BLACK BEAR MARK TREES IN THE SMOKY MOUNTAINS

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Abstract: A total of 691 black bear (*Ursus americanus*) mark trees were located in the Great Smoky Mountains National Park. Mark trees along preselected index trails were tagged, physiognomic parameters around the trees measured, and characteristics of the tree and mark recorded. Trees along the index trails were reobserved periodically from April to December 1976–77 (biweekly between May and October) to monitor fresh marking. Eight different coniferous and 26 different hardwood species were marked; the choice of species apparently reflects their availability in areas of high bear use. Mark trees were located primarily along abandoned trails and ridge tops. Most fresh marking occurred during May, June, and July. Thirty-one percent and 23% of the mark trees along index routes exhibited fresh marks during 1976 and 1977, respectively. Reduction of aggression may not be the only function of marking. The incidence of fresh marking may be useful as an index to population density.

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Bear mark trees, sign posts, or scratching trees have puzzled naturalists and biologists for many years. The function of and motivation for bears' biting, clawing, and rubbing against trees have prompted a variety of theories. Most hypotheses have not been tested and none seem satisfactory for all the different types of bear marking.

Mills (1919) considered the trees as "information places" and did not speculate any further. Seton (1929) concurred and also suggested that they had the same function as the urinary signpost of the canids. Meyer-Holzapfel (1957) suggested marking might serve as some type of body care and possibly functioned in social communication. In a later paper she proposed that rubbing resinous objects on the body could reduce ectoparasite numbers (Meyer-Holzapfel 1968).

Tschanz et al. (1970) studied rubbing behavior in captive brown bears (*Ursus arctos*). They described seasonal, sex, and age differences in rubbing techniques and patterns. Responses when bears were moved between pits (enclosures) indicated that the marking bear may also use the marks as part of a spatial relations (orientation) system (Tschantz et al. 1970). Harger (1974) and Rogers (1977) found that most black bear marking occurred during or just prior to the breeding season. Shaffer (1971) found no seasonal pattern of visits of black and grizzly bears to mark trees in Montana. However, Shaffer marked all his trees with conspicuous red bands that could have altered normal marking behavior. Tschanz et al. (1970) and Rogers (1977) observed that most marking was done by adult male bears.

Most mark trees found by other investigators have been conifers (Mills 1919, Seton 1929, Dokken 1954, Meyer-Holzapfel 1957, Shaffer 1971, Rogers 1977); only Spencer (1955) and Rogers (1977) mentioned angiosperm mark trees. Mark trees are located along trails (Grinnell et al. 1937) and are marked on the portion of the tree facing the trail (Shaffer 1971).

Most mark trees are conspicuous and easily identified. The fresh mark is relatively permanent; consequently, marks are an ideal bear sign for continued observation. The marks may be useful as an index to population density. Spencer (1955) used signs (including mark trees) with limited success to estimate relative black bear abundance in Maine. Objectives of the present study included a descriptive study of mark trees and marking occurrence and an evaluation of the potential use of mark trees as a population index.

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STUDY AREA

This study was conducted within a 506 km^2 quadrant on the northwest side of the Great Smoky Mountains National Park (GSMNP). Access to the study area was limited to 64 km of improved roads, 88 km of unimproved roads, 400 km of maintained foot trails, and over 240 km of abandoned trails and railroad beds. Elevational range (270 to 2,024 m), varied topography, and high precipitation are responsible for a diverse and interspersed array of forest types. Major forest types included spruce-fir, (*Picea* spp. and *Abies* spp.), northern hardwood, open oak (*Quercus* spp.) and pine (*Pinus* spp.), closed oak, hemlock (*Tsuga* spp.), and cove hardwood (Whittaker 1956).

METHODS AND MATERIALS

Definition

Black bear mark trees must be distinguished from other bear "sign" associated with trees. Specifically a mark tree is not an aspen (*Populus* sp.) that has been climbed and retained the claw marks as reported by Minor (1946), and it is not a tree which has had its bark ripped off and its cambium eaten by a bear, as described by Poelker and Hartwell (1973). A mark tree is one that has been bitten or clawed, and possibly rubbed, by a bear at approximately the height of a standing animal such that the damage did not occur while feeding upon or climbing the tree. The mark will persist for a single season or several years, depending upon the intensity of marking and re-marking.

Fig. 1. Yellow pine (*Pinus* sp.) mark tree illustrating fresh mark of a black bear, GSMNP.

Data Collection

Beginning in August 1975, mark trees were located throughout the study area and identified, usually to species. Searches were conducted both on and off trails. Trails were classified as abandoned or maintained; maintained trails were classified into 2 categories as the Appalachian Trail or other trails. The Appalachian Trail represented a unique segment of trail in the study area because of the high visitor use and its topographic location. Off-trail searches were classified according to the type of search. Unstructured searches were conducted in the immediate vicinity of 6 well-used panhandler bear sites along the transmountain road in the spruce-fir forest type; 3 sites were located on the original road and 3 on a newer portion of the road. Twenty-five 1,000-m random transects were searched throughout the study area; 21 km of off-trail searches followed ridge tops, valley bottoms, or nothing (cross-country). These wilderness searches were conducted in all forest types, but not proportionately so.

Among the trails searched, 135 km of preselected trails were classified as index routes. These 6 routes had portions located in all major vegetation types. The routes were composed of 116 km of maintained trails (18 km of which are part of the Appalachian Trail) and 18 km of abandoned trails. Mark trees located on index routes were inconspicuously tagged with a permanent, numbered metal tag placed at the base of the tree away from the trail. The index routes were hiked biweekly from late spring (May) to early fall (October) and monthly as weather permitted during other months of 1976 and 1977. When a fresh mark or other change in a tree's appearance was observed, it was noted and a sketch of the mark was drawn for comparison during the following visits. For most mark trees along index routes, measurements of the tree and mark were made.

Chi-square tests were used in analysis unless otherwise specified.

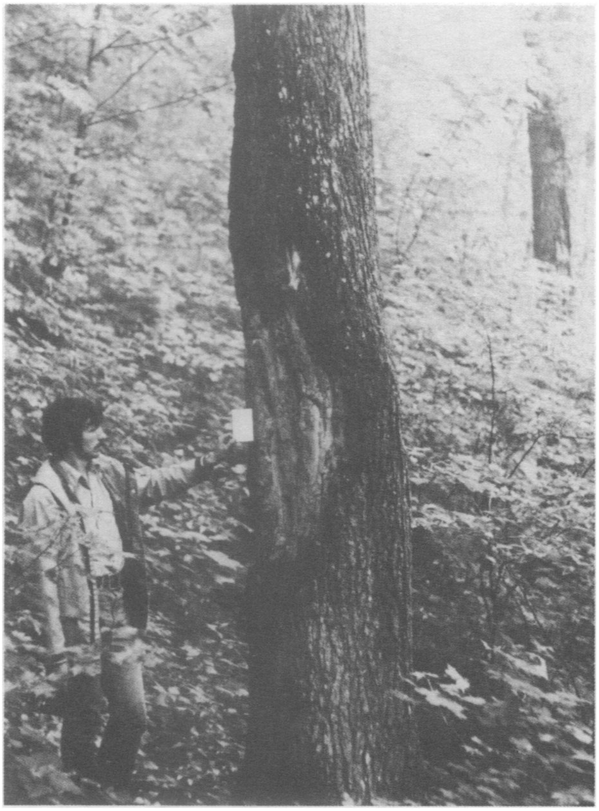

Fig. 2. Eastern hemlock (*Tsuga canadensis*) mark tree, GSMNP.

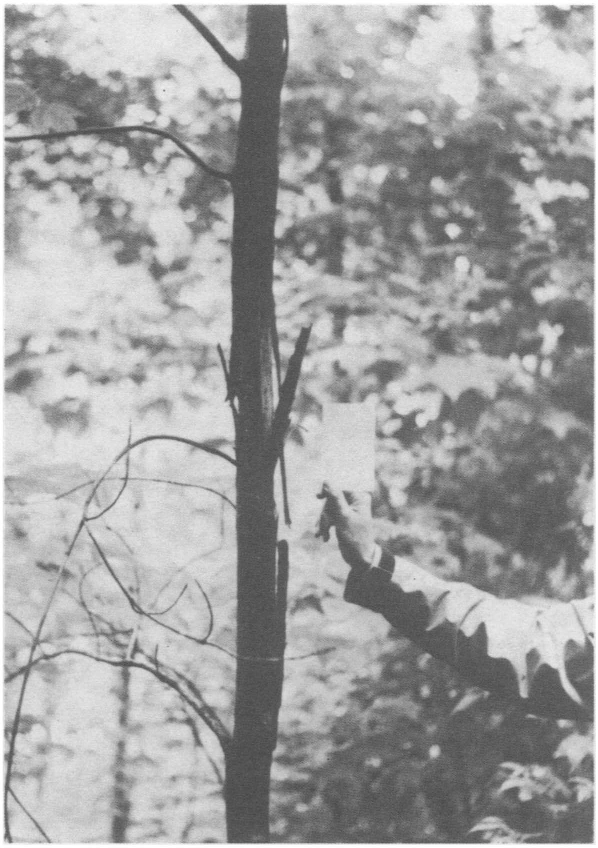

Fig. 3. Striped maple (*Acer pensylvanicum*) mark tree, GSMNP.

RESULTS AND DISCUSSION

Description of Mark Trees

Most marks were easily discerned by humans; the disruption of the bark pattern was severe. Marks were centered at 1.6–1.7 m above the ground and most often faced the trail and up the slope (Burst 1979). Bark, and often sapwood, was removed from the trunk of mark trees by the biting and clawing of bears (Figs. 1–5). Individual tooth and claw marks were obvious (Fig. 1). Sap commonly exuded from conifers (140 of 211 trees) and some hardwoods (7 of 204 trees) but was more noticeable on conifers. Bear hair and/or mud was sometimes stuck in the sap or to a rough place on the tree. The size of the scar varied with the size and species of tree marked and with the age, intensity, and number of marks (Figs. 1–5). Marking completely encircled 31 of 378 trees. The exposed sapwood on old marks eventually fades to a dirty gray; if not re-marked, bark grows over the scar.

Recent markings (Fig. 1) appeared yellow or red and were distinguished from older marks for up to 2 years and possibly longer; however, the mark did not appear fresh for this long. Fading of some new marks was detected in less than 2 weeks on some trees. More accurate aging of marks was generally not feasible.

While the size of some scars was relatively large (Burst 1979), fresh marks varied from only a single bite or scratch to multiple bites and scratches leaving fresh marks nearly as large as the previous scar (marks). Most fresh marks were small (Fig. 1).

The use of trees by bears for marking as opposed to the substrate has several advantages. The elevated mark and sap may help retention and dispersal of scent (Rogers 1977). The visible mark would also attract attention to the tree when the odor is not perceptible from a distance; however, the location of at least some mark trees is apparently known to resident bears (Mills 1919, Rogers 1977).

Fig. 4. Red maple (*Acer rubrum*) mark tree illustrating bulge at mark and typical spatial relation to the trail, GSMNP.

Fig. 5. Sugar maple (*Acer saccharum*) mark tree illustrating bulge at the mark and growth over old marks, GSMNP.

Angiosperm and gymnosperm mark trees and their marks differed considerably in appearance (Figs. 1–5 and Burst 1979). Marks were generally longer on gymnosperms ($\bar{X}$ = 84 cm, N = 205, SE = 3.62) than on angiosperms ($\bar{X}$ = 41 cm, N = 176, SE = 1.52). The angiosperms often had large conspicuous bulges at the location of the mark (Figs. 4 and 5); these were not so conspicuous on the gymnosperms. More bark was missing from the gymnosperms and the average gymnosperm was larger in diameter.

The different physical appearances of scars and marks on angiosperms and gymnosperms were apparently due to the properties of the wood and the tree's healing patterns as opposed to different marking behavior. Fresh marks were made at approximately the same times ($P > 0.25$) for both groups over 12 index trail periods during 1977. Proportionately and absolutely more angiosperms than gymnosperms received fresh marks during the study (Burst 1979).

Thirty-three different species of trees were marked, 8 gymnosperms and 25 angiosperms (Burst 1979). Only Spencer (1955) and Rogers (1977) have reported angiosperm mark trees; Spencer found no preference among species marked. Observations during this study indicate that preference and availability are both important in determining the species marked; however, preference can only be inferred from the low percentage (< 25%) of species marked.

Generally, pines were marked along dry ridge tops, but red maples (*Acer rubrum*), oaks, and sourwoods (*Oxydendrum arboreum*) were also marked frequently in these areas. Yellow birch (*Betula alleghaniensis*), siverbell (*Halesia carolina*), and American beech (*Fagus grandifolia*) were used at higher elevations. Red spruce (*Picea rubens*) and Fraser fir (*Abies fraseri*) were used almost exclusively in the spruce-fir forest type. The use of manmade trails has probably increased the variety of species marked because

Table 1. Frequency of black bear mark trees along different search and trail types in the Great Smoky Mountains National Park.

Search or trail type	Distance searched[a] (km)	No. of mark trees	Mark trees/km
Off-trail	58	67	1.1
Along ridge tops	9	48	5.2
Along valley bottoms	12	7	0.6
Cross-country	12	9	0.8
Line transects[b]	25	3	0.1
6 panhandler bear sites[c]		26	
On-trail	173	598	3.5
Index routes	135	448	3.3
Maintained trails	116	276	2.4
Appalachian trail	18	8	0.4
Other trails	98	268	2.7
Abandoned trails	18	172	9.3
Non-index routes	38	150	3.9
Maintained trails	25	72	2.9
Appalachian trail	13	15	1.2
Other trails	12	57	4.7
Abandoned trails	14	78	5.7

[a] All off-trail distances estimated; line transects were paced off.
[b] All 3 trees located on ridge tops.
[c] Not included in totals of trees/km calculations.

86% of the off-trail mark trees were found along ridge tops and valley bottoms (Table 1).

In addition to trees, front porch posts and various types of sign posts (with and without creosote) were marked. Harger (1974) reported marked telephone posts and Tschanz et al. (1970) reported rubbing activity on the walls of zoo bear pits. A live tree is not requisite as a marking post.

Distribution in Space

If the tree was not along a manmade trail, ridge top, or valley bottom, there was a distinct game trail passing close to the tree. These game trails were usually short and hard to follow but were more distinct near mark trees. Along ridge tops with distinct game trails, mark trees were sometimes found 1–3 m from the main game trail but having paths leading to the mark tree and back to the main trail. Such paths were less than 5 m long and had distinct track-like depressions in the duff that appeared to have been formed over several years by repeated visits to the tree. Most mark trees found along index routes were adjacent to the trail (74%); the farthest from the trail was 15 m. Seventy-five percent of mark trees along index routes were on the downhill side of the trail (Burst 1979).

The number of mark trees found per km of searching varied with trail and search type (Table 1). The differences were significant ($P < 0.05$) in many cases. Abandoned manmade trails and ridge tops had more mark trees per km searched than any other type of trail. The Appalachian Trail and valley bottoms had the fewest mark trees per km of trail. Cross-country walking and line transects also resulted in few mark trees per km. Trails along index routes were compared separately because the trails were walked so often; therefore, it is felt that a greater percentage of marked trees along these trails were located. A higher proportion of mark trees was found along trails with low visitor use; this was expected because of the high occurrence of scats reported in these areas by Matthews (1977).

Rogers (1977) found that mark trees in Minnesota were located in open areas with less vegetation; he proposed that sparse vegetation would allow better odor dispersal. While open areas are scarce in the Park, ridge tops could serve a similar function. The abundance of mark trees along ridge tops could simply be coincidental to the bears' use of ridges as travel lanes.

The location of mark trees along trails would increase the efficiency of a communications system involving the trees and would also make relocation of the trees easier for bears in rarely visited areas. It is also possible that bears maintain trails (through use) to all mark trees, although the large number of mark trees makes this improbable. It seems unlikely that all mark trees found along trails were completely coincidental to the bears' extensive use of those trails.

The distribution of mark trees along the index routes appeared clumped to researchers walking index routes; however, "runs up and down tests" (Gibbons 1976:371–377), of the distance from the last mark tree indicated that the distribution was clustered for only 1 index route ($P < 0.05$). (The median was arbitrarily given the value of 100 m). Other index routes exhibited either randomness or slight mixing.

Extensive searches for mark trees at 6 known panhandler bear sites along the transmountain and Clingman's Dome roads yielded 27 mark trees. Of the 6 panhandler bear sites searched, the 3 along the more recently constructed portion of the transmountain road yielded only 1 mark tree. Panhandling activity was essentially equal at all sites. The lack of mark trees near panhandler bear sites by the newer road probably relates to the bears' traditional habits.

Table 2. Number and percentage of fresh marks found each 2-week index route period (1 May–15 October) with cumulative totals for 1976 and 1977, Great Smoky Mountains National Park.

Period	Number		Percentage		Cumulative total		Total
	1976	1977	1976	1977	1976	1977	
1–8 May	18	10	12	18	18	10	28
20–22 May	4	15	3	12	22	25	19
4–8 Jun	25	17	17	14	48	42	43
17–20 Jun	24	18	16	14	72	60	42
2–5 Jul	5	12	3	10	77	72	17
15–19 Jul	26	18	17	14	103	90	44
29 Jul–1 Aug	23	7	15	6	126	97	30
12–15 Aug	3	6	2	5	129	103	9
25–29 Aug	3	5	2	4	132	108	8
9–12 Sep	4	6	3	5	136	114	10
23–27 Sep	4	5	3	4	140	119	9
7–10 Oct	9	6	6	5	149	125	15
Total	149	125	100	100			274

Distribution Over Time

Evidence indicated that mark trees were frequently used for many years. Ninety percent of the fresh marks on the index routes were on previously marked trees. The track-like depressions in game trails seldom used (by man) and the sheer size and appearance of some mark trees and groups of mark trees also indicated a long history of marking. However, the largest mark trees, which usually have large marks, are not open to the tree's center at the mark. This would not be true if it had been marked frequently since the tree was small. One of the largest mark trees found (a 106-cm dbh eastern hemlock, *Tsuga canadensis*) had a very small mark. Other large mark trees had a flattened front with a bulge on the back and sides which is typically found on injured trees. Frequent marking over many years would prevent symmetric growth around the tree and predispose it to wind breakage, eliminating that type of tree. Thirty-three mark trees broke off during the study.

Marking Occurrence

Amount.—In 1976, 399 mark trees were found along index routes; in 1977, 54 additional trees were found along the same routes. Less than 21% of the trails in the study area produced 448 standing mark trees at the end of 1977.

In 1976, 152 fresh marks were found on 125 different trees along index routes. Marking activity declined to 126 fresh marks on 104 trees during 1977. The difference between years in the numbers of fresh marks or trees marked prior to mid-October (Table 2) was not significant ($P > 0.05$) for the whole study area or for any individual index route (Burst 1979).

Periodicity.—The distribution of fresh marks among index periods was not random (one sided Kolmogorov-Smirnoff test, $P = 0.01$ for the value 18) (Table 2). During 1976, the number of fresh marks declined after 1 August; a similar decline occurred 2 weeks earlier in 1977 (Table 2). In 1977 the number of fresh marks after 2 August did not differ from the number prior to that date (one-sided Z-test, Hays 1973:724, $P < 0.05$). "A" runs up and down test (Gibbons 1976:371–377) over time for all trails indicated that the marking was clustered prior to mid-July during 1977 ($P = 0.002$).

Individual index routes with greater than 15 fresh marks per year exhibited a slightly different pattern; in each instance the marking frequency peaked on 1 weekend or 2 consecutive weekends and was low on all other weekends (Burst 1979). When marking frequency peaked on 2 weekends, the peaks were smaller and consecutive. Peaks occurred at different times on different routes. Bears in different areas apparently respond to different levels of factors initiating marking, or the levels of factors themselves vary.

Mechanics and Function

Mechanics of marking.—Marking behavior in most species is primarily associated with glandular scent deposition. Consequently the apparent lack of external scent glands would be of paramount importance in the development of marking behaviors in bears. The ability to perceive

Table 3. A comparison of characteristics of bear tree marking with 8 marking characteristics reported for other mammalian species (Thiessen and Rice 1976).

Characteristic of marking reported in several mammals	Agreement	Source and discussion
Sexually dimorphic	Yes	Tschanz et al. 1970, Rogers 1977.
Age dependent	Yes	Tschanz et al. 1970, Rogers 1977.
Seasonal development	Yes	Tschanz et al. 1970, Rogers 1977, this paper.
Circadian	No information	
Dominance related	Possibly	Rogers 1977; scant positive data, but no negative data.
Stimulated by agression	Yes	Rogers 1977, J.E. Tate 1979 (pers. comm. Univ. of Tenn.).
Stimulated by sex	No positive information	Lack of positive information could be construed as negative data.
Androgen dependent in males	Probably	No laboratory data, but Rogers (1977) reported that male black bears marked most while serum testosterone levels were highest.

and distinguish nonchemical signals should also be important. These ideas are important in the conceptualization of a combined visual and chemical marking system.

Obviously, mark trees contain both visual and chemical signalling capacities. Bacon (1973) reported that black bears possess excellent visual acuity for both hue and shape. Rogers (1977) reported that he could distinguish the odor of bears on a recently marked tree, and Tschanz et al. (1970) noted that captive brown bears sniffed each other's marks. Consequently bears are well equipped to perceive both chemical and visual signals, and both types of signals are present at mark trees.

Why are there 2 signals? Ewer (1973:242) suggested that visual and chemical signals used together may complement each other. Rogers (1977) suggested that the elevated mark would help disperse the scent and that the tree's sap may help in retention of scent. It is also possible that 1 signal (potentially either, but most likely the visual one) simply designates the location of the other signal. Regardless of the specific information available at a mark tree, 2 modes (chemical and visual) of information transmission are available and perceptible to the bear; consequently, both modes are likely to be in use.

In order to leave a signal on a mark tree, bears assume specific postures and engage in specific behaviors, i.e., rubbing, biting and clawing (Tschanz et al. 1970, Rogers 1977). These postures and behaviors have special significance in the development of marking. Ewer (1968) stated that marking glands should develop in areas already having contact with the environment. The dorsal surface of the body is the most difficult for a bear to reach with its paws and mouth and is the most likely to be rubbed on other objects as a form of grooming (Jordan 1979); this portion would then likely be used in marking. Tschanz et al. (1970) reported just that; however, most portions of the body were rubbed at times. The apparent absence of a marking gland should again be emphasized, and it should also be noted that in the process of biting and clawing trees, saliva or an unfound interdigitary gland (Jordan 1979) may come into function. Urination while marking trees was reported by Tschanz et al. (1970) and Shaffer (1971). However, neither author observed a high incidence of this behavior. Consequently, the function of urine as a component of marking is still in question.

Function.—Though most authors now refer to behaviors associated with bear mark trees (or some artificial substitute) as marking behaviors (Meyer-Holzapfel 1957, Tschanz et al. 1970, Rogers 1977, Jordan 1979), some skeptics may remain. Rogers (1977) stated that proposed non-marking functions failed to account for sex- and age-related differences in the frequency of the behavior. A more convincing case can be made by comparing characteristics of bear marking with pattern of marking in species with identified scent glands and well-known marking repertoires. Thiessen and Rice (1976) noted 8 characteristics of marking in 12 diverse species. Bears are not known to violate any of the 8 characteristics and satisfy most of them (Table 3). Only 1 of the 12 species satisfied all 8 characteristics.

Given that marking by bears is a form of social communication, a wide range of possible functions remains. Ewer (1968:104–105) describes how an animal's own scent scattered throughout its home range can become a signal of ownership, reassuring the owner and even threatening transients and neighbors. Hornocker (1969) reported a mutual avoidance system in mountain lions (*Felis concolor*) probably involving the use of scrapes. Eaton (1970) demonstrated the use of a "moving territory" demarcated by urine scent marks in the cheetah (*Ancinonyx jubatus*). Rogers (1977), noting Hornocker, Eaton, and other authors, proposed that dominant male bears (in aggressive moods) mark trees so that other males could better avoid mutually damaging conflicts. Tschanz et al. (1970), Rogers (1977), and this study have all shown that marking frequency is greatest prior to and during the breeding season. Tschanz et al. (1970) and Rogers (1977) both demonstrated that marking was done by adult male bears. Rogers (1977) speculated that there should be strong natural selection for the scent (presumably at mark trees) of mature male bears to promote estrus, thus synchronizing it with the male's presence.

The above hypothesis would explain the high frequency of marking several weeks prior to the breeding season. Second, in the GSMNP, marking within 1 km (along the trail) of capture sites of estrous females (based on swollen vulvas) occurred several weeks prior to estrus (capture data). This was true for 3 females captured in 1976 and 1977. No further intensive marking occurred along index routes near any of the capture sites.

Marking by females and marking after the breeding season are unexplained. Tschanz et al. (1970) found that marking by females peaked at the end of the moult. In addition, Tschanz et al. (1970) reported that captive brown bears used their marks as part of a spatial relations systems. Rogers (1977) only observed 3 incidents of females marking, all in late summer or early fall. Widespread movement by black bears in the GSMNP occurs in late summer and early fall in response to the mast crop (Beeman 1975, Garshelis 1978). Marking is known to increase in several species upon entrance to new areas (Ralls 1971). Marking may be of use in orientation during visits to new or rarely visited areas.

Population Index Potential

While this study did not demonstrate a relationship between the incidence of fresh marks and population density, marks offer potential as a population index. Data from the present study indicate that marks are a visible, identifiable, accessible, and persistent sign. Environmental factors such as rain or snow are less likely to affect the detectability of marks as compared to other signs such as scats or tracks. Because of the above, we feel this may be a more reliable index than other types of bear signs. However, marking may involve several different behaviors or sex or age classes; the ability to discriminate among these components may be necessary in order to monitor the population, since population changes could selectively affect the different behaviors.

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