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Forage in Aspen: Ecology and Management in the Western United States

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FORAGE

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The extensive forests and isolated clones of quaking aspen in the western United States have been valued for many years as wildlife habitat and livestock summer range (Sampson 1919). The actual amount of forage produced beneath the aspen trees differs appreciably among sites. Houston (1954) indicated that although many sites produce 1,000 to 2,000 pounds per acre (1,120 to 2,240 kg per ha), some produce more than 4,000 pounds per acre (4,480 kg per ha), and others less than 500 pounds per acre (560 kg per ha). Such variability is caused by environmental differences, levels of livestock grazing, and the successional status of the community.

Ellison and Houston (1958) noted that although aspen communities are generally capable of supporting much forage for livestock and wildlife (fig. 1), most aspen communities in the Intermountain Region have been depleted by prolonged overgrazing. Overgrazing probably has adversely affected many aspen rangelands throughout the West (see the ANIMAL IMPACTS chapter). Excessive grazing generally alters forage composition (fig. 2) and frequently reduces production (Houston 1954). Fortunately, unless grazing abuse is extreme, the potential productivity of most sites is not reduced appreciably by soil erosion. However, livestock grazing (Sampson 1919) and also local concentration of big game animals can jeopardize the perpetuation of aspen dominated communities (see the ANIMAL IMPACTS chapter).

Forage Composition and Use

As discussed in detail in the VEGETATION ASSOCIATIONS chapter, the undergrowth of aspen communities in the West is generally composed of a multilayered, complex mixture of shrubs, forbs, and graminoids. In the Intermountain Region, this mixture consists of an almost unlimited combination of some 300 species (Houston 1954). Costello (1944) reported that 10 to 15 species of graminoids, 20 to 40 species of forbs, and several shrubs are commonly encountered on a single, 100-foot-square (9-m^2) area, on aspen rangelands in Colorado and Wyoming. Such species diversity is typical of aspen communities throughout the West. However, exceptions exist where only a few species of graminoids and forbs are prominent. Such floristic simplicity may be attributed to a long period of grazing abuse (Costello 1944, Beetle 1974), to the effects of a coniferous understory, or also may reflect the natural undergrowth characteristics of adjacent vegetation types (Houston 1954) (fig. 3).

Not all plants within a community produce forage. Plant species differ greatly in relative palatability to grazing animals, and different kinds of animals prefer different plants. A common perception is that sheep and deer prefer forbs and browse, and cattle prefer grass. Although these ungulates can be highly selective in forage preferences, they are also very adaptive. Even plants somewhat distasteful to the animals will be readily eaten if little else is available. In complex vegetation, such as the aspen type, many species are eaten by all kinds of grazing animals. The most palatable are often specifically sought out and usually the first to decrease under continued grazing pressure; species not readily eaten frequently increase in abundance because of reduced competition. As the more palatable species decrease, the less palatable are more readily eaten. Under prolonged grazing, then, community composition changes gradually to a mix of fewer species and greater abundance of plants low in palatability.

Figure 1.—Many aspen communities in the West can support a wide variety of undergrowth species that produce more than 2,000 pounds per acre (2,240 kg/ha) of forage for livestock and wildlife.

Figure 2.—Prolonged sheep grazing gradually can alter a rich mixture of forbs and graminoids in aspen undergrowth into grass-dominated cover with little species diversity (Dixie National Forest, Utah).

These changes in species composition under grazing can be used as indicators of general forage preferences. Forage desirability ratings of species commonly are based upon this concept. Table 1 lists desirable, intermediate, and least desirable livestock forage species frequently found in aspen communities in the West.

Table 1 does not distinguish differences in palatability between kinds of animals nor differences attributable to the amount of each species that is present. For example, many of the forbs and shrubs listed as intermediate may be avidly eaten by sheep, but only moderately by cattle; the reverse would be true for grasses and sedges. Usually the more abundant a moderately palatable species is in the community, the less will be eaten of each individual of that species. However, intense grazing pressure may force animals to eat even the least desirable species.

In some instances, a species which is quite palatable to one kind of animal may be toxic to another. *Delphinium barbeyi* and *D. occidentale* (tall larkspurs), common members of aspen communities in the West, are readily eaten by sheep but are highly poisonous to cattle.

In one of the few studies of actual forage consumption by livestock in the aspen type, Paulsen (1969) found that a sedge, *Carex geyeri*, and a forb, *Thalictrum dasycarpum*, provided most of the forage consumed by cattle on Black Mesa, in Colorado. Other major forage producing forbs on this cattle range were *Helianthella quinquinerius*, *Erigeron macranthus*, *Lathyrus leucanthus*, and *Agoseris* spp. Paulsen found that the forbs, as a group, decreased in the cattle diet as they became dry toward the end of August, even though their content of crude protein, phosphorus, and calcium remained adequate for animal nutrition. Costello (1944) found that *Symphoricarpos oreophilus* (a shrub) and *Carex* spp. were valued sheep forage in the aspen type of Colorado and Wyoming. He also observed that the continued presence of *Thalictrum fendleri*, *Vicia americana*, *Lathyrus leucanthus*, and *Galium boreale* were indicators of moderate but not excessive sheep use; these species became scarce with prolonged, heavy sheep grazing.

Figure 3.—The unusually species poor undergrowth dominated by pine grass in this aspen community within the Cliff Lake Bench Natural Area, in southwestern Montana, reflects the natural undergrowth characteristics of nearby lodgepole pine stands.

Wild ungulates have somewhat different forage preferences than livestock. Smith (1952) found the following species to comprise the bulk of the summer diet of deer in the aspen forests of central Utah: *Populus tremuloides*, 27%; *Lupinus alpestris*, 27%; *Stipa columbiana*, 4%; *Carex* spp., 3%. Collins (1979) and Collins and Urness (1983) determined summer diet composition of both deer and elk in an aspen forest in north central Utah. Using a bite-count technique with tame animals enabled them to determine species preferences on a dry-weight intake basis (table 2). The most abundant undergrowth species were *Symphoricarpos oreophilus*, *Agastache urticifolia*, *Rudbeckia occidentalis*, *Prunus virginiana*, *Valeriana occidentalis*, *Mertensia arizonica*, and *Senecio serra*. The diet of the deer consisted of 38% shrubs, 61% forbs, and less than 1% graminoids; the elk diet consisted of 24% shrubs, 51% forbs, and 25% graminoids.

Aspen reproduction is a nutritious forage that, when abundant, can form a substantial portion of the diet of both livestock and wild ungulates. Tew (1970b) found that aspen leaves averaged 17% protein in June, 13% in July, and 12% in September; fat content averaged 7% in June, 8% in July, and 10% in September. The variation in nutrient content between clones, however, can be substantial.

The bark and wood of mature aspen trees also has a potential value as livestock feed. Baker, et al. (1975) determined aspen bark to be about 50% digestible and aspen wood about 35% digestible by both in vitro and in vivo tests. Singh and Kamstra (1981) found that ground and pelleted aspen wood, supplemented with soybean meal, could comprise as much as 48% of the diet of growing cattle without adversely affecting weight gains and meat quality. Aspen pellets made from whole trees also can substitute for half of the corn silage roughage ordinarily fed lactating dairy cows when they are past peak production (Schingoethe et al. 1981). Steam-cooked aspen wood is very similar to alfalfa in energy digestibility, and presumedly can satisfactorily replace much of the hay ordinarily used in ruminant feed (Al-Rabbat and Heaney 1978). Feeding trials indicate that steamed aspen can make up 30% of the dry matter diet of beef steers without adversely affecting gains or meat quality (Sharma et al. 1980), and that up to 30% steam-processed aspen chips can be used as a roughage substitute in maintenance rations for mature sheep (Sharma et al. 1979).

Forage Productivity

Productivity within a vegetation type is usually expressed as total annual production of above-ground herbage. This often is separated into vegetation classes, and sometimes it is categorized by species. Such total productivity figures, however, are only an index of usable forage production. The term "usable forage" ap-

Table 1.—Common undergrowth plants in western aspen forests, categorized according to desirability as livestock forage (Houston 1954).[1,2]

Desirable	Intermediate	Least desirable
Angelica spp.	*Amelanchier alnifolia*	*Achillea millefolium*
Aster engelmannii	*Agropyron subsecundum*	*Arnica* spp.
Deschampsia caespitosa	*Agastache urticifolia*	*Artemisia* spp.
Glyceria spp.	*Bromus marginatus*	*Aster* spp. (low)
Heracleum lanatum	*Calamagrostis rubescens*	*Berberis repens*
Ligusticum spp.	*Carex* spp.	*Circium* spp.
Mertensia spp.	*Erigeron* spp.	*Cerastium* spp.
Osmorhiza spp.	*Elymus glaucus*	*Epilobium* spp.
Phleum spp.	*Festuca* spp.	*Eriogonum* spp.
Polemonium spp.	*Galium boreale*	*Fragaria* spp.
Trifolium spp.	*Hackelia floribunda*	*Geranium* spp.
	Lupinus spp.	*Geum* spp.
	Melica spp.	*Helenium hoopesii*
	Pachistima myrsinites	*Iris* spp.
	Poa spp.	*Lathyrus* spp.
	Prunus virginiana	*Lonicera* spp.
	Rosa spp.	*Madia* spp.
	Sambucus spp.	*Nemophila breviflora*
	Senecio serra	*Pedicularis* spp.
	Symphoricarpos spp.	*Penstemon* spp.
	Thalictrum spp.	*Phlox* spp.
	Valeriana spp.	*Potentilla* spp.
	Vicia americana	*Pteridium aquilinum*
		Rudbeckia occidentalis

[1]*U.S. Department of Agriculture, Forest Service. 1968. Range environmental analysis handbook. U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Denver, Colo.*

[2]*U.S. Department of Agriculture, Forest Service. 1970. Range environmental analysis handbook. U.S. Department of Agriculture, Forest Service, Intermountain Region, Ogden, Utah.*

Table 2.—Composition of deer and elk summer diets (percentage of total weight consumed) in an aspen forest in north central Utah (Collins 1979).

Deer	Elk
24% *Symphoricarpos oreophilus*	20% *Symphoricarpos oreophilus*
14% *Valeriana edulis*	15% *Aster foliaceus*
13% *Aster foliaceus*	14% *Agropyron subsecundum*
10% *Vicia americana*	6% *Thalictrum fendleri*
10% *Lathyrus lanzwertii*	5% *Heracleum lanatum*
6% *Populus tremuloides*	5% *Bromus carinatus*
3% *Aster engelmannii*	5% *Aster engelmannii*
3% *Amelanchier alnifolia*	5% *Lathyrus lanzwertii*
3% *Agastache urticifolia*	4% *Vicia americana*
	4% *Populus tremuloides*
	3% *Mertensia arizonica*
	3% *Erigeron peregrinus*

plies to that portion of the total palatable vegetation that can be eaten by grazing animals without adversely affecting long-term plant vitality. Usable forage can be converted to grazing capacity in animal unit months (AUM); an AUM is one cow or five sheep for a 1-month period. Capacities are expressed either as the number of acres required to sustain one AUM (acres per AUM) or, conversely, the number of AUMs that can be carried on 1 acre (AUMs per acre). Recommended grazing capacities developed by the Routt National Forest in Colorado[1] for the aspen-weed type in various condition classes are:

[1]*U.S. Department of Agriculture, Forest Service. 1968. Range environmental analysis handbook. U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Denver, Colo.*

Range condition	Acres per AUM	Hectares per AUM
Excellent	4–5	1.6–2.0
Good	5–6	2.0–2.4
Fair	7–10	2.8–4.0
Poor	13–20	5.3–8.1

Usually, however, the amount of usable forage produced in aspen communities must be inferred from published figures on total above-ground biomass of undergrowth vegetation. These are most often expressed in the literature as air-dry production of annual herbage growth.

Geographical Variation

Forage production is considerably less in both the northern and southern portions of aspen's geographical distribution than in the central portion. Pringle et al. (1973) reported herbage yields from aspen communities in northern British Columbia and Alberta as low as 103 pounds per acre (115 kg per ha). Bailey and Wroe (1974) reported average annual yields of 462 ± 68 pounds per acre (518 ± 76 kg per ha) in the aspen groves of Alberta parklands. In Arizona, near the southern distribution of aspen forests, Reynolds (1969) found aspen groves producing 245 pounds per acre (275 kg per ha) of dry herbage, about an equal mix of forbs and grasses. Patton (1976) reported even lower figures—100 pounds per acre (112 kg per ha)—for an aspen-conifer forest in Arizona.

Farther north, on the Dixie National Forest, in southern Utah, Smith et al. (1972) found undergrowth production of an aspen community was 802 pounds per acre (898 kg per ha), 50% of which was forbs, 49% grass, and 1% shrubs. On the Fishlake National Forest, in southern Utah, air-dry undergrowth production in two ungrazed aspen communities was between 625 and 758 pounds per acre (700 and 850 kg per ha), more than 50% of which was forbs (Mueggler and Bartos 1977). Harper found understory production of aspen communities on the Manti-LaSal National Forest, in central Utah ranged from 700 to 1,700 pounds per acre (785 to 1,905 kg per ha).[2] On the Wasatch National Forest, in northern Utah, air-dry production of undergrowth vegetation ranged from 401 to 2,052 pounds per acre (449 to 2,300 kg per ha); the average was 1,088 ± 78 pounds per acre (1,219 ± 87 kg per ha).[3]

Still farther north, on the Bridger-Teton National Forest in western Wyoming, Youngblood and Mueggler (1981) found undergrowth production in different community types ranged from an average of 330 pounds per acre (370 kg per ha) in the least productive types to 2,095 pounds per acre (2,348 kg per ha) in the most productive type. In this same area, Bartos and Mueggler (1979) found production from three clones growing on a fairly dry hillside averaged 1,472 pounds per acre (1,650 kg per ha); between 55% and 75% of this was forbs, 12% to 35% was grass, and 10% to 27% was shrubs. Undergrowth herbage production from a sample of 144 aspen stands on adjacent National Forests in eastern Idaho ranged from 244 to 2,047 pounds per acre (273 to 2,294 kg per ha), and averaged 937 ± 34 pounds per acre (1,050 ± 38 kg per ha) (Mueggler and Campbell 1982). Composition of this herbage averaged 13 ± 2% shrubs, 45 ± 2% forbs, and 42 ± 2% graminoids. Overall suitability of the herbage as livestock forage averaged 55% desirable, 40% intermediate, and 5% undesirable. Both production and composition of the undergrowth varied appreciably among the 23 community types described.

[2]Data provided by K. T. Harper, Department of Botany and Range Science, Brigham Young University, Provo, Utah.

[3]Data on file at the Intermountain Forest and Range Experiment Station's Forestry Sciences Laboratory at Utah State University, Logan, Utah.

Production of aspen undergrowth in northern Nevada ranged between 800 and 1,700 pounds per acre (897 and 1,905 kg per ha);[4] and in western Oregon (Hall 1973), production was about 1,400 pounds per acre (1,569 kg per ha). Woods et al. (1982) found the range in undergrowth production of 20 stands in northern Colorado was 498 to 2,028 pounds per acre (558 to 2,273 kg per ha), with an average of 1,482 pounds per acre (1,661 kg per ha). A sampling of 12 stands in the Black Hills of South Dakota yielded 479 to 1,186 pounds per acre (537 to 1,329 kg per ha), about equally divided among forbs, grasses, and shrubs (Severson and Kranz 1976).

Forest Versus Openings

Despite considerable forage production in most aspen communities, the overstory trees compete with the undergrowth plants for moisture, light, nutrients, and space. Consequently, adjacent vegetation types lacking such overstory competition potentially may produce more forage than the aspen forest. Bailey and Wroe (1974) found this true in Alberta, where aspen groves produced an average 462 pounds per acre (518 kg per ha) of undergrowth, whereas adjacent *Festuca scabrella* grasslands produced 1,795 pounds per acre (2,012 kg per ha). Paulsen (1969) reported similar findings for western Colorado; only half as much herbage was produced by aspen undergrowth as in adjacent *Festuca thurberi* grasslands. Ellison and Houston (1958) noted that undergrowth vegetation in aspen communities in Utah was typically taller and more productive than in openings within or adjacent to the aspen. They attributed this to a combination of heavier grazing and a harsher microenvironment in the openings. They found that where the vegetation had not been subjected to a history of livestock grazing, production in the openings exceeded that under the aspen.

Stand Density and Conifer Succession

In most forest types, the more tree overstory there is, the fewer herbs and shrubs there are. This generalization applies to aspen forests that are rapidly seral to conifers, but usually not to mature aspen communities that are stable. Warner (1971) examined 42 pure aspen stands in Utah and found no significant relationship between numbers of stems greater than 4 inches (10 cm) d.b.h. and undergrowth production. Harper[2] found no correlation between the basal area of aspen trees and annual production of undergrowth vegetation in central Utah. He determined, however, that undergrowth production decreased progressively as the proportion of conifers in the stands increased.

[4]Information obtained from two typescript documents. Lewis, Mont E. 1971. Flora and major plant communities of the Ruby-East Humboldt Mountains. U.S. Department of Agriculture, Forest Service, Intermountain Region, Humboldt National Forest, 62 p. Elko, Nev.; and Lewis, Mont E. 1975. Plant communities of the Jarbridge Mountain Complex. U.S. Department of Agriculture, Forest Service, Humboldt National Forest, 22 p. Elko, Nev.

Seral aspen communities averaging 162 square feet per acre (37.2 m² per ha) total tree basal area, 15% of which was conifers, produced 743 pounds per acre (833 kg per ha) of undergrowth; those with 183 square feet per acre (42 m² per ha) basal area, 34% conifers, produced 422 pounds per acre (473 kg per ha); and those 234 square feet per acre (53.7 m² per ha) basal area, 68% conifers, produced only 213 pounds per acre (239 kg per ha) of undergrowth. Stable aspen communities in the same locality with an average basal area of 187 square feet per acre (42.9 m² per ha), all of which was aspen, produced 1,471 pounds per acre (1 649 kg per ha) of undergrowth.

Composition of the undergrowth vegetation in the seral aspen communities with 68% conifers was 44% forbs, 5% graminoids, and 51% shrubs; in the stable aspen communities, the undergrowth averaged 60% forbs, 20% graminoids, and 20% shrubs. Thus, not only was the undergrowth less productive in the strongly seral stands, but it consisted of a smaller proportion of herbs and greater proportion of shrubs as well.

Severson and Kranz (1976) also concluded that undergrowth production is not related to the basal area or stand density of the aspen trees. Kranz and Linder (1973) found that the amount of undergrowth in the Black Hills aspen communities decreased as the amount of conifers mixed with the aspen increased. A predominantly aspen type produced 590 pounds per acre (661 kg per ha) of undergrowth; a mixed aspen/ponderosa pine type produced 415 pounds per acre (465 kg per ha); and a predominantly pine type produced only 215 pounds per acre (241 kg per ha) of undergrowth. Similar relationships exist in Arizona between predominantly aspen and mixed conifer forests. Reynolds (1969) found that aspen groves produced 245 pounds per acre (275 kg per ha) of undergrowth, whereas adjacent mixed conifer forests produced only 60 pounds per acre (67 kg per ha).

Only one report on overstory-undergrowth relations in aspen forests supports the generalization that undergrowth production is negatively related to the amount of tree cover. Woods et al. (1982), comparing 20 pure aspen stands growing under similar environments in Colorado, but with widely different amounts of aspen basal area, obtained a significant coefficient of determination (R^2) of 0.61 between aspen overstory and undergrowth. They concluded that thinning aspen stands to basal areas less than 44 square feet per acre (10 m² per ha) would significantly increase undergrowth production.

Yearly Variability

Forage production varies from year to year in response to weather. Paulsen (1969) found almost a twofold yearly difference in both total undergrowth production and composition in an aspen community in western Colorado. Production over a 10-year period ranged from 582 to 1,066 pounds per acre (652 to 1,195 kg per ha) and averaged 740 pounds per acre (829 kg per ha). During this period, forbs comprised from 41% to 70% and graminoids from 28% to 59% of the undergrowth production. Bartos[5] found similar variability in undergrowth production in three aspen stands in northern Utah, over a 4-year period. Production during the high year in each of the three stands was 121%, 145%, and 168% that of the low year; means and standard errors over the four years were 1,253 ± 57 pounds per acre (1,404 ± 64 kg per ha), 1,093 ± 87 pounds per acre (1,225 ± 98 kg per ha), and 1,433 ± 168 pounds per acre (1,606 ± 188 kg per ha). In the stand that fluctuated the most, the proportion of forbs varied from 41% to 88%, and the proportion of grass varied from 10% to 56%, figures surprisingly similar to Paulsen's.

During approximately the same 4-year period in western Wyoming, undergrowth production in an aspen stand during the high year was 127% of that in the low year (Bartos and Mueggler 1979). Average production for the period was 1,780 ± 109 pounds per acre (1,995 ± 122 kg per ha). There, the proportion of forbs ranged from 64% to 71%, graminoids ranged from 11% to 25%, and shrubs ranged from 11% to 20% of the total undergrowth production.

Clearcutting

Smith et al. (1972) compared the effects of partial cutting (50% of the larger trees removed) and clearcutting on herbage production in an aspen stand in northern Utah. Average production during the first 3 years after cutting increased 36% on the partial cut and 87% on the clearcut. The proportion of forbs, grasses, and shrubs was not altered appreciably.

Bartos and Mueggler (1982) also found substantial increases in herbage production after clearcutting aspen in northern Utah. After adjusting for production variability attributable to yearly weather differences, they found that herbage production progressively increased during at least the first 3 years after cutting. By the third year, the aspen community with a predominantly forb/grass undergrowth (70% forbs, 26% grass, 3% shrubs) had a 76% increase in production. The community with a pronounced shrub stratum (59% forbs, 15% grass, and 27% shrubs) increased 137%.

The maximum increase in forage production that might be expected by clearcutting aspen as well as the time after cutting when competition and shading by aspen regeneration would begin to reduce production are not known. However, increased production might be sustained if aspen regeneration is prevented. Mueggler and Bartos (1977) found that a clearcut aspen community maintained free of aspen reproduction by deer browsing was still producing 60% more herbage than an adjacent uncut stand after 41 years. In a similar comparison at a higher elevation, however, the reproduction-free area was producing only 75% as

[5]*Data provided by D. L. Bartos and on file at the Intermountain Forest and Range Experiment Station's Forestry Sciences Laboratory at Utah State University, Logan, Utah.*

much herbaceous growth as its uncut companion after 41 years. During this period, composition of the vegetation on both of the reproduction-free areas shifted from a preponderance of forbs to more than 50% graminoids.

Burning

Information on the effects of fire on the undergrowth vegetation is meager. (See the FIRE chapter for a discussion of the effects and behavior of fire in aspen forests.) In western Wyoming, Bartos and Mueggler (1979) found a sharp decrease in herbage production in the first year after fire, followed by a dramatic increase the second and third years. After adjusting for yearly fluctuations attributable to weather, production on a moderate intensity burn decreased by 50% the first year, but increased to 175% the second year, and 200% by the third year. On a high intensity burn, production the first year was less than 25% of that before burning; but, by the third year, production was 80% greater than before burning. Herbage composition changed from less than 10% annuals before burning to 60% annuals on the moderate intensity and 70% on the high intensity burns by the third year after burning. Almost two-thirds of this "annual" category was composed of *Epilobium angustifolium*, which is actually a perennial forb that behaves as an aggressive pioneer species after fires. *Lupinus parviflorus* also was conspicuously favored by burning. Although production and composition can be expected to gradually revert to pre-burn norms, such trends had not begun by the third post-burn year.

Kleinman (1973) found that conifer reproduction generally entered seral aspen communities about 15 to 20 years after a fire. Forage production appeared to peak about this time and then rapidly decline in both quantity and quality when conifer basal area approached 50 square feet per acre (11.5 m^2 per ha). He concluded that if fire set back succession every 20 to 30 years in seral aspen communities, forage production would continue.