APPLICATION OF HARVEST DATA TO EXAMINE RESPONSES OF BLACK BEARS TO LAND-USE CHANGES

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Abstract: Habitat of black bears (*Ursus americanus*) in the eastern United States has been substantially altered by increases in human populations and associated habitat change. Radio telemetry has been the primary technique used in examining the effects of development on bears. However, most state agencies do not have the resources necessary to collect long-term telemetry data, but do routinely collect annual harvest data to monitor trends in their bear populations. We investigated the potential use of annual harvest data for assessing impacts of habitat alteration on local bear abundance. We compared bear harvests within townships of New Hampshire to changes in human populations, road densities, and land-use patterns during 1961-84. Harvests tended to be negatively related to human-population density, roads in town, roads subject to bars and gates, and developed land. Harvests tended to be positively related with national forest roads and agricultural land. Comparisons of long-term harvest data with human demographic variables also may provide baseline information on threshold densities of human demographic variables that affect local bear abundance. However, before accurate conclusions can be reached, additional information is required to improve the sensitivity of the harvest data. We recommend that wildlife managers index hunter effort, monitor the availability of major foods used by bears, and verify the exact location of each bear kill.

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During the past century, the habitat of black bears in the eastern United States has been severely reduced and fragmented by expanding human populations. Black bears in the southeastern United States occupy only 5-10% of their historic range (Maehr 1984), and only a few regions of the northeastern United States support harvestable populations (Maehr and Brady 1984). Although the effects of habitat deterioration on black bear populations have been documented (Cardoza 1976, Manville 1983, Maehr 1984, Pelton and Burghardt 1985), few data exist on how the progression of habitat alteration influences local bear abundance. Radio telemetry has been the primary technique used in studies examining the effects of development on bears (Manville 1983, Tietje and Ruff 1983, McLellan and Shackleton 1988, Brody and Pelton 1989). However, many state wildlife agencies do not have the resources necessary to collect long-term telemetry data, but routinely collect annual harvest data to monitor trends in their bear populations (Carlock et al. 1983). We investigated the potential use of annual harvest data to assess the effects of habitat alteration on the local abundance of bears. Specifically, we examined the relationships between annual harvests of bears and changes in human populations, road densities, and land-use patterns in New Hampshire from 1961 to 1984. During those 24 years, human population in New Hampshire increased approximately 57% (U.S. Bureau of the Census 1962, 1990), accompanied by substantial habitat alteration.

METHODS

We obtained annual statewide bear harvest records from 1961 to 1984 from the New Hampshire Fish and Game Department. In 1961, the first firearm season for hunting black bears in New Hampshire was established. Bear hunting regulations remained relatively unchanged in the state until 1971, when a limit of 1 bear per hunter was implemented. Major revisions in the hunting regulations occurred in 1985, when the bear hunting season was closed in the 7 southern counties of the state (Orff 1987). Therefore, we restricted our study period from 1961 to 1984.

Information on hunter effort was not available during the study period, and data from 1962 were excluded from the analysis because of incomplete records. Annual bear harvests were tallied by townships (Fig. 1). Townships without any harvests were excluded from the study, and those <30 km^2 were combined with adjacent townships to reduce the variation associated with small samples. We calculated the average annual kill for each township for 5 intervals (1961-65, 1966-70, 1971-75, 1976-80, and 1981-84), multiplied the averages by 100, and standardized the results by dividing by the km^2 for each township (N = 91-120). These data were then ranked and divided into 5 equal groups (quintiles) in order to facilitate comparisons between harvest levels.

Human populations for each township were obtained for 1960, and annually from 1964 to 1984 from the New Hampshire Office of State Planning. We estimated missing population data using the average rate of change between 2 known data points. We then calculated the average population density per township for the 5 intervals. The abundance of roads within each township (1960-85, 5-year intervals) were obtained from the New Hampshire Department of Public Works and Highways. Roads were grouped into 7 classes (Table 1), and road densities for each township were

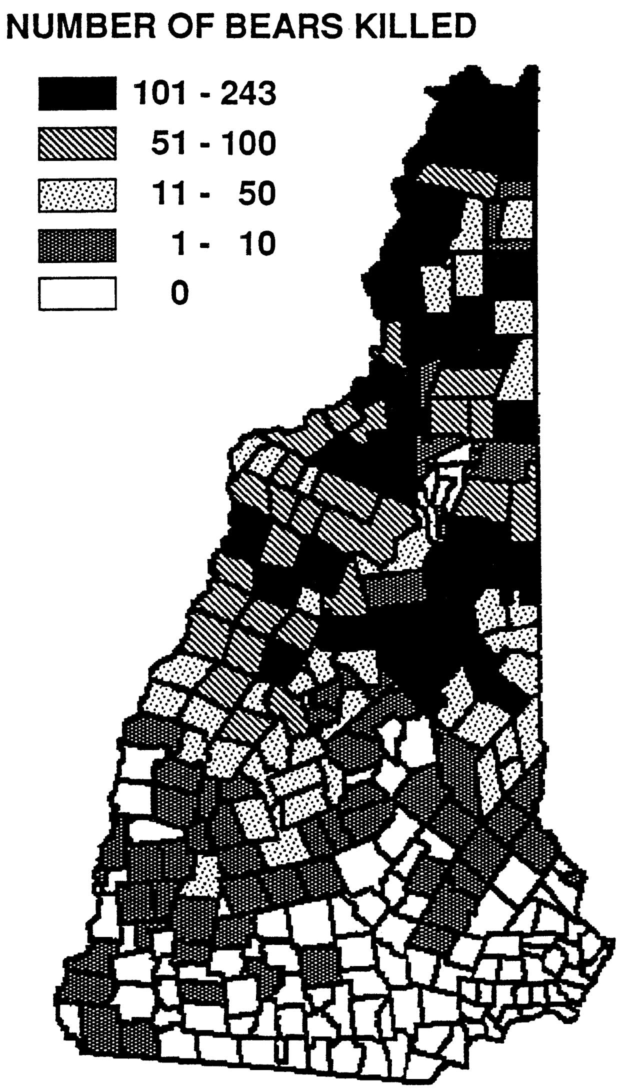

Fig. 1. Harvest distribution of black bears in New Hampshire from 1961 to 1984.

calculated by dividing the total km of each road class within a township by the total km^2 of each township. Road densities were calculated for each of the 5 time intervals. We used 5 land-use classes compiled by the U.S. Agricultural Stabilization and Conservation Service for 1950 and 1970 (Table 2). The 1950 land-use data were compared to the harvest intervals 1961-65 and 1966-70, and the 1970 land-use data were compared to the harvest intervals 1971-75, 1976-80, and 1981-84. The information obtained from the land-use data may be limited, however, because a large proportion of development occurred in New Hampshire during the late 1970s.

Table 1. Definitions of road classes as defined by the New Hampshire Department of Transportation.

Class	Definition
Class 1	Primary state highway system (2-4 lane).
Class 2	Secondary state highway system (2 lane).
Class 3	Recreation roads (2 lanes).
Class 4	Highways within cities and towns with human populations greater than 3,000.
Class 5	Town roads regularly maintained (2 lane).
Class 6	All other public ways including those discontinued as open highways and made subject to bars and gates (1-2 lane).
Class 7	National forest and forest development highways not otherwise classified (primarily gravel 2 lane).

Table 2. Definitions of land uses as defined by Befort et al. (1987).

Land use	Definition
Agriculture	Tilled cropland, pasture, haylands, orchards, nurseries, greenhouses, and other open areas being cultivated, hayed or mowed.
Developed	Residential, commercial, industrial and recreational lands including extractive operations, powerline routes, golf courses, ski areas, and cemeteries.
Forest	Land supporting tree growth with a minimum of 30% canopy closure.
Idle	Former agricultural land reverting to forest, and cutover forest land.
Other	Swamps, marshlands, beaches, open sand and bare rock areas.

We used nonparametric statistics because the harvest data were not normally distributed (Zar 1984). Within each time interval, Kruskal-Wallis tests were used to examine differences in human densities, road densities, and percent coverage of each land class among the 5 harvest groups. Comparisons between time intervals were not made because of the large amount of inherent variability in the harvest data between time intervals. The accepted level of significance was adjusted to an alpha of 0.004 using the Bonferroni t procedure because multiple Kruskal-Wallis tests were performed (Kirk 1982). If the Kruskal-Wallis test was significant, Mann-Whitney U-tests were then used to examine group differences within a time interval (Zar 1984). Although many of the variables examined in this study may interact and their combined effects on local bear abundance are important, we chose a univariate approach in order to more accurately evaluate the potential of harvest data for assessing impacts of human demographic variables on local bear abundance.

RESULTS

No statistically significant relationships were found between the bear harvests and the human demographic variables examined (Table 3). However, a number of general trends were evident between the harvest rates and certain human demographic variables. A downward trend was apparent between human density and the number of bears harvested (Fig. 2). Towns with high bear kills generally had smaller human densities than towns with low bear kills. In addition, town roads, roads subject to bars and gates (road classes 5 and 6, respectively; Fig. 3), and developed lands (Fig. 4) also exhibited downward trends with the bear harvest. In contrast, density of national forest roads (road class 7, Fig. 3) and agricultural lands (Fig. 4) tended to be positively related with the bear harvest.

Table 3. All *P*-values of Kruskal-Wallis tests for 5 time periods comparing townships having similar black bear harvest rates to human densities, road densities, and percent coverage of 5 land classes.

	Period of black bear harvest rates				
Variable	1961-65	1966-70	1971-75	1976-80	1981-84
Human densities	0.887	0.235	0.763	0.302	0.166
Primary highways	0.185	0.280	0.764	0.965	0.458
Secondary highways	0.332	0.815	0.404	0.477	0.245
Recreation roads	0.640	0.726	0.698	0.382	0.373
Highways within towns	0.064	0.193	0.726	0.201	0.899
Town roads	0.537	0.052	0.607	0.249	0.201
Roads subject to bars and gates	0.388	0.031	0.647	0.030	0.483
National forest roads	0.888	0.005	0.209	0.036	0.037
Agricultural lands	0.043	0.241	0.288	0.099	0.272
Developed lands	0.909	0.569	0.083	0.038	0.029
Forested lands	0.270	0.888	0.848	0.126	0.047
Idle lands	0.321	0.323	0.344	0.189	0.071
Other lands	0.063	0.094	0.140	0.006	0.044

[a] Accepted level of significance equals 0.004 because of multiple comparisons.

DISCUSSION

The general downward trends between the bear harvest and the density of human population (Fig. 2), town roads (Fig. 3), and developed lands (Fig. 4) found in this study are supported by results of other studies that used radio telemetry (e.g., Manville 1983, McLellan and Shackleton 1988, and Brody and Pelton 1989) and demonstrate the utility of harvest data for assessing the impacts of human encroachment and urbanization on local bear abundance.

In addition, the general upward patterns between the bear harvest and the density of national forest roads (Fig. 3) and agricultural lands (Fig. 4) are also supported by studies that utilized radio telemetry (e.g., Manville 1983, Meddleton and Litvaitis 1990, Hellgren et al. 1991). Agricultural lands are an important habitat component of bears in the Northeast, and provide a supplemental food source during the summer and fall months, especially during years of hard-mast failure (Cardoza 1976, Willey 1978, Mclaughlin and Matula 1985).

The apparent upward trend found between the bear harvest and agricultural lands may also be a reflection of an increase in vulnerability of bears to hunters due to the localized food supply and the greater visibility in these more open areas (Kane 1989). Likewise, the upward trend found between the bear harvest and the density of national forest roads also may be related to an increase in vulnerability of bears to hunters as access into the national forest increases (Manville 1983, Brody and Stone 1986, McLellan and Shackleton 1988, Brody and Pelton 1989).

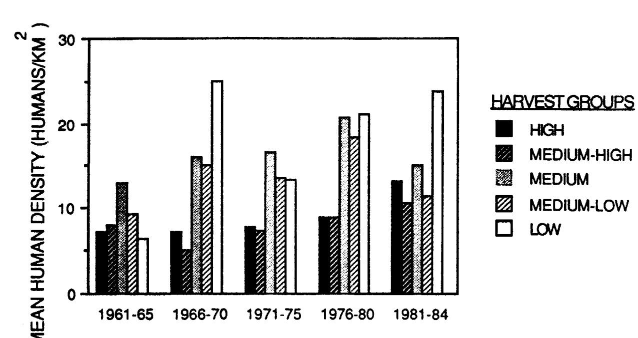

Fig. 2. Mean human density (humans/km^2) of townships in New Hampshire having similar harvest rates (high harvest group = top 20% of townships ranked by harvest rate, low harvest group = bottom 20% of townships ranked by harvest rate).

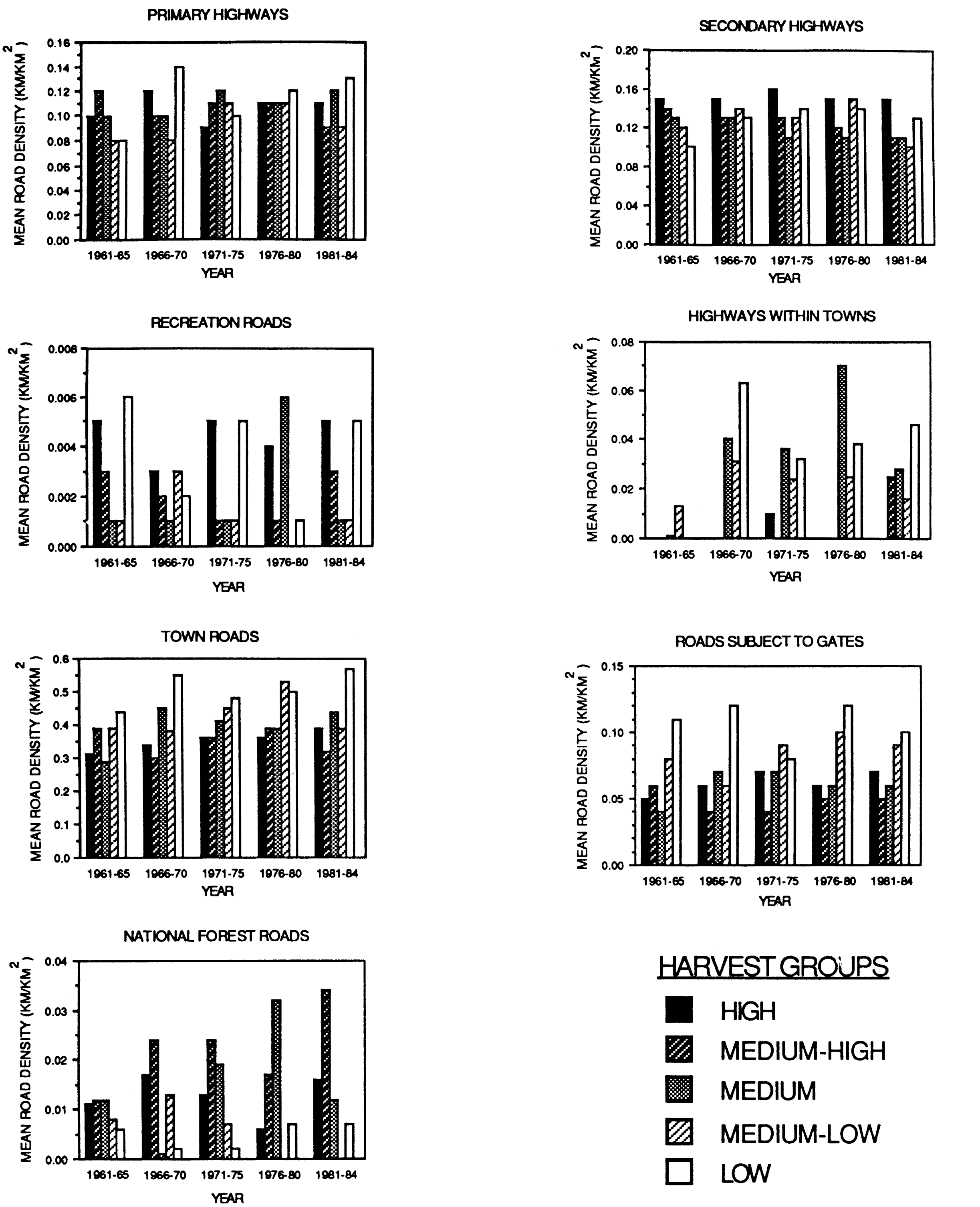

Fig. 3. Mean density of 7 road classes (km/km^2) of townships in New Hampshire having similar harvest rates (high harvest group = top 20% of townships ranked by harvest rate, low harvest group = bottom 20% of townships ranked by harvest rate).

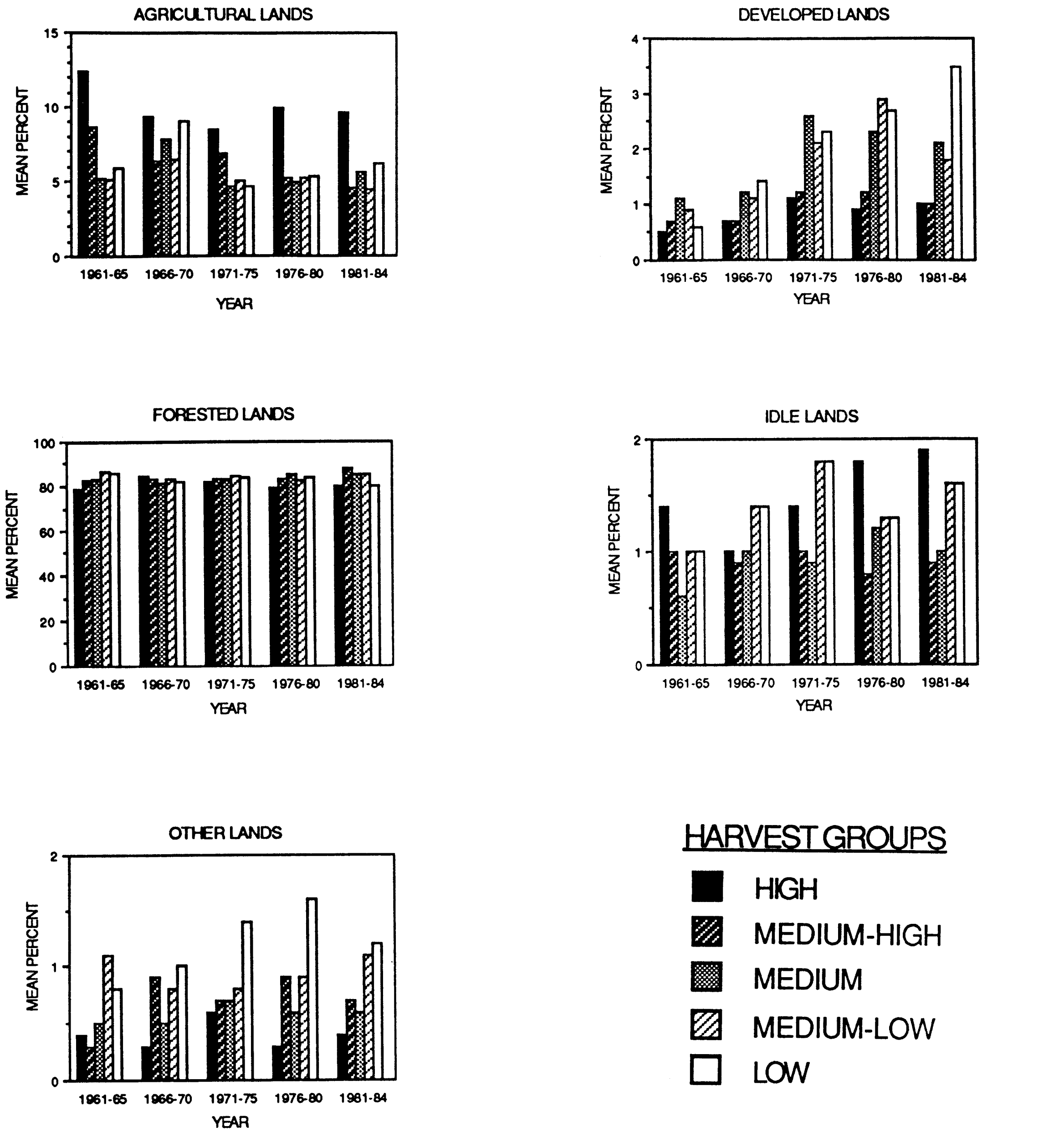

Fig. 4. Mean percent coverage of 5 land classes of townships in New Hampshire having similar harvest rates (high harvest group = top 20% of townships ranked by harvest rate, low harvest group = bottom 20% of townships ranked by harvest rate).

To our knowledge there are few reported estimates of threshold levels for human demographic variables that impact local bear abundance. Such threshold levels may begin to be estimated by comparing long-term harvest data with human demographic variables. For example, in Figure 2, there is an approximate delineation between the high and low harvest groups among the 5 time periods at a human density of approximately 10 humans/km^2.

Other threshold levels also may be estimated for variables that show apparent trends with the harvest data. The density threshold level for town roads (road class 5) can be estimated at approximately 0.4 km/km^2, and for roads subject to bars and gates (road class 6) at approximately 0.06 km/km^2 (Fig. 3). At thesethreshold levels, bears may begin to be adversely affected or displaced. In Norway, Elgmork (1978) reported that observations of brown bears (*Ursus arctos*) declined 5-fold as road densities increased from 0.1 km/km^2 to 0.75 km/km^2. The density threshold level for town roads estimated in this study is within the range reported by Elgmork.

Although a threshold level is not apparent for the density of national forest roads (road class 7) in this study (Fig. 3), comparisons may be made between the relative densities of roads in national forests. For example, Brody (1984) reported that bears in the southern Appalachians began to avoid national forest roads at densities of 0.5 km/km^2. Results of our study indicate that the density of roads in the White Mountain National Forest are well below that level, and therefore, bears in the White Mountain National Forest may not yet exhibit this avoidance behavior. However, the road data used in this study do not account for private roads and logging roads, which are extensive within the White Mountain National Forest (K. Garfield, N.H. Dep. of Transportation, pers. commun.). Furthermore, information on traffic volume should be assessed before valid comparisons can be made between the relative densities of roads in different regions (Beringer et al. 1989).

CONCLUSIONS

The objective of this study was to examine the potential use of annual harvest data for assessing the impacts of human demographic variables on local bear abundance. Although harvest data are useful for monitoring population trends (Downing 1980), additional information is required to accurately evaluate those trends. Caution must be used when interpreting the results of this study because data were not available on hunter effort during the study period. However, the general relationships between the harvest data and human demographic variables found in this study were logical and are supported by results from studies that used radio telemetry.

Results of this study indicate that annual harvest data may have the potential for assessing impacts of human demographic variables on local bear abundance if the sensitivity of the harvest data are increased. In addition, comparison of long-term harvest data with human demographic variables may provide baseline information on threshold densities that are critical to future management of bears. To improve the sensitivity of the harvest data, we recommend that agencies implement several procedures. First, hunter effort needs to be estimated to standardize the data and reduce the variability of the harvest between years. This could be accomplished by a simple questionnaire asking hunters what species they intend to hunt. A more accurate method would be the mandatory purchase of an inexpensive bear-hunting stamp. Second, an index of annual food abundance should be established, particularly for hard mast, because the sensitivity of the harvest data is related to autumn food availability (Kane 1989). A simple ocular index of mast abundance would allow annual fluctuations in the bear harvest to be monitored in relation to the spatial distribution of mast availability in each township. Finally, verifying the location of each bear kill would improve the accuracy of the harvest data. Successful hunters could be asked at check stations to locate the site of their kill on a topographic map.

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