Summer habitat use and activity patterns of domestic sheep on coniferous forest range in southern Norway

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Abstract

Eight domestic sheep (*Ovis aries* L.) ewes were fitted with radio collars and tracked during the 1985 grazing season in Trysil, Hedmark County, southern Norway. The ewes were relocated 761 times between 11 June until 13 September. All relocations were used to describe activity patterns, and 565 were plotted and used to estimate habitat use. Range use was initially concentrated on and about areas previously influenced by man (e.g., abandoned homesteads, old fields) and on adjacent stands of rich spruce/fern (*Picea abies* (L) Karsten)/(*Dryopteris* spp.) forest. This preference was displayed especially during the day; poorer forest types were used more in the evening and at night. As the season progressed, use of the meadow/old-field habitat type declined in favor of the forest types. Activity peaks were at mid-morning and late evening. Animals camped in groups at midday and at night, always further upslope at night than during the day. Sheep were less active in cold, wet weather. Habitat selection and activity patterns observed in this study were similar to those of both wild and domestic sheep studied elsewhere.

Key Words: *Ovis aries* L., radiotelemetry, sheep diet, sheep grazing, forest grazing

With their ability to utilize plant biomass in areas unsuitable for cultivation, domestic sheep (*Ovis aries* L.) are economically important in many parts of the world. Their value as a source of meat and wool has led to extensive research into sheep genetics, physiology, and nutrition. However, the activity and utilization patterns of sheep grazing freely on open range and in forests have received less attention (Noble 1975). Many such studies have involved fenced, sown, and fertilized pasture (Hunter 1962, Lynch 1971, De Leeuw and Bakker 1986) and major predators have been absent (Grubb and Jewell 1974, Scott and Sutherland 1981).

In Hedmark county, in southeastern Norway, over 130,000 of the country's 2,300,000 sheep graze unattended (Bergøy 1982). In this region, vast tracts of coniferous forest provide ample forage for the many herds scattered throughout the county. Detailed knowledge of their activity patterns and habitat use in these forested areas is lacking. This lack of data comes at a time when outside interests are pressing for greater development of tourist facilities, and when current management plans call for an increase in native carnivore populations (primarily wolf (*Canis lupus* L.), brown bear (*Ursus arctos* L.), and wolverine (*Gulo gulo* L.)) (Vaag et al. 1986).

Before the impact of larger predator populations and increased human encroachment on sheep grazing can be assessed, analysis of sheep activity patterns, habitat selection, and range use is necessary.

A herd of sheep at Lutnes, Trysil, was followed intensively throughout the 1985 summer grazing season. Results of this work are presented here.

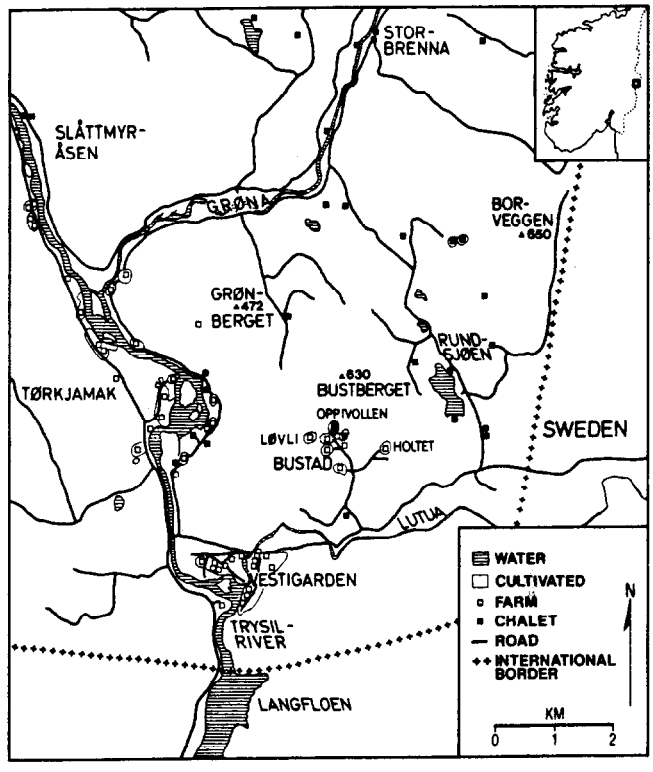

Fig. 1. Study area in Trysil, Hedmark County, Norway.

Study Area

The study area of approximately 50 km² lies in the southeast corner of Trysil, in Hedmark County in southern Norway (Fig. 1). Sheep graze in the area east of the Trysil River, between the Grøna River to the north and the Lutua River to the south. Grazing in Sweden is rare because of extensive bogs just east of the border. The landscape is rolling, with rounded peaks and narrow valleys. Altitude ranges from 300 to 700 m. Topography is locally steep and rocky, with Borveggen (650 m) and Bustberget (630 m) the dominant summits. A few small lakes and ponds dot the region. Forested and unforested bogs are common.

Climate in the region is classified as semi-continental with warm summers, cold winters, and no drought period (climate type D_3, Nordisk ministerraad 1977). Precipitation is heaviest in summer and winter. Winter snow pack can be substantial. Average January and July temperatures at the Plassen weather station, 10 km north of the study area, are -10.1 and +14.4° C, respectively. Average annual precipitation is 716 mm, increasing with altitude (Lystad 1978). Vegetation in the region is primarily boreal coniferous forest. Norway spruce (*Picea abies* (L.) Karsten) and Scots pine (*Pinus sylvestris* L.) are the dominant tree species. Pure stands of

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spruce and of pine are found on moister, more fertile, and dryer, more infertile sites, respectively. A mixture of the 2 species is most common, however, with pine often dominating mixed stands. Birch (*Betula odorata* Bechst.) may also be well represented in these mixed stands. Other species include aspen (*Populus tremula* L.) and mountain ash (*Sorbus aucuparia* L.).

Understory vegetation varies from heather (*Calluna vulgaris* (L.) Hull)/lichen (*Cladonia* spp.) in the dry, infertile pine stands, to blueberry (*Vaccinium myrtillus* L.)/fern (*Dryopteris* spp.) in the richer spruce stands. In the mixed stands, understory vegetation is variable, consisting mainly of blueberry, heather, and hairgrass (*Deschampsia flexuosa* (L.) Trin.).

The Lutnes area along the Trysil River was first settled in the late 1600s by Finnish immigrants. Cultivation and livestock grazing were subsequently begun on the south slope of Bustberget, as this higher-lying area was less subject to early frosts. Human activity on Bustberget increased steadily for more than 200 years. By the early 1900s, 3 farms and 6 small holdings (crofts) dotted Bustberget. Today, many of these are abandoned, with just 5 houses still inhabited. None of these graze livestock, and cultivation is minimal. Timber harvesting and sheep grazing (the study herd from Vestigarden) are the only major activities on Bustberget today.

On some sites, holdings established and abandoned between 1700–1950 have been invaded by the surrounding forest. Tracts that were once open meadows and gardens are now covered with birch and spruce. Other once-cultivated areas have been reforested with spruce and pine since 1950. Regardless of the source of the prevailing overstory vegetation (by invasion or planting), the area's use from 1700–1950 is still reflected by the understory.

Materials and Methods

On 8 June 1985, 8 ewes in the Lutnes herd were selected from a total of 112 ewes which were accompanied by 193 lambs; selection was designed to reflect roughly flock composition with regard to ewe breed and age. Each ewe was fitted with a motion-sensing radio collar (model TX-IC-2 SMA*142, Televilt of Sweden) weighing about 150 g. The transmitters operate on a frequency of 142 HMz with a maximum output of 3 mW. A separation of 10 KHz between each transmitter allows easy identification of individuals by frequency.

The collared ewes, along with most of the remaining flock, were driven on foot from the farm Vestigarden to Loϕvli on Bustberget, a distance of about 4 km. The remainder of the flock, about 40 animals, were driven by truck to Borveggen, an area 5 km northeast of Loϕvli (Fig. 1). On Bustberget and Borveggen the sheep were left to graze freely throughout the remainder of the summer.

Radio tracking was done on foot beginning 11 June. A portable receiver (Televilt RX-81) was used with a hand-held 4 element Yagi antenna. This system was tested on sheep in Trysil in 1984 with good results (Mysterud et al. 1985). Initially, animals were located every 36 hours; 1000 the first day, 2200 the second, and not at all on the third day. After about 2 weeks, experience gained with the equipment, topography, and the flock allowed tracking frequency to be increased. It also became clear that the original tracking strategy was inadequate. A realistic description of the animals' habitat use and activity patterns was not being provided by the original tracking schedule.

Four new times—0600, 1400, 1800, and 0200—in addition to the original times, 1000 and 2200, were used. Animals were located every 28 hours; 0600 the first day, 1000 the second, 1400 on the third, and so on. On the seventh day the tracking cycle began again from 0600.

Ewes were located primarily by triangulation (Cochran 1980). Several limitations associated with the triangulation procedure have been described (Springer 1979, Garrott et al. 1986, Schober 1986). Relocation accuracy depends upon the number and accuracy of receiving stations, and the distance between the transmitter and receiver (White 1985). Animals were relocated using 2–3 bearings. Since sheep are easily approached, most bearings were taken <250 meters from the collared animals.

Direct observations of collared animals were also common. Only direct observations and locations that resulted from a triangulation angle of 35–145° (Litvaitis et al. 1986) were plotted. These observations were plotted on a 1:5000 economic map. An 8-digit UTM (Universal Transverse Mercator) coordinate was assigned each location (Østbye 1971).

Tracking ended 13 September, when the flock was herded and returned to Lutnes.

Site classification was recorded for each observation. This was read directly from the 1:5000 economic map of the study area. Readings were related to habitat type as shown in Table 1.

Table 1. Habitat type as related to site classification. (Devised from Landskogstakseringen 1961, Fremstad and Elven 1987).

Site classification[1]	Habitat types in this study	Vegetation types[2]
Highly productive coniferous forest	*Picea abies*/ *Dryopteris* spp.	Large-herb spruce forests Small herb spruce forest Large fern spruce forest Small fern spruce forest
Middling productive coniferous forest	*Picea abies*/ *Vaccinium myrtillus*	Blueberry spruce-forest Berry/shrub mixed forest
Lesser productive coniferous forest	*Pinus sylvestrius*/ *Calluna vulgaris*/ *Cladonia* spp.	Heather-, lichen-rich pine forest
Fully/lightly cultivated land	Meadow/old-field	Cleared pasture on small fern spruce sites Abandoned meadow/ old-field (calcium poor)

[1]From 1:5000 economic map.
[2]After Fremstad and Elven 1987.

Availability of habitat types was calculated by placing a 1,050-point grid over a map of the area and systematically recording habitat type at each point on the grid. This tally is assumed to give an adequate estimate of the relative proportion of the types available (Mysterud 1983). A chi-square test of homogeneity was used to compare type use to type availability.

A motion switch which changed the pulse rate of the transmitter when an animal was either active or inactive was incorporated into each transmitter. An active animal is indicated by a slow pulse rate; an inactive animal by a rapid pulse rate. Collared animals were often observed directly, as well as located by telemetry. When observed, a more detailed description of their activity was recorded. Since determination of animal activity/inactivity did not depend upon accurate triangulation, all 761 relocations could be used to describe activity patterns.

The relationship of warm/cool weather to activity/inactivity was tested using a 2×2 contingency table.

Results

Habitat Preference

The 8 sheep frequented all 4 of the study area's habitat types. Habitat use was not in proportion to habitat availability, however ($P<0.01$). Use of the richer meadow/old-field and spruce/fern types was proportionally greater than availability. The common spruce/blueberry type and the poorer pine/heather/lichen type were used proportionally less than availability (Table 2).

Table 2. Availability and use of each habitat type in the Lutnes study area, southern Norway.

Habitat type[1]	Availability (%)	Use (%)
Picea abies/*Dryopteris* spp.	19.1	32.8
P. abies/*Vaccinium myrtillus*	70.5	51.0
Pinus sylvestrius/*Calluna vulgaris*/*Cladonia* spp.	5.8	4.5
Meadow/old-field	4.1	11.6

[1]Habitat types are descried in Table 1.

Habitat use varied significantly with time of day ($P<0.01$). Use of meadow/old-field and spruce/fern habitat types occurred primarily during morning and early afternoon. Of a total of 255 relocations falling within these 2 types, 167 (65%) were recorded between 0600 and 1400. In contrast, 88 (35%) were recorded between 1800 and 0200.

While the richer types were preferred during the day, the more common spruce/blueberry and the poorer pine/heather/lichen types were preferred in the evening and at night. Of a total of 310 relocations falling within these 2 types, 206 (66%) were recorded between 1800 and 0200. One hundred and four (34%) were recorded between 0600 and 1400 (Table 3).

Table 3. Number (percent)[1] of relocations in each habitat type by time of day (TOD) in the Lutnes study area, southern Norway.

	Habitat type[2]				
TOD	*Picea abies*/*Dryopteris* spp.	*P. abies*/*Vaccinium* sp.	*Pinus sylvestris*/*Calluna* sp., *Cladonia* spp.	Meadow/Old-field	Total
0200	6 (13.3)	29 (64.4)	8 (17.7)	2 (4.4)	45
0600	8 (16.0)	35 (70.0)	3 (6.0)	4 (8.0)	50
1000	89 (50.2)	43 (24.2)	3 (1.6)	42 (23.7)	177
1400	13 (29.5)	20 (45.4)	0 (0.0)	11 (25.0)	44
1800	19 (47.5)	17 (42.6)	2 (5.0)	2 (5.0)	40
2200	54 (25.8)	140 (66.9)	10 (4.7)	5 (2.3)	209
Total	189	284	26	66	565

[1]Number of relocations in habitat type h at TOD t/Total number of relocations obtained at TOD t.
[2]Habitat types are given in Table 1.

Habitat preference varied significantly as the grazing season progressed ($P<0.01$) (Table 4). Use of the meadow/old-field habitat type declined from the beginning of the season to the end. Thirty-two of the 66 relocations (48%) falling within this type were obtained during the first 1/3 of the season. Only 10 relocations (15%) fell within this type in the final 1/3 of the season. Use of the 3 forest types, which accounted for 95% of the available habitat, contrasted sharply to this. In the first 1/3 of the season they contained 70% (24) of the 106 relocations; in the final 1/3, this had increased to 96% (247 of 257 relocations).

Activity Patterns

Sheep activity on Bustberget was rhythmic and consistent. Grazing began around sunrise and continued until midday. Activity started on and about the campsite used the previous night. From this starting point, movement was not random, but directed downslope. Sub-flocks grazed hurriedly and sporadically, often trotting or running downslope 10–50 meters only to stop suddenly and begin grazing again. Of 289 relocations obtained between 0600 and 1000, 201 (70%) were noted as active.

Table 4. Number (percent)[1] of relocations in each habitat type obtained in the beginning, middle, and end of the grazing season, in the Lutnes study area, southern Norway.

	Habitat type[2]				
Period	*Picea abies*/*Dryopteris* spp.	*P. abies*/*Vaccinium* sp.	*Pinus sylvestris*/*Calluna* sp., *Cladonia* spp.	Meadow/Old-field	Total
11.06–10.07	35 (33.0)	34 (32.1)	5 (4.7)	32 (30.2)	106
11.07–10.08	51 (25.2)	121 (60.0)	6 (3.0)	24 (11.9)	202
11.08–13.09	103 (40.1)	129 (50.2)	15 (5.8)	10 (3.9)	257
Total	189	284	26	66	565

[1]Number of relocations in habitat h during period p/Total number of relocations obtained during period p.
[2]Habitat types are given in Table 1.

Most of the flock was inactive for 2–5 hours in the middle of the day. Sheep lay idle until mid-afternoon, often gathered in large flocks and lying tightly huddled. This time was also spent ruminating.

Grazing began again around mid-afternoon—gradually at first, with only a few individuals grazing. Within a short time all were active. A total of 60 relocations were made at 1400. Of these, 40 (67%) were recorded as active. By 1800 this had increased to 98% (49 of 50 relocations).

Movement in the afternoon was directed upslope. This movement was more gradual than that of the morning. Flocks dispersed during the course of the evening, but often gathered again in groups of 5 to 20 at the night's campsite. Here, animals grazed until just after sunset. By nightfall most of the sheep were bedded down for the night. Fifty-two percent (155 of 299) of the relocations from 2200 were recorded as active. At 0200, only 1 of 64 (<2%) relocations indicated an active animal.

Night camping was in groups, though these groups were more loosely assembled than those formed at midday. Huddling was not observed. Little night time activity was noted. This daily cycle continued throughout the season, though it was affected by both weather conditions and day length. Cold or wet weather, defined as a temperature at observation time of <10° C, and/or rainy or foggy conditions, significantly reduced the herd's overall activity level ($P<0.01$). Under such conditions, 52% (171 of 327) of the signals received indicated an inactive animal. This is compared to 33% (144 of 434) received under dryer conditions.

After 23 June, the days became shorter. This delayed the starting point in the morning and made for earlier camping in the evening.

Discussion

Habitat Preference

A relatively stable diel pattern of habitat use was established early in the grazing season. Use of the culturally modified areas and the adjacent spruce/fern forest type was most common during the day, while the poorer forest types were utilized more in the evening and at night. The largest congregations of sheep were observed at midday at Løvli. However, modified areas such as Løvli, were seldom, it ever, used as a campsite at night. Similar behavior in sheep has been noted elsewhere (Hewson and Wilson 1979, Scott and Sutherland 1981). Pratt et al. (1986) observed that both cattle and ponies displayed a diel redistribution from more open grasslands during the day to denser woodland at night. They suggested this to be shelter-seeking behavior, as it was more pronounced with extreme weather conditions. Welch (1981) also reported diel movement by sheep, from richer grassland to the coarser heather.

The daily migration of sheep (and other livestock) is perhaps best described in terms of structural rather than vegetational preference. Sheeps' preference for higher-lying ground at night is well documented (Bowns 1971, Arnold and Dudzinski 1978, Scott and Sutherland 1981, Welch 1981). This preference was consistently displayed in Trysil, where sheep typically camped on high, open ridges. It is doubtful that this uphill movement was in response to nutritional needs. Richer meadow vegetation and salt were located downslope from the usual campsites.

Higher altitudes may provide other advantages at night. Biting insects are more numerous in the dense, calm forest stands. Insect pests may be effectively evaded by moving to open breezy ridges. Uphill movement may also be a behavioral mechanism used for predator avoidance (Martin 1963). Though predation was not noted in this study, losses to bears in this region are prevalent (Mysterud and Warren unpublished). The open, high-lying campsites in Trysil afforded a wide view of the surrounding terrain. Evening breezes may also have provided the bedded sheep with olfactory information about their surroundings. High, open areas may therefore offer the safest bedding sites. The notion that uphill movements serve as an anti-predator strategy has been questioned (Hewson and Verkaik 1981). In Scotland, Hewson and Wilson (1979) stated that the vegetation found higher up on the hill consisted of 'birch trees and scrub [that] gave better cover to foxes.' This behavioral trait may, however, be a remnant from wild sheep. An affinity for camping and bedding sites on high, relatively inaccessible ground with good visibility is common among bighorn sheep (*Ovis canadensis* Shaw) (Woolf et al.1970, Simmons 1980, Gionfriddo and Krausman 1986). If such behavior in modern domestic sheep is a remnant from ancestral forms, it may well conflict with present-day conditions in Scotland.

Preference for the culturally influenced meadow/old-field type was predominant in the beginning of the season. Decades of cultivation on sites chosen because of their fertility, favorable exposure, and drainage has certainly enhanced production of highly palatable forage plants. Similar observations were made in Wales by Hughes et al. (1975). Here, the highest concentrations of sheep were consistently found '. . . on land affected by man from an earlier period.'

Use of this habitat type declined in favor of the forest types as the season progressed. Snow retreats first from open sites, thus allowing the growing season to commence several days (or even weeks) earlier than in denser forest stands. As forage plants in the openings mature, their fiber content increases and nutritional value declines. Many of the same preferred forage species are found on the forested sites, but at an earlier stage of development. Sheep likely followed a phenological gradient, from open sites early in the season, into the denser forest as the season progressed, in order to locate preferred forage plants and maximize nutrient intake.

The increased use of the forest types as the season progressed may have been prompted by an increased avoidance of the meadow/old-field type in addition to an increased preference for the forest. The heavy use of the meadow/old-field sites at the beginning of the season led to their early contamination with excrement. Sheep are known to avoid contaminated forage (Hulet et al. 1975). At some point in the first half of the grazing season, some contamination threshold may have been reached, causing the herd to shun this previously favored type. In the chi-square calculations, the negative use of the meadow/old-field type at the end of the season was surpassed only by the strong preference of this type early in the season.

Use of the pine/heather/lichen type was also observed, but to a lesser extent than was use of the richer areas. The attraction to such areas may be related to the distribution and development of fungi. The utilization of fungi by livestock is apparently common. Bjugstad and Dalrymple (1968) found that cattle used otherwise non-preferred habitats in search of fungi. Syrjälä-Qvist (1986) found fungi to contain the highest percent of crude protein of all forage species tested. Crude protein in fungi was more than double that in hairgrass. Little is known about the relative importance of fungi in the sheep's diet, though they are recognized as a seasonally important component in that of deer (*Odocoileus* spp.) (Miller and Halls 1969, Crawford 1982) and cattle (Bjugstad and Dalrymple 1968). It is possible that areas generally viewed as very poor sheep range can in fact contribute significantly to the animal's diet.

Temperature and precipitation greatly influence vegetation growth and production. The summer of 1985 was exceptionally rainy and cool. Precipitation was nearly double the normal in many parts of Trysil. The unusual weather likely affected the study area's vegetation by delaying development and preventing or delaying the drying out of exposed areas. Such weather would also favor fungi production. How habitat use deviated in 1985 from that of a "normal" year is unknown. The general patterns observed in Trysil are, however, similar to those observed elsewhere in the region (Ola Bustad per comm., Mysterud and Warren 1987).

Activity and Movements

The cyclic activity pattern displayed by the Bustberget herd is typical for both wild and domestic sheep. From the Stone's sheep (*Ovis dalli stonei* Allen) and desert bighorn in North America, to domestic breeds in New Zealand, Australia, and Great Britain, the same daily cycle is displayed (Lynch 1971, Simmons 1980, Scott and Sutherland 1981, Welch 1981, Seip and Bunnell 1985).

In this study, it was not only the basic activity pattern that was typical. Observations made in Trysil were comparable, in detail, to studies done elsewhere. Bowns (1971), working with purebred Rambouillet, Targhee, and Columbia sheep in USA, described the same behavior as observed in Trysil. In his study, sheep travelled further, and in a shorter period of time, in the morning than in the evening; morning grazing was more sporadic. Moreover, movements from the campsite and from the midday bedding site were not random, but consistently directed downslope and upslope, respectively. Also, as observed in Trysil, Bowns' sheep 'reached the bedgrounds before they were ready to bed down. . . They spent this time feeding.'

As no predation was noted in this study, it is not known how the cyclic activity pattern may be affected by the presence of large predators. However, the predictable activity exhibited by the sheep would likely make them highly susceptible to predation, since an intelligent predator would quickly learn and take advantage of the seemingly consistent pattern.

The 8 ewes monitored in this study were less active in chilly, damp weather. With the transmitters used here, detailed description of sheep activity was not possible. More detailed time-budget studies elsewhere have shown that most "activity" is grazing (Grubb and Jewell 1974; Arnold and Dudzinski 1978, Scott and Sutherland 1981). The many direct observations made in Trysil support this. There was no basis on which to judge animal performance in this study. It is therefore impossible to say how a possible reduction in grazing time may have affected performance.

Literature Cited

Arnold, G.W., and M.L. Dudzinski. 1978. Ethology of free-ranging domestic animals. Elsevier Publ., Amsterdam.

Bergøy, O. 1982. Development and Goal-setting, p. 11-35. *In.* O. Bergøy (ed), Sheep husbandry in the future. (In Norwegian). Landbruksforlaget, Oslo.

Bjugstad, A.J., and A.V. Dalrymple. 1968. Behavior of beef heifers on Ozark ranges. Missouri Agr. Exp. Sta. Bull. 870.

Bowns, J.E. 1971. Sheep behavior under unherded conditions on mountain summer ranges. J. Range Manage. 24:105-109.

Crawford, H.S. 1982. Seasonal food selection and digestability by tame white-tailed deer in Central Maine. J. Wildl. Manage. 46:974-982.
Cochran, W.W. 1980. Wildlife telemetry, p. 507-520. *In:* S.D. Schemnitz (ed), Wildlife management techniques manual. Wildlife Society, Washington, D.C.
De Leeuw, J., and J.P. Bakker. 1986. Sheep grazing with different foraging efficiencies in a Dutch mixed grassland. J. Appl. Ecol. 23:781-793.
Fremstad, E., and R. Elven (eds). 1987. Units for vegetation mapping in Norway. (In Norwegian). Økoforsk report 1987:1. Univ. of Trondheim, Trondheim.
Garrott, R.A., G.C. White, R.M. Bartman, and D.L. Weybright. 1986. Reflected signal bias in biotelemetry triangulation systems. J. Wildl. Manage. 50:747-752.
Gionfriddo, J.P., and P.R. Krausman. 1986. Summer habitat use by mountain sheep. J. Wildl. Manage. 50:331-336.
Grubb, P., and P.A. Jewell. 1974. Movement, daily activity and home range of Soay Sheep, p. 160-194. *In:* P.A. Jewell, C. Milner and J.M. Boyd (eds), Island survivors-The ecology of the Soay sheep of St. Kilda. Athlone Press, London.
Hewson, R., and C.J. Wilson. 1979. Home range and movements of Scottish blackface sheep in Lochaber, NW Scotland. J. Appl. Ecol. 16:743-751.
Hewson, R., and A.J. Veraik. 1981. Body condition and ranging behaviour of blackface hill sheep in relation to lamb survival. J. Appl. Ecol. 18:401-415.
Hughes, R.E., J. Dale, M.D. Mountford, and I.E. Williams. 1975. Studies on sheep populations and environment in the mountains of north Wales. II. Contemporary distribution of sheep populations and environment. J. Appl. Ecol. 12:165-178.
Hulet, C.V., G. Alexander, and E.S. Hafez. 1975. The behaviour of sheep, p. 246-294. *In:* E.S. Hafez (ed), The behaviour of domestic animals. Bailliére Tinndall, London.
Hunter, R.F. 1962. Hill sheep and their pasture: a study of grazing sheep in south-east Scotland. J. Ecol. 50:651-680.
Landskogstakseringen. 1961. Appraisal of Norwegian forests, Hedmark County. (In Norwegian). E. Sem, Halden.
Litvaitis, J.A., J.A. Sherburne, and J.A. Bissonette. 1986. Bobcat habitat use and home range size in relation to prey density. J. Wildl. Manage. 50:110-117.
Lynch, J.J. 1971. Merino sheep: some factors affecting their distribution in very large paddocks. Int. Union Conserv. Natur. Nat. Resour. Pub. 2:697-707.
Lystad, S.L. 1978. Weather and climate, p. 49-65. *In:* S. Moren (ed), Hedmark. (In Norwegian). Gyldendal, Oslo.
Martin, D.J. 1963. The diet of Scottish blackface sheep. Ph.D. Thesis, Univ. of Glascow.
Miller, H.A., and L.K. Halls. 1969. Fleshy fungi commonly eaten by Southern wildlife. USDA, Forest Serv. Res. Pap. SO-49.
Mysterud, I. 1983. Characteristics of summer beds of European brown bears in Norway. Int. Conf. Bear Res. Manage. 5:208-222.
Mysterud, I., B. Vaage, F. Gyllstrøm, and F. Jacobsen. 1985. Radiocollaring of sheep in Hedmark. Testing of equipment 1984. (In Norwegian). Landbrukskontoret in Trysil and Biological Institute, Univ. of Oslo.
Mysterud, I., and J.T. Warren. 1987. Radio-collaring of sheep in Hedmark 1986. (In Norwegian) Landbrukets Utmarkskontor and Biological Institute, Univ. of Oslo.
Noble, I.R. 1975. Computer simulations of sheep grazing in the Arid Zone. Ph.D. Thesis, Univ. of Adelaide.
Nordisk Ministerraad. 1977. Natural geographic regions of the nordic countries. (In Swedish). Nordiska Ministerraad, Stockholm.
Pratt, R.M., R.J. Putman, J.R. Ekins, and P.J. Edwards. 1986. Use of habitat by free-ranging cattle and ponies in the New Forest, Southern England. J. Appl. Ecol. 23:539-557.
Schober, F. 1986. Radio triangulation and its limitations for wildlife research. (In German). Z. Jagdwiss. 32:65-75.
Scott, D., and B.L. Sutherland. 1981. Grazing behaviour of merinos on an undeveloped semi-arid tussock grassland block. N.Z. J. Exp. Agr. 9:1-9.
Seip, D.R., and F.L. Bunnell. 1985. Foraging behaviour and food habits of Stone's sheep. Can. J. Zool. 63:1638-1646.
Simmons, N.M. 1980. Behavior, p. 124-145. *In:* G. Monson and L. Sumner (eds), The desert bighorn-its life history, ecology and management. Univ. of Arizona Press, Tucson.
Springer, J.T. 1979. Some sources of bias and sampling error in radio triangulation. J. Wildl. Manage. 43:926-935.
Syrjälä-Qvist, L. 1986. Improvement of natural pasture utilization by sheep, p. 157-167. *In:* O. Gudmundsson (ed), Grazing research at northern latitudes. Plenum Press/NATO Scientific Affairs Division, New York.
Vaag, A.B., A. Haga, and H. Granstuen. 1986. Suggested plans for management of bear, wolverine and wolf in Norway. (In Norwegian). Viltrapport. 39. Directorate for Nature Management, Trondheim.
Welch, D. 1981. Diurnal movements by Scottish blackface sheep between improved grassland and a heather hill in northeast Scotland. J. Zool. 194:267-271.
White, G.C. 1985. Optimal locations of towers for triangulation studies using biotelemetry. J. Wildl. Manage. 49:190-196.
Woolf, A., T. O'Shea, and D.L. Gilbert. 1970. Movements and behavior of bighorn sheep on summer ranges in Yellowstone National Park. J. Wildl. Manage. 34:446-450.
Østbye, E. 1971. Use of the UTM system in location assignment in zoological research. (In Norwegian). Fauna. 24:1-9.

SRM Election Results

The Elections Committee counted the ballots for new officers at the Society for Range Management headquarters. Elected officers are:

Second Vice President—**Gary B. Donart**
Directors (1991 - 1993)—**Barbara H. Allen-Diaz** and **Deen Boe**

Directors Allen-Diaz and Boe will replace retiring Directors Johnson and Nelson in February 1991.

Ballots and tally sheets are retained in the Denver office for one year for review. Approximately 30% of the membership voted.