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SUMMER HABITAT USE BY RUFFED GROUSE WITH BROODS IN CENTRAL PENNSYLVANIA

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Abstract.—We radio-tagged and monitored adult female Ruffed Grouse (*Bonasa umbellus*) with broods to evaluate effects of habitat management on home-range size and patterns of habitat use. Experimental habitat management consisted of short-rotation clearcutting of 1-ha forest patches to create various-aged forest stands of mixed oak (*Quercus* spp.) and aspen (*Populus tremuloides, P. gradidentata*)/scrub oak (*Q. Ilicifolia, Q. prinoides*). Home range size was not significantly different between grouse occupying managed and an adjacent unmanaged forest. Female grouse with broods selected mixed oak/scrub oak habitats and avoided herbaceous areas, recent clearcuts, and pitch pine (*Pinus rigida*)/scrub oak habitats throughout the study area. On the managed area, grouse selected 10-yr-old clearcut patches in mixed oak and aspen/scrub oak. Sites used by grouse had higher densities of woody stems 2.5–7.5-cm dbh, greater % cover of live vegetation at 0–2 m, and were closer to edges and openings than random sites. Habitat management practices positively affected one microhabitat component, distance to nearest edge, that was selected by female grouse with broods.

USO DE HÁBITAT VERANIEGO EN LA PENNSYLVANIA CENTRAL POR *BONASA UMBELLUS* CON CRÍAS

Sinopsis.—Ajustamos radiotransmisores y monitoreamos hembras adultas de *Bonasa umbellus* con crías para evaluar los efectos del manejo del hábitat en tamaño del territorio de uso común y en los patrones de uso del macrohabitat y del microhabitat. El manejo experimental del hábitat consistió en rotar por poco tiempo la limpieza de parchos de 1 hectárea de bosque para crear cotos de bosques de varias edades con *Quercus* sp., y hábitats mixtos de *Populus tremuloides, P. gradidentata/Q. ilicifolia, Q. prinoides*. El tamaño del territorio de uso común no difirió significativamente entre las áreas manejadas ocupadas por la especie y un bosque sin manejo adyacente. Hembras con crías seleccionaron hábitats mixtos de *Populus tremuloides, P. gradidentata/Q. ilicifolia, Q. prinoides* y evitaron áreas herbáceas, recién cortadas, y hábitats de Pinus rigida/*Q. ilicifolia, Q. prinoides* através del área de estudio. En el área manejada, la especie seleccionó parchos limpiados hace 10 años en hábitats mixtos de *Populus tremuloides, P. gradidentata/Q. ilicifolia, Q. prinoides*. Lugares usados por la especie tuvieron densidades mayores de tallos leñosos entre 2.5 y 7.5 cm de dbh, mayor porciento de covertura de vegetación viva entre los 0–2 m, y estaban más cerca de los bordes y a las aperturas que lugares seleccionados al azar. Las practicas de manejo de hábitat afectaron positivamente un componente del microhabitat, la distancia al borde más cercano, el cual fué seleccionado por hembras con crías de esta especie.

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Small (1-ha) clearcuts that create diverse forest structure can provide suitable habitat for Ruffed Grouse during all seasons (Gullion and Svoboda 1972). Gullion (1977) reported a density of one breeding pair per 4 ha could be achieved using small clearcuts in aspen forests in upper Midwestern states. In 1975, the Pennsylvania Game Commission initiated research at State Game Lands 176 in Centre County, Pennsylvania to evaluate the population response of Ruffed Grouse to 1-ha clearcuts in aspen and mixed-oak stands.

The objective of our study was to evaluate effects of short-rotation clearcuts on summer home range and habitat use by female Ruffed Grouse and their broods. Availability and distribution of suitable brood-rearing habitat directly affects brood production and survival (Bump et al. 1947, Stewart 1956, Sharp 1963, Berner and Gysel 1969). Thus, an understanding of the effects of habitat manipulation on habitat use by brood-rearing females is essential for evaluating the success of habitat management.

STUDY AREA

Our study was centered at the 1120-ha Grouse Habitat Management Area on State Game Lands 176 (40°50′N, 77°53′W), approximately 8 km west of State College, Pennsylvania (Liscinsky 1980, McDonald et al. 1993, Storm et al. 1993). The study area consisted of two low ridges (elevations 360–450 m) encompassing a broad valley. The area was primarily forested within a matrix of small private woodlots and agricultural lands. Two major cover-types, aspen/scrub oak on the valley floor and mixed oak on the higher elevations, were present in the study area (Schmaltz 1978).

The area was divided into a 544-ha treated area and an adjacent 576-ha untreated area (Storm et al. 1993). Relative proportions and conditions of forest types were similar between areas prior to management. The treated area was divided into 136, 4-ha blocks (60 aspen/scrub oak, 76 mixed oak). Each block was further divided into four 1-ha patches, designated A, B, C, or D. In Pennsylvania, rotations of 40 and 80 or more years are considered typical forest management practices for aspen and mixed oak, respectively. Because most of the forest on our study area was approaching maturity, initial rotations were reduced to 20 yr (one patch cut every 5 yr) for aspen/scrub oak and 40 yr (one patch cut every 10 yr) for mixed oak. The A patch in each of the 136-ha blocks was clearcut in 1976–1977, B patches in aspen/scrub oak were cut in 1981–1982, and C patches in aspen/scrub oak and B patches in mixed oak were cut in 1985–1987.

METHODS

We located Ruffed Grouse by systematically searching along transect lines with and without trained hunting dogs and during routine (unsystematic) periods of checking traps and radio-tracking grouse. Systematic searches were equally allocated among treated and untreated portions of the study area. Searches were conducted 27 May–25 Jun. 1986 and 26 May–29 Jun. 1987.

Female grouse were captured using modified shorebird traps (Liscinsky and Bailey 1955, Gullion 1965) or in a mist net in conjunction with a taped distress call of a 16-d-old chick (Lyons 1981). Age and sex were determined at the time of capture (Bump et al. 1947). Adult female grouse were marked with a numbered leg band and fitted with a 164-MHZ transmitter package attached with a poncho-style collar (14–19 g) (Amstrup 1980) or a backpack harness (25–27 g) (Brander 1968).

During 1986 and 1987, radio-tagged grouse were located once per day from the time of capture until 9 August and five times per week, separated by at least 1 d, from 10 August–9 September. Each grouse was located randomly between 0600 and 2000 h. An effort was made to sample all grouse equally to insure estimates of habitat selection and home range size would not be unduly influenced by the behavior of any given individuals. Grouse locations were estimated from direct observations, circling grouse within a 50-m circle using a hand-held yagi antenna, and triangulation from points of known coordinates. Direct observation by flushing, at least once every 14 d, insured that broods were with radio-tagged females, but accurate counts of brood size were not possible. Locations on the treated area were also recorded by patch type. Locations were assigned a quality code (high, low) based on the method of location and its estimated accuracy. High-quality locations were those that could confidently be placed within a 0.25-ha area. These included most locations determined from flushing or observing the grouse and some locations determined by triangulation. Only high-quality locations were used for analyses of habitat use and home-range size.

Summer home ranges of grouse with broods were estimated between the time of capture and 9 Sep. 1986 and 1987. September was considered the onset of brood break-up and dispersal (Chambers and Sharp 1958, Godfrey and Marshall 1969). Home ranges were estimated by harmonic mean 95% contour (Dixon and Chapman 1980) and minimum convex polygon methods (Mohr 1947) for comparison to previous research. Home ranges of grouse on the treated and control areas were compared using one-way analysis of variance.

We examined patterns of habitat selection at three levels: cover-type composition, patch type relative to rotation, and microhabitat characteristics (Table 1). Estimates of cover-type selection were based on dominant overstory vegetation throughout the entire study area, whereas estimates of patch selection were limited to the treated area.

Eight cover-types were identified based on vegetation and land use (Williams 1986) (Table 1). A cover map was updated each year using aerial photography and field reconnaissance to account for ongoing clearcutting activities. Use of cover types and patches were estimated by the number of grouse locations in each category. Use of cover-types and patches were compared-to their availability within the study area using Chi-square goodness-of-fit tests and Bonferroni 95% confidence intervals (Neu et al. 1974). These tests were conducted with pooled data for all grouse. Cover type selection was estimated throughout the entire study area, rather than

TABLE 1. Variables used to detect habitat selection by Ruffed Grouse rearing broods at State Game Lands 176, Centre County, Pennsylvania, during May–September 1986 and 1987.

Macrohabitat				
Cover type		Patch		Microhabitat
HB/CC	Herbaceous/Clearcut	AS-A	Aspen Scrub Oak (cut in 1976)	Canopy height
PI/SO	Pine Scrub Oak		(60 patches)	Canopy cover
AS	Aspen	AS-B	Aspen Scrub Oak (cut in 1981)	Small woody stem density
SO	Scrub Oak		(60 patches)	Large woody stem density
AS/SO	Aspen/Scrub Oak	AS-C	Aspen Scrub Oak (cut in 1986)	Basal area
AS/MO	Aspen/Mixed Oak		(23 patches in 1986, 90	Number of woody species
MO/SO	Mixed Oak/Scrub Oak		patches in 1987)	Distance to nearest edge
MO	Mixed Oak	AS-U	Untreated Aspen Scrub Oak (97	Distance to nearest opening
			patches in 1986, 79 patches	Percent slope
			in 1987)	*Percent coverage*
		MO-A	Mixed Oak (cut in 1976) (76	Live vegetation <2m
			patches)	Dead vegetation <2m
		MO-B	Mixed Oak (cut in 1986) (76	Organic litter
			patches in 1987)	Bare ground
		MO-U	Untreated Mixed Oak (228	Logs
			patches in 1986, 179	Moss and lichens
			patches in 1987)	Herbaceous vegetation

within treated and untreated areas, because habitat management only altered forest stand age and structure and did not affect cover type composition.

Sixteen vegetative and physiographic variables were measured at sites used by Ruffed Grouse with broods and at randomly located sites to estimate microhabitat selection and to assess changes in microhabitat due to forest management. Variables were measured at 120 sites used by radio-tagged grouse (60 each on the treated and untreated areas), and at 60 random sites (30 each on the treated and untreated areas). Used sites were randomly selected from weekly sets of radio locations from each grouse, obtained 5 Jun.–7 Aug. 1986 and 1987. A location was only selected if it was of high quality, if there was no known disturbance to the grouse prior to estimating the location, and if the location was >12 m from any previously selected site. Random sites were selected by randomly generating coordinates within the study area. Random sites located on gravel roads, buildings, standing water, and maintained lawns were rejected.

Basal area and density of tree species (≥7.5-cm dbh) were determined by total stem counts within a 0.04-ha circular plot centered on each site (James and Shugart 1970). Height and percent overhead cover were also determined from within the 0.04-ha plot. Density of small woody stems (2.5–7.5 cm dbh) was estimated using two crossing one-by-20 m belt transects centered on each site. Percent cover of ground and understory vegetation was estimated using the point intercept method at 1-m intervals along belt transects (Hays et al. 1981). Slope and distance variables were measured within circular plots or using aerial photographs of the study area.

Microhabitat data were analyzed with multivariate analysis of variance using the Statistical Analysis System (Helwig and Council 1985). Variables were compared between used sites and random sites on the entire study area, and between random sites on the treated and untreated areas. Significant differences between used and random sites throughout the entire study area suggested microhabitat selection by brood rearing grouse, whereas differences between random sites on the treated and untreated areas indicated effects of habitat management practices on microhabitat composition.

RESULTS AND DISCUSSION

Capture and marking.—Adult females with broods were sighted 28 times during 153 person hours of systematic searches and 31 times during unsystematic searches (effort undetermined). During 1986 and 1987, 78.3 h were expended to locate 16 broods on the treated area (4.9 h/brood), whereas 74.3 h were expended to locate 12 broods on the untreated area (6.2 h/brood). Twenty-nine grouse were captured using modified shorebird traps (12 females, 3 males; 994 trap nights) and mist nets (14 females; 34 attempts). Twenty-three adult females with broods were fitted with radio transmitters, 13 in 1986 and 10 in 1987. Of the radio-equipped hens, one moved 2400 m from the boundary of the management area within 7 d of capture; another was found dead 710 m from its capture location 20 d after capture. The 21 remaining birds stayed within the study area, and survived at least 30 d from the time of capture. A total of 919 high-quality locations were determined by radio tracking between time of capture and 9 Sep. 1986 and 1987. An average of 44 locations (SD = 12.3) were recorded for each radio-tagged grouse during these periods.

Home range estimates.—Mean home range of all grouse was 59.4 ha (SD = 45.8, range = 16.4–181.6) using the 95% harmonic mean method, and 84.4 ha (SD = 67.8, range = 23.5–279.7) using the minimum convex polygon method. Eight grouse stayed almost entirely (≥95% of locations) within the untreated area; six grouse stayed almost entirely within the treated area. The seven remaining grouse were located within both the untreated and treated areas. Mean home range of grouse located within both the untreated and treated areas ($\bar{x}$ = 89.9 ha, SD = 64.7, range = 32.8–181.6) was twice that of grouse on the untreated area ($\bar{x}$ = 43.7 ha, SD = 27.2, range = 23.0–93.4) and treated areas ($\bar{x}$ = 44.9 ha, SD = 18.9, range = 16.4–68.2) ($F_{2,18} = 2.74$, $P = 0.01$). Grouse were located uniformly throughout the treated area, whereas 67% of all grouse locations on the untreated area were within the northern half of the study area.

Mean home range of female grouse rearing broods in our study was larger than reported in previous studies. Godfrey (1975) collected 509 locations from six broods, during the same time of year in Minnesota, and estimated an average home range size of 12.0 ha. Other estimates of home range size of broods or female grouse with broods, during different times of the year, range from 12–16.5 ha (Bump et al. 1947, Archibald 1975, Godfrey 1975, Maxson 1978). The expansive home ranges we observed may have been due, in part, to larger sample sizes (telemetry locations) relative to other research. Home range estimators in general, particularly the minimum convex polygon technique, can be strongly influenced by sample size (Boulanger and White 1990). Larger home ranges estimated in this study may also have been due to the fact that broods were located into September and may have ranged greater distances just prior to breakup and dispersal. The sizes of areas used by females with broods on the treated area were similar to those in the untreated area suggesting suitable habitat components for broods were available and perhaps distributed similarly on both the treated area and the northern section of the untreated area.

Macrohabitat use.—Cover-types were used disproportionately to their availability ($\chi^2 = 106.8$, df = 7, $P < 0.001$). The mixed oak/scrub oak type was selected, the herbaceous/clearcut and pine/scrub oak types were avoided, and the scrub oak, aspen, aspen/mixed oak, aspen/scrub oak, and mixed oak types were used in proportion to their availability (Table 2).

Selection of the mixed oak/scrub oak habitat type was expected be-

TABLE 2. Cover-type use by adult female Ruffed Grouse with broods, State Game Lands 176, Central Pennsylvania, during May–September 1986–1987.

Cover-type[a]	% availability	Number of locations	% use	Use vs. avail.[b]
MO/SO	22.1	309	33.6	+
AS	1.3	16	1.7	=
SO	3.0	17	1.8	=
AS/MO	6.3	43	4.7	=
AS/SO	1.2	16	1.7	=
MO	56.1	485	52.8	=
HB/CC	8.2	28	3.1	−
PI/SO	1.8	5	0.5	−

[a] See Table 1.
[b] (−), (+), and (=) indicate habitat type used in less, greater, or equal proportion to availability ($P \leq 0.05$), respectively.

cause this type had a relatively open overstory and a dense understory layer, and contained the 10-yr-old forest stands on the treated area (MO-A patches). Our observations that grouse used habitat types with an aspen component (AS, AS/MO, AS/SO) in proportion to their availability agreed with results of Maxson (1978) and Porath and Vohs (1972), that documented preferential use of oaks or mixed hardwoods in both aspen and mixed-oak or mixed-hardwood habitats. Other research from the Midwest suggests preferential use of aspen habitat by Ruffed Grouse broods (Berner and Gysel 1969, Rusch and Keith 1971, Gullion and Svoboda 1972).

Avoidance of the herbaceous/clearcut habitat type was consistent with findings by Maxson (1978) and Porath and Vohs (1972) who reported that grouse avoided large openings. Gullion (1970) reported recent clearcuts with slash hindered movement of young grouse and provided cover for predators. The avoidance of pine/scrub oak habitat may have been related to an increased exposure to avian predators. Grouse survival is adversely affected by the presence of conifers in some habitats (Gullion 1970, Rusch and Keith 1971), and tall pitch pines in the pine/scrub oak habitat may have provided concealed perch sites for raptors. Thompson et al. (1987) detected lower densities of conifers at sites used by broods in Missouri.

Patch types were used disproportionately to their availability on the treated area in both 1986 ($\chi^2 = 267.9$, df = 5, $P < 0.001$) and 1987 ($\chi^2 = 40.2$, df = 5, $P < 0.001$). The mixed oak-A patch type was selected in 1986, and was used in proportion to its availability in 1987. In 1986, all other patch types were avoided. In 1987, aspen-A patches were selected, aspen-B, mixed oak-U, and aspen-U patch types were used in proportion to availability, and mixed oak-B and aspen-C patches were avoided (Table 3).

Selection of 10-yr-old mixed-oak patches (MO-A) and avoidance of all other untreated mixed-oak patches concurs with reported high use of

TABLE 3. Use of Grouse Habitat Management Area patch types by adult female Ruffed Grouse with broods, State Game Lands 176, Central Pennsylvania, during May–September 1986–1987.

Year	Patch type	% available	Number of locations	% use	Use vs. avail.[b]
1986	MO-A	14.0	128	49.0	+
	AS-A	11.0	14	5.4	−
	AS-B	11.0	9	3.4	−
	AS-C	4.0	1	0.4	−
	MO-U	41.9	79	30.3	−
	AS-U	18.1	30	11.5	−
1987	AS-A	11.0	38	20.1	+
	MO-A	14.0	37	19.6	=
	AS-B	11.0	23	12.1	=
	MO-U	32.9	47	24.9	=
	AS-U	14.5	35	18.5	=
	MO-B/AS-C	16.6	9	4.8	−

[a] See Table 1.

[b] (−), (+), and (=) indicate habitat type used in less, greater, or equal proportion to availability ($P \leq 0.05$), respectively.

young-aged, mixed-oak forest stands by females with broods (Bump et al. 1947, Sharp 1963, Berner and Gysel 1969, Porath and Vohs 1972). Selection of the 10-yr-old aspen patches in 1987 agrees with previous studies which have documented preferential use of young aspen (Gullion 1970, Gullion and Svoboda 1972, Kubisiak 1978). Differential use of 5-yr-old aspen/scrub oak patches between 1986 and 1987 possibly indicated effects of patch maturation. Increased use of aspen-B patches (3.4% in 1986 to 12.1% in 1987) corresponded with a decreased use of 10-yr-old patches (54.4% in 1986 to 39.7% in 1987) suggesting a shift in grouse activity to younger forest patches.

Microhabitat use.—Significant differences ($P < 0.001$) were evident between used sites and random sites throughout the entire study area for two vegetation variables and two distance variables (Table 4). Density of woody stems 2.5–7.5-cm dbh and percent cover of live vegetation <2 m in height were greater at used sites than at random sites. Total density of woody stems >2.5 cm dbh at sites used by grouse in this study ($\bar{x}$ = 21,400 stems/ha) was above the 5000 stems/ha considered the minimum density suitable for grouse cover, and within the 12,400–29,000 stems/ha considered optimal brood habitat in aspen forests in Minnesota (Gullion 1970, 1977).

Distance to nearest edge and distance to nearest opening were less at used sites than at random sites suggesting that forest openings and habitat edges were important components. Edges of clearcuts, large openings, and small forest openings are recognized as important components of brood habitat (Bump et al. 1947, Berner and Gysel 1969, Porath and Vohs 1972, Maxson 1978).

Several differences in microhabitat components were evident between

TABLE 4. Microhabitat comparisons between sites used by adult female Ruffed Grouse with broods (n = 120) and random sites (n = 60), and between random sites on the Grouse Habitat Management Area treated (n = 30) and untreated areas (n = 30), State Game Lands 176, Central Pennsylvania, During May–September 1986–1987.

	Used		vs. Random			Treated		vs. Untreated		
Variable	$\bar{x}$	SE	$\bar{x}$	SE	P	$\bar{x}$	SE	$\bar{x}$	SE	P
Canopy height (m)	14.1	0.9	16.7	1.2	0.092	17.5	1.9	16.0	1.4	0.539
Canopy cover (%)	77.7	2.0	79.3	2.8	0.257	78.8	5.4	79.8	5.2	0.896
Small stem density (/ha)	21,106	1558	11,496	2130	<0.001	12,479	3771	10,513	2044	0.648
Large stem density (/ha)	294.2	32.4	429.2	85.1	0.075	542.0	166	315.8	33.0	0.185
Basal area (m^2/ha)	11.0	0.6	11.3	1.0	0.936	11.3	1.5	11.3	1.5	0.961
No. woody species (no.)	4.0	0.2	4.9	0.4	0.283	5.4	0.8	4.4	0.4	0.256
Cover live veg <2 m (%)	78.4	1.5	65.6	3.1	<0.001	64.0	4.2	67.2	4.7	0.616
Cover dead veg <2 m (%)	8.3	0.8	9.0	1.1	0.587	9.0	1.84	8.9	1.32	0.965
Distance to edge (m)	24.8	2.1	52.3	3.3	<0.001	28.1	3.3	76.5	17.3	0.008
Distance to opening (m)	40.4	7.1	70.1	13.5	0.006	54.1	19.9	86.1	18.1	0.239
Slope (%)	11.5	0.6	11.0	0.9	0.736	10.6	1.2	11.4	1.2	0.877
Ground cover										
Organic litter (%)	95.9	0.5	96.3	0.6	0.575	94.6	1.0	98.0	0.7	0.006
Bare ground (%)	0.6	0.1	1.3	0.4	0.027	1.8	0.7	0.8	0.4	0.214
Logs (%)	2.9	0.4	2.3	0.4	0.280	3.4	0.7	1.2	0.3	0.009
Moss and lichen (%)	1.0	0.3	0.6	0.2	0.498	0.7	0.3	0.4	0.3	0.615
Herbaceous (%)	24.8	2.0	27.5	3.7	0.492	27.2	4.2	27.8	6.1	0.940

random sites on treated and untreated areas suggesting habitat management had affected microhabitat composition (Table 4). Percent organic litter was greater and and percent logs was less on the untreated area. Of the four microhabitat components selected by brood-rearing grouse, only distance to edge was directly affected by habitat management practices. Distance to edge was less on the treated area suggesting that habitat management had positively affected brood microhabitat suitability.

CONCLUSIONS

We believe the large home ranges of adult female grouse with broods observed during this study, on both treated and untreated areas, indicated a response to patchy distributions of suitable habitats. In the treated area, this distribution was created and maintained by short-rotation clearcutting. Recent clearcuts (1986–1987) composed 17% of available habitat but received low use by female grouse with broods. These clearcuts were interspersed among mature stands of mixed oak, 136 10-yr-old patches (1-ha) of mixed oak and aspen/scrub oak, and 60 5-yr-old (1-ha) patches of aspen/scrub oak which resulted in a uniform distribution of suitable habitat throughout the treated area.

A patchy distribution of suitable habitat within the untreated area resulted from naturally occurring stands of mature aspen, aspen/scrub oak, and herbaceous areas within a matrix of mature, mixed oak (Williams 1986). Habitat heterogeneity on the untreated area was greater within the northern half of the study area; the southern half consisted of a more homogeneous matrix of mature mixed oak with little dispersion of other forest types.

Selection of 10-yr-old clearcut patches and avoidance of uncut patches in mixed oak suggested that experimental habitat management created suitable brood habitat in areas of mixed oak forest which might otherwise have been unsuitable. This was further supported by the fact that female grouse with broods were captured and located throughout all portions of the treated area, whereas grouse within the untreated area were most often located within the northern section where diversity and interspersion of cover types was greatest.

Female Ruffed Grouse with broods selected areas which had greater densities of woody stems (2.5–7.5-cm dbh), had greater percent coverage of live vegetation <2 m, and were closer to edges and openings than other areas. Experimental habitat management positively affected one microhabitat component (distance to nearest edge) preferred by brood rearing grouse. High use of edges by adult grouse with broods suggests a positive response to plant community diversity.

The assumption that increased availability of preferred habitats should be positively related to grouse density is supported by the fact that more females with broods were observed within the treated portion of the study area. Other investigations have documented an increasing trend in density of breeding males, particularly within the treated area, during the duration of this study and throughout early 1990s (McDonald et al. 1993; G. L. Storm, unpubl. data).

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