded, in the hope of finding better varieties.

Some interesting trends in percent ground cover may be observed in Table 4. All of these entries are ground cover of the seeded species. Although we made the measurements of total ground cover, we did not report these data, however in most cases it was greater than 90%. The one exception to this was for the two perennial ryegrass varieties which had total ground covers less than 75% (data not shown).

In the case where plots were harvested each year, essentially half of the entries had ground covers in excess of the minimum value for bond release (i.e. 80%). This is under the assumption that had larger areas been seeded to pure stands, the same amount of ground cover would have been found in the absence of a close "weed" source of other grass varieties.

Table 3. Estimated ground cover[1] for each seeded species established in the fall and spring at Ken mine area

Entry Number	Variety	Established Fall				Established Spring			
		1978	1981	1985	1985*	1978	1981	1985	1985*
		%							
1	Troy	48.4	85.0*	95.0	41.5	30.0	90.0*	98.8	45.0
2	Kenblue	42.0	61.8*	85.0*	30.0	33.4	88.4*	93.3	36.7
3	Parade	54.2	82.2*	100.0*	20.0	28.4	55.6*	66.7	10.0
4	Rubens	80.8	81.6	95.0	45.0	28.8	84.0	100.0	46.7
5	Ky 31	51.6	65.8*	85.0*	56.7	45.4	92.2*	100.0	6.7
6	Kenhy	70.4	75.4	91.7	36.7	50.0	77.8*	100.0*	21.7
7	Festal	60.4	72.2	83.3	15.0	30.0	72.2*	98.3*	6.7
8	Scaldis	61.2	81.1	93.3	53.3	41.6	93.8*	98.3	15.0
9	Dura	64.8	71.6	90.0	33.3	30.0	71.2*	73.3	16.5
10	Bundy	65.8	76.2	96.7*	1.7	40.0	54.4	91.7*	0.0
11	F-1377	37.6	66.2	86.3*	6.7	29.2	78.8*	100.0*	3.3
12	Fortress	66.2	71.2	96.7*	25.0	41.6	70.0*	80.0	0.0
13	Clair	68.6	65.4	80.0	46.7	35.6	77.8*	95.0	30.0
14	Boone	62.2	68.0	88.3*	6.7	45.0	67.2*	96.7*	13.3
15	Common	74.2	65.4	96.7*	35.0	31.8	70.0*	91.7*	6.7
16	Common	49.4	56.8	73.3*	48.3	48.4	81.6*	96.7	45.0
17	Common	45.8	70.8*	86.6	78.3	45.0	92.2*	95.0	60.0
18	Common	48.4	64.6*	80.0	30.0	33.4	76.6*	98.3*	46.7
19	Jacklin	64.4	82.8*	98.3*	60.0	26.6	62.8*	91.7*	1.7
20	Nordon	59.2	59.6	73.3	0.0	32.8	75.0*	91.7*	11.6
21	Tegmar	50.2	61.2	83.3*	16.7	25.6	39.4	71.7*	33.3
22	Common	69.0	76.6	93.3	58.3	54.2	86.6*	95.0	50.0
26	Ky31/Common	68.0	70.4	80.0	**	47.8	79.0*	96.7	**
27	Ky31/Common	75.8	86.8	96.7	**	41.4	58.8	83.3*	**
28	Ky31/Common	62.8	77.8	95.0*	**	45.0	61.2	90.0*	**
29	Ky31/Common	69.6	61.2	93.3*	**	56.6	84.2*	100.0*	**
30	Petra	56.6	44.2	68.3*	100.0*	66.6	74.4	98.3*	1.7
31	Revielle	76.0	71.2	100.0*	0.0	52.0	65.6	86.7*	0.0
32	Omega	75.4	48.2*	80.0*	0.0	46.4	55.6	91.7*	0.0

[1] Significant changes in ground cover between years are indicated by asterisk at alpha = .10.

* Second cover of seeded species only.

** Contained only tall fescue and other grasses - no P ryegrass detected.

In addition, under the "unmanaged" system essentially one-fourth of the 16 entries gave sufficient ground covers at the end of 5 years to meet bond release standards, although these were not the same varieties and/or species that gave the better ground covers under a "hay-land" management system. There were two entries 'Kenblue' bluegrass and 'Clair' timothy that exceeded 80% ground cover under both systems of management.

Redtop (entry 15) had good ground covers under both management systems as well as having the highest yield from the seeded species point of view. If one multiplies the decimal fraction of the ground cover by the total yield, an adjusted yield may be calculated, i.e. 3288 x 0.77 = 1722 kg/ha for the redtop entry. The top 6 entries for adjusted yield are common redtop; 'Clair' timothy, 'Barton' western wheatgrass, 'Hawk' orchardgrass, 'Kenhy' tall fescue, and 'Kenblue' bluegrass, with yields of 1722, 1580, 1399, 1180, 1094 and 965 kg/ha, respectively. The five lowest adjusted yields were 'Manhattan' P ryegrass, 'Omega' P ryegrass, 'Nordon' crested wheatgrass, 'Creeping' red fescue and 'Vantage' Reed canarygrass with yields of 11, 26, 88, 158, and 288 kg/ha, respectively. It should be noted that total biomass removed from the 'Manhattan' P. ryegrass in 1985 was greater than for any other plot, 3335 kg/ha, but since only 2% of this yield was from the seeded species, the remainder of the plant material was "weeds" or grasses seeded on adjacent plots and this results in the lowest adjusted yield.

In 1984, 'Barton' western wheatgrass was the highest yielding entry, with 'Clair' timothy, ,Ky 31' tall fescue and 'Kenblue' bluegrass also giving excellent yields.

In comparisons of the various varieties within the individual species, most entries were not significantly different. 'Hawk' appeared to have a better adjusted yield than the other two entries, 'Hallmark' and 'Boone.' On the otherhand, 'Barton' was the best of the wheatgrasses but these really were not multiple entries as they are different species.

It is also interesting to note that in 1984, in every case, yields from the "hay-land" management system outyielded the "unmanaged" system. In all but one case, 'Barton' western wheatgrass, these differences are significantly different. However, after only the first cutting had been take in 1985, in 14 of the 16 cases, yields from this second year of harvesting the "unmanaged" systems were greater than those under the "hay-land" management system. In other words, removal of hay appeared to stimulate the species rather than harming it. For the other two cases, yields from 'Hawk' orchardgrass were essentially equal and yields from the red fescue entry were similar.

Legumes.--Both yields and estimated ground covers for each of 16 entries from the Sinclair Mine study are given in Table 5. This table also contains data for plots from two management system, i.e. "hayland" and "unmanaged." Ground cover data from the Ken Mine study are not reported here.

With the exception of birdsfoot trefoil and crown vetch, all ground covers for the seeded legume species had declined. However, this area had a good to excellent ground cover, but it was largely tall fescue. This decline in stand of the legume and a simultaneous increase in ground cover of the grass was most likely the result of a severe drought that occurred in 1983. This allowed the grasses to spread as they produce seed early; whereas, most legumes normally produce their seed later and hence were hurt more by this dry weather. We believe that birdsfoot trefoil is doing well as a result of its ability to produce and scatter seed earlier and over a longer period. Other entries that were doing fair were some of the lespedeza entries. Red clover and alfalfa plants were few and far between. Crown vetch was growing very well, but it did not appear to be spreading that much.

At Sinclair Mine,(Table 5) the ground covers of some species declined with time, for example white clover, and alfalfa; whereas, the ground cover for red clover and birdsfoot trefoil varieties fluctuated widely as a result of natural reseeding. All of the ground coverages in 1984 were low due to a severe drought that occurred in late 1983. Had we harvested some of these entries in 1983 and not allowed the few scattered plants to set seed, we believe that the yields in 1984 and 1985 would have been much lower. Very good reseeding occurred for the 'Fergus' and 'Dawn' birdsfoot trefoil and most of the red clover entries. There was some improvement in stand of alfalfa in 1985 over 1984, but most varieties remained at the low coverage established at the time of the drought. In addition, in the case of alfalfa, severe heaving also occurred in the winter and early spring of 1984. Many of the alfalfa plants were raised at least 5 cm in this process, and the first mowing killed the otherwise surviving plant.

Alfalfa yields from the "unmanaged" varieties in 1984 were good to excellent. For example, one variety, 'Vernal,' had a yield of 7146 kg/ha which was about 75% of that needed for bond release for prime land. However, these yields should be considered as being "mixed hay," as a significant amount of tall fescue "weeds" occurred in these as well as most all of the "unmanaged" plots.

Yields as well as ground covers from the 'Viking' entry of birdsfoot trefoil were less than those from the other varieties. This

Table 4. Yields and ground cover estimations for various grasses on topsoiled mined land - Sinclair Mine.

Entry Number	Grass Variety	---1981---- Yield kg/ha	G.C. %	---1982---- Yield kg/ha	G.C. %	---1983---- Yield kg/ha	G.C. %	---1984---- Yield kg/ha	G.C. %	---1985*--- Yield kg/ha	G.C. %	---1984**-- Yield kg/ha	G.C. %	---1985**-- Yield kg/ha	G.C. %
2	Kenblue	2732	84	2108	91	1350	96	3605	87	1070	90	1386	55	1131	80
5	Ky 31	3754	96	2256	83	1896	79	4296	89	1004	90	1281	39	1561	72
6	Kenhy	4571	100	2377	80	1714	81	3250	61	1224	89	1374	44	1904	77
12	Common	2654	90	2345	44	2038	59	4290	13	1728	13	1951	46	1660	32
13	Clair	4189	96	2465	59	2415	75	5169	81	1692	84	2229	49	2582	83
14	Boone	2512	80	2637	39	2066	40	3421	56	1067	83	1444	23	1513	51
15	Common	3143	89	3240	74	3144	81	5013	52	2068	82	2427	54	3288	77
20	Nordon	3051	91	1633	47	1692	39	4037	12	1435	7	1868	26	1737	9
32	Omega	4776	98	893	38	1224	44	2984	24	1152	2	1368	3	1383	22
34	Slate	3712	99	2020	56	1342	45	3609	54	1143	56	2347	61	1288	78
35	Barton	2451	58	3328	73	2563	74	6938	73	1725	79	6069	90	2339	86
36	Luna	4198	83	2053	40	2162	44	5482	37	1682	47	2702	66	1818	75
37	Hallmark	2865	73	2108	35	1792	40	2844	32	1206	66	1699	27	2001	65
38	Hawk	2960	87	2157	41	1954	40	3001	21	1495	80	1946	22	1480	67
39	Manhattan	4912	100	701	20	302	15	4266	30	1353	1	1988	2	3335	2
40	Vantage	1834	63	2238	30	1784	38	3498	18	949	27	2480	30	1551	34

* Values represent only the first harvest. For other years, 2 cuttings were taken, with the first harvest representing about 66% of the yield for the entire year.

** Yield data taken in 1984 and 1985 following 3 years in which plots were allowed to grow unmanaged; however, 1985 values represent only one harvest or about 66% of total expected yield.

Table 5. Yields and ground cover estimations for various legumes on topsoiled mined land - Sinclair Mine.

Entry Number	Grass Variety	---1982--- Yield kg/ha	G.C. %	---1983--- Yield kg/ha	G.C. %	---1984--- Yield kg/ha	G.C. %	---1985* --- Yield kg/ha	G.C. %	---1984** --- Yield kg/ha	G.C. %	---1985** --- Yield kg/ha	G.C. %
1	Apollo	3564	56	3776	69	3048	33	1632	60	5597	19	1951	24
2	Classic	3905	55	3652	73	2714	32	1644	49	5792	18	2425	26
3	Hy-Phy	4310	64	4195	63	2707	33	1876	47	5938	23	2076	20
4	Trident	3056	48	3076	69	2521	25	1621	47	4901	17	2306	26
5	Phytor	3430	55	3092	61	2465	25	1567	24	4392	8	1961	18
6	Vernal	3849	50	3630	55	2251	25	1885	48	7146	26	2087	30
7	Redland II	2279	61	4249	71	NH	1	1120	46	2200	6	2152	81
8	Weevelcheck	3256	45	3122	64	2573	17	1461	55	6394	21	1672	34
9	Kenstar	2322	44	4717	53	NH	3	1158	41	2314	7	1883	71
10	E-688	2277	49	3923	45	NH	5	1633	52	1767	12	2566	85
11	Dawn	2622	70	2992	41	NH	3	1781	57	3040	7	1845	73
12	Viking	1742	41	2679	18	NH	1	1026	20	2304	6	1332	46
13	Fergus	3281	83	3483	69	NH	5	1636	70	2871	7	2338	68
14	Ladino	1111	35	1352	66	NH	3	1131	16	2090	3	1486	4
15	B.F. Vetch	1770	8	1749	13	NH	10	954	7	2705	37	1434	5
16	Kenland	2181	35	3345	40	NH	2	1162	35	2345	6	1415	55

* Yield represents only one harvest to date for 1985. These data represent about 50% of expected yield.

** Data collected in 1984 and 1985 following three years in which the plots were allowed to grow unmanaged; however, in 1985, values represent only one harvest or about 50% of total yield.

NH = Not harvested in 1984 to allow reseeding from the plants that existed on these plots.

statement is largely based on 1985 data, although this trend appeared both years. However, there didn't seem to be much difference among the alfalfa and red clover varieties. Perhaps 'Vernal' and 'Classic' were the better varieties of alfalfa, with experimental line 'E-688' and 'Redland II' being the better red clover varieties. On the other hand, 'Weevelcheck' was the poorest alfalfa variety and 'Kenland' the poorest red clover entry.

Both white clover and big flower vetch had poor ground covers and yields in 1985. The value for big flower vetch would be expected to he low, as this is a winter annual and most of it's production was not harvested due to lodging.

CONCLUSIONS

1. For both mine spoils and topsoiled areas, grasses with the best survival included Ky bluegrass, Canadian bluegrass, timothy, redtop, tall fescue, and western wheatgrass. For hay and/or pasture utilization, all but the western wheatgrass are excellent, based on their digestible components (Laue, 1983).

2. Many of the grasses that give good yields and ground covers also spread into adjacent areas, primarily due to movement of seed by the wind.

3. Birdsfoot trefoil gave both good yields and maintained a good ground cover. This species was the only one that migrated significantly over an eight-year period at the Ken Mine Study. However, under a "hayland" management system, during periods of drought, management to promote seed production may be required to keep this species in the stand.

4. Red clover persisted in the stand on topsoiled areas but stands thinned during periods of drought. When allowed to set seed, this species will survive at least five years under both "hay-land" and "unmanaged" systems.

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