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MOOSE HABITAT USE AND SELECTION PATTERNS IN NORTH-CENTRAL IDAHO

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Abstract: Twelve radio-collared moose (*Alces alces shirasi*) were monitored in north-central Idaho from January 1979 through April 1982. Moose selected vegetative types where forage was abundant in all seasons. Old-growth grand fir (*Abies grandis*)/Pacific yew (*Taxus brevifolia*) stands were critical moose winter habitat. Winter habitat use patterns did not differ among years even though snowfall varied dramatically. Even-aged pole timber stands and open areas, including clear-cuts and lakes, were used most by moose during summer. During deep snow periods, preferred moose habitat was characterized by dense cover and abundant forage.

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An association of Shiras moose with grand fir stands containing dense Pacific yew understories in a part of north-central Idaho was observed by U.S. Forest Service personnel (F. Gordon, pers. commun.) in the 1970's. The degree to which these old-growth stands served as important winter range for this species quickly became a concern as logging in the region intensified. Pacific yew is a highly shade-tolerant species which forms a dense subcanopy serving as both food and cover for moose in winter in this region. Questions concerning the degree to which clear-cuts with well-developed seral shrub communities might substitute for these old-growth stands were raised because of the well-known association of moose with these shrub communities elsewhere. This study was designed to describe habitat use patterns of moose in this region and to provide recommendations for managing moose habitat as a part of ongoing land management practices in this area.

We are indebted to L. J. Nelson for contributing to the statistical design and subsequent analysis of data. J. P. Copeland and M. D. Scott recorded many of the radiolocations of moose and provided valuable support and assistance during fieldwork. Thanks are also due to field assistants J. D. Hugo, E. W. Werner, T. S. Vogel, and H. L. Westberg. The Nez Perce Natl. For., especially F. Gordon, contributed facilities and support during fieldwork. Funding was provided by Intermountain For. and Range Exp. Stn., U.S. For. Serv., and Univ. of Idaho McIntire-Stennis Proj. MS-22. This is contribution No. 263, For., Wildl. and Range Exp. Stn., Univ. of Idaho.

STUDY AREA

The 118,000-ha study area was located along the South Fork of the Clearwater River (Fig. 1). Elevations ranged from 600 to 2,700 m. Most of the forest occurred within the grand fir and subalpine fir (*Abies lasiocarpa*) vegetation zones (Steele et al. 1976). Average annual snowfall was 353 cm at Elk City (1,230 m elevation). Snowfall during the winters of this study was 330 cm in 1978–79, 226 cm in 1979–80, 155 cm in 1980–81, and 473 cm in 1981–82.

METHODS

Habitat use patterns were determined from relocations of 12 radio-collared adult moose (8 females and 4 males). During winter (1 Dec–15 Apr) animals were located from the air approximately every 12

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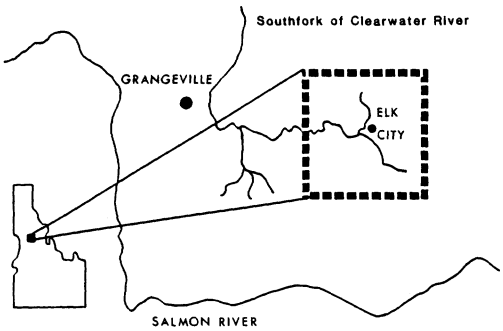

Fig. 1. Location of moose study area near Elk City, Idaho.

days. Accuracy of aerial relocations was sampled by locating planted collars and by comparing the simultaneous aerial location and known location of a moose tracked on the ground. Error polygons associated with aerial relocations were consistently less than 2 ha and were never larger than 4 ha. Vegetation at 147 winter locations was sampled during summer. Locations obtained during spring (16 Apr–2 June), summer (21 Jun–31 Aug), and autumn (1 Sep–31 Nov) were sampled while following radio-collared animals on the ground. A minimum of 1 hour elapsed between consecutive locations of the same animal. Error associated with ground locations was less than 1 ha. Animals were always approached within 50 m before locations were recorded. Habitat availability was sampled by visiting 177 randomly selected plots within the area used by the radio-collared moose.

Vegetation characteristics at winter locations and availability plots were intensively sampled within a 375-m^2 circular plot (Pfister et al. 1977). Percent canopy cover of all species within each plot was ocularly estimated. Habitat types at all plots were identified from Steele et al. (1976). Overstory height and canopy density were measured using a clinometer and densiometer (Lemmon 1957, Strickler 1959), respectively. Average diameter at breast height (dbh) for each tree species was recorded. All trees within each plot were counted and treated as either mature (dbh $\geq$ 12 cm) or sapling (dbh $<$ 12 cm).

Less intensive vegetation sampling was conducted at spring, summer, and autumn locations. Ocular estimation of the dominant overstory tree species and percent canopy cover of abundant shrubs were recorded at all ground locations. In addition, each location (all seasons) and availability plot was assigned to one of four cover types: old-growth, mature, pole timber, and open canopy (including clearcuts, lakes, and dredge ponds). Cover types were identified on the basis of overstory size class, dominance level of climax tree species, and distribution of size classes and spacing of trees within a stand.

Stepwise multivariate analysis of variance (MANOVA) (Nie et al. 1975) was used to test for differences in structural characteristics of the overstory among cover types. Variables entered into the analysis were chosen on the basis of potential values to moose (Holmes 1981, Whitmore 1981) and the correlation matrix of all the measured variables (Beale et al. 1967, Dueser and Shugart 1979). When variables were highly correlated with one another ($r \geq 0.60$), the variable that contributed most to the MANOVA was retained. The stepwise procedure used Wilks' lambda criteria (alpha = 0.05) with 3 and 173 degrees of freedom.

Comparisons of frequency of occurrence of plant species among cover types within habitat types and among habitat types within cover types were made using a chi-square test of association. Frequency of occurrence data for old-growth stands on grand fir/clintonia (*Clintonia uniflora*) and grand fir/goldthread (*Coptis occidentalis*) habitat types were taken

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Table 1. Average values (and range) per ha of overstory characteristics according to cover type at 177 random plots located within the areas used by radio-collared moose near Elk City, Idaho, 1978–82.

Attribute	Old growth (N = 32)	Mature (N = 90)	Pole timber (N = 49)	Open canopy (N = 6)
Total trees in overstory (N)	349 (107–933)	384 (27–1,600)	613 (80–3,200)	24 (0–107)
Total saplings (N)	547 (0–2,507)	827 (53–2,693)	987 (0–4,026)	600 (53–1,653)
Average tree diameter (cm), dbh[a]	42 (18–85)	27 (12–68)	18 (4–29)	6 (2–18)
Canopy density (%)[a]	78 (56–91)	69 (9–90)	78 (25–96)	4 (0–16)
Tree height (m)[a]	35 (25–50)	24 (6–49)	21 (11–35)	6 (3–14)
N grand fir/subalpine fir in overstory[a]	229 (27–640)	133 (0–853)	85 (0–693)	10 (0–80)
N grand fir/subalpine fir in understory[a]	440 (0–2,480)	576 (0–2,400)	507 (0–2,640)	155 (27–345)
N Douglas-fir/western larch in overstory[a]	94 (0–293)	112 (0–720)	91 (0–720)	3 (0–27)
N Douglas-fir/western larch in understory	88 (0–640)	125 (0–1,253)	109 (0–613)	213 (0–480)
N lodgepole pine in overstory[a]	15 (0–400)	117 (0–987)	373 (0–1,840)	11 (0–80)
N lodgepole pine in understory[a]	2 (0–80)	96 (0–2,000)	336 (0–2,640)	229 (0–1,573)

[a] Variables included in stepwise multivariate analysis of variance to determine differences in structural characteristics of overstory between cover types.

from Steele et al. (1976) because over 90% of the old-growth stands we sampled were restricted to the grand fir/ginger (*Asarum caudatum*) habitat type.

Snow depths were measured at 59 sites during the winter of 1979–80 following Hepburn (1978). Sites were visited every 2 weeks through the winter. Five depth measurements were averaged for each site during each visit. All averaged values were summed within a cover type to estimate an average snow depth for the period 1 December through 1 April. These values were compared among cover types using an analysis of variance. Multiple comparisons were made using a least square means test (Helwig and Council 1979).

Univariate differences in structural characteristics and floristics of sites used by moose vs. availability were tested following Marcum and Loftsgaarden (1980). Selection was assumed when percent use exceeded percent availability. Habitat use and selection patterns were examined for differences among years, seasons, and individuals using chi-square tests. All tests were conducted with an alpha level of 0.05.

RESULTS

Structure and Vegetation Composition

Old-growth stands were characterized by broken canopies with tall grand fir or subalpine fir trees dominant (Table 1). Average tree dbh was greater than 40 cm. Stocking densities were moderate at 349 trees/ha. Sapling densities (547/ha) were less than in all other cover types.

Overstory trees in mature stands were thinner (dbh = 27 cm) and shorter (canopy height = 24 m) than those in old-growth stands. Mature mixed-age stands were also moderately stocked, averaging 384 trees/ha in the overstory. Tree regeneration density was relatively high. Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), and grand fir were the overstory dominants. The average canopy density tended to be less in mature cover types than in old-growth or pole timber types.

Pole timber had the most continuous overstory canopy with stocking densities averaging more than 613 trees/ha. All

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Table 2. Average snow depths (cm) from 1 December 1979 to 1 April 1980 in each cover type according to elevation, near Elk City, Idaho.

	Elevation			
	1,000–1,500 m		1,500–2,000 m	
Cover type	(cm)	*N*	(cm)	*N*
Old growth	4 A[a]	29	18 A	25
Mature mixed age	12 B	54	33 B	42
Pole timber	20 C	42	39 B	27
Open canopy	—	—	75 C	12

[a] Snow depths followed by the same capital letter are not different.

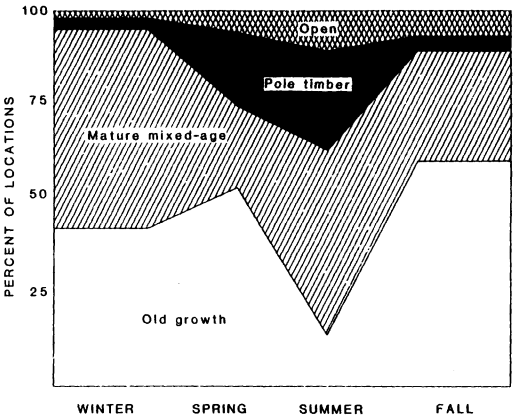

Fig. 2. Seasonal distribution of all radio-collared moose relocations in old-growth, mature mixed-age, pole timber, and open areas based on 147 relocations in winter (Dec–Apr), 203 in spring (May–20 Jun), 321 in summer (21 Jun–Aug), and 222 in fall (Sep–Nov) for the 1979–82 study period at Elk City, Idaho.

trees were generally in the same size class ($\bar{x}$ = 18 cm dbh) and were evenly distributed throughout the stands. Lodgepole pine was the dominant tree species, accounting for over 70% of the total trees on a plot. Tree regeneration was densest in this cover type.

Open canopy stands sampled represented young clear-cuts without an overstory (canopy density averaged 6%). Tree regeneration was moderate on these sites.

Composition of important moose forage species (Pierce 1983) varied among cover types and habitat types ($P < 0.001$ for all tests). Pacific yew was dominant in old-growth communities on grand fir/ginger habitat types and was virtually nonexistent on all other habitat types. Alder (*Alnus sitkensis*) was most frequent in pole timber and least in old growth on grand fir/clintonia habitat types. Menziesia (*Menziesia ferruginea*) was most common in pole timber and mature mixed-age stands within the grand fir/clintonia habitat type and in old-growth stands on grand fir/ginger habitat types. Its constancy was lowest in all cover types on grand fir/goldthread habitat types.

Snow depth varied ($P < 0.001$) with cover type (Table 2). The taller, often multi-storied canopies of the old-growth stands intercepted approximately twice as much snowfall as did mature and pole timber stands. The latter two cover types intercepted equal amounts of snow at higher elevations (1,500–2,000 m), although snow was deeper under pole stands at lower elevations (1,000–1,500 m). Snow depths under all three timbered types were substantially less than depths in clear-cuts.

Table 3. Yearly variation in the number (%) of moose locations at elevational categories according to season, near Elk City, Idaho, 1978–82.

	Winter (Dec–Apr)				Summer (Jun–Aug)		
Elevation (m)	1978–79	1979–80	1980–81	1981–82	1979	1980	1981
1,200–1,500	32 (71)	14 (54)	36 (44)	40 (70)	12 (27)	23 (19)	29 (29)
1,500–1,800	13 (29)	26 (46)	44 (54)	17 (30)	18 (40)	56 (46)	48 (47)
1,800+	0 (0)	0 (0)	1 (2)	0 (0)	15 (33)	42 (35)	24 (24)
Total	45	40	81	57	45	121	101

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Table 4. Percent of moose use and availability[a] of old-growth (O), mature (M), pole (P), and no overstory (NO) cover types by individuals and for all moose combined by season. Availability[b] represents the proportions within the 118,000-ha study area, Elk City, Idaho.

	Winter (Dec–Apr)					Spring (May–20 Jun)					Summer (21 Jun–Aug)					Autumn (Sep–Nov)				
Moose	O	M	P	NO	*N*	O	M	P	NO	*N*	O	M	P	NO	*N*	O	M	P	NO	*N*
12	57	39	4	0	23	—	—	—	—	—	—	—	—	—	—	84	16	0	0	19
43	25	69	6	0	16	20	0	80	0	40	5	5	29	61	38	30	0	0	70	10
48	25	75	0	0	4	0	100	0	0	10	24	17	59	0	42	87	13	0	0	31
77	50	43	7	0	14	100	0	0	0	17	12	62	26	0	26	—	—	—	—	—
72	0	80	0	20	5	—	—	—	—	—	21	64	11	4	47	71	0	29	0	17
38	42	58	0	0	12	—	—	—	—	—	67	17	17	0	12	100	0	0	0	10
21	29	64	0	7	14	—	—	—	—	—	0	95	0	5	40	28	72	0	0	29
33	71	29	0	0	7	69	0	0	31	29	5	88	0	7	43	0	0	0	100	2
13	21	74	5	0	19	78	0	22	0	41	0	40	44	16	45	75	19	0	6	16
31	69	31	0	0	16	100	0	0	0	4	0	0	100	0	3	78	22	0	0	36
53	35	59	0	6	17	42	56	0	2	62	11	33	56	0	27	26	58	6	10	52
Total	41*[b]	54*	3*	2	147	52*	22*	20	6	203	12	50	27	11*	321	59*	30*	4*	7	222

[a] Availability for each cover type was O = 18, M = 52, P = 27, and NO = 3, based on 177 randomly located plots.
[b] * indicates use was significantly greater than availability ($P < 0.01$).

Moose Use and Selection of Cover Types

Moose appeared to concentrate in localized areas at low elevations during winter (Table 3). Moose dispersed and inhabited higher elevations during summer. One of the 176 winter relocations occurred above 1,800 m during the four winters of this study, whereas 30% of the 300 summer relocations were recorded above this elevation. Greatest use of the lowest elevations of the study area occurred during the more severe winters of 1978–79 and 1981–82 ($\chi^2 = 9.57$, $P < 0.01$). Summer relocations did not differ in elevation among years.

Approximately 50% of the 572 autumn, winter, and spring moose relocations occurred in old-growth stands (Fig. 2). Mature stands were used throughout the year; 50% use occurred during summer and winter. Open canopy sites were used most during summer and least during winter. Pole timber stands were rarely used during winter and autumn, but were frequented regularly by moose during spring and summer.

Moose selected cover types disproportionate to availability in all seasons (Table 4). Old growth was used more than expected during all seasons except summer. Average use of old-growth sites during winter, spring, and autumn was 59, 41, and 52%, respectively, while the availability of this cover type was estimated to be only 18%. During summer, moose used old-growth stands in proportion to availability.

The vegetation analysis of 147 moose winter relocations further indicated that moose selected old-growth communities (Table 5). Moose showed strong selection for sites with high cover values of yew. Approximately 30% of the moose winter relocations were in dense Pacific yew stands, whereas these communities made up less than 5% of the study area. Stands containing Douglas-fir and lodgepole pine were avoided, and when they occurred on sites used by moose they were less dominant in the overstory than expected. Moose also used sites that had fewer trees in the overstory and saplings in the understory than were found on the randomly located plots.

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Table 5. Comparisons of the tree component in stands used by moose during winter ($N = 155$) with the tree components of 177 randomly located plots. Numbers in parentheses are from random plots, Elk City, Idaho, 1979–82.

	Constancy[a] (%)	Mature tree density (trunks/ha)	Sapling tree density (trunks/ha)
Grand fir	95 (85)	165 (119)*[b]	296 (445)*
Engelmann spruce	56 (56)	44 (52)	59 (84)
Western larch	32 (29)	52 (74)	10 (25)
Lodgepole pine	23 (65)*	124 (245)*	52 (205)*
Douglas-fir	42 (58)	42 (69)*	35 (82)*
All species	100 (100)	272 (395)*	395 (741)*
Dense Pacific yew stands[c]	32 (4)*	—	—

[a] Constancy = (N plots of occurrence/N plots sampled) × 100.
[b] * indicates significant difference (alpha = 0.05).
[c] Stands where Pacific yew canopy cover was greater than 20%.

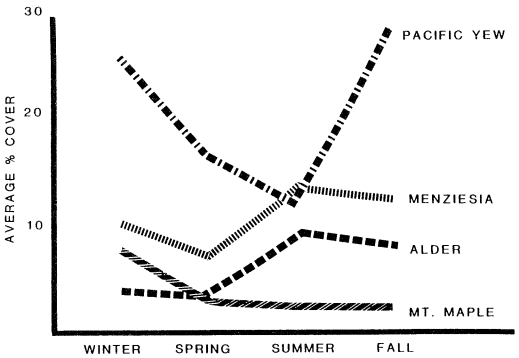

Fig. 3. Average percent canopy coverage of four woody forage species used by moose according to season at sites used by moose, Elk City, Idaho, 1979–82.

Mature stands were avoided by moose during spring and autumn, although they were the most common cover types. Moose used this cover type in proportion to its availability during summer. During winter, moose selected mature stands that occurred on grand fir/ginger habitat types.

Pole stands were used less than expected during winter and autumn: 5% of the moose relocations compared to 27% of the availability plots were classified as pole timber. Pole stands were used in proportion to their availability during spring and summer. Open canopy stands were selected during summer and used in proportion to availability the remainder of the year.

Habitat use patterns did not change significantly among winters, nor from early to late winter. Moose possibly selected for more open canopies during the 1978–79 winter ($P = 0.09$) and for stands with higher Pacific yew cover during late winter ($P = 0.06$).

Greatest variation in habitat selection among individual moose took place during summer (Table 4). One moose selected and four moose avoided old-growth stands. Four moose avoided and four selected mature mixed-age stands. Similar variation occurred in use of pole timber in summer.

The radio-collared moose were more similar in habitat selection during the autumn, winter, and spring. Seven of eight moose selected old-growth stands and all moose avoided pole stands during winter. Similar consistency in habitat use occurred during autumn and spring.

Moose Habitat Use Related to Forage Abundance

Forage species that received the greatest utilization by moose on the study area were Pacific yew, menziesia, alder, and mountain maple (Pierce 1983). Pacific yew was most abundant on sites used by moose during autumn and winter and least during summer (Fig. 3). The average cover of mountain maple was 6% on sites used during winter and less than 1% on those used during spring, summer, and autumn. Cover of menziesia and alder was highest on sites used by moose during summer and autumn. The abundance of each species on sites used by moose was greatest during the season in which it was most dominant in the moose diet (Pierce 1983).

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Table 6. Comparison of moose relocations with randomly located plots having more than 15% canopy cover of seasonally preferred forage, Elk City, Idaho, study area, 1979–82.

Season	Preferred forage	*N* moose locations (%)	*N* random plots (%) (*N* = 177)	*P* value[a]
Winter (*N* = 155)[b]	Mountain maple, Scouler willow	36 (23)	21 (12)	0.08
Spring (*N* = 138)	Scouler willow	0 (0)	11 (6)	0.01
Summer (*N* = 297)	Menziesia, alder	166 (56)	69 (39)	0.01
Autumn (*N* = 220)	Pacific yew, Scouler willow	117 (53)	34 (19)	0.01

[a] *P* value determined following Marcum and Loftsgaarden (1980).
[b] Number of moose locations.

Summer and autumn use of sites with abundant seasonally preferred forage was disproportionate to availability (Table 6). For example, 56% of all moose summer locations were at sites where the combined canopy cover of menziesia and alder was greater than 15%, whereas 39% of the randomly located plots met this criterion. During winter, selection for sites with high amounts of maple and willow was not significant ($P = 0.08$). Fewer spring moose locations had abundant preferred forage than expected.

DISCUSSION

Habitat use patterns in summer appeared to be indicative of a relaxation of requirements rather than active selection for particular overstory characteristics, as was evident in winter. In general, moose in this study area selected for forage-producing areas. The selection for open canopy cover types during summer can be attributed to the use of high-elevation lakes and dredge ponds by two moose, while another showed no preference for readily available lakes. Four moose did not show affinity for available clear-cuts. Moose used all timbered cover types in proportion to their availability from June through August. Tree densities and canopy height did not appear to be overriding factors in determining summer habitat use by moose.

Winter use of different cover types by Shiras moose varies among areas and also according to winter severity and snow accumulation (Peek et al. 1982). Willow stands are commonly used habitat for Shiras moose (Knowlton 1960, Houston 1968, Dorn 1970). The use of conifer cover types, first reported by McDowell and Moy (1942), was considered characteristic of marginal moose winter habitat by Peek (1974), although Stevens (1970) reported extensive use of conifer cover by moose in southwestern Montana where willow bottoms were sparse.

Moose use of four cover types on this study area remained virtually unchanged from mid-September to April. Snow depths were consistently above 65 cm from late December through April in open canopy cover types, even when total annual snowfall was well below average. This depth has been reported to affect habitat use and movements (Kelsall 1969, Kelsall and Prescott 1971, Thompson and Vukelich 1981).

Selection for tall canopies and dense timber during winter by moose is not unusual when snow characteristics preclude use of more open cover types (Telfer 1970, Peek et al. 1976, Eastman 1977, Ritchie 1978, Thompson and Vukelich 1981). Moose move to areas of high food availability conditional upon snow, where they can minimize metabolic requirements and enhance energy intake (Coady 1974).

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MacArthur and Pianka (1966) predicted selection of habitat patches (such as old-growth grand fir/Pacific yew stands) to occur under conditions where absolute food densities were greatest in patches or when a higher density of available forage in patches relative to the surrounding environment occurred.

MANAGEMENT RECOMMENDATIONS

Pacific yew and other shade-tolerant species growing in old-growth forest communities were important food sources for moose in this area. Other research has shown that during periods of deep snow, clear-cuts received substantially less moose use than nearby native forests (Telfer 1974, Ritchie 1978). The best habitat management plan for moose on this study area would be to avoid timber harvest in old-growth grand fir/Pacific yew stands. Theoretically, these communities are near climax and would provide quality winter habitat over an extensive period.

Historically, the most common practice of clear-cutting and broadcast burning has virtually eliminated Pacific yew on harvested sites (Stickney 1980, Crawford 1983). When logging is anticipated, efforts to retain the yew component and rapidly restore the overstory are necessary. Single tree or group selection methods are recommended. Slash should be removed by piling and burning rather than by broadcast burning. Whole tree removal should be employed whenever feasible to reduce the need for slash disposal. Natural regeneration of shade-tolerant species such as grand fir and Engelmann spruce, and supplemental plantings of more commercially desirable species such as Douglas-fir in small clearings created during logging should be encouraged. This system would allow for adequate yew recovery, browse production, and tree regeneration providing both moose winter habitat and merchantable timber.

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