Raccoon (*Procyon lotor*) Diurnal Den Use within an Intensively Managed Forest in Central West Virginia

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Abstract - Intensive forest management may influence the availability of suitable den sites for large den-seeking species, such as *Procyon lotor* (Raccoon). As part of a Raccoon ecology study on an industrial forest in the Allegheny Mountains of central West Virginia, we radio-tracked 32 Raccoons to 175 diurnal den sites to determine relative use of dens that included cavity trees, rock dens, log piles, slash piles, and exposed limbs. Patterns of den use significantly differed between sexes and among seasons. Overall, we recorded 58 cavity dens in 12 tree species with 7 maternal dens found in 5 tree species. Raccoons selected larger-diameter den trees than available cavity trees and non-cavity trees. Because the abundance of suitable tree cavities is known to influence Raccoon densities and recruitment at fine spatial scales and female Raccoons in this study used tree cavities as maternal den sites, the continued harvest of large-diameter trees (i.e., those capable of developing den cavities) without replacement may impact Raccoon recruitment within intensively managed forests throughout the central Appalachians.

Introduction

Procyon lotor L. (Raccoons) are highly adaptable meso-predators and important members of many ecological systems throughout their broad distributional range (Byrne and Chamberlain 2011, Gehrt 2003). Raccoons are efficient avian nest predators (Schmidt 2003) as well as vectors or hosts for a number of diseases and parasites that can affect humans and other wildlife (Rees et al. 2009, Rosatte et al. 2010). Furthermore, Raccoons have historically been an important game animal and are commonly harvested throughout the central and southern Appalachian Mountain region (Rogers 2012).

A high degree of behavioral plasticity has enabled Raccoons to use a wide variety of habitat types and denning resources, including tree cavities, underground burrows, rock outcrops, and human-made shelters (Chamberlain et al. 2007, Henner et al. 2004, Rabinowitz and Pelton 1986). Raccoon use of particular den types is known to vary seasonally and between sexes (Endres and Smith 1993). For example, several researchers have reported selection of tree cavities as dens during

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periods of breeding and parturition in a variety of habitat types and geographic locations (Endres and Smith 1993, Henner et al. 2004, Wilson and Nielsen 2007). In forested landscapes, tree cavities are thought to be an important resting and denning resource for Raccoons because they provide stable thermal environments and protection from predators (Rabinowitz and Pelton 1986). Furthermore, female Raccoons are known to select tree cavities as maternal den sites (Endres and Smith 1993), and therefore, a lack of suitable tree cavities can limit recruitment and influence local population dynamics (Beasley and Rhodes 2012).

Compared to other cavity-dwelling species, Raccoons require robust cavities because of their large body size (minimum cavity dimensions > 100 cm^3; Robb et al. 1996). Accordingly, this often means that suitable cavity trees for Raccoons are large (e.g., diameter at breast height [dbh] > 70 cm), mature, and in a state of decline (Robb et al. 1993, Smith and Endres 2012). In the central Appalachian Mountains, particularly on private forestlands, large-diameter trees with den cavities may be of limited quantity and quality due to past timber harvests and present forest management (Rosenberg et al. 1988). Moreover, an absence of suitable tree cavities may require Raccoons to use alternative den sites (e.g., rock dens or log piles), which may displace other den-seeking animals such as *Neotoma magister* Baird (Allegheny Woodrat), disrupt predator-prey associations, and alter disease contact parameters (Endres and Smith 1993, Owen et al. 2004). Specifically, the potential for increased interaction between Raccoons and the Allegheny Woodrat is important because the Allegheny Woodrat can be affected adversely by larvae of *Baylisascaris procyonis* (Raccoon Roundworm), which has contributed to Allegheny Woodrat population declines in the northeastern United States (Wright 2010).

In contrast to other portions of their range (e.g., southeastern United States), there is limited information available on Raccoon den use in the central Appalachians generally and within intensively managed forests specifically. Furthermore, the degree to which changes in forest structure and species composition impact tree cavity availability and use is not well known. Consequently, our objectives were to: (1) determine seasonal and sex-specific patterns of Raccoon den use and (2) estimate availability and use of tree cavities within an intensively managed forest landscape in central West Virginia. Based on previous research investigating Raccoon habitat selection, we hypothesized that den use would vary between sexes and among seasons. Specifically, we predicted that tree cavities in the heavily forested central Appalachians would be important denning resources for female Raccoons, whereas males would exhibit greater plasticity in den selection throughout the annual cycle.

Field-Site Description

Our study was centered on the 3630-ha former MeadWestvaco Wildlife and Ecosystem Research Forest (MWERF) located in the Allegheny Mountain and Plateau physiographic sub-province in Randolph County, WV. The MWERF was an intensively managed forest dedicated to the study of the interaction between industrial forestry operations and Appalachian ecosystems. Elevations are 700–1200 m, with steep side-slope mountains, broad ridge tops, and narrow valleys, and emergent rock outcrops are common along mountain ridgelines. The climate is cool and moist, with a growing season of approximately 150 days (Smith 1995). At the time of our study, the MWERF contained a mix of second- and third-growth Allegheny-northern hardwood forest dominated by *Prunus serotina* (Black Cherry), *Acer saccharum* (Sugar Maple), *A. rubrum* (Red Maple), *Betula alleghaniensis* (Yellow Birch), *Fagus grandifolia* (American Beech), and *Quercus rubra* (Northern Red Oak) except for higher elevations that were characterized by *Picea rubens* Sargent (Red Spruce) and *Tsuga canadensis* (Eastern Hemlock) communities. Riparian areas were characterized by the aforementioned tree species and *Rhododendron maximum* L.(Rosebay Rhododendron).

Five forest-stand types were found on the MWERF: (1) intact mid-aged to mature (30–90 years old) forest, (2) diameter-limit harvests, (3) deferment harvests, (4) clearcuts, and (5) open roads or non-forest areas. Intact forests were second-growth stands with no mechanical disturbance since stand initiation. Diameter-limit stands had approximately 50% of the basal area removed during repeated harvests over the previous two decades. Deferment harvests and clearcuts were similar in silvicultural function, but approximately 10% of the initial basal area was retained in deferment harvests, whereas all trees >2.5-cm dbh were removed in clearcuts. Most deferment and clearcut stands were 0–10 years of age.

Materials and Methods

Capture, telemetry, and habitat sampling

We used 38 × 38 × 107 cm and 25 × 25 × 81 cm cage traps (Havahart, Woodstream Corporation, Lititz, PA) baited with sardines, other forms of rancid meats, and marshmallows to live-capture Raccoons. We chemically immobilized Raccoons with 30 mg/kg Ketamine plus 4 mg/kg Xylazine (Kreeger 1996), and used Yohimbine (0.15 mg/kg) as an antagonist to Xylazine. We aged immobilized Raccoons as juvenile or adult (Kramer et al. 1999), determined sex according to external characteristics, recorded weights, and marked each individual with a uniquely numbered Jiffy size 3 aluminum ear-tag (National Band and Tag Co., Newport, KY). Measurements were taken for total length, ear length, and hind-foot length. We equipped adult males and females with mortality sensitive radio collars (Advanced Telemetry Systems, Asanti, MN; AVM Instrument Company, Ltd., Colfax, CA) that weighed approximately 70 grams and had a battery life of 18 months. We only tagged adults because of the possiblity of sub-adults dispersing from the study area. Capture and handling methods were approved by the West Virginia University Animal Care and Use Committee (permit number 00-0813).

We employed Wildlife Materials TRX-2000S receivers (Wildlife Materials Inc., Carbondale, IL) and 3-element Yagi antennas to locate den sites of transmittered Raccoons using homing techniques during diurnal periods of inactivity. We located den sites of transmittered individuals approximately 2–3 times weekly and approached dens on foot and confirmed actual locations visually. We considered each location as independent and calculated relative frequency of use based on number of locations for each den type among seasons, and between sex and year. We defined seasons as spring (March–May), summer (June–September), and winter (October–February).

We conducted cavity-tree surveys to determine the availability and distribution of suitable cavities across the MWERF and compared characteristics of used cavity trees (den trees) to those available within the study area. We searched the study area for available tree cavities by randomly establishing eight 0.25-ha availability plots within each of 4 vegetation cover types (upland and riparian zones of both intact forest and diameter-limit stands) within the maximal area used by Raccoons on the MWERF (minimum convex hull polygon; S.F. Owen, unpubl. data). We did not include deferment harvest or clearcuts in cavity-tree searches because we found no Raccoons using tree cavities within deferment harvests and cavity trees were absent within clearcuts. Cavity trees were considered available to Raccoons if diameter at breast height (dbh) was >30 cm (based on the minimal size of used cavity trees in this study) and contained a cavity that appeared to be potentially useable (i.e., large enough) by Raccoons (Robb et al. 1996).

Statistical analyses

We developed log-linear regression models using the vcdExtra package implemented within program R (R Core Development Team 2012) to determine if den use differed between sexes and among seasons. We also tested for 2-way interactions among these variables and assessed significance based on likelihood ratio tests. After detecting significant findings from log-linear regression, we used multiple chi-squared contingency table analyses to compare differences within seasons and between sexes. We used one-way ANOVA to test for differences in mean tree dbh among den trees and available cavity- and non-cavity trees (>20 cm dbh) within our availability plots. We applied Tukey's honest significant difference (HSD) post-hoc test to determine pair-wise differences among groups. Measurements of dbh were log-transformed to better approximate the normal distribution; however, untransformed data are presented for ease of interpretation. We set significance levels for all statistical tests at $P = 0.05$, and means are presented ± standard error (SE).

Results

Diurnal den use

We radio-collared and monitored den use of 32 adult Raccoons (19 males, 13 females) from October 2000–March 2003. From those 32 individuals, we located 175 diurnal den sites (mean locations per individual = 5.8 ± 1.06). We classified den sites into 5 categories (Table 1) including: (1) tree cavities ($n = 58$), (2) rock dens ($n = 47$), (3) exposed limbs ($n = 34$), (4) residual waste-log piles at loading decks ($n = 19$), and (5) other ($n = 17$; slash piles, stump holes, downed-hollow logs and a small out-building). Relative frequency of den use (including initial location and revisits to the same den site; $n = 275$) was distributed among den types as follows: 104 (38%) tree cavities, 70 (25%) rock dens, 45 (16%) log piles, 40 (15%) exposed limbs, and 16 (6%) other.

Patterns of Raccoon den use differed between sexes (χ^2_{24} = 185.01, P < 0.001) and among seasons (χ^2_{23} = 72.45, P < 0.001) (see Table 1); however, 2-way interactions among these variables were not significant (χ^2_{10} = 10.61, P = 0.388). Both sexes used tree cavities more often in summer than in spring or in winter (χ^2_2 = 7.89, P = 0.019). Log piles were used to a similar degree across seasons, and were used less than expected compared to other den types used (χ^2_2 = 7.77, P = 0.021). Rock dens were used more often in winter than in spring or summer (χ^2_2 =23.99, P < 0.001). Females used tree cavities more often than males (χ^2_2 = 23.11, P < 0.001), whereas males used rock dens more often than females (χ^2_2 = 7.84, P = 0.005). Males also used log piles slightly more than females, although the difference was not statistically significant (χ^2_2 = 3.74, P = 0.053).

In spring and summer, females used tree cavities more than all other den types, (χ^2_2 = 13.49, P = 0.001). Females used log piles (χ^2_2 = 26.68, P < 0.001) and rock dens (χ^2_2 = 7.88, P = 0.019) more frequently relative to all other den types in winter than in both spring and summer. During summer males used tree cavities to a similar degree as all other den types (χ^2_2 = 1.66, P = 0.434). However, the relative frequency of rock-den use by males was higher in winter than in spring and summer (χ^2_2 = 21.04, P < 0.001), while log piles were used evenly among seasons (χ^2_2 = 2.13, P = 0.344).

Table 1. Proportion of *Procyon lotor* (Raccoon) seasonal diurnal den use on the MeadWestvaco Wildlife and Ecosystem Research Forest, Randolph County, WV, 2000–2003. Type = den-type use within season (sums down); season = seasonal den use within type (sums across).

	Both sexes			Female			Male		
Den type	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter
Cavity									
n	10	43	5	5	18	2	5	25	3
Type	0.56	0.32	0.21	0.56	0.45	0.25	0.56	0.27	0.19
Season	0.17	0.74	0.09	0.20	0.72	0.08	0.15	0.76	0.09
Limb									
n	2	32	-	2	7	-	-	25	-
Type	0.11	0.24	-	0.22	0.18	-	-	0.27	-
Season	0.06	0.94	-	0.22	0.78	-	-	1.00	-
Log Pile									
n	3	11	5	1	2	3	2	9	2
Type	0.17	0.08	0.21	0.11	0.05	0.38	0.22	0.10	0.13
Season	0.16	0.58	0.26	0.17	0.33	0.50	0.15	0.69	0.15
Rock Den									
n	2	31	14	1	6	3	1	25	11
Type	0.11	0.23	0.58	0.11	0.15	0.38	0.11	0.27	0.69
Season	0.04	0.66	0.30	0.10	0.60	0.30	0.03	0.68	0.30
Other									
n	1	16	-	-	7	-	1	9	-
Type	0.06	0.12	-	-	0.18	-	0.11	0.10	-
Season	0.06	0.94	-	-	1.00	-	0.10	0.90	-

Tree-cavity use and availability

Raccoons denned in cavities of 12 different tree species (Table 2). Seven of 8 maternal dens occurred within cavities in 5 tree species including *Liriodendron tulipifera* (Yellow-Poplar) (n = 3), *Tilia americana*. (American Basswood) (n = 1), *Magnolia fraseri* (Fraser Magnolia) (n = 1), American Beech (n = 1), and Black Cherry (n = 1) with a mean dbh of 58 cm ± 5.8 (range = 39.4–71.1). We also found 1 maternal den in a small out-building. We surveyed 790 trees across the study area for available cavities and found only 14 trees (1.8%) with cavities potentially suitable for use by Raccoons (see Table 2) for an estimated density of 1.3 cavity trees per hectare. Den trees had significantly larger dbh than both available cavity trees and non-cavity trees within the MWERF ($F_{2,849}$ = 98.61, $P < 0.001$; Fig. 1).

Discussion

The relative importance of dens within the hierarchy of resources required by Raccoons in central Appalachian forested landscapes is uncertain, but varies among seasons and between Raccoon age and sex classes within seasons (Endres and Smith 1993). Raccoons on the MWERF used a wide variety of den types consistent with the generalist habits and opportunistic behavior described by others across a variety of landscapes (Henner et al. 2004, Rabinowitz and Pelton 1986, Wilson and Nielsen 2007). Similar to other studies, our results indicate considerable variation in den-type use among seasons and between sexes, with the greatest within-season variation occurring during the warmer periods of spring and summer (Rabinowitz and Pelton 1986). Endres and Smith (1993) suggested that the high

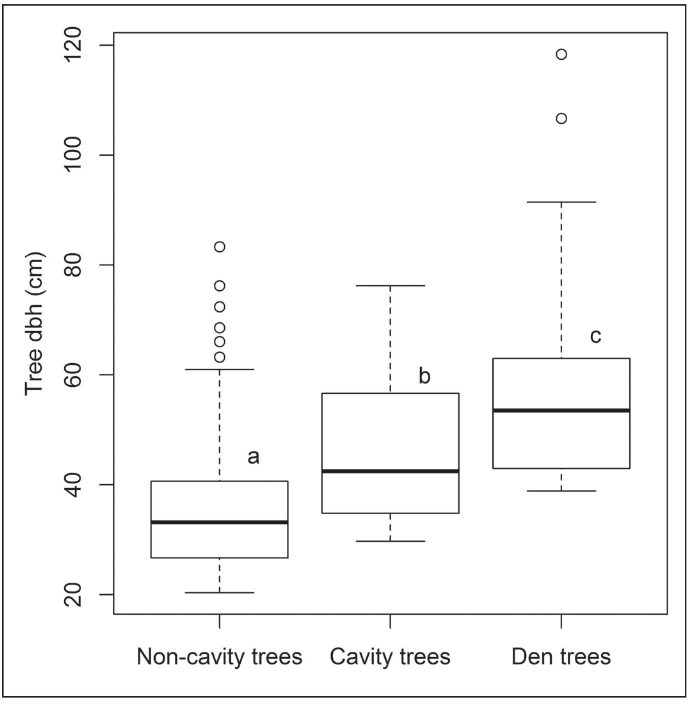

Figure 1. Differences in median tree diameter at breast height (dbh) among *Procyon lotor* (Raccoon) den trees and available cavity and non-cavity trees on MeadWestvaco Wildlife and Ecosystem Research Forest, Randolph County, WV, 2000–2003. Tree categories marked with different lower case letters significantly differed in pairwise comparisons based on Tukey's 95% HSD post-hoc test.

Table 2. Relative abundance and mean (± SE) diameter at breast height (dbh) of *Procyon lotor* (Raccoon) den trees, available cavity trees, and non-cavity trees within MeadWestvaco Wildlife and Ecosystem Research Forest, Randolph County, WV, 2000–2003. Rel. abund = relative abundance.

	Available trees				Available cavity trees				Den trees			
Species	Mean	SE	*n*	Rel. abund. (%)	Mean	SE	*n*	Rel. abund. (%)	Mean	SE	*n*	Rel. abund. (%)
Acer rubrum L. (Red Maple)	31.4	1.01	88	11.3	49.4	13.60	3	21.4	-	-	-	-
Acer saccharum Marsh (Sugar Maple)	31.1	0.65	133	17.1	44.2	4.86	4	28.5	64.2	18.21	4	6.9
Betula alleghaniensis Britton (Yellow Birch)	28.8	0.73	63	8.1	-	-	-	-	-	-	-	-
Betula lenta L. (Black Birch)	28.1	0.90	31	4.0	-	-	-	-	-	-	-	-
Fagus grandifolia Erhart (American Beech)	30.8	0.76	60	7.7	56.6	0.00	1	7.1	53.5	3.04	5	8.6
Fraxinus americana L. (White Ash)	30.1	3.42	6	0.8	-	-	-	-	57.2	0.00	1	1.7
Fraxinus pennsylvanica Marshall (Green Ash)	33.5	0.00	1	0.1	-	-	-	-	-	-	-	-
Liriodendron tulipifera L. (Yellow Poplar)	41.3	0.94	84	10.8	42.4	0.00	1	7.1	49.1	2.86	16	27.6
Magnolia acuminata L. (Cucmber Tree)	33.6	1.52	25	3.2	-	-	-	-	53.9	0.00	1	1.7
Magnolia fraseri Walter (Fraser Magnolia)	35.1	2.50	14	1.8	35.5	4.54	3	21.4	49.7	3.72	6	10.3
Prunus serotina Ehrhart (Black Cherry)	39.8	0.89	129	16.6	57.7	0.00	1	7.1	63.4	3.33	4	6.9
Quercus prinus L. (Chestnut Oak)	32.8	2.25	16	2.1	-	-	-	-	56.5	11.94	4	6.9
Quercus rubra L. (Northern Red Oak)	39.8	1.76	49	6.3	42.4	0.00	1	7.1	88.9	17.78	2	3.4
Robinia pseudoacacia L. (Black Locust)	33.9	5.17	3	0.4	-	-	-	-	-	-	-	-
Tilia americana L. (American Basswood)	36.1	0.88	50	6.4	-	-	-	-	44.0	2.96	3	5.2
Tsuga canadensis Carriere (Eastern Hemlock)	30.4	1.98	22	2.8	-	-	-	-	64.0	7.69	6	10.3
Oxydendrum arboreum (L.) DC. (Sourwood)	-	-	-	-	-	-	-	-	52.1	0.00	1	1.7
Unknown	30.7	0.25	2	0.3	-	-	-	-	60.5	1.59	5	8.6
Summary	33.4		776		46.9		14		58.2		58	

degree of seasonal variation observed in Raccoons in central Tennessee was related to seasonal weather patterns. During winter, Raccoons likely are constrained to use protected den sites that provide stable microclimates to conserve energy (e.g., rock or ground dens; Berner and Gysel 1967). Rabinowitz and Pelton (1986) found warmer and more stable air temperatures in rock dens during the winter months compared to cavity trees, and this pattern may explain the increase in rock-den use during winter compared to spring and summer. Although not previously reported, log piles may provide similar thermal conditions to rock dens. On the MWERF, large log piles were formed during timber harvests when excess slash (limbs and undesirable stems) was consolidated next to log landings. Generally, these log piles contained numerous available chambers, crevices, and potential den sites, many of which measured several cubic meters in size. Although we were unable to fully quantify individual den sites within each log pile, Raccoons used these structures throughout the year on the MWERF. Furthermore, we found evidence of den sharing within these structures, with multiple Raccoons simultaneously using the same log pile, particularly during the winter. Due to the large size and intricate internal structure of log piles, we could not determine whether these individuals were in direct contact or shared specific den sites (crevices). We speculate that log piles may support similar thermal microclimates as rock dens, although the relative importance of log piles as denning resources for Raccoons remains uncertain and should be investigated further.

Raccoon use of tree cavities has been well documented in forested habitats throughout their annual cycle (Henner et al. 2004, Smith and Endres 2012, Wilson and Nielsen 2007). We found Raccoons using tree cavities most often during the spring and summer periods of breeding and parturition. Wilson and Nielsen (2007) found that Raccoons in Illinois bottomland forests almost exclusively use tree cavities during this period. The importance of tree cavities during spring and summer can be somewhat attributed to female use of tree cavities as maternal den sites (Berner and Gysel 1967, Endres and Smith 1993, Rabinowitz and Pelton 1986, Wilson and Nielsen 2007). We found female Raccoons extensively using tree cavities during the natal period of mid-May to late-June. The majority (86%) of maternal dens were located in tree cavities, and individual females would typically remain in the same tree cavity for up to 3 weeks during parturition. Although advantages of tree cavities as maternal dens are uncertain and often explained as inherent behavioral aspects of pregnancy and parturition (Endres and Smith 1993), tree cavities can provide reduced conflict from interspecific competition, suitable microenvironments, and protection from predators (Berner and Gysel 1967, Endres and Smith 1993).

Species composition has rarely been reported as a significant factor in Raccoon den-tree selection (but see Smith and Endres 2012). Raccoons selected cavity tree species roughly in proportion to their overall availability, suggesting that availability of suitable tree cavities is more important than selecting for a particular tree species. However, certain tree species are more prone to cavity development, and therefore may be of greater importance to den-seeking animals in managed forests. We found 28% (n = 16) of all cavity trees used and 42% (n = 3) of all maternal dens in Yellow

Poplar, a common tree on the study area and throughout the central Appalachians below 1000 m (see Table 2). Yellow-Poplar is a shade-intolerant, fast-growing, and cavity-prone species capable of producing large cavity trees because of its lack of decay resistance (Moorman et al. 1999) and may be an important denning tree for Raccoons in managed forests where its regeneration and persistence is favored.

Presence of suitable cavity trees has been suggested as a potential limiting factor to Raccoon recruitment (Beasley and Rhodes 2012) and abundance (Beasley et al. 2011) because females select tree cavities for parturition and rearing young. In the central Appalachians on private land, extensive timber harvesting in the early 1900s and again from the early 1980s until the economic slowdown in 2008 has produced a complex landscape of forest stands ≤80 years old (McGarigal and Fraser 1984, Rosenberg et al. 1988, Widmann 2012) with fewer older-age–class stands containing old-growth attributes. Raccoons on the MWERF selected den trees with larger dbh than available cavity and non-cavity trees (see Fig. 1), and this finding may be an indication that only the largest remnant trees on the MWERF contained cavities suitable for use by Raccoons that require robust cavities to accommodate their large body size. Intensive forest management on the MWERF has likely reduced the abundance of suitable cavity trees, and continued reductions of large-diameter trees may therefore negatively impact future cavity development and Raccoon recruitment.

We estimated Raccoon relative density on the MWERF to be 1.5 individuals/km² (USDA APHIS Wildlife Services relative-density estimator protocol), which is considerably lower than comparable estimates from 2 other forested habitats in the state (6.8 and 7.0 individuals/km²; USDA APHIS Wildlife Services 2004), and substantially lower than reported in southwestern Pennsylvania (23.3 individuals/km²; USDA APHIS Wildlife Services 2004). Historically high interest in recreational Raccoon hunting with dogs likely contributed to low Raccoon densities throughout forested portions of the central and southern Appalachians (Hodges et al. 2000, Rogers 2012). However, as interest in Raccoon hunting has steadily declined in recent decades, Raccoon populations appear to be slightly increasing throughout the region (Rogers 2012), and it is doubtful that present-day Raccoon populations in the central Appalachians are limited solely by recreational harvest. Therefore, a reduction of suitable tree cavities may in part explain the low density of Raccoons on the MWERF, although several other factors (e.g., availability of food resources) likely also contributed to the observed densities.

On our study area and many other industrial lands in the region, forest-management practices include leaving uncut riparian management zones (RMZ) along stream corridors. Chamberlain et al. (2002) found that Raccoons on an intensively managed pine *Pinus* spp. forest in Mississippi frequently use hardwood riparian zones, in part because they offer access to free water—an important resource for Raccoons (Ghert 2003). RMZs provide the potential for future large-diameter trees and Raccoon den sites in managed forests; however, in our study, only 21% of the estimated available cavity trees occurred in this habitat type. Certain intermediate silvicultural treatments and harvests can also provide potential cavity trees via stem damage due to harvest operations, skid trail construction, and other activities throughout the tree-felling process. Forest-management practices may also produce alternate den structures such as log piles that can be used by Raccoons throughout the year. In forests where tree cavities are being reduced and rock-den abundance is limited, log piles could serve as important, albeit temporary, alternate den sites. Log piles may also provide den sites for a number of other meso-mammals including *Didelphis virginianus* Kerr (Virginia Opossum), *Mephitis mephitis* Schreber (Striped Skunk), *Urocyon cinereoargenteus* Schreber (Gray Fox), *Canis latrans* Say (Coyote), and even the lone large mammalian carnivore in the region, *Ursus americanus* Pallas (Black Bear).

Although Raccoons are highly adaptable and capable of using a variety of den resources for shelter and resting in managed forests, Raccoon abundance and recruitment can be influenced by the availability of tree cavities for use as maternal den sites (Beasley and Rhodes 2012, Beasley et al. 2011), and only mature, large-diameter trees appear capable of producing suitable tree-den sites. Therefore, local Raccoon population densities within industrial forestlands in the central Appalachians may be closely related to the presence and abundance of large-diameter den trees. Furthermore, because trees capable of producing cavities suitable for Raccoons are likely also useable by other, smaller den-seeking animals, Raccoons may serve as useful indicators that intensively managed forestlands contain sufficient large-diameter trees on the landscape, although further assessment would be necessary to determine the validity of Raccoons as a model species.

Raccoons likely benefited from harvest practices that increased certain den resources (i.e., log piles) and seasonally available food resources (e.g., *Rubus* spp. growth in regenerating forest stands; Miller et al. 2009); however, the overall effects of current forest-management practices and the reduction of suitable tree cavities due to intensive harvest may limit Raccoon abundance and alter local population dynamics (Beasley and Rhodes 2012). Consideration for the recruitment of large-diameter (dbh >50 cm) trees when implementing silvicultural treatments will therefore increase available den resources for Raccoons and other den-seeking animals within managed forests of the central Appalachians. The extent to which central Appalachian Raccoon populations are influenced by intensive forest management at larger spatial scales (e.g., within a mosaic of managed and unmanaged forests) needs further research to elucidate these effects as well as investigate the influence of forest-management strategies on other aspects of Raccoon demography (e.g., adult survival) and spatial use.

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