Grass-Legume Seeding to Improve Winter Forage for Roosevelt Elk: A Literature Review

Special Report 763
February 1986

Agricultural Experiment Station
Oregon State University, Corvallis

GRASS-LEGUME SEEDING TO IMPROVE WINTER FORAGE FOR ROOSEVELT ELK: A LITERATURE REVIEW

Katherine J. Ramsey

Graduate Research Assistant

and

William C. Krueger

Professor and Head

Department of Rangeland Resources

Oregon State University

Corvallis, Oregon

March 1986

BACKGROUND

The earliest attempt by the Oregon State Game Department to improve western Oregon big game habitat through forage seeding was in 1950 (Game Division Annual Report 1950). A cooperative program between the Oregon State Game Department and State Board of Forestry resulted in seeding of 214 acres within the Tillamook Burn to a mixture of grasses, legumes and other forbs. Official records do not report further seeding projects until 1970 (Wildlife Division Annual Report 1970), when the Oregon Department of Fish and Wildlife (ODFW) began aerial seeding and fertilizing programs on Roosevelt elk (Cervus elaphus roosevelti) winter ranges in the mountains of western Oregon. This program has continued to the present with major cooperation from the USDA Forest Service and private timber companies. The elk habitat improvement program has focused on development of temporarily improved forage areas by seeding forages and fertilizing clearcuts planted to Douglas-fir (Pseudotsuga menziesii). Seeding of these plantations has been with legumes or grass and legume mixes. The first seeding on the Alsea Ranger District of the Siuslaw National Forest was in 1977 (USFS, file data). Since then the Alsea District has become the principal cooperator in this habitat improvement program.

Researchers with the Department of Rangeland Resources at Oregon State University have frequently contributed technical information and research to assist the Northwest Regional Office of ODFW in quantitative evaluations of these habitat improvement programs. This literature review is intended to be a state-of-the-art report, including both published work and unpublished information drawn from ODFW and U.S. Forest Service (USFS) files.

LITERATURE REVIEW

Distribution and Home Range

Roosevelt elk are a subspecies which range primarily through the heavily forested coastal mountains of northern California, Oregon, and Washington into extreme southwestern British Columbia on Vancouver Island. Herds have been successfully reintroduced on Afognak Island, Alaska (Troyer 1960, Batchelor 1965), and on the west slope of the Cascades in Oregon by the Oregon Department of Fish and Wildlife (Harper 1971), where they also ranged in earlier times (Bryant and Maser 1982).

Roosevelt elk differ from the Rocky Mountain subspecies (*Cervus elaphus nelsoni*) morphologically (Graf 1943, Schwartz and Mitchell 1945, Hines 1972, Lemos and Hines 1974, Dean et al 1976) and behaviorally. While most Rocky Mountain elk herds tend to be migratory, traveling substantial distances between summer and winter ranges, Roosevelt elk are often sedentary (Graf 1943, Franklin et al 1975, Logsdon 1965, Jenkins 1980, Witmer 1982). Roosevelt elk may shift their range use seasonally along altitudinal gradients, responding to availability of green forage (Graf 1943). Annual home range sizes vary, tending to be smaller in managed forests than in unmanaged forests. Franklin et al (1975) found home ranges approximated 300 hectares in managed forests in northern California, while in managed forests of Oregon and Washington, average home ranges were 512 hectares (Graf 1943, Schwartz and Mitchell 1945) and 400 hectares (Witmer 1982). In Olympic National Park's unmanaged forests, home ranges were 1000 hectares (Jenkins 1980). Witmer (1982) noted that managed forests offer a more diverse environment compared to lands in the National Park system and consequently allow elk to meet all their biological needs within a smaller area.

Reproduction and Recruitment

Roosevelt elk also differ reproductively from the Rocky Mountain elk subspecies. In 1971, Trainer found Roosevelt elk cows generally reproduce every second year, whereas Rocky Mountain elk normally reproduce annually. Examining uteri from harvested Roosevelt elk cows, he found 50% pregnancy rates compared to Rocky Mountain elk cows which had an 86% pregnancy rate. Roosevelt elk appeared to calve for the first time normally at age 4 (Trainer 1971, Hines and Lemos 1975), whereas Rocky Mountain cows generally give birth to their first calf at 2 years of age. Trainer (1971) found lactating Roosevelt cows generally were in poor body condition relative to non-lactating cows, possessing considerably lower fat reserves. Generally, only dry cows which had not borne a calf the previous spring were able to conceive the following fall; those cows that did conceive generally did so later in the breeding season than did dry cows. Trainer (1971) believed the inability to conceive was related to low energy reserves due to inadequate nutrition from available forage in the Coast Range, and the consequent inability to rebuild energy reserves reduced by lactation demands. Kuttel (1975), studying a Roosevelt elk herd in Washington's Willapa Hills, found 83% of the pregnant cows were also lactating (from age 2 1/2), but noted that the last several winters had been exceptionally mild, possibly permitting pregnant cows to maintain unusually good physical condition. He also found 83.3% of the cows were pregnant during the 1973-74 and 1974-75 winters. Lemos and Hines (1974) found, over three years' study of Roosevelt elk on the Millicoma Tree Farm, that calf production was inversely related to physical condition of the cows. Their results indicated that low production was attributable to service being totally by yearling bulls in the enclosure herd, and predominantly by yearlings in the free-ranging herd. Calf production was much higher in 1963-64, when service was predominantly by mature bulls (Lemos and Hines 1974, Hines and Lemos 1975). Trainer (1971) found Roosevelt calf-cow ratios averaged 41:100, compared to 51:100 for Rocky Mountain elk. Oregon Department of Fish and Wildlife records (Annual Report 1979) showed Roosevelt elk populations in Oregon were generally stable or increasing. The ODFW annual spring census of the Mid-Coast District, Alsea Unit sample block in 1985 recorded the highest count ever recorded for the area, 859 animals compared to 658 counted in 1984 (ODFW unpublished data). However, calf-cow ratios remained low, ranging from 31:100 (Alsea Unit data 1985) to 44:100 statewide in 1979 (ODFW Annual Report 1979). This apparent high recruitment rate on the Alsea unit is probably a result of sampling error rather than immigration or grossly underestimated cow:calf ratios. Calf production was equally low for Roosevelt elk populations in California (Mandel 1979) but appeared to be tied to overgrazing and subsequent malnutrition (Harper et al 1967). With herd reductions on overgrazed, overpopulated range in 1951-54, extremely low 22:100 calf-cow ratios increased dramatically to more than 88:100 in 1957, 1958 (Harn 1958, Bentley 1959, Harn 1969, Harper 1962, Stevens 1965, Harper et al 1967). Overpopulation developed once more and by 1978 (Mandel 1979) calf-cow ratios again dropped to an average 20:100. Harper (1962) thought poor forage quality could have been a leading cause for the observed poor condition and low nutritional status of populations on Boyes Prairie, California, solely or in combination with overpopulation. The coastal prairies on which California Roosevelt elk depend (Harper et al

1967) are primarily composed of annual grasses and forbs of little nutritional value, particularly in fall (Bentley 1958). Green feed is in short supply during winter months (Harn 1958). High calf mortalities in these herds possibly were due to low calcium levels in forage, leading to insufficient milk production for calves (Bentley 1959, Harn 1958). However, Mandel (1979) observed only one calf death from malnutrition, which may have been attributable to human interference. Nutrition quality impacts on reproductive success have been demonstrated for domestic sheep and cattle, as well as for Rocky Mountain elk. Allden (1970) found females fed low-quality forages conceived at older ages and later in breeding seasons than those on high-quality diets. Bond et al (1958) found similar results; beef heifers suffered 17-20% weight losses on severely reduced intakes of protein and energy, and oestrus cycles stopped at 17-20% weight losses. For sheep, cattle, and elk, females on higher quality forage produced heavier offspring (Allden 1970, Thorne et al 1976, Wallace and Raleigh 1964). Thorne et al (1976) related elk calf weights to protein and energy levels in cows′ diets; Wallace and Raleigh (1964) found that Hereford cows produced lighter calves when on low-energy diets, but that low-protein diets did not affect calf weights. Calf weight is closely tied to calf survivorship during the 30 days after parturition in Rocky Mountain elk. Thorne (1973) found elk calves weighing approximately 15.9 kg at birth had 90% survivorship over the next 30 days, while elk calves weighing less than 11.4 kg had less than a 50% chance of surviving the first month after birth.

Nutritional Quality

Protein (nitrogen) content is commonly used as an index of forage nutritional value (Crampton and Harris 1969, Cowan et al 1970, Rhodes 1984, Mereszczak 1979, Leslie 1982, Dietz 1970). Dietz (1970) believed protein content in forage to be the most important nutritive constituent for ruminants. Protein deficiences in domestic livestock diets impair reproductive success, growth, milk production, and fat deposition rates (Church 1980). Decreased growth rates for deer fawns (Verme and Ozoga 1980), reproduction (Verme 1969), and antler development (French et al 1956) for deer have been linked to insufficient levels of protein in diets. Body condition showed strong positive correlations with crude protein content in black-tailed deer forages (Einarsen 1946), leading Einarsen to conclude crude protein content is a good index of forage quality. Forage plants commonly showed trends of decreased protein content, forage digestibility and, consequently, lowered digestible protein and digestible energy contents progressively from spring to winter.

Mautz (1978) found big game body condition varied directly with trends in forage quality. In spring and summer, when forage qualities were highest, ungulates commonly increased forage intake, thus maximizing fat reserves. In fall and winter, big game reduced intake of low-quality available forage and began to metabolize fat stores. Subsequently, body condition deteriorated.

Nelson and Leege (1982) stated that elk required a minimum 6-8% crude protein for maintenance purposes, while Hobbs (1981) concluded that 35% *in vitro* dry matter digestibility (IVDMD) was a submaintenance diet for Rocky Mountain elk, implying inadequate dietary digestible energy.

Leslie et al (1984) found 40% IVDMD in forage produced in coastal old-growth forest, which is still submaintenance for spring-summer diets, according to Amman et al (1973). In Mereszczak's study (1977), decadent bentgrass (Agrostis tenuis) ranges supplied inadequate levels of both digestible protein and digestible energy required for elk maintenance through the demanding winter months. Improved pastures seeded to perennial ryegrass (Lolium perenne) consistently met or exceeded elk nutrient requirements for both maintenance and lactation.

When ODFW began seeding newly planted Douglas-fir plantations with big game forage mixtures of grasses and legumes and fertilizing annually, Cleary and Mereszczak's (1977) 3-month initial evaluation showed elk preferred seeded plantations 6:1 over unseeded plantations for foraging. Seeded plantations showed lower forage nutrition values than improved grasslands, but showed similar patterns when compared to respective unimproved areas. Forage from the improved plantation provided adequate crude protein for maintenance at 8%, and more than adequate digestible energy at 61%. Forage from the unimproved clearcut consisted primarily of salal,(Gautheria shallon) bentgrass, and brackenfern (Pteridium aquilinum), and supplied only marginal crude protein (6%) and very inadequate digestible energy (18%). Brackenfern was not counted as palatable forage. Foraging by elk in the unimproved area was too light to accurately measure and no use was made of brackenfern.

Elk and black-tailed deer diets on the Olympic Peninsula, Washington, consisted of shrub and tree species. Winter forages contained 6-10% crude protein (Leslie 1982), adequate for maintenance. However, Leslie also found IVDMD percentages (21-32%) in winter forages were inadequate for maintenance requirements. Submaintenance IVDMD (Leslie 1982) indicated digestible energy levels were inadequate for Roosevelt elk diets during winter months in the Olympic Peninsula. Hines et al (1971) studied crude protein and mineral composition of shrub, tree, and forb species comprising the dominant portions of elk diets on the Millicoma Tree Farm. There were significant nutritive differences in forages collected from the east and west sides of the Farm; these were suspected to be related to the lower elevations and milder interior valley climate on the east side; whereas, the west side has higher elevations and a coastal maritime climate. Past herd histories showed generally higher calf crops on the east side relative to the west side and Hines et al (1971) believed nutrient composition influenced physical condition and thus helped explain differences in reproduction between the two sides of Millicoma Tree Farm. Rochelle (1980) studied forage quality and nutrition of black-tailed deer in mature forests of Vancouver Island relative to nutrition of deer primarily feeding in cut-over lands. He found no consistant differences in forage quality between forest stands and clearcuts during any season of the year and attributed this to microclimatic variations and subsequent phenological variations between forests and clearcut areas. Rochelle devoted particular attention to arboreal lichen use and nutritional composition, as these lichens comprised a major part of winter litterfall and available forage in mature forests in his study. He found that while crude protein content of the lichens _Alectoria_ spp. and _Lobaria oregana_ was less than 2%, these lichens were highly digestible, comprised a high proportion of gutfill in deer rumens examined, and apparently have an enhancement effect on overall digestibility of forage mixtures relative to individual species digestibilities. Kufeld (1973) and Hash (1973) noted low levels of lichens in Rocky Mountain elk diets in the Oregon Blue Mountains and the Lochsa drainage in northern Idaho.

Rhodes (1984) examined nutritive quality of 15 common forage species in young (0-7 years) clearcuts in the Oregon Coast Range, comparing areas which were grazed by sheep during spring and summer, and ungrazed clearcuts. He found crude protein content of browse, forbs and grasses all exceeded the 13% required for maximum gain and lactation for elk (Nelson and Leege 1982) during early spring and spring, but crude protein declined as the season progressed to marginal or adequate levels for maintenance in summer and fall. Percent IVDMD for shrubs, forbs, and grasses also followed a seasonal pattern: highest in spring and declining through summer and fall. Browse showed lower relative IVDMD values throughout the year, with average marginal (38%) values for maintenance. Because Rhodes (1984) found acid-detergent fiber (ADF) and cell-wall content (CWC) percentages were lower for browse species than for grasses and forbs as digestibilities declined through the seasons, he reasoned that these unexpected results indicated that other factors cause low IVDMD values in browse species. Shrubs examined by Rhodes (1984) had tannin levels ranging from 1.3 to 4.6% by weight; those levels are within the range Reed (1982) found inhibited forage digestibility for ruminants. Low IVDMD values of Coast Range shrubs have been attributed to high tannin levels (Leslie 1982, Rhodes 1984, Leslie and Starkey 1985, Mould and Robbins 1981), one of several phenolic compounds Li (1974) found in analyses of a number of browse species in western Oregon. Tannins may affect forage digestibility by inhibiting rumen microflora (Lyford et al 1967, Jung 1985, Lohan et al 1981) and by chemically reacting with available protein, rendering it unavailable (McLeod 1974, Reed et al 1982). Oregon State University researchers are continuing research on evolutionary aspects of the development of phenolic compounds in shrub species as an antiherbivory mechanism (Sharrow, personal communication 1985). Future results may reveal information relevant to nutritional quality for big game species.

Rhodes (1984) found that sheep grazing in spring and summer months reduced net growth of browse and forbs in clearcuts, averaged over two years. Grasses and sedges were not affected by sheep grazing in a predictable pattern, indicating their ability to regrow following foliage removal. Fall IVDMD values for forbs, grasses, and sedges were higher in grazed areas compared to ungrazed situations. Crude protein values for these forage classes also were higher in October in the grazed areas relative to ungrazed sites. Spring and summer grazing by sheep disrupted the phenological development of these plants, maintaining the crude protein and IVDMD levels present in earliest stages of growth through October. After sheep were removed from the areas in late summer or early fall, this higher-quality forage remained available to deer and elk through fall and winter months. Deer and elk select more palatable and/or higher-quality forages as they become available (Swift 1948, Rochelle 1980). Rhodes (1984) further noted that sheep grazing apparently increased the quantity of high-quality forage in the spring, a critical period for elk. He indicated there was more high-quality (new growth) forage in grazed clearcuts, particularly of grasses, than in ungrazed plantations in March. U. S. Forest Service personnel on the Alsea Ranger District, Siuslaw National Forest, are beginning an elk radiotelemetry study in 1985 to investigate interactions and habitat use relationships among elk and sheep grazing on forage-seeded clearcuts on the Alsea District (Smith, personal communication 1985).

Forage Preferences and Palatability

Both Rocky Mountain and Roosevelt elk forage preferences have been studied extensively. The concensus has been that elk strongly prefer grasses over forbs and shrubs as winter forage (Hansen and Clark 1977, Buechner 1952, Harper et al 1967, Harper 1962, Schoen 1977, ODFW 1974, Harper 1968, Cleary and Mereszczak 1977). In studies where grasses were a minor component of the available forage, and grass species were considered unpalatable, Roosevelt elk turned to swordfern (Polystichum munitum) and woody species as the main portion of their diets (Harn 1958, Harper 1968, Swanson 1970).

Grasses formed a smaller dietary component of Roosevelt elk diets in Olympic National Park than expected during seasons of grass abundance (Leslie 1982, Leslie et al 1984). Kufeld's (1973) comment may have relevance in this instance, as in those other cases where browse was the major dietary component; ie. elk preferences for grass over other winter forages may be influenced by relative availabilities of specific shrub and grass species. Relative palatabilities of available species are implicated in this observation. Everist (1972) stated, " No matter how abundant or how nutritious a plant may be, it has no value as fodder (forage) unless animals (are willing to) eat it." Lassiter et al (1956) learned that dairy cattle ate less when forced to eat feed known to be fairly unpalatable, relative to amounts consumed of forage known to be more palatable. Furthermore, this study showed cattle gained less weight and produced less milk when fed less palatable feed than when fed more palatable forage. Forage palatability has been improved in many cases by the addition of nitrogen fertilizers for elk and cattle (Cook 1965, Geist 1974, Heady 1975). Fertilizer also has been shown to increase nutritional quality of forage (Knott 1956). However, increased palatability following fertilization is not universally true. Reid et al (1966) found sheep preferred unfertilized orchardgrass (Dactylis glomerata) to orchardgrass fertilized with nitrogen. Mereszczak (1979) found elk showed no preference between fertilized and unfertilized bentgrass pastures on the Beneke Creek Meadows Wildlife Management Area in Oregon. In the same study, (Mereszczak 1979, Mereszczak et al 1981) Roosevelt elk showed strong preferences for fertilized perennial ryegrass pastures over fertilized colonial bentgrass pastures for winter foraging. Elk preferred rehabilitated, improved (ryegrass) winter pastures 11:1 over decadent (bentgrass) pastures in that study. Analyses of forage quality showed decadent grasslands provided no digestible protein while improved grass range provided forage with an average 16% digestible protein to elk during harsh winter months. Improved grasslands also provided forage with more than twice the digestible energy of forage from decadent sites (2.9 millicalories per kilogram vs. 1.2 millicalories per kilogram).

Seeding, Fertilization and Forage Production

Leininger (1984) reported forage production ranged from 1951 to 2459 kilograms per hectare in young seeded plantations on the Alsea Ranger District, with grasses comprising 61 to 83 percent of total production between May and August. Production in older unseeded plantations, in comparison, ranged from 764 to 2301 kilograms per hectare and graminoids composed 23 to 57 percent of forage produced. In any month of a given year, both production and grass percentage composition were significantly higher in seeded clearcuts. Hemstrom and Logan (1984) found that, in mature timber stands over 50 years old, biomass production ranged from 558 to 2472 kilograms per hectare (green weight); swordfern contributed the majority of herbaceous biomass, but the exact amount was not identified.

A study of June production on seeded, fertilized clearcuts on Alsea Ranger District (Rinaldi 1984) showed apparent significant differences between fertilized plots and unfertilized plots, between NE and NW aspects, for grasses, legumes, palatable and unpalatable species other than grasses and legumes. "Unpalatable" and/or "unusable" in the remainder of this paper refers to the following species: brackenfern, swordfern, woodrush (Luzula parviflora), sedge (Carex sp), foxglove (Digitalis purpurea), and tansy ragwort (Senecio jacobaea). Differences were only apparent as the study design did not allow statistical analyses. Results suggested production of unpalatable species was greater on NE aspects than on NW aspects, while NW aspects produced greater quantities of legumes and palatable species. Although NW aspects showed no apparent differences of grasses and legumes between fertilized and unfertilized plots, more palatable forage and less unpalatable forage was produced in fertilized plots. On NE aspects, there were no differences between fertilized and unfertilized plots for any forage class. Results led Rinaldi (1984) to conclude that fertilizer helped establish grasses and legumes in the first year, evidenced by higher production the second year, while second year fertilization did not appear to enhance grass and legume production.

Klingler (1982) reported on grass seeding and fertilization trials and found significant reductions in shrub and noxious weed production in treated plots on clearcuts. Total biomass production was not significantly different, but production of higher-quality forage was greater in treated plots. In five years, seeded wheatgrasses declined from 35 to 6 percent cover, and other seeded grass species followed the same trend; conversely, big trefoil (Lotus uliginosus) increased from 1 to 48 percent cover in the same period. These trends were attributed to relative inherent differences in longivity and aggressiveness between species. Klingler (1982) studied four different seed mixtures suited respectively to the following situations: (1) brush control where domestic livestock use is unlikely, (2) deer and brush control on dry sites, (3) elk and brush control with expected use by domestic livestock, and (4) brush control with livestock grazing. Table 1 gives seeding mixtures used in this study. Klingler's (1982) study was the basis for choice of current seeding mixture decisions for silvicultural and wildlife-livestock management on the Siuslaw National Forest (Klingler 1984, USFS 1985) (Table 2). At present, implementation is primarily occurring on the Alsea Ranger District; however, seeding practices are extending to Waldport, Hebo, and Mapleton Ranger Districts. The elk forage mixture developed by Cleary (Personal communication 1985) (Table 2) is not used on the Alsea Ranger District, but is used elsewhere on the Siuslaw National Forest and on private timber land and is not intended for brush control. Seeding mixtures used in Alsea's original seeding trials were based on recommendations from Cleary (1972) and Anderson et al (1971). Currently, ODFW fertilizes forage-seeded clearcuts yearly, up to 10 years. After the first year, however, units are fertilized selectively. Only those receiving heavy elk use continue to be fertilized, and generally only benches and shallower slopes within a unit which are likely to receive regular elk use. U. S. Forest Service brush control seedings receive fertilizer only the year of initial planting. The Siuslaw National Forest position regarding seeding for all conceivable purposes is stated in Berry et al (1983), a revision of a draft environmental assessment on Mapleton Ranger District (Petersen et al 1981, Petersen 1982) in which on-going concerns, purposes and further research needs for seeding practices are discussed.

While meadow development is not a priority, some small meadow areas have been developed as forage areas for wildlife on the Siuslaw. Farstvedt (1977) reported on production of a forage-seeded meadow developed for wintering deer and elk on Dean Creek, Douglas County, under a cooperative agreement between the Oregon State University Department of Forestry and ODFW. With seeding and fertilization, forage production was increased two-fold and ranged from 89 kilograms per hectare in January to 1368 kilograms per hectare in June, with estimated production over an 8-month period totalling 4061 kilograms per hectare. Comparison between fertilization and non-fertilization showed a 57% higher production where fertilizer was used, and that spring growth began in February rather than in April. Earlier growth is important, as late winter-early spring is normally the period of greatest nutritional stress for deer and elk.

Table 1. Seeding mixtures from Alsea seeding trials, 1977-82 (Klingler 1982)[a]

Mix #1. Brush control; no domestic livestock use likely:

Common Name	Scientific Name		lbs/A
Colonial bentgrass, 'Highland'	*Agrostis tenuis*		2
Orchardgrass, 'Potomac'	*Dactylis glomerata*		5
Big trefoil, 'Marshfield'	*Lotus uliginosus*		3
		Total	10

Mix #2. Deer forage and brush control on dry sites:

Common Name	Scientific Name		lbs/A
Dwarf pubescent wheatgrass 'Tegmar'	*Agropyron trichophorum*		30
Intermediate wheatgrass	*Agropyron intermedium*		5
Orchardgrass, 'Potomac'	*Dactylis glomerata*		3
		Total	38

Mix #3. Elk forage and brush control with expected use by domestic livestock:

Common Name	Scientific Name		lbs/A
Red fescue, 'Pennlawn'	*Festuca rubra*		10
Orchardgrass, 'Potomac'	*Dactylis glomerata*		5
Big trefoil, 'Marshfield'	*Lotus uliginosus*		3
		Total	18

Mix #4. Brush control with domestic livestock grazing:

Common Name	Scientific Name		lbs/A
Pubescent wheatgrass, 'Luna'	*Agropyron trichophorum*		30
Orchardgrass, 'Potomac'	*Dactylis glomerata*		5
Big trefoil, 'Marshfield'	*Lotus uliginosus*		3
		Total	38

[a] Fertilizer used was 10-20-20 at 250 lbs/A.

Table 2. 1985 Seed mixtures used by Alsea Ranger District[a] and by ODFW[b] (USFS 1985, Cleary pers. comm. 1985).

Mix #1. Brush control with or without big game use; little chance of domestic livestock use:

Common Name	Scientific Name		lbs/A
Dwarf or dwarf-like orchardgrass ('Latar', 'Potomac')	Dactylis glomerata		4
Perennial ryegrass (new variety, longer-lived)	Lolium perenne		1
Pubescent wheatgrass ('Topar', 'Luna')	Agropyron trichophorum		5
'New Zealand' white clover	Trifolium repens		3
'Mt. Barker' subterranean clover	Trifolium subterraneum		2
Big trefoil, 'Marshfield'	Lotus uliginosus		1
		Total	16

Mix #2. Deer forage and brush control on dry sites:

Common Name	Scientific Name		lbs/A
'New Zealand' white clover	Trifolium repens		4
Mt. Barker' subterranean clover	Trifolium subterraneum		10
Big trefoil, 'Marshfield'	Lotus uliginosus		2
		Total	16

Mix #3. Elk forage and brush control with or without livestock grazing:

Common Name	Scientific Name		lbs/A
Annual ryegrass (tetraploid)	Lolium annuum		4
Perennial ryegrass	Lolium perenne		2
Dwarf orchardgrass	Dactylis glomerata		2
Mt. Barker subterranean clover	Trifolium subterraneum		10
White clover	Trifolium repens		2
Big trefoil, 'Marshfield'	Lotus uliginosus		2
		Total	22

Mix #4. Brush control with livestock grazing:

Common Name	Scientific Name	lbs/A
Annual ryegrass (tetraploid)	Lolium annuum	2
Perennial ryegrass	Lolium perenne	2
Dwarf orchardgrass	Dactylis glomerata	1
Mt. Barker subterranean clover	Trifolium subterraneum	3

White clover	Trifolium repens	5
Big trefoil, 'Marshfield'	Lotus uliginosus	2
	Total	15

Mix #5. Elk forage only. Not for brush control:

Common Name	Scientific Name	lbs/A
Mt. Barker subterranean clover	Trifolium subterraneum	5
Perennial ryegrass	Lolium perenne	2.5
Annual ryegrass	Lolium annuum	5
Orchardgrass	Dactylis glomerata	5
White clover	Trifolium repens	2.5
Big trefoil, 'Marshfield'	Lotus uliginosus	2.5
	Total	22-24

[a] Mixes 1-4 used only by Alsea Ranger District.

[b] Mix #5 used by ODFW on other Siuslaw National Forest districts and on private timber lands. Fertilizer used in 1985 was 0-37.65-0, with 11.25 (sulfur) and .67 (boron) at 188 lbs/Ac for establishment. For older sites (5-6 years) where legumes are disappearing, fertilizer is switched to 15-15-15.

In other forage production studies during the spring and summer, Smith (undated) on the Alsea Ranger District found little difference in total production between seeded and unseeded sites, but that "usable" forage produced was 2213 pounds per acre and 1537 pounds per acre, respectively. Total utilization of palatable forage in seeded sites was 1407 pounds per acre while dropping to 557 pounds per acre on unseeded sites. On seeded sites, ryegrass (Lolium perenne) and orchardgrass (Dactylis glomerata) were 79% of the total utilization. Twenty-seven acres were seeded within the 81 acre clearcut used in the above study, and Smith calculated that the area had a potential carrying capacity of 4.4 elk-unit-months (EUM) on the seeded portion, and 3.0 EUMs on the remaining unseeded area. He further calculated the total area (81 acres) as a forage area which could support 48 head of elk for 6 summer months; whereas, without the 27 seeded acres, the unit could only provide forage for 41 animals during the same period. Carrying capacity in this study is based on estimated minimum consumption per month of 500-600 pounds for elk and deer together with 360 pounds for elk alone, a figure estimated by Phillips (personal communication 1985) to be closer to true consumption than the usual ODFW estimated 320 pounds per month consumption. Phillips (1981) correlated plantation age-classes to dominant shrub species. He established average shrub dry-weights by species to permit weight estimates in calculations of forage production where shrub size and actual weight data by species are lacking, but where species density data are available.A forage production and utilization monitoring plan was initiated in summer 1984 on Waldport Ranger District; first year results showed seeded units produced an average 1155 pounds per acre and an average 725 pounds per acre of palatable forage (Villejas 1984).

Winter forage production information is scarcer than for spring-summer. Cleary and Mereszczak (1977) found in their initial study on forage-seeded clearcuts, that the treated plantation produced 1201 pounds per acre, 901 pounds of which were considered useable forage. In the unseeded situation, 1090 pounds per acre total production contained only 306 pounds per acre of useable forage. Smith (undated) found forage produced in mature red alder (Alnus rubra) stands and mature (80+ years) Douglas-fir (Pseudotsuga menziesii) timber stands averaged 1106 pounds per acre and 1220 pounds per acre, respectively. Ferns dominated herbaceous production in alder stands followed by sedges and grasses. In Douglas-fir stands, ferns composed the majority of available forage; salal was second. In second-growth Douglas-fir stands, (40-80 years), forage production dropped to 663 pounds per acre. Between 40-150 years, forage production averaged 1035 pounds per acre in Douglas-fir stands. In this study, ferns were considered as potential forage. However, their low palatability suggested they may not actually be used. When ferns were disregarded, forage yield averaged 89 pounds per acre in the mature alder and 413 pounds per acre in the mature Douglas-fir. The greatest production in second-growth Douglas-fir stands was 550 pounds per acre of forage, at 40-150 years; forage production (not including ferns) averaged 458 pounds per acre in Douglas-fir stands. Utilization on red huckleberry (Vaccinium parvifolium) and trailing blackberry (Rubus ursinus) was estimated at 75-80%, while forbs and grasses were only utilized 30-40%. Average salal use was estimated to be 20%, but locally heavy use was noted.

Summary, Conclusions and Recommendations

Smith's clipping data in the above study is the basis for an elk forage-carrying capacity model developed by Phillips (USFS) and Sturgis (ODFW) (Phillips, personal communication 1985), built around the premise of an even flow of forage produced on the Siuslaw National Forest. By definition, in management guidelines developed by Siuslaw National Forest and ODFW biologists, forest land is divided into 3 habitat classes: cover-including timber stands over 10 years old; unimproved clearcuts less than 10 years old, and improved clearcuts up to 10 years old. Clearcuts up to 10 years, both unimproved and improved are defined as foraging areas (Woolington 1982, 1983).

Woolington (1983) provided a sample application of the above model with comments on its limitations. A pertinent note on the model is that higher quality forage produced from improved clearcuts is not accounted for in the model, thereby underestimating the expected potential growth in population numbers correlated with better nutrition.

A study initiated in 1984 to determine whether elk using improved forage show greater reproductive success than elk without access to higher-quality forage thus far shows inconclusive results from aerial censuses during July 1984 and spring and fall 1985 (Ramsey 1985, ODFW 1984, 1985 unpublished). Herd composition records (Taylor personal communication) in Tillamook County, Oregon, between 1976 and 1978 have been stratified into 2 classes, animals with access to agricultural land (located within 1 mile from pastures or cropland) and animals without access to agricultural land. Cow-calf ratios for grassland populations in 1976 were 52:100 cows, and in 1977 were 47:100 cows, both years higher than the averages reported by Trainer (1971). Calf production has averaged 20% higher for populations with access to agricultural grasslands for the past 3-4 years in this area (Taylor personal communication 1985).

It is now accepted that low reproductive success of Roosevelt elk results from poor quality natural forage throughout their range, especially in winter. However, attempts to evaluate population responses to habitat that has been managed principally for forest products, and with special emphasis on elk habitat, have been unsuccessful. It appears that extensive telemetry studies will be necessary to assess impacts of habitat improvements on population parameters. Currently, the opinion of biologists managing the habitat improvement effort is that it is successful in increasing the coastal Roosevelt elk herds.

The revegetation program has changed over the years, including changes in forage seeding mixes, fertilizers used and application procedures. Currently, revegetation projects on the Siuslaw National Forest are more site-specific; they are based on soil fertility tests, plant nutrient requirements and management objectives. This approach has been successful. Reference is made to specific seeding and fertilization procedures in this report. We recommend that site-specific modification of the generalized procedures always be included to optimize control of brush or production of elk forage through revegetation programs.

LITERATURE CITED

Allden, W. G. 1970. The effects of nutritional deprivation on the subsequent productivity of sheep and cattle. Nutr. Abstr. Rev. 40:1167-1184.

Ammann, A. P., R. L. Cowan, C. L. Mothershead, and B. R. Baumgardt. 1973. Dry matter and energy intake in relation to digestibility in white-tailed deer. J. Wildl. Manage. 37:195-201.

Anderson, W., W. Billings, et al. 1971. Oregon Interagency Guide for Conservation and forage Plantings. U.S.D.A. Soil Conservation Service, Plant Materials Center, Corvallis, OR.

Batchelor, R. F. 1965. The Roosevelt elk in Alaska: its ecology and management. Project Rep. W-6-R-5, Work Plan D. Alaska Dept. Fish and Game, Juneau. 37 p.

Bentley, W. W. 1959. The range relationships of Roosevelt elk, Cervus canadensis roosevelti (Merriam), at Prairie Creek Redwoods State Park, Humboldt County, California, in 1958. M.S. Thesis, Humboldt State College, Arcata, CA. 82 p.

Berry, J., D. Dipert and M. Frazier. 1983. Unpublished. Position paper on grass and forage seeding on the Mapleton Ranger District. On file at Mapleton Ranger District, Siuslaw National Forest. Mapleton, OR.

Bond, J., J. N. Wiltbank and A. C. Cook. 1958. Cessation of estrus and ovarian activity in a group of beef heifers on extremely low levels of energy and protein. J. Anim. Sci. 17:1211.

Bryant, L. D. and C. Maser. 1982. Classification and distribution. pp. 1-60. IN: Thomas, J. W. and D. E. Toweill (eds.), Elk of North America: Ecology and Management. Stackpole Books. Harrisburg, PA.

Buechner, H. K. 1952. Winter range utilization by elk and mule deer in southeast Washington. J. Range Manage. 5:76-80.

Church, D. C. 1980. Ed. Digestive physiology and nutrition of ruminants, Vol. 3--Practical Nutrition. 2nd ed., O and B Books, Inc., Corvallis, OR.

Cleary, D. V. 1972. Wildlife Seeding Guide for Western Oregon. Ore. St. Game Comm., Portland, OR.

Cleary, D. V. and I. M. Mereszczak. 1977. Fertilization and legume seeding of clearcuts. Oregon Dept. Fish and Wildl., Corvallis, OR. 17 p.

Cook, C. W. 1965. Plant and livestock responses to fertilized rangelands. Utah Agr. Exp. Sta. Bull. 455. 35 p.

Cowan, R. L., J. S. Jordan, J. L. Grimes and J. D. Gill. 1970. Comparative nutritive values of forage species. pp. 48-56 IN: Range and wildlife habitat evaluation--a research symposium. U.S.D.A. Forest Service Misc. Publ. 1147. 220 p.

Crampton, E. W. and L. E. Harris. 1969. Applied animal nutrition. W. H. Freeman and Co., San Francisco. 753 p.

Dean, R. E., E. T. Thorne and I. J. Yorgason. 1976. Weights of Rocky Mountain elk. J. Mammal. 57:186-189.

Dietz, D. R. 1970. Definition and components of forage quality. pp. 1-9 IN: Range and wildlife habitat evaluation--a research symposium. U.S.D.A. Forest Service Misc. Publ. 1147. 220 p.

Einarsen, A. S. 1946. Crude protein determination of deer food as an applied management technique. Trans. N. Amer. Wildl. Conf. 11:309-312.

Everist, S. L. 1972. Australia. pp.16-25 IN: C. M. McKell, J. P. Blaisdell and J. R. Goodin, eds. Sect. 1. Continental aspects of shrub distribution, utilization and potentials. Wildland shrubs--their biology and utilization. U.S.D.A. Forest Service Gen. Tech. Rep. INT-1.

Farstvedt, G. 1977. A report on forage production and utilization at Dean Creek elk pasture. Ore. Dept. Fish and Wildl. 19 p.

Franklin, W. L., A. S. Morseman and M. Dale. 1975. Social organization and home range of Roosevelt elk. J. Mamml. 56:102-118.

French, C. E., L. C. McEwan, N. D. McGruder, R. H. Ingram and R. W. Swift. 1956. Nutrient requirements for growth and antler development in the white-tailed deer. J. Wildl. Manage. 20:221-232.

Geist, J. M., P. J. Edgerton and G. S. Strickler. 1974. 'Yucky to Yummy' - with fertilizers. Rangeman's Journal 1:39-41.

Graf, W. 1943. Natural history of the Roosevelt elk. PhD Thesis, Oregon State College, Corvallis. 222 p.

Hansen, R. M. and R. C. Clark. 1977. Foods of elk and other ungulates at low elevations in northwestern Colorado. J. Wildl. Manage. 41:76-80.

Harn, J. H. 1958. The Roosevelt elk, <u>Cervus canadensis roosevelti</u>, at Prairie Creek Redwoods State Park, Humboldt County, California. M.S. Thesis, Humboldt St. Coll., Arcata. 93 p.

Harn, J. H. 1960. Natality and mortality of Roosevelt elk in northern California. Proc. Ann. Conf. Western Assoc. State Game and Fish Comm. 40:220-223.

Harper, J. A. 1962. Daytime feeding habits of Roosevelt elk on Boyes Prairie, California. J. Wildl. Manage. 26:97-100.

Harper, J. A. 1968. Fed. Aid Project W-59-R-5. Annual Fed. Aid Progress Report. Ecological study of Roosevelt elk: elk enclosure study. Oregon Wildl. Comm.

Harper, J. A., J. C. Lemos and L. Carver. 1971. Annual Progress Report, Fed Aid Project W-7-R-1. Ecological study of Roosevelt elk: elk enclosure study. Ore. Wildl. Comm. 37 p.

Harper. J. A., J. H. Harn, W. W. Bentley and C. F. Yocum. 1967. The status and ecology of the Roosevelt elk in California. Wildlife Monogr. 16:49.

Hash, H. S. 1973. Movements and food habits of the Lochsa elk. M.S. Thesis, Univ. of Idaho, Moscow. 76 p.

Heady, H. F. 1975. Rangeland Management. McGraw-Hill Book. Co., San Francisco. 460 p.

Hemstrom, M. A. and S. E. Logan. 1984. Preliminary Plant Association and Management Guide, Siuslaw National Forest. U.S. Forest Service, Willamette National Forest, Eugene, OR. 90 p.

Hines, W. W. 1970. Annual progress report., Fed. Aid Project W-59-R-7. Ecological study of Roosevelt elk: elk enclosure study. Ore. Wildl. Comm., Portland. 25 p.

Hines, W. W., J. C. Lemos and L. Carver. 1971. Annual progress report, Fed. Aid Project W-7-R-1. Ecological study of Roosevelt elk: elk enclosure study. Ore. Wildl. Comm., Portland. 37 p.

Hines W. W., and J. C. Lemos. 1975. Annual progress report, Fed. Aid Project W-70-R-5. Ecological study of Roosevelt elk: elk investigations. Ore. Wildl. Comm., Portland. 18 p.

Jenkins, J. J. 1980. Home range and habitat use by Roosevelt elk in Olympic National Park, Washington. M.S. Thesis, Oregon State Univ., Corvallis. 84 p.

Jung, H. G. 1985. Inhibition of structural carbohydrate fermentation by forage phenolics. J. Sci. Food Agric. 36:74-80.

Klingler, G. E. 1982. Unpubl. report. Effect of grass-legume competition on shrub and hardwood invasion in newly harvested clearcuts. Alsea Ranger District, Siuslaw National Forest. 29 p.

Klingler, G. E. 1984. Integrated management of range, wildlife, and silviculture on the Alsea Ranger District, Siuslaw National Forest. Unpubl. report., Alsea Ranger District, Siuslaw N. F.

Knott, N. P. 1956. Possible effects of fertilization on forage production and game use. Proc. Ann. Conf. W. Assoc. State Game and Fish Comm. 36:207-209.

Kufeld, R. C. 1973. Foods eaten by Rocky Mountain elk. J. Range Manage. 26:106-112.

Kuttel, M. P. 1975. Second report on the Willapa Hills elk herd. Wash. Game Dept. 63 p.

Lassiter, C. A., D. M. Seath, J. W. Woodruff, J. A. Taylor and J. W. Rust. 1956. Comparative value of Kentucky bluegrass, Kentucky-31 fescue, orchardgrass, and bromegrass as pastures for milk cows. II. Effect of kind of grass on the dry matter and crude protein content and digestibility and intake of dry matter. J. Dairy Sci. 39:581-588.

Leininger, W. C. 1984. Silvicultural impacts of sheep grazing in Oregon's Coast Range. PhD Diss., Oregon State Univ., Corvallis. 203 p.

Lemos, J. C. and W. W. Hines. 1974. Annual progress report, Fed. Aid Project W-70-R-4. Millicoma Roosevelt elk research. Oregon Wildl. Comm.

Leslie, D. M. 1982. Nutritional ecology of cervids in old growth forests in Olympic National Park, Washington. PhD Diss., Oregon State Univ., Corvallis. 141 p.

Leslie, D. M., E. E. Starkey, and M. Vavra. 1984. Elk and deer diets in old-growth forests in western Washington. J. Wildl. Manage. 48:762-775.

Li, C. Y. 1974. Phenolic compounds in understory species of alder, conifer, and mixed-conifer stands of coastal Oregon. Lloydia 37:603-607.

Lohan, O. P., D. Iall, H.P.S. Makker and S. S. Negi. 1981. Inhibition of rumen urease activity by tannins in oak leaves. Ind. J. Anim. Sci. 51:279-281.

Logsdon, H. S. 1965. The immobilization and movements of the Roosevelt elk. M.S. Thesis. Humboldt State Coll., Arcata. 89 p.

Lyford, S. J., W.W.G. Smart and T.A. Bell. 1967. Inhibition of rumen cellulose digestion by extracts of sericea Lespedesa. J. Anim. Sci. 26:632-637.

Mandel, R. D. 1979. The ecology of Roosevelt elk in and around Redwood National Park. M.S. Thesis, Humboldt State Univ., Arcata. 69 p.

Mautz, W. W. 1978. Sledding down a brushy hillside: the fat cycle in deer. Wildl. Soc. Bull. 6:88-90.

McLeod, M. N. 1974. Plant tannins--their role in forage quality. Nutr. Abstr. Rev. 44:803-815.

Mereszczak, I. M. 1979. The effects of three levels of range improvements on Roosevelt elk nutrition. M. S. Thesis, Oregon State Univ., Corvallis. 86 p.

Mereszczak, I. M., W. C. Krueger and M. Vavra. 1981. Effects of range improvement on Roosevelt elk winter nutrition. J. Range Manage. 34:184-187.

Mould, E. D. and C. T. Robbins. 1981. Nitrogen metabolism in elk. J. Wildl. Manage. 45:323-334.

Nelson, J. P. and T. A. Leege. 1982. Nutritional requirements and food habits. pp. 323-367. IN: Elk of North America: Ecology and Management. J. W. Thomas and D. E. Toweill, eds. Stackpole Books, Harrisburg, PA.

Oregon State Game Commission, Game Division--Annual Report. 1950, 1970.

Oregon Department of Fish and Wildlife, Game Division--Annual Report. 1974, 1979.

Oregon Department of Fish and Wildlife, Northwest Regional Office--Unpublished data. 1984, 1985.

Phillips, C. E. 1981. Unpublished report. Analysis of forage data. Supervisor's Office, Siuslaw National Forest, Corvallis, OR.

Phillips, C. E. 1985. Personal communication.

Petersen, R. A. 1982. An assessment of grass and forage seeding on the Mapleton Ranger District of the Siuslaw National Forest. M. S. Thesis, Washington State Univ., Pullman.

Petersen, R. A., P. Cooley and B. Cleary. 1981. Unpublished. Draft environmental assessment of grass and forage seeding on Mapleton Ranger District. On file at Mapleton Ranger District, Siuslaw N. F., Mapleton, OR. 75 p.

Ramsey, K. J. 1985. Unpublished. Annual progress report on: The effects of improved quality winter forage on Roosevelt elk. Dept. of Rangeland Resources, Oregon State Univ., Corvallis. 11 p.

Reed, J. D., R. E. McDowell, P. J. Van Soest and P. J. Horvath. 1982. Condensed tannins: a factor limiting the use of cassava forage. J. Sci. Food Agric. 33:213-220.

Reid, R. L., G. A. Jung and S. J. Murray. 1966. Nitrogen fertilization in relation to the palatability or nutritive value of orchardgrass. J. Anim. Sci. 25:636-645.

Rhodes, B. D. 1984. Sheep grazing in Douglas-fir plantations of Oregon's Coast Range and its impact on big game habitat. M. S. Thesis. Oregon State Univ., Corvallis. 136 p.

Rinaldi, K. 1984. Unpublished. FY 1984 report of the grass seed/fertilization study on the Alsea Ranger District. On file at Alsea Ranger District, Siuslaw National Forest, Alsea, Oregon.

Rochelle, J. A. 1980. Mature forests, litterfall and patterns of forage quality as factors in the nutrition of black-tailed deer on northern Vancouver Island. PhD Diss., Univ. of British Columbia, Vancouver, B.C. 296 p.

Schoen, J. W. 1977. The ecological distribution and biology of wapiti (Cervus elaphus nelsoni) in the Cedar River Watershed, Washington. PhD Diss., Univ. of Washington, Seattle. 406 p.

Schwartz, J. E. and G. E. Mitchell. 1945. The Roosevelt elk on the Olympic Peninsula, Washington. J. Wildl. Manage. 9:295-319.

Sharrow, S. H. 1984. Personal communication. Dept. of Rangeland Resources, Oregon State Univ., Corvallis.

Smith, S. Undated, unpublished. Forage seeding for elk management. On file at Alsea Ranger District, Siuslaw National Forest, Alsea, OR.

Smith S. 1985. Personal communication. Alsea Ranger District, Alsea, OR.

Stevens, M. C. 1965. A preliminary study on the movement, distribution, abundance, and sex and age composition of the Roosevelt elk in and adjacent to the Prairie Creek Redwoods State Park. M.S. Thesis, Humboldt State Coll, Arcata, CA. 122 p.

Swanson, D. O. 1970. Roosevelt elk-forest relationships in the Douglas-fir region of the southern Oregon Coast Range. PhD Diss., Michigan State Univ., East Lansing. 173 p.

Swift, R. W. 1948. Deer select most nutritious forages. J. Wildl. Manage. 12:109-110.

Taylor, D. 1985. Personal communication. Oregon Dept. Fish and Wildlife, Tillamook, OR.

Thorne, E. T. 1973. Nutritional requirements of elk for reproduction. Job Progress Report. Wyoming Game and Fish Department. FW-3-R-20. pp. 22-23.

Thorne, E. T., R. E. Dean and W. G. Hepworth. 1976. Nutrition during gestation in relation to successful reproduction in elk. J. Wildl. Manage. 40:330-335.

Trainer, C. E. 1971. The relationship of physical condition and fertility of female Roosevelt elk (Cervus canadensis roosevelti). M.S. Thesis, Oregon State Univ., Corvallis. 95 p.

Royer, W. A. 1960. The Roosevelt elk of Afognak Island, Alaska. J. Wildl. Manage. 29:74-79.

U.S. Forest Service. Undated, unpublished. Forage clipping (production) statistics. On file at Alsea Ranger District, Siuslaw National Forest, Alsea, OR.

U.S. Forest Service. 1985. Management regimes for grass-legume seedings. Alsea Range District, Siuslaw National Forest, Alsea, OR. 2 p.

Verme, L. J. 1965. Reproduction studies on penned white-tailed deer. J. Wildl. Manage. 29:74-79.

Verme L. J., and J. J. Ozoga. 1980. Influence of protein-energy intake on deer fawns in autumn. J. Wildl. Manage. 44:315-324

Villejas, D. 1984. Unpublished. Status report on Waldport Monitoring Plan for forage production and utilization. On file at Waldport Ranger District, Siuslaw National Forest, Waldport, OR.

Wallace, J. D. and R. J. Raleigh. 1964. Calf production from Hereford cows wintered at different nutrition levels. Proc. West. Sec. Amer. Soc. Anim. Sci. 15:57.

Witmer, G. W. 1982. Roosevelt elk habitat use in the Oregon Coast Range. M.S. Thesis. Oregon State Univ., Corvallis. 104 p.

Woolington, D. 1983. Unpublished. Elk forage production model. On file at Mapleton Ranger District, Siuslaw National Forest. Mapleton, OR. 10 p.

Woolington, D. 1985. Personal communication. Mapleton Ranger District, Siuslaw National Forest, Mapleton, OR.

Woolington, D. 1982. Unpublished. Notes from ODFW and USFS elk management meeting concerning cooperative road closure area on Mapleton Ranger District. On file at Mapleton Ranger District, Siuslaw National Forest, Mapleton, OR.