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FROM TEST PLOT TO NEST BOX: AN OVERVIEW OF RECLAMATION RESEARCH AT A COAL MINE IN SOUTHEASTERN BRITISH COLUMBIA

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Introduction

The previous three papers have dealt with specific, short term projects that have been undertaken at Westar Minings Balmer Operation. The intent of this paper is to describe several of the long term research and monitoring programs that are also going on with this company in order to give some idea of the range of research activities that are being carried out.

Due to limitations of time and space, three specific projects were chosen in order to portray this range of research interests. The first is the history of the oldest reclamation research test plot that is on the Balmer mine site, including some of the results that have been extracted from this ten-year-old species trial plot. The second describes some of the findings that have been taken from the oldest operationally (i.e., not test plot) reclaimed site, regarding species biomass dynamics and the response in species composition to the cessation of maintenance fertilizer. The third section will deal with the direction of the effort in reaching the stated end land use goal of wildlife habitat by presenting some excerpts from the current mine plan for the Balmer Property.

In many ways, these three projects, along with the research topics discussed by the previous three speakers, represents the evolution of reclamation research at Westar Mining. Moving from early survival plots, through research on ecosystem functioning, stability and environmental impact to definition of end land use goals and operational testing of these findings.

Test Plot Number One

Test plot number one was established at the highest point on Harmer Knob (2100 m) in 1972. The area chosen for the plot is very exposed to both sun and wind. Parent material consists of very dark fine carbonaceous shales mixed with coal. The original experiment had 53 varieties of commercially available grasses, forbs and legumes seeded directly into I square meter plots, one cultivar per plot. No topsoil was added to any plot. The species chosen for the original seedings are shown in Table I. It quickly became apparent that only a small number of species that were originally tried were going to become established and survive for long periods of time at these elevations in such an exposed harsh site. By I960, the only species that were left were Brome Grass, Canada Bluegrass, Kentucky Bluegrass, Meadow Foxtail, Redtop, Creeping Red Fescue, Spike Trisetum, Timothy and Yarrow. In addition, one species of native Poa had also invaded the plot as well as Fireweed Epilobium angustifolium.

Up until 1979 the plot had been assessed by recording the percent cover of the species that had been originally sown into the plot. In 1979 it was decided that a visual estimate of the percent cover of all species that were present in each grid within the plot would be recorded in order to better map the species dynamics of this plot.

The maps of species distribution for this test plot for the years I960, 1982, and 1983 are shown in Figures I, 2, and 3. Several interesting trends can be seen from these maps. The most "successful" species has been the Creeping Red Fescue. Originally sown in *6* of the original 55 test plots, by 1980 it had spread to 45 of the I-meter square grids. This expansion had increased over time, and by 1983 the species was present in every grid in the test plot. This is a similar pattern to

Table 1

Showing the species and cultivars originally sown in Test Plot number one

1.	Yarrow	Achillea millefolium
2.	Yarrow	Achillea millefolium
3.	Crest wheatgrass cv. Nordan	Agropyron cristatum
4.	Crest Wheatgrass	Agropyron cristatum
5.	Tall wheatgrass	A. elongatum
6.	Tall Wheatgrass	A. elongatum
7.	Pubescent Wheatgrass	A. trichoparum
8.	Redtop	Agrostis alba
9.	Redtop	Agrostis alba
10.	Meadow Foxtail	Alopecurus pratensis
11.	Alpine columbine	Aquilegia alpina
12.	Rockcress cv Snowcap	Arabis alpina
13.	Rockcress cv "white"	Arabis alpina
14.	Rockcress cv "rose"	Arabis alpina
15.	Alpine aster	Aster alpinus
16.	Smooth Brome cv. Manchar	Bromus inermis
17.	Smooth Brome cv. Baylor	Bromus inermis
18.	Poplar Brome	Bromus sp.
19.	Harebell	Campanula carpatica
20.	Cornflower	Centaurea cyanus
21.	Cornflower	Centaurea montanus
22.	Oxeye Daisy cv. Alaska	Chrysanthemum leucanthemum
23.	Oxeye Daisy cv. May Queen	Chrysanthemum leucanthemum
24.	Crown vetch cv. Pennigift	Cornonelia varia
25.	Chinook Orchardgrass	Dadtylis glomerata
26.	Tall Fescue	Festuca arundinaceae
27.	Creeping Red Fescue cv. Dawson	F. rubra
28.	Creeping Red Fescue cv. Erica	F. rubra
29.	Creeping Red Fescue	F. rubra
30.	Creeping Red Fescue	F. rubra
31.	Chewings Fescue cv. Highlight	Festuca spp.

Table I continued

32.	Pea vine	Lathyrus latifolius
33.	Perrenial Ryegrass cv. Norlea	Lolium perenne
34.	Birdsfoot trefoil cv. Maitland	Lotus cornicultus
35.	Birdsfoot trefoil	Lotus cornicultus
36.	Birdsfoot trefoil var Les.	Lotus cornicultus
37.	Russel Lupine mix	Lupinus polyphilus
38.	Russel Lupine Blue and White	Lupinus polyphilus
39.	Timothy cv. Astra	Phleum pratense
40.	Timothy cv. Sport	Phleum pratense
41.	Timothy cv. Climax	Phleum pratense
42.	Canada Bluegrass	Poa canadensis
43.	Canada Bluegrass cv. Canon	Poa canadensis
44.	Kentucky Bluegrass cv. Primo	P. pratensis
45.	Kentucky Bluegrass cv. Sydsport	P. pratensis
46.	Kentucky Bluegrass	P. pratensis
47.	Kentucky Bluegrass cv. Nugget	P. pratensis
48.	Kentucky Bluegrass	P. pratensis
49.	Statice	Sinuata hybrid
50.	Alsike Clover	Trifolium hybridum
51.	Alsike Clover cv. Tetra	Trifolium hybridum
52.	Sainfoin	Lotus corniculatus
53.	Cicer Milk Vetch	Astragalus cicer
54.	Not seeded	
55.	Not seeded	

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40
41	42	43	44	45
46	47	48	49	50
51	52	53	54	55

Original configuration of test plot showing location of seeded species

Figure 1

Showing Percentage Cover of Each Species in all Plots (1980)

Distribution of Plant Species on Plot I of Hammer II (seeded I 972)

Assessed 1980

Brome Grass

		▨ 25	▨ 5	▨ 45
		15	5	
		1	2	
		5		

Canada Bluegrass

		15	15	5
		10	10	30
		▨ 50	▨ 25	5
		10	20	2
5	5		5	
	5	5		
				10

Kentucky Bluegrass

10	70		30	70
45	95	▨ 60	▨ 20	▨ 90
▨ 92	▨ 97	45	60	30
90	5	70	20	2
40	10	5	60	
			2	15
	15	20	10	10
5	20	10		5
5			15	20
			5	20
5				

Foxtail

			2	
		1		
	5	2		2
10	15		30	5
60	35	15	20	5
▨ 95	10	15	30	10
70	10	15	10	10

Redtop

2				
				2
	2			2
			1	
7	2	5		
5	35	5	5	20
	▨ 20	▨ 60	30	35
15	10	30	55	15

Fowl Bluegrass*

5	3			3
			1	
3	3		7	5
	20	25	10	40
	50	10		5
	10	20	5	

Creeping Red Fescue

				5
7	1	2	5	2
2	2			
	20	2	20	30
15	20	75	55	▨ 80
▨ 90	▨ 95	▨ 90	▨ 90	▨ 50
40	60	50	80	60
20	40	25	35	25
	10	15	15	10
	2		15	10
5	65	30	5	15

Spike Trisetum

		2		
5	1			
			2	
5	5			
				5
10		5	1	
10		5		
▨ 5	10			

Timothy

1		15	10	2
5	1		2	2
		1	2	▨ 20
▨	▨		10	20
5	10			
2		2		
	2	2	2	5
5	5	5		
5		5	5	
			5	
		2	5	15

Fireweed (F)* & Yarrow (Y)

▨ 2-Y	▨ 5-Y			
1-F				
		1-F		
1-F	1-Y			
			1-F	
	5-Y			

Numbers refer to % cover in each 1m² plot.

*Native species not included in the original sowings.

▨ - Plot where originally seeded.

Figure 2

Showing Percentage Cover of Each Species in all Plots (1982)

Distribution of Plant Species on Plot I of Hammer II (seeded 1972)

Assessed 1982

Brome Grass					Canada Bluegrass					Kentucky Bluegrass					Foxtail					Redtop				
25	20	25	20	15			10	5	5	5	15	15	10	15		5	5	5					5	5
20	25	10	10			5	30	5	20			20	10					5						
			2	20			60	30	10					10										
			5				15	20																
2	2									5	2													
				5															2					5
	2																							
2	5	30	5	5	3	3		2	5										1					
						10	3																	
75	60	25								2	5	5			5		10				10	5		
65	20	30	20	10				2	5	5	5	5	2	5	15	5	5	5	2					

Fowl Bluegrass*					Creeping Red Fescue					Spike Trisetum					Timothy					Fireweed (F)* & Yarrow (Y)				
15	10	5	10	5	50	45	15	5	55	5	5	5	5					10					20-Y	
	40	10			30	20	30	20	3	5	5	10	5											
									5				5	2				2	5			3-Y		
						10	2	15	20	2	5	5									2-Y			
	5	10	2		25	40	60	70	70	5	5		10		2						5-F			
					60	85	80	75	40					2					1					
					30	55	50	60	40	10		5	2											
					10	45	30	40	20	15	2	5	2	2					1				2-Y	
					2	5	10	10	10	3	5		2			2							15-F	
1	15	5			10	10	50	5	5				1	2	3		3							
5	5	10	10	30	20	60	50	55	50	5	5	5	1	20					1				3-Y	

Numbers refer to % cover in each $1m^2$ plot.

*Native species not included in the original sowings.

- Plot where originally seeded.

Figure 3

Showing Percentage Cover of Each Species in all Plots (1983)

Distribution of Plant Species on Plot I of Hammer II (seeded 1972)

Assessed 1983

Brome Grass

3	20	15		
1				
1		15	1	5
20	3	5	1	2
		1		
		////	////	////
5				

Canada Bluegrass

		////	////	
	5			
	20	20		
	5			
5	3	5		

Kentucky Bluegrass

1	15			
20	25	//// /10/ ////	//// //3/ ////	//// //// ////
//// /15/ ////	//// /30/ ////	25	15	0
20	20	30	60	5
5	15	5		1
10	5			
	20	2	30	40
5	30	65	70	90
40	45	50	60	70
80	60	75	10	55
60	30	15	70	70

Foxtail

10	20	20	5	10
15	25	45	60	80
	10	20	60	20
2	1	2	3	10
			4	1
//// //// ////	1	1		
	5	3		

Redtop

5	1	1		
1				2
		5	1	3
1	2	2	2	3
			3	
			1	
1				
	//// //// ////	//// //// ////		

Fowl Bluegrass*

5	5	10	5	
4	2	5	15	
1		1	5	
	1			
	1			

Creeping Red Fescue

30	20	35	80	70
20	25	15	5	3
80	35	20	10	15
30	70	35	10	40
80	80	90	90	//// /70/ ////
//// /70/ ////	//// /80/ ////	//// /95/ ////	//// /95/ ////	//// /90/ ////
80	60	85	40	20
75	30	30	20	5
20	10	10	25	20
1	10	10	10	20
10	5	5	5	5

Spike Trisetum

5	3	3		
5	7	3	2	1
1	3	3	5	2
5	2	2	5	15
1	2	2	2	20
1				
		1		
1	3		2	4
//// //// ////	2	1	5	1
1			10	2
1	3		1	

Timothy

	5			
//// //// ////	//// //// ////			
			1	
			1	5
5	2	1		
15	2			
	2			
1	3	3		

Goldenrod (G)* Fireweed (F)* & Yarrow (Y)

//// /F1/ ////	//// /G2/ /Y5/			F1
F4	F1			
F4		Y1	Y1	
F1 Y1	Y3			
F2				
			F3	
	Y1			
	Y1			
	Y10			

Numbers refer to % cover in each $1m^2$ plot.

*Native species not included in the original sowings.

//// //// //// – Plot where originally seeded.

Figure 3 continued

Sitanion hystrix (S)* Carex sp. (C)* Dandelion (D)* Intermediate Wheatgrass (I)					Polytrichum juniperimem					Ceratodon purpureus					Reed Canary Grass				
							1								2	3			
2I						2	3				2					3	1		
			1D					1	5			1						3	
													1	2					
							2			5	4	2	1	1					
					5	5	5	2	2		5	5		2					
					5	5	5			5	5	5							
		1S		1C	2	1	2			2	5	2							1
					5	1	1			5	1	2	2						
								2	2				2	2	1				
								5	5				1	1					

that which occurs on operationally reclaimed sites at high elevations on the Balmer Mine. Creeping Red Fescue is usually a highly successful species in harsh sites. It should be noted, however, that in those grids within this test plot that received Creeping Red Fescue, it is the only species within that test plot. If the reclaimer desires a diverse stand of vegetation, then perhaps Creeping Red Fescue should be avoided or included in seed mixes in small amounts only.

Other species have shown trends that are more difficult to interpret. Meadow Foxtail, for example, had become widespread by the summer of 1980 (Figure 1), however, showed a tremendous decrease in the number of grids it occupied in 1982 (Figure 2). In 1983, however, the species showed a marked increased in the area it covered again (Figure 3).

Since its initial establishment, the test plot has had several species of native grasses, forbs, and one species of moss and one Carex invade the site naturally. By 1983 there were 19 species of plants present within the test plot. Of these 19 species, 10 were species that had been seeded in the original experiment: one is an agronomic grass that has moved in from other reclaimed sites (Reed Canary Grass), the remaining species are native or widely naturalized species.

Interestingly, the grids with the highest number of different species in them are the grids that either received no seed at all or those grids that had no or poor survival of the seeded species.

The information that has been extracted from this 10-year-old test plot is very different from what it was originally set up to indicate. It shows that the systems that exist on the reclaimed sites are far more dynamic than had been previously thought, with active recruitment and rapid replacement of older individuals taking place very rapidly. It shows some signs of allowing native species to encroach upon the sites (albeit somewhat slowly), and indicates that some "successful" species may hinder the reclaimer's aim of re-establishing stands with high species diversity.

Reclamation Assessment

Every reclaimed site on the Balmer Property is assessed at the end of each growing season. The assessment consists of clipping all the above-ground vegetation in & square meter plots, separating out each individual species, drying and weighing each species to give estimates of total biomass and percent biomass contribution by each species. Figure 4 shows the data that has been collected for a high elevation reclaimed site (2100 m A.S.L.) that was reclaimed in 1974. Data has been collected annually since 1975. The site received maintenance fertilizer applications every year except 1979, 1981, 1982 and 1983.

It can be seen from Figure 4 that there have been tremendous shifts in the major contributors to the total above-ground biomass from one year to the next, despite the fact that there has been no significant change in above-ground biomass levels on this site since 1977.

As expected, there has been an increase in the importance of the legume component of the system following the withdrawal of maintenance fertilizer. Initial fears that legumes could not fix nitrogen at these elevations appear to be unfounded, with the nodules on both Alfalfa (Medicago sativa) and Alsike Clover (Trifolium repens) show being bright pink and have been shown to be active using the acetylene reduction technique (Fyles, unpublished data).

While Alfalfa was the most important legume in the system for the initial years after the fertilization was stopped, Alsike Clover appears to be increasing in the percent contribution it makes to the system. It is expected that the importance of Alsike Clover in this system will increase. Seed collected from Alsike Clover collected in 1983 showed an average of nearly ninety percent germination.

Wildlife Habitat

The end land use of the Balmer mine site is wildlife habitat. The framework in which research findings are interpreted is governed by this end land use goal. The

remainder of this paper deals with satisfying the end land use goal in light of the research that has been carried out, both on the Balmer property per se, as well as the large body of literature that deals with this topic. This information is presented here as excerpts from a recently submitted mine plan, as an example of the application of a wide body of research findings to the stated end land use of the Balmer Mine Site.

The End Land Use

The final end land use of the mine land is accomplished by fulfilling a succession of specific objectives. These objectives include restoration of watershed values, control of surface erosion, aesthetics and encouraging ecosystem development to a point of total self-sufficiency. These initial objectives may be achieved in a number of ways.

After consultation between the company and government in 1974, it was agreed that the final end land use of the land disturbed by mine activity was wildlife habitat. Wildlife includes a variety of organisms, including both game and non-game animals.

The potential for wildlife on reclaimed sites is high. Sufficient forage is produced in the summer time, none of the materials show toxic qualities, pH ranges of the spoil material is suitable for many plant species, colonization by insects is relatively fast (Lawrence, 1981), elk use in existing reclaimed sites on some sites is very high (Courtney, 1971; Gould, 1980; Stanlake et al, 1978). At the same time, limitations to wildlife use are many. Plant species diversity is low (usually less than 20 species). Structural diversity is low, and forest cover is virtually non-existent, which obviously limits the use of the reclaimed sites by many species.

Major Target Species

While we are managing the reclaimed sites for many different species, the two "featured species" are elk and mule deer. Optimum habitat for deer and elk has been characterized as land containing the maximum possible proper use of the maximum possible area by the animals. For elk, the ratio of 40 percent of a land type in cover and 60 percent in forage approximates optimum cover, based on several studies (Reynolds, 1962, 1966; Harper, 1969; Thomas, 1979). Deer and elk also require water, particularly on summer range (Schmidt-Nelson and Schmidt-Nelson, 1952). Reclaimed sites that contain areas of potable water on Westar's property within relatively short distances tend to be heavily used (Gibson, pers. comm; Gould, 1981; Courtney, 1974). Small pockets of water on high elevation sites are also commonly used, as evidence by tracks and pellet groups. Optimum habitat has potable water within 0.8 km of any point (Mackie, 1970).

The reclaimer has many options to consider when reclaiming large tracts of land. The pattern of vegetation, tree and shrub species used, drainage patterns and to some extent, topography, may all be controlled.

Deer and elk respond dramatically to some topographic features and to the arrangement and pattern of different vegetation types (Thomas, 1979). For example, steep south facing slopes at low elevations are used as winter range. Stringer forest stands interdigitating with grasslands are heavily used as thermal cover and travel corridors. The reclamation process, therefore, must take into account the topography, the vegetation that is established on the reclaimed site, as well as the behaviour of elk and deer.

There are several assumptions made regarding the role that the reclaimer can play in the management for the use of sites by elk and deer (adapted from Thomas et al, 1979).

1. Forage, water and cover are the habitat factors that limit deer and elk populations.
2. The amount, type and interspersion of forage, water and cover can be manipulated to increase deer and elk use.
3. The capacity for summer range creation far exceeds the capacity for winter range creation.
4. Habitat suitability can be judged by the ratio of cover areas to forage areas and their size and arrangement in time and space.

5. Proper location and management of access roads is an essential part of deer and elk habitat management, especially if the reclaimed sites are to be opened to hunting after mining.

Hiding Cover

Hiding cover is defined as cover capable of hiding 90% of an animal from the view of a human at distance equal to or less than 61 m (Thomas, 1979). Based on Lodgepole pine and spruce growth on the Harmer reclaimed sites, and spacing at approximately 2 m, this should be attainable within a IO to 20 year period with these species, given current growth rates. Improved tree planting techniques and better attention to site preparation and increased maintenance should enable this time to be shortened. Low elevation sites planted with faster growing species can be expected to reach this stage earlier.

Topography has not been demonstrated to serve as a substitute for vegetation cover; however, it can have an impact on how suitable a stand of vegetation is as cover (Thomas, 1979). In addition, topography manipulation can be used to increase the survival of trees and shrubs and reduce costs in the reclamation procedure.

The effect that topography has upon the value of vegetation as hiding cover can be seen in Figure 4.

Size of Hiding Cover

Reynolds (1966) and Harper (1969) have shown that heavy use by elk and deer occurred within 183 m of the edge between cover and forage areas. Therefore, circular patches with a diameter of 2 x 183 (366 m) are the minimum size of a useful patch of hiding cover where the animal has hiding cover from all sides. In areas where visibility occurs from one side only, the size of the patch can be correspondnigly decreased.

Thermal Cover

Thermal cover permits an animal to conserve energy by allowing the animal to choose sites that are near its thermoneutral zone (Black et al, 1976). The effect cover has on air temperatures, radiation inputs and wind effects has been well documented. In addition to vegetative cover, topographic situation and general climatic patterns play a major role in changing thermal regimes. Summer thermal cover is required to keep the animals cool, winter thermal cover to protect the animals from excessive wind chill and radiational heat loss. Tree trunks, low vegetation and presumably topographic features can reduce animals' radiational heat loss by reducing air movement (Moen, 1973; Ozaga and Gysel, 1972). By the same token, summer thermal cover tends to be north facing slopes with high canopies, but low understory development that provides shade with air movement (Shaw, 1977).

Optional thermal cover for elk is regarded as stands of coniferous trees I 2 m or more tall. Since it is unlikely that 12 m tall trees will become established on reclaimed sites within a reasonable time frame, these sites must be maintained at the edge of reclaimed sites, and be accessible to the animals. Stringers of woody vegetation will be established as hiding cover from adjacent undisturbed stands of thermal cover to allow access onto the reclaimed sites.

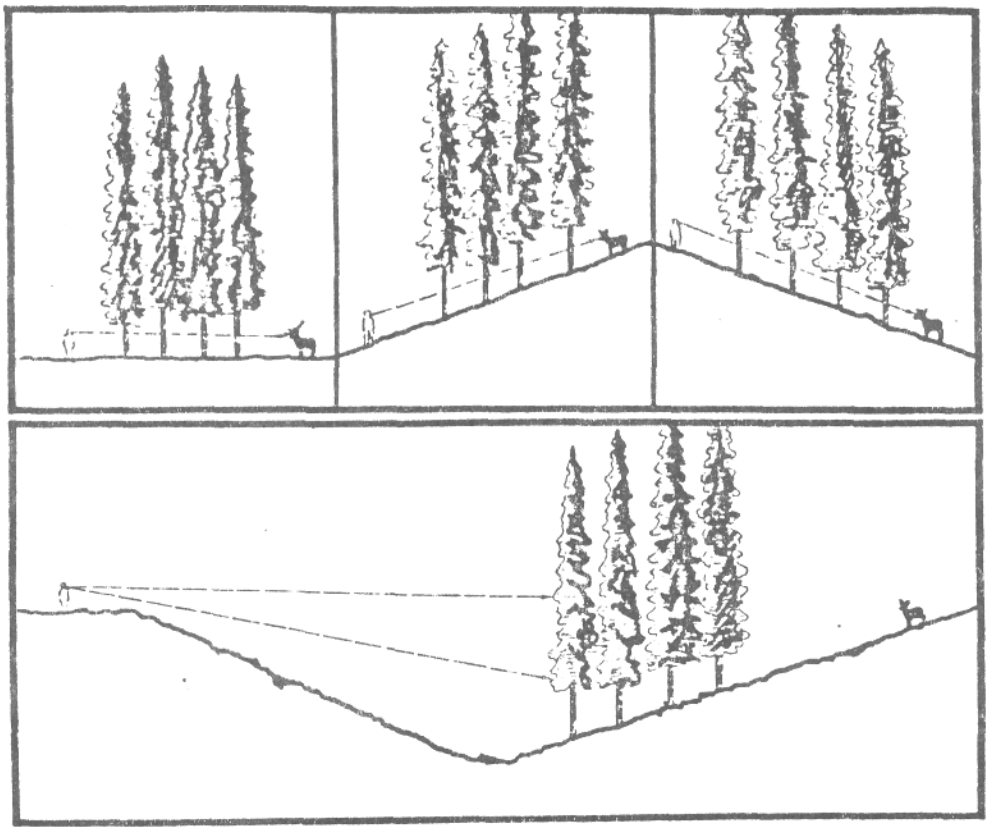
Thermal cover for deer is regarded as being much more easily established. The thermal cover requirements of deer include small trees and shrubs at least 1.5 m tall with 75% crown closure and are used on spring, summer and fall range. Winter thermal cover is similar but, of course, must be evergreen. In addition, deer social groups are generally smaller than those of elk, and thermal cover requirements are met by stands of forest only 0.8 to 2.0 ha in size (Loveless, 1964).

Calving and Fawning Areas

Calving and fawning areas contain forage, hiding cover and thermal cover. Hiding cover usually contains downed logs, stumps, shrubs or root wads. Slopes are usually less than 15 percent and often they occur as benches on more steeply sloping topography. Water is usually found within 305 m, and succulent forage is available for lactating

Figure 4

Showing how topography can change effective hiding cover.
From Thomas et al (1979).



cows (Thomas, 1979). Fidelity to calving grounds is not known, nor has their value been thoroughly studied. Since areas that have the characteristics of good calving grounds would also make good hiding cover and thermal cover, several such areas will be included in the system of tree islands and stringers on the reclaimed sites.

Roads and Habitat Use

Road access is generally regarded as a factor that decreases habitat use (Leege, 1976; Thiessen, 1976; Perry and Overly, 1977). However, on the Balmer Property road edge, use appears to be very high, probably because the area is closed to hunting (Gibson, M.Sc. thesis in prep.). Since the reclaimed sites have the potential to be opened up to hunting once mine activity has finished, the planning and control of road access should be considered with potential detrimental effects in mind.

Spoil dumps and slash piles will be windrowed to decrease visibility along access roads, and tree and shrub plantings can be placed to serve the same purpose.

Travel Corridors

Timbered stringers along travel lanes provide hiding cover for movement between areas that provide different habitat components. Timbered draws between foraging areas and potable water can be very important if both habitat components are to be used to their full advantage.

The Balmer Properly as Deer and Elk Habitat

The diverse topography created during the mining process has the potential to increase wildlife use (e.g., Steele and Grant, 1982; Allaire, 1979; Tyus and Lockhart, 1979; Harju, 1980; Karr, I960). Topographic variation will be further increased in the resloping procedure, when economically feasible. Where possible, water catchment areas will be created in order to provide potable water for deer and elk. These ponds are anticipated to be most easily created in the flat-topped, heavily compacted areas at the tops of large wrap-around dumps and in the bottom of pits. If necessary, these areas may be treated with Bentonite in order to increase water holding capacity. Pools and ponds have several special considerations in the revegetation procedure.

Other Target Species

In reclamation of the Balmer Mine, there is potential for a wide variety of habitats and, therefore, wide variety of wildlife. Topographic relief has been shown to be important in the cration of diverse wildlife habitat (Steele and Grant, 1982; Allaire, 1979; Tyus and Lockhart, 1979; Harju, 1980; Karr, 1980). Several different types of "habitat" will be created in the mining and reclamation process. Appendix II shows the species of birds and mammals that are considered "target species" — that is, species that could potentially use the reclaimed sites. The lag period between the initial reclamation phase and use of the reclaimed site varies from species to species. For example, Water Pipits use high elevation sites for breeding relatively quickly after reclamation (Fraser, 1983) where the potential for the creation of red squirrel habitat at similar elevations may take 40 or more years. For some species the long period will have to be accepted; however, the intent of the program is to create the potential for each of the target species.

The habitat requirements for many of the species found in the Blue Mountains of Washington and Oregon were summarized by Thomas (1979); many of these species are the same as those found in southeastern British Columbia, and habitat requirements for these species have been extrapolated from Thomas and other literature sources as well as based on field observations by Westar Mining personnel.

For other species, habitat features that restrict use of reclaimed sites can be quickly created or simulated. For example, a 1982 experiment at Westar Mining included the placement of a "snag" and several logs usable as perching sites on a two-year-old reclaimed site. It took less than 20 minutes for the

perching site to be used, and nesting on the snag by tree swallows occurred within the first year. The materials used were free and labour costs minimal to recreate the habitat requirement for several species.

Some types of disturbance produced in the mine process are impossible to economically reclaim. Head walls and foot walls are such disturbances, and while these will not be "reclaimed" in the strictest sense of the word, they can be made into "useful" areas for wildlife.

Other Land Uses

The primary end land use is as wildlife habitat. However, managing for this particular goal will result in the potential for recreational land uses. These include game viewing, hunting, hiking, snowmobiling, fishing, cross country skiing, photography. While these are not specific goals, they are end land uses compatible with our primary goal.

Major Vegetation Types That Will Be Created
Revegetating the Disturbance

Resloping. Dumps are resloped to distribute fines over the area and to reduce dump steepness.

Seeding. The initial revegetation steps will be accomplished using a mixture of commercially available grasses and legumes. Seed mixes currently used at Westar's Balmer Operation are in Appendix I. For large areas, seeding will be carried out using a helicopter to spread the seed. Smaller areas may be seeded using hand-held cyclone seeders, and very steep "problem" areas will be hydroseeded.

After seeding, the areas are harrowed using a large pipe harrow pulled by a dozer.

Trees and shrubs will be planted the year after seeding. This will allow the trees and shrubs to become established before grass competition becomes a problem.

Grassland Vegetation

Based on vegetation currently growing on reclaimed sites, it is anticipated that two types of grassland will be created: I. Short grass stands— these stands tend to develop on the reclaimed sites on exposed ridge tops and dry sites at high elevations. They tend to be dominated by Creeping Red Fescue and several Poa species. Where present, the clovers form the major legume species. These sites will be used by species in Group A (Appendix II). They simulate high alpine grasslands, although they have much lower species diversity. Forage production generally varies from 800 to 1500 kg/ha (above-ground dry weight). 2. Tall grass/legume stands — these stands tend to develop on reclaimed sites below 1500 m in elevation and in moister sites at higher elevations. Alfalfa (Medicago sativa), Brome grass (Bromus inermis) and Orchardgrass (Dactylis glomeratg) are important species with the Wheatgrass (Agropyron spp) forming important components on lower elevation sites. Forage production varies from 1000 to 3000 kg/ha (above-ground dry weight) and spring, summer and fall use on this vegetation type by elk is high (Gould, 1980).

Ecological Functioning: The Role of Shrubs in Grassland Vegetation Types

The need for shrubs in reclaimed grasslands arises for several reasons. They provide floristic and structural diversity in grasslands, the lack of which is thought to be a limiting factor for some birds (Krementz and Sauer, 1982). Shrubs also can be important in slope stabilization (Schiechtl, 1980). They are important in ungulate nutrition, providing a source of essential vitamins in winter months and, in the case of heavy snow years, providing most of the available forage (Leege and Hickey, 1977; Gaffrey, 1941 reviewed by McLelland, 1978). In areas that have the potential to be used as winter range (low elevation south facing slopes), it is important to re-establish the shrub component, especially as winter range is generally regarded as the limiting factor governing elk and deer populations in the East Kootenays.

Stocking Rates

The stocking rates of shrubs in the areas that are designated as summer forage

areas (i.e., not tree islands) will be low. The role shrubs serve in these areas is primarily for passerine bird perches, nest sites for birds and small mammals and to increase floristic diversity. Shrubs will be placed at IO to 20 m spacings to accomplish this goal. Microsite considerations will be given high priority to encourage growth and survival of shrub plantings. Species selections will be based on Table 2. For winter range areas, stocking densities are much higher, and shrubs will be spaced at 3 - 5 meter spacings. Both palatable and non-palatable browse species will be used.

Grassland Management

The success and stability of the soil/ plant systems established during the reclamation procedure have been under investigation at Westar Mining for several years.

The incorporation of dead plant material into the spoil material, and its subsequent decomposition and release of nutrients, is essential for the development of a self-sustained grassland. Fyles (I960) indicated that useful pools of organic matter are built up in the reclaimed spoil over a period of *6* years.

Lawrence (unpublished thesis, in prep.) has shown good colonization of these sites by a variety of soil organisms, important in organic matter decomposition and soil structure formation. However, vermiform organisms are absent from these sites, and research is underway investigating the feasibility of introducing Lumbricid worms onto the sites, as well as investigating their potential in increasing decomposition rates. There is also some concern regarding innoculation sources for soil organisms. Winged forms colonize the sites actively; however, non-winged forms, and forms with functionless wings, do so possibly by wind or more often by downslope movement through drainage and surficial runoff. If natural sources of these organisms are not present close enough to the reclaimed site, then the placement of small pockets of fresh (unstockpiled) topsoil may be required to serve as innoculating sites.

Tending (maintenance fertilization) activities will continued for 5 to 8 years after the vegetation stand is established, after which time maintenance fertilizer plays a relatively small role in the nitrogen dynamics of the vegetation (Fyles, unpublished thesis, jn prep.). The systems that have been createa[1] so far appear capable of sustaining relatively heavy grazing presence by elk (Gould, 1981).

Forested Islands and Corridors

Forested lands will cover approximately 30 percent of the area disturbed by the Balmer operation. "Forested" here refers to areas with dense tree and shrub cover. Corridors are long stringers of forested vegetation planted as hiding cover for wildlife species travelling to and from reclaimed areas, to aid in the initial colonizing of tree islands.

The position, size and species composition of islands depends on the following criteria:

1. Species suitability for a particular site, based on slope, aspect, elevation, spoil characteristics.
2. Structural characteristics desired in the stand.
3. Cost and availability of planting stock.
4. Road access.
5. The size and shape of the reclaimed site.
6. The anticipated routes of travel by ungulates.
7. Aesthetic considerations

Species Selection

Species were chosen on the basis of their ecological suitability and ease of propagation. For planning purposes, the entire mine site was divided into 4 units based on elevation and aspects.

Stand Structure

The structural makeup of a stand (the number and height size of understories) affects its use by wildlife (Thomas, 1979). However, prediction of stand structure on island plantings on reclaimed sites is not possible at this time. Monitoring of these

stands over time, their internal structure, and their use by wildlife will be required before predictions of how stand structures affect wildlife use can be made.

Site Selection

A few guidelines for selecting island sites will be kept in mind.

1. Sites with good road access will be chosen, since long haul distances can raise costs substantially.
2. Sites with friable, uncompacted spoil will be chosen. If necessary, the site may have to be ripped. Planting on loose spoil material is approximately five times faster than planting on compacted spoil material (Westar Mining, unpublished data). Tree survival and subsequent growth has been shown to be markedly better on loose compacted spoil (Kolar and Ashby, 1982) and ripping to a depth of 80 cm is standard practice to increase tree survival and growth on untopsoiled mine spoils in the United Kingdom (Fourt, 1981).

Future research efforts will be directed at investigating the role that site preparation and stock type has on the economics of aforestation.

Optimum Mix of Types of Cover

Thomas (1979) gives the following recommendations for deer: 20% hiding cover, 10% thermal cover, 5% fawning cover, 5% hiding, thermal or fawning cover, and 60% foraging areas. Many areas qualify as several types of cover. For elk, Thomas recommends 20% hiding cover, 10% thermal cover, 10% hiding or thermal cover and 60% foraging areas.

Hiding cover for elk and deer should be attainable in IO to 15 years from planting, given growth rates of experimental plantings on Harmer. Summer thermal cover requirements, however, will be harder to meet. Thomas outlines these for the Blue Mountains of Oregon as stands of conifer trees 12 m or more with an average canopy closure of 70%. Minimum size is 12 hectares. In the area near the Harmer minesite, however, growth rates of trees and shrubs planted on the site are too slow to create this type of habitat quickly.

At the same time, however, it is recognized that the guidelines discussed by Thomas (1979) represent "optimal thermal cover", and it is possible to have useful wildlife habitat, albeit at some sub-optimal level. The problem of summer thermal cover will be solved in two ways. Stands of coniferous vegetation will be planted on north facing dumps, sites where growth occurs quickly, and microsite conditions are such that the areas might become useful as thermal cover before reaching the 12 m in height and 70% crown closure outlined by Thomas. The second is to create stands of cover along travel corridors that will allow efficient movement of animals onto the reclaimed sites from adjacent, undisturbed stands of summer thermal cover.

There are other factors that also present problems in providing "optimum" habitat for elk and deer. The first and major problem is the lack of available winter range. The areas that are to be reclaimed contain little land that has the potential to become winter range, due to snow accumulation, the result of slope, aspect and valley position limitations.

For this reason, the "sub-optimal" ratio of 30% cover and 70% forage areas has been chosen. Of this, 10% will be planted in sites that show good potential for thermal cover production, 20% will serve as hiding cover, and the remainder will serve as foraging areas.

The Shape of Stands:
Edge Considerations

An edge is the line where different plant communities or successional stages meet. An ecotone is the area along this line where transition between one vegetation zone and another occurs. Edges and ecotones are generally richer in wildlife than homogeneous areas, for both small animals and large game (Harper, 1969; Reynolds, 1966).

Two factors are important in determining the use an edge receives. One, of

course, is the amount of edge, and the amount of interspersion between edges, i.e., how the edge is arranged (Thomas, 1979).

In addition to island/grassland juxtaposition, edges can be created within island plantings. Planning for edges and ecotones within stands will also create spatial diversity. One of the benefits of island planting of trees and shrubs is the potential for the creation of many such edges. In addition, because edge contrast will increase as the island stands age, it should be possible to create patterns of vegetation that will increase in wildlife values through time.

Table 2 shows the proposed species to be used in island plantings on the Balmer minesite, along with relative percentiles for the species. Stands will be planted at approximately 2000 stems/ha.

Structure and Size of Islands

The structure of the final vegetation pattern was designed using the following criteria:

1. The major vegetation patterns are de signed for ungulate use, primarily mule deer and elk.
2. Native trees and shrubs will be used.
3. Where economically possible, the area will be made suitable for other wildlife use.

The following quantitative guidelines from Thomas et al (1979) will be referred to:

1. If properly arranged, the optimum cover-to-feeding area ratio is approximately 2:3, i.e., 40% cover, 60% foraging area.
2. Deer and elk use declines dramatically at distances greater than 137 meters from cover. Therefore, the cover requirement can be calculated.

Road Access

Road access is important in determinng the costs of establishing tree and shrub islands, and island creation will generally be confined to areas that have good road access, it will be remembered, however, that road access can limit the use of hiding cover by deer and elk (literature reviewed in Thomas, 1979, p. 122-123). Presumably, this couid be particularly important in the design of hiding cover in treed stringers that are intended to serve as travel corridors. In travel corridors that are anticipated to receive heaviest use, roads that are used for planting access should be ripped and planted. If retention of access in corridors is essential, then they should have island plantings to the edge of the road, and no section of the road should be straight for greater than 0.4 km (0.25 miles) or closed to all but emergency traffic. In addition, road access that goes through reclaimed sites will be modified to prevent long line-of-site distances (Figure 5).

Size and Shape of the Reclaimed Site

Deer and elk use of a foraging area is limited by the distance from cover. If a minesite already has a forested edge, then this cover can be used by deer and elk. Obviously, the use of the reclaimed site depends largely on the size of the grassland created. This effect can be mediated by the shape of the forest-reclaimed site edge. Irregular edges and intrusions into the reclaimed site by cover will increase the area useful to wildlife and decrease the number of island plantings required to increase use of the reclaimed site.

Travel Corridors

Travel corridors for deer and elk tend to be areas that follow topographic lines of least resistance, such as valley bottoms, or ridge tops. Cover along these routes increases their usefulness. Travel corridors will be created by using timbered stringers of irregularly sloped islands that will connect major habitat features. In general, they will be placed along the bottom of the reclaimed dumps and along north facing slopes to improve tree survival and subsequent growth.

Aesthetics

Increasing the aesthetic value of the mined lands is one of a reclaimer's goals. It is desirable to reduce the visual impact of the disturbance in the reclamation process. An important part of this process is to integrate the reclaimed site into the surrounding landscape by reducing the regularity of the

Table 2

Proposed Tree and Shrub Plaings for Island Plantings
(Numbers refer to proposed proportions (%) of species)

High Elevation East and North Facing Slopes

Slope Position:	Shedding	%	Mesic	%	Receiving	%
	Engelmann Spruce	60	Engelmann Spruce	60	Mountain Alder	50
	Whitebark Pine	40	Mountain Alder	30	Engelmann Spruce	40
			Whitepark Pine	10	Willow	10

Low Elevation East and North Facing Slopes

Slope Position:	Shedding	%	Mesic	%	Receiving	%
	Engelmann Spruce	70	Engelmann Spruce	60	Engelmann Spruce	40
	Lodgepole Pine	30	Wavy-leaved Alder	20	Wavy-leaved Alder	30
	Cottonwood	10	Cottonwood	10	Willow	10
					Red Osier Dogwood	10
					Cottonwood	10

High Elevation West and South Facing Slopes

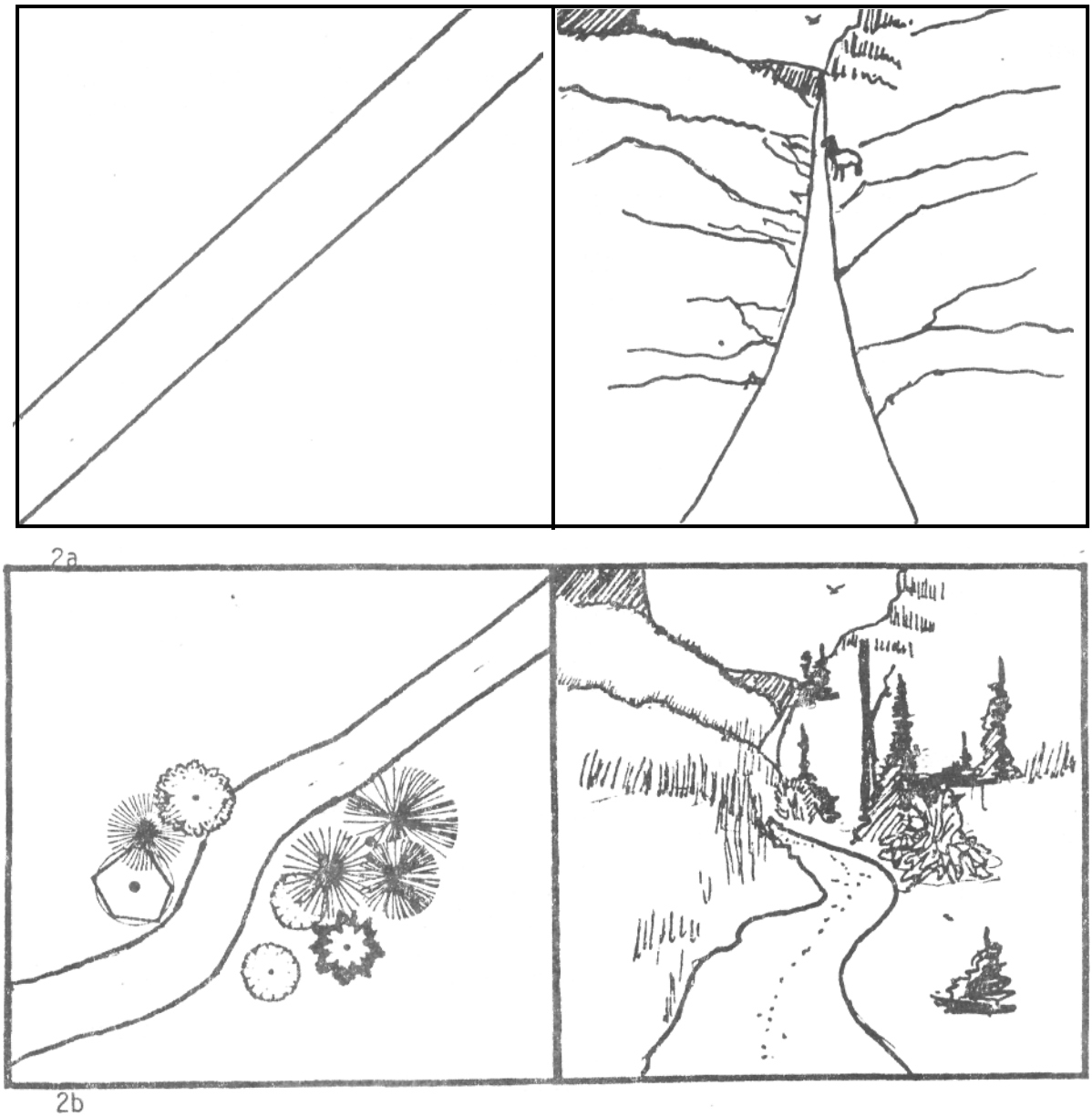
Slope Position:	Shedding	%	Mesic	%	Receiving	%
	Saskatoon	45	Lodgepole Pine	35	Trembling Aspent	50
	Rose	45	Whitebark Pine	10	Engelmann Spruce	20
	Oregon Grape	10	Trembling Aspen	35	Willow	20
			Saskatoon	10	Saskatoon	10
			Rose	10		

High Elevation West and South Facing Slopes

Slope Position:	Shedding	%	Mesic	%	Receiving	%
	Saskatoon	40	Western Larch	10	Douglas Fir	20
	Rose	40	Douglas Fir	10	Western Larch	20
	Oregon Grape	20	Lodgepole Pine	20	Spruce	10
			Trembling Aspen	20	Cottonwood	20
			Douglas Maple)		Red Osier Dogwood	10
			Saskatoon)		Willow	10
			Rose)	40	Black Hawthorne	10
			Willow)			
			Cottonwood)			

Figure 5

Where road access must be maintained after mine activity has ceased, long line-of-sight distances will be avoided by the creation of bends in roads and strategic placement of island plantings and single-load dumps of overburden material, a) before and b) after line-of-sight distances have been decreased.



topography and emulating surrounding vegetation patterns. Softening the regular topography of wraparound dumps with trees and shrubs increase the aesthetic appeal of the revegetated site (Figure 6).

In addition to increasing the "naturalness" of the site by mimicking observed vegetation patterns, this should increase survival rates of tree and shrub plantings and reduce costs as well as improving tree growth rates.

The Herbaceous Components in Cover Islands

The herbaceous component of forest stands varies from stands with virtually nonexistent herbaceous cover to stands with a herbaceous cover that has high diversity and substantial biomass associated with it. The role that this component plays in terms of a stand's nutrient cycling and the wildlife use of a site is poorly understood.

Understory herbaceous plants are considered important components in aforestation of reclaimed sites in Britain, insofar as nonpalatable nitrogen fixing legumes are used to eliminate the need for nitrogen fertilization (Fourt, 1981).

Increasing light penetration to increase forb production and thereby increase wildlife values is a technique mentioned in Thomas (1979) and Yoakum et al (I960). A thorough literature review on this topic is required.

Other Habitat Components

Habitat components other than the major vegetation types are also important for many species of wildlife. These include such specifics as nesting, roosting and perching sites, and specific habitat features such as talus slopes for pikas, rock outcrops for marmots, etc.

Terrain Considerations

There are a few areas of activity that have as great an impact on topography as open pit mining in a mountainous area. Economics govern the formation of the major terrain pattern; however, within the framework left the reclaimer there is a tremendous amount of flexibility at the meso and microtopographic stages.

The Balmer operation will consist of a series of terraces, the top of which is at 2100 m in elevation, stepping down at approximate 30 m intervals to a low elevation of 1580 m. Within the 2600 ha of total disturbance, there will be large expanses of flat areas, both long and short slopes occurring with a wide variety of aspects.

Dumps will be resloped in the reclamation process (except for a few small areas). The surface terrain will be left rougher than in previous reclamation efforts, as the seed catch is higher in these areas. More microsites for arthropods and small mammals are created and results in less surface compaction, an important consideration for tree and shrub growth (Fourt, 1981; Kolar and Ashby, 1982).

In general, the areas will be resloped to give a hill and swale topography. This should increase snow accumulations, decrease line of sight visibility and provide microsites protected from wind.

Large flat areas will have "free dumped" overburden placed on them to cut down wind affects on high elevation sites, and increase topographic diversity.

Where possible, small pockets of compacted material will be left to serve as pools to increase the amount of open water available to deer and elk on the sites. Areas adjacent to these pools will be backfilled or ripped in order to plant tree and shrub cover near water sources.

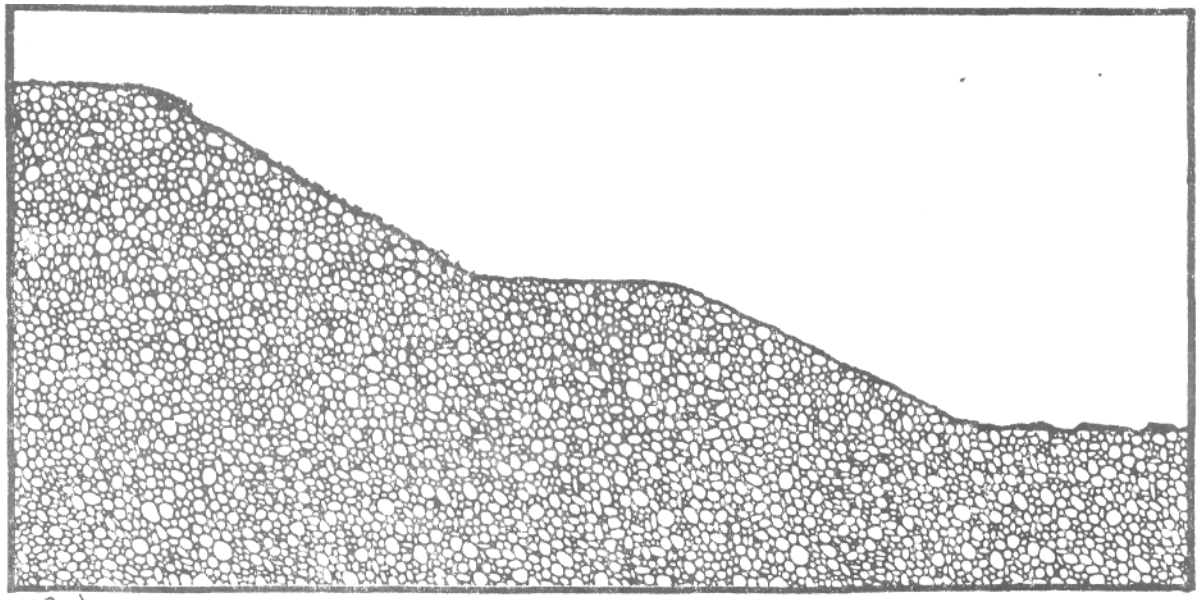
Areas that are intended to become "winter range" will be left to encourage wind action that blows off or sublimated accumulated snow loads. Large areas of this type of topography have not been reclaimed at Westar as of this time, and some experimental work may have to be attempted on these sites when they become available if the "standard" reclamation approach proves to be unsuitable.

Rocks

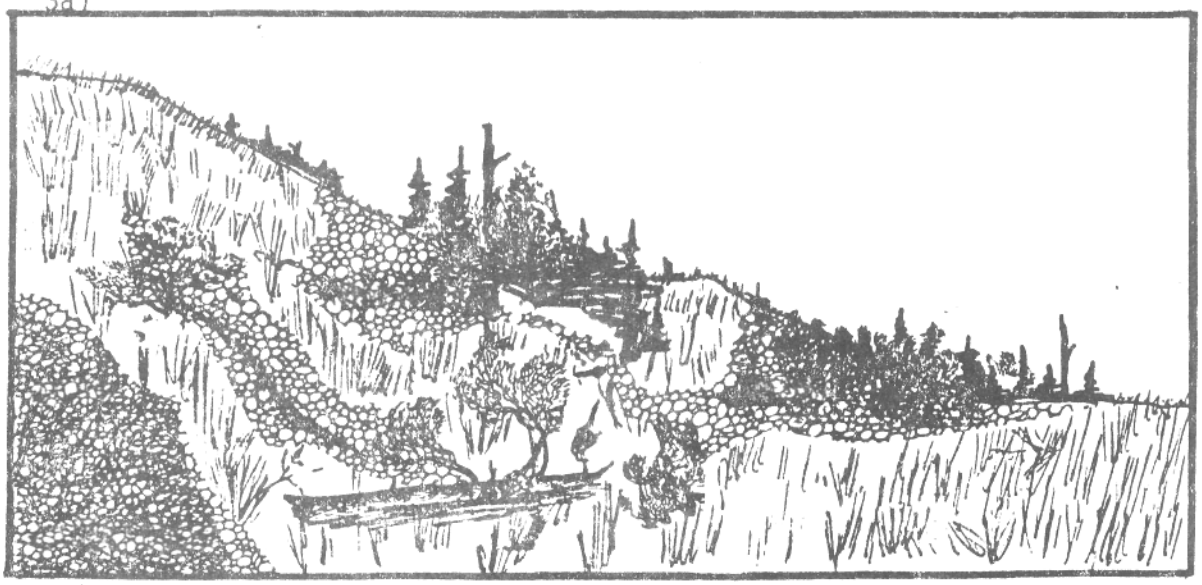
Up until the present, large rocks were dumped or buried in the reclamation process. Observations of natural systems indicate that large rocks may well serve as perching sites

Figure 6

Shows how the regular topography of a terraced dump can be softened by island planting of trees and shrubs. Figure 3a) shows the dump before planting and 3b) shows the dump after planting.



3a)



3b)

for a number of birds, especially gallancious birds, raptors and grassland passerines. Rock piles placed on high elevation reclaimed sites have been used by American Kestrels, Blue Grouse, Water Pipits and Horned Larks. They also may provide cover for rodents and provide cover for arthropods, especially during periods of drought, where microsite protection may be important. Small piles of rock will be left on the reclaimed sites to provide this habitat component. Relatively large rocks of irregular shape will be used to provide interstitial spaces to serve as hiding cover. It is not known what density is "optimum"; however, several piles per hectare will be tried on an experimental basis.

Logs

Elton (in Maser et al, 1979) estimated that systems with no dead or down woody material lost more than 1/5 of its fauna. Down and woody material is present in all the forested systems occurring in and around the Balmer mine property, including those that are predominently grasslands (Fraser, unpublished M.Sc. thesis, in prep.). In addition, they are felt to be important in mineral cycling, and mycorrhizal colonization of new areas (Harvey et al, 1976). Maser et al outlined several other important features associated with logs. In an experimental reclaimed site on Harrner, Westar Mining found increased tree survival on spruce outplanted on the leeward side of logs (Environmental Services, Westar Mining, unpublished data). In addition, logs have been used in reclamation of bauxite spoil in Australia to encourage arthropod recolonization (Maser et al, 1982).

Generally speaking, the larger the log, the more useful it is as wildlife habitat (Maser et al, 1979).

Because of their mycorrhizal colonization properties, their wildlife value and increased tree survial associated with log-created microsites, logs will be placed on the reclaimed sites in those areas that will be planted into tree and shrub islands.

Log placement will be along the contour of the hill (rather than up and down a slope) to collect moisture, organic matter, nutrients and fines on the upslope side of the log (Ausmus, 1977 in Moser et al, 1979).

Logs have been classified into 5 groups based on degree of composition (Fogel et al, 1973), see Table 3. Wildlife use of logs increases as the log decomposes and moves from Class I to Class 5. Class I and 2 logs can easily be transported onto tree island sites; however, Class 3, 4 and 5 logs will probably break, causing Class 4 and 5 logs to lose much of their wildlife value (although they still serve as fugal innoculation sources and nutrient pools).

Islands will have approximately five Class I or Class 2 logs per hectare, following the recommendations by Moser et al (1979). Species that are expected to use logs are listed in Table 4.

Where found, hollow logs will be taken over sound logs, as these show higher wildlife use than sound logs (various authors cited in Thomas, 1979).

Brush Piles

For some wildlife species, brush cover can supply many of the habitat components that would be supplied by a cover of woody vegetation (Warrick, 1976). They can be used to encourage upland bird use of an area (Yoakum et al, 1980), as well as other species such as White-crowned Sparrows (Yoakum et al, 1980), rabbits (Shomon et al, 1966), porcupines (Taylor, 1933 cited in Maser et al, 1979) and fishers (Couler, 1966 cited in Maser et al, 1979), as well as being useful cover for a variety of other small mammals. Slash and brush piles can also be used as hiding cover for large ungulates (Thomas, 1979).

Brush piles also serve as germinating sites for a number of trees and shrubs (Yoakum et al, I960).

Brush piles have the advantage of being cheap, quickly established hiding cover when compared to revegetating sites with trees and shrubs. They decompose quickly, however, and therefore serve in the interim period between the initial reclamation stages and the stages where good vegetation cover is attained.

Table 3

Log Classes, Showing Criteria for Placement in a Class
(Adapted from Foget et al, 1979)

Log Characteristics	Log Class				
	1	2	3	4	5
Bark	intact	intact	trace	absent	absent
Twigs <3 cm (1.18 in)	present	absent	absent	absent	absent
Texture	intact	intact to soft	hard, large pieces	soft, blocky pieces	soft and patchy
Shape	round	round	round	round to oval	oval
Colour of wood	original colour	original colour	original to faded	light brown to faded brown or yellowish	faded to light yellow or gray
Portion of log on ground	log elevated on supports	log elevated but sagging	log sagging	all log on ground	all log on ground
Withstand moving on reclaimed site	yes	yes	yes, but may break	no	no

Table 4

Species Expected to Use Logs Placed on Reclaimed Site

In addition to those listed, there are a number of other passerine expected to use Class I logs as perching sites. Largely adapted from Thomas (1979).

Species	Log Class	Hiding Cover	Thermal Cover	Nest Site	Lookout or Display Site	Feeding	Other	References
Snowshoe Hare	1	*	*	*				Winn 1976
Porcupine	1,3	*	*					Taylor 1935
Spruce Grouse	1,4,5	*	*	*	*		Dusting Site	Thomas 1979
Blue Grouse	1,4,5	*	*	*	*		Dusting Site	Thomas 1979
Dusky Shrew	2	*	*	*				Thomas 1979
Yellow Pine Chipmunk	2	*	*	*	*			Thomas 1979
Longtailed Vole	2	*	*	*				Thomas 1979
Winter Wren	2			*				Thomas 1979
Deer Mice	2,3	*	*					Winn 1976
Shrew spp.	3	*	*	*				Thomas 1979
Redback Vole	3		*	*				Winn 1976 Maser and Franklin 1979
Tree Squirrel	4,5				*	*	Food Cache	Thomas 1979
Golden Mantled Ground Squirrel	1,2,3				*			Thomas 1979
Ruffed Grouse	1,2	*	*	*	*			Thomas 1979
Tree Swallow	1				*			Fraser 1983
Water Pipit	1				*			Fraser 1983

Size and spacing of brush piles depends on the species that is being managed for (Yoakum et al). However, most species requirements can be met with brush piles I - 2 m high and at least 1.5 m in diameter. Piles will *be* placed at a rate of approximately I pile for every 2 ha of reclaimed site.

Snags

Snags, in the natural environment, are standing dead trees from which the leaves and most of the limbs have fallen. In the Balmer property, over twenty species of vertebrates use cavities in snags for nesting or shelter (Species Group I). In general, they fall into two categories, those that make their own cavities and those that utilize cavities made by others.

Snags can be classified into hard or soft (Thomas et al, 1979) depending upon their state of decay. Different species use hard and soft snags, and good forest management includes retention of both types of snags (Thomas et al, 1979). Numerous literature reviews indicate that shortage of suitable nesting areas limits breeding bird use in forests (Thomas et al, 1975). Most birds that nest in snags are insectivorous, and represent a major part of the insectivorous fauna in coniferous forests. The role of insectivorous birds in regulating and controlling tree and shrub pests has voluminous literature associated with it.

In addition to providing nesting sites for cavity nesting birds, snags also provide nesting sites and perching sites for raptors and a variety of other small passerines. A test installation of a snag on the Balmer minesite has received high use by both raptors (Redtail Hawks, American Kestrels and Northern Harriers) as well as a variety of passerines (Fraser, 1983). The installation of suitable perching posts for raptors has been suggested as a method of controlling mice populations on reclaimed sites (Schiectl, 1980).

Hard snags can be placed on the reclaimed sites relatively easily. They will serve as perching sites and nesting sites for primary excavators. Soft snags, however, will not withstand moving and habitat requirements for soft snag requiring species as well as species that nest in existing cavities will be partially mitigated with the installation of nest boxes.

The number of species that can use a snag depends on the size of the snag as well as its state of decay (Thomas et al, 1979). Generally speaking, the larger the snag, the greater the use. The largest and most common excavator that can be expected to use the reclaimed site is the Common Flicker. The minimum snag size required by this species is 30.5 cm (12 inches) or larger, and this will be the minimum snag size that will be used on the reclaimed site.

Snags will be between 3 and IO m in height in order to satisfy habitat requirements for a variety of species (Thomas et al, 1979).

Soft snag requirements can be partially filled by the installation of nest boxes. In general, two sizes of nest boxes will be used, one using the size recommended by Campbell and Hosford (1978) for kestrels, the other the size recommended for bluebirds. This will satisfy nesting requirements for a large number of species. There will be I - 2 snags placed on each tree island.

"Special Areas" — Capitalizing on Areas With Unique Constraints

Headwalls and Footwalls

Several types of areas created in the mining process are regarded as being economically "unreclaimable" in the traditional sense. Headwalls and footwalls that are not backfilled are not capable of being revegetated. However, these areas can be made useful in terms of wildlife habitat. Steele and Grant (1983) reported that manmade cliffs contributed significantly to bird populations on reclaimed sites in Colorado and New Mexico. Cliffs near water (within .25 miles) are used more than cliffs further away from water (Maser, Rodick and Thomas, 1979).

Talus

Talus slopes are natural landscape

Table 5

Target Species for Talus Slope Areas on the Westar Minesite

Species that use Talus	Use Comments
Bluegrouse	Display areas
Greycrowned Rosy Finch	Feeding, nesting
Pika	Hiding, reproduction, obligate
Golden Mantled Ground Squirrel	Highest densities on or near talus
Neotoma Wood Rat	Hiding, reproduction

features of the Balmer area. While it is recognized that large acreages of talus is not an acceptable reclamation goal, several small areas of steep, large-diameter rubble will be left in order to satisfy the habitat requirements of those species listed in Table 5. Of the species listed, one is an obligate talus species, the Pika; two are seldom found in any other habitat type on the Balmer property (Golden Mantled Ground Squirrel and Neotoma Wood Rat). These species have colonized two reclaimed slide areas on the Balmer property that satisfy the habitat component of large, loose rubble. Areas that will be left as steep, unrevegetated talus for pikas will have to be deep in order to satisfy the thermal requirements described by Krear (1965) in Maser, Rodick and Thomas (1979).

Water Pools

Based on ungulate requirements in the literature (Thomas, 1979), it is expected that availability of water will be the limiting factor affecting the summer use of the Balmer minesite. To alleviate this, water ponding will be encouraged in several areas of the reclaimed mine. Two ponds are expected to be formed in the mine process. In addition, it may prove to be feasible to create others on flat compacted areas. All ponds will be small, and will not affect dump stability. The following guidelines (from Allaire, 1979) will be used to increase wildlife use of ponds created in the mining process:

1. Water areas of at least 0.5 ha should be built wherever possible.
2. Water areas should be terraced just below the surface wherever possible.
3. Ponds should have at least one side shallowing sloping (preferably more).
4. Perching sites should be placed near, or preferably over the water.
5. Areas intended for use by Loons and Grebes should be at least 200 m long to allow for take-off flights.
6. Increase seeding rates adjacent to water.
7. Emergent vegetation (reeds, cattails), an important habitat component for some species, should be encouraged.

In addition, efforts will be made to intensively plant areas adjacent to water as these will be heavily used by ungulates.

Logs will be placed partially submerged to serve as physical links between aquatic and terrestrial habitats, as they are considered important habitat components (Maser et al, 1979; Gore and Johnson, 1979).

In the Balmer minesite, it is anticipated that two ponding areas of any size will be left. To increase wildlife values, these areas will not be backfilled, so that open water will be available. Where possible, overburden will be placed to create a bench area with water standing no more than I m deep around the

edge so as to allow an area for the establishment of emergent vegetation.

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Appendix I

Seed Mixes Currently Used at Westar Mining's Balmer Operations

High Elevation Seed Mix

Creeping Red Fescue	15%
Meadow Foxtail	15%
Orchardgrass (Chinook)	15%
Canada Bluegrass (Canon)	10%
Kentucky Bluegrass (Geronimo)	5%
Redtop	5%
Timothy (Climax)	10%
Smooth Brome (Manchar)	5%
Alsike Clover	5%
White Clover	15%

South Facing Coarse Refuse Mix

Crested wheatgrass	20%
Creeping Red Fescue	10%
Bromegrass	30%
Intermediate Wheatgrass	10%
Canada Bluegrass	5%
White Clover	20%
Kentucky Bluegrass (Troy)	5%

(This seed mix is used in conjunction with seed oats as a nurse crop. Rate of 25 kg/ha)

Special Gravel Pit Mix

Orchardgrass	30%
Brome-Carlton	15%
Timothy	5%
White Clover	10%
Creeping Red Fescue (Boreal)	10%
Tetraploid Italian Ryegrass	20%
Canada Bluegrass	5%
Alsike Clover	5%

Low Elevation - Lagoon Mix

Smooth Brome (Manchar)	20%
Intermediate Wheatgrass	10%
Crested Wheatgrass	10%
Canada Bluegrass (Canon)	5%
Timothy (Climax)	5%
Creeping Red Fescue	5%

Red top	5%
Alfalfa	30%
Alsike Clover	5%

(Used with Fall Rye as a cover crop at an application rate of 55 kg/ha)

Low Elevation Seed Mix

Smooth Brome (Manchar)	20%
Intermediate Wheatgrass	10%
Crested Wheatgrass	10%
Canada Bluegrass (Canon)	5%
Timothy (Climax)	5%
Creeping Red Fescue	5%
Redtop	5%
Perennial Ryegrass	5%
Alfalfa	10%
Sainfoin	10%
Cicer Milkvetch (Oxley)	10%
Alsike Clover	5%

Appendix II

Target Wildlife Species for Balmer Mine Site

TARGET SPECIES GROUP "A": Reproduce on ground, in short grass, high elevation grasslands with little or no shrub component.

Birds: Water Pipit
Horned Lark

Mammals: Deer Mouse
Meadow Vole
Jumping Mouse Columbia
Ground Squirrel Yellow
Badger

TARGET SPECIES GROUP "B": Reproduce on ground, in grassland vegetation with tall and legume grass species.

Birds: Northern Harrier
Short Eared Owl
Vesper Sparrow

Mammals: Deer Mouse
Meadow Vole
Jumping Mouse

TARGET SPECIES GROUP "C": Reproduce on ground in grassland vegetation with scattered shrub component.

Birds: Horned Lark
Savannah Sparow
Vesper Sparrow

Mammals: Deer Mouse Meadow Vole
Jumping Mouse Columbia
Ground Squirrel Yellow
Badger

TARGET SPECIES GROUP "D": Reproduce on ground in grassland/tall shrub association.

Birds: Blue Grouse
Ruffed Grouse
Hermit Thrush
Veery
Townsends Solitaire
Wilson's Warbler
Orange-crowned Warbler
Nashville Warbler

Mammals: Deer Mouse Meadow Vole
Jumping Mouse Long-
tailed Weasel Short-tailed
Weasel Least Weasel
Columbia Ground Squirrel
Yellow Badger Coyote
White tail Deer Mule
Deer Rocky Mountain
Elk

TARGET SPECIES GROUP "E": Reproduce in shrubs or deciduous trees.

Birds: Calliope Hummingbird
Great Horned Owl
Mourning Dove

Cedar Waxwing Willow
Flycatcher Dusky
Flycatcher Least
Flycatcher Eastern
Kingbird Common Crow
American Robin
Swainsons Thrush
Red eyed Vireo
Warbling Vireo
Soliary Vireo
American Redstart
MacGillvarys Warbler
Red-winged Blackbird
Brown-headed Cowbird
Lazuli Bunting American
Goldfinch Chipping Sparrow
Brewers Sparrow
White-crowned Sparrow Fox
Sparrow Song Sparrow

TARGET SPECIES GROUP "F": Reproduce on ground, in coniferous vegetation.

Birds: Blue Grouse
Ruffed Grouse
Spruce Grouse
Hermit Thrush
Dark eyed Junco

Mammals: Deer Mouse
Red-backed Vole
Long-tailed Vole
White tail Deer
Mule Deer
Rocky Mountain Elk
Moose
Lynx
Coyote

TARGET SPECIES GROUP "G": Reproduce in coniferous vegetation.

Birds: Goshawk
Sharpshinned Hawk
Coopers Hawk
Merlin
Long-eared Owl Great
Horned Owl Rufous
Hummingbird
Hammond's Flycatcher
Western Wood Peewee
Gray Jay Steller's Jay
Clark's Nutcracker

Mammals: Red Squirrel
Pine Martin

Common Crow
Varied Thrush
American Robin
Ruby-crowned Kinglet
Golden-crowned Kinglet
Evening Grosbeak
Cassins Finch
Pine Grosbeak
Pine Siskin

TARGET SPECIES GROUP "H": Make their own excavations in snags placed on reclaimed site.

Birds: Common Flicker
Pileated Woodpecker
Yellow bellied Sapsucker
Hairy Woodpecker
Downy Woodpecker
White breasted Nuthatch
Red breasted Nuthatch

TARGET SPECIES GROUP "I": Reproduce in hole made in snag by another species in a natural cavity or in an artificial nest box.

Birds: Wood Duck
Barrows Goldeneye
Bufflehead Hooded
Merganser Common
Merganser American
Kestrel Pygmy Owl
Barred Owl Saw Whet
Owl Boreal Owl Vaux's
Swift Violet-green
Swallow Tree Swallow B
lack-capped Chickadee
Mountain Chickadee
Boreal Chickadee Brown
Creeper House Wren
Mountain Bluebird
Starling House Sparrow

Mammals: Myotis spp.
Northern Flying Squirrel
Pine Martin

TARGET SPECIES GROUP "J": Utilize cliffs (headwalls, cut faces) or outcrops.

Birds:
- Peregrine Falcon
- Black Swift
- Barn Swallow
- Cliff Swallow
- Common Raven
- Rock Wren
- Gray-crowned Rosy Finch

Mammals:
- Bushy tailed Wood Rat
- Golden Mantled Ground Squirrel
- Hoary Marmot
- Puma
- Mountain Goat
- Bighorn Sheep

TARGET SPECIES GROUP "K": Utilize talus (large diameter-sized overburden dumps).

Birds:
- Grey-crowned Rosy Finch

Mammals:
- Bushy tailed Wood Rat
- Golden Mantled Ground Squirrel
- Pika