USDA

United States
Department of
Agriculture

Forest Service

Northeastern
Research Station

Research Paper NE-727

Response of Eastern Chipmunks to Single Application Spring Prescribed Fires on the Fernow Experimental Forest

Ella L. Rowan
W. Mark Ford
Steven B. Castleberry
Jane L. Rodrigue
Thomas M. Schuler

Abstract

We used radiotelemetry to examine the effects of spring prescribed fire for preharvest oak (*Quercus* spp.) shelterwood management on eastern chipmunk (*Tamias striatus*) home-range attributes and burrow use on the Fernow Experimental Forest in the central Appalachian Mountains of West Virginia. Results for 21 chipmunks showed that prescribed fire had little discernable effect on home-range or core-area size, extent of conspecific overlap, or burrow use. Fire tolerance of this common forest rodent provides additional evidence supporting the use of prescribed burning to achieve vegetation management objectives in the central Appalachians where appropriate.

Authors

ELLA L. ROWAN is a graduate research assistant, D.B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602.

W. MARK FORD is a research wildlife biologist, USDA Forest Service, Northeastern Research Station, Parsons, WV 26287.

STEVEN B. CASTLEBERRY is an associate professor, D.B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602.

JANE L. RODRIGUE is an ecologist, USDA Forest Service USDA Forest Service Northeastern Research Station, Parsons, WV 26287.

THOMAS M. SCHULER is a research silviculturist, USDA Forest Service, Northeastern Research Station, Parsons, WV 26287.

Manuscript received for publication 25 April 2005

Cover Photo: Eastern chipmunk (*Tamias striatus*) that has been ear-tagged.

Published by:
USDA FOREST SERVICE
11 CAMPUS BLVD SUITE 200
NEWTOWN SQUARE PA 19073-3294

August 2005

For additional copies:
USDA Forest Service
Publications Distribution
359 Main Road
Delaware, OH 43015-8640
Fax: (740)368-0152

Visit our homepage at: **http://www.fs.fed.us/ne**

Introduction

Composition in many central Appalachian forest stands has been shifting from oak-dominated species to mast-poor, shade-tolerant species. This shift has occurred through natural processes and anthropogenic influences such as fire suppression and timber harvesting without regard for regeneration. The resulting stands dominated by red maple (*Acer rubrum*), sugar maple (*A. saccharum*) and American beech (*Fagus grandifolia*) often are less beneficial to many wildlife species (Schuler and Gillespie 2000, Schuler 2004). Future reductions in acorn production from a declining oak component and/or the failure to successfully recruit oak into future forests will have serious implications for both game and nongame species in the region (Wentworth et al. 1992, Wolff 1996, McShea 2000, Castleberry et al. 2001). Regionally, forest managers are experimenting with preharvest and postharvest prescribed fires to: 1) reduce or inhibit advance regeneration of shade-tolerant, late successional species prior to harvest; 2) select against mast-poor, shade-intolerant species such as yellow-poplar (*Liriodendron tulipifera*) that show rapid growth characteristics following harvest; and 3) promote oak seedling recruitment preharvest and competitive oak stem retention postharvest (Barnes and Van Lear 1998, Brose and Van Lear 1998, Brose et al. 1999). Although the maintenance or enhancement of the oak component usually is beneficial to forest wildlife, the reintroduction of fire in moderate to mesic communities after decades of suppression has unknown effects on many ecosystem attributes, including wildlife (Brose et al. 2001).

Eastern chipmunks (*Tamias striatus*; hereafter "chipmunk") could represent a potential model species for assessing prescribed fire effects on common ground-dwelling fauna in eastern deciduous forest types. Chipmunk diets include understory vegetation, soft fruits, fungi and inverterbrates in the spring and summer and they rely heavily on acorns and other hard mast in the fall and winter (Aldous 1941, Martin et al. 1961, Elliott 1978, Wrazen and Svendsen 1978, Mahan and Yahner 1996, Whitaker and Hamilton 1998). As larder hoarders, chipmunks serve valuable functions in forest ecosystems as dispersers of acorns and other plant seeds (Steele et al. 2001). Moreover, they are an important prey for numerous other vertebrate (Whitaker and Hamilton 1998).

Although numerous live-trapping studies have estimated home-range size for chipmunks in undisturbed habitats (Blair 1942, Smith 1942, Manville 1949, Yerger 1953 and 1955, Forbes 1966, Dunford 1970, Forsyth and Smith 1973, Ickes 1974, Mares et al. 1976, Elliott 1978, Lacher and Mares 1996), reliable radiotelemetry data on home-range structure and variability are lacking for chipmunks in eastern deciduous forests treated with prescribed fire. Moreover, Hackett and Trevor-Deutsch (1982) and Bergstrom (1988) found live-trapping greatly underestimated chipmunk and various other *Tamias* spp. home-range size when compared to radiotelemetry estimates. Generally, there is considerable amount of overlap among individual chipmunk home ranges at the local scale (Blair 1942, Yerger 1953, Forsyth and Smith 1973, Ickes 1974, Elliott 1978, Getty 1980, Getty 1981a), although to date no research actually has quantified overlap extent or whether this is in response to resource availability.

Nonetheless, chipmunk home ranges are not static, with home-range size fluctuating with resource availability (Allen 1938, Mares et al. 1976 and 1982, Mares and Lacher 1987, Getty 1981b, Bowers et al. 1990) and reproductive condition (Bowers and Carr 1992). As larder hoarders, hard-mast caches are vital to their survival during low-forage availability periods, such as early spring prior to green-up and substantial soft fruit production. Cache defense and predation risk may limit distances animals will venture from their burrows, thereby confounding the resource availability hypothesis to some degree (Elliott 1978, Anderson 1978, Taylor 1988). Chipmunk use of plants and fungi during the spring and early summer might be impacted severely in the initial growing seasons after a prescribed fire. Additional reduction in vegetative cover also could increase their exposure to avian and mammalian predators. In the near term, spring fires often decrease initial growing season forage resources to force increased home-range size for rodent species with some ecological similarity to chipmunks (Harestad and Bunnell 1979, Mares et al. 1982, Ostfield 1986, Ims 1987, Jones 1990, Castleberry et al. 2001). Accordingly, the objectives of our study were to examine the impact of spring prescribed fire on: 1) chipmunk home-range and core-area size; 2) extent of home-range and core-area overlap among conspecifics; and 3) temporal attributes of burrow use.

Materials and Methods

Study Area

Our study was conducted on the 1900 ha Fernow Experimental Forest in Tucker County, West Virginia (39.03° N, 79.67° W). Located within the Allegheny Mountains portion of the Central Appalachian Broadleaf Forest (McNab and Avers 1994), elevations range from 530 to 1115 m, the growing season is approximately 145 days, and annual precipitation averages 143 cm. The forest stands used were mid-elevation (730 to 800 m) oak-dominated Allegheny hardwood sites containing an overstory mix of northern red oak (*Q. rubra*), chestnut oak (*Q. prinus*), white oak (*Q. alba*), yellow poplar, American beech, sugar maple and eastern hemlock (*Tsuga canadensis*). The midstory shrub layer consisted of sugar maple, American beech, striped maple (*Acer pensylvanicum*), and rosebay rhododendron (*Rhododendron maximum*). The groundcover was dominated by a mixture of Christmas fern (*Polystichum acrostichoides*), hay-scented fern (*Dennstaedtia punctilobula*), wood fern (*Dryopteris* spp.) and groundpine (*Lycopodium* spp.) along with patches of greenbrier (*Smilax* spp.), blueberry (*Vaccinium* spp.), violet (*Viola* spp.), wood nettle (*Laportea canadensis*) and wild yam (*Dioscorea quaternata*).

We chose one control (unburned) and one burn stand as study sites in 2002 and 2003 (four stands total). Our criteria for stand selection (i.e., to match burn treatment with control stands) included the presence of chipmunk and similarity in overstory composition, size classes, stand age, and topography. All stands were established from natural regeneration and ranged from 70 to 95 years old (Schuler and Gillespie 2000). Our 2003 burn stand had been thinned approximately 20 years prior to the study to a 60 to 75 percent stocking level (Schuler and Miller 1995). Each burn stand had undergone a low-intensity, single-day prescribed fire in April preceding our research for that year. The 2002 and 2003 burn stands encompassed 12 ha and 19 ha, respectively. The 2002 control stand encompassed approximately 5 ha and was located approximately 400 m from the 2002 burn stand on a portion of the Fernow not assigned to any past or current research effort. The 2003 control consisted of the 7 ha upper portion of a watershed[1] (known as Watershed 4) that serves as an unmanaged control for the forest's watershed research program.

Capture and Radiotelemetry

In late spring through mid-summer of 2002 and 2003, we maintained 0.35 ha trapping grids in each control and treatment stand. Our trapping grids consisted of six by eight arrays of #102 Tomahawk traps (Tomahawk Live Trap, Tomahawk, WI)[2] spaced 10 m apart (48 traps/stand) and baited with peanut butter and rolled oats. We trapped chipmunks on an *ad hoc* basis to maintain three to five radio-collared individuals per study stand that could be adequately monitored simultaneously. For all captured chipmunks, we determined their sex, weight, and reproductive condition. Female reproductive condition was assessed by palpating the abdomen and/or examining the mammary glands for signs of lactation. Male reproductive condition was determined by scrotal size and position. We classified all chipmunks as juvenile, subadult, or adult based on weight, external measurements, and sexual characteristics (Forbes 1966, Tryon and Snyder 1973).

We marked all chipmunks with uniquely numbered Monel #1 ear tags (National Band and Tag Co., Newport, KY), and attached radio collars to all adults or subadults

---

[1] For watershed description, see www.fs.fed.us/ne/parsons/feft00.htm

[2] The use of trade, firm, or corporate names in this report is for the information of the reader. Such use does not constitute an official endorsement or approval by the USDA Forest Service of any product or service to the exclusion of others than may be suitable.

(≥ 70 g). Each chipmunk was lightly anesthetized with halothane (Halocarbon Laboratories, River Edge, NJ) and fitted with PD-2, whip antenna radio transmitters (Holohil Systems, Ontario, Canada) attached like a necklace with either light wire and rubber tubing or with a plastic zip-tie. The combined mass of the transmitter and collar attachment (3.5 to 4.2 g) was ≤ 5 percent of body weight. We allowed each individual chipmunk caught approximately 48 hours to adjust to their collars and all traps and bait were removed from the stand before telemetry efforts commenced.

We determined chipmunk locations by simultaneous triangulation using TRX 2000-S radio receivers and handheld three-element Yagi antennas (Wildlife Materials, Carbondale, IL). Recording stations were established to maintain triangulation angles as near 90 degrees as possible. Our telemetry efforts were conducted from June through August of 2002 and 2003, for 1 to 3 hours/day between 1000 and 1800 hours when chipmunks were most active. To ensure independence among individuals' locations, readings were taken on each tracked individual no more than every 10 minutes during each telemetry session. We determined telemetry error by estimating locations on test transmitters located on the study area (White and Garrott 1990). Our mean telemetry error was 22 degrees (SD = 18.6; n = 16) at a mean distance of 84 m from the test transmitters.

Home Range Analysis

We obtained Universal Transverse Mercator (UTM) coordinates for all telemetry observer stations with a mobile global position system unit (GPS; Trimble Navigation Ltd., Sunnyvale, CA) and PathFinder software (PathFinder Software, Glendale, AZ). All GPS locations were differentially corrected. We used program LOCATE (J.G. Kie, Fresno, CA) to determine chipmunk locations by converting compass bearings from known observer station UTM coordinates into location UTM coordinates. We entered these locations into ArcView 3.2 (ESRI, Redlands, CA) and applied the Animal Movement Extension (Hooge and Eichenlaub 2000) to calculate chipmunk home ranges and core areas. We defined home range as the estimated area of about 95 percent of a chipmunk's recorded locations. Similarly, we defined the core area as the smallest area surrounding a chipmunk's burrow area that contained 50 percent of a chipmunk's recorded locations and therefore accounted for the highest proportional use of all of the individual's recorded locations.

To improve accuracy, we only accepted chipmunk's locations that created intersection angles between observers of 35 to 145 degrees. Each individual's acceptable locations then were subject to a 5 percent outlier removal using the harmonic mean method (Dixon and Chapman 1980). We only retained data on chipmunks possessing a minimum of 28 acceptable locations for subsequent home-range analysis (Seaman et al. 1999). We then used the fixed kernel method with least squares cross validation as a smoothing parameter to construct our 95 percent (home range) and 50 percent (core area) contour utilization distributions (UD) (Silverman 1986, Worton 1989). We used Neil's Ute Extension (Free Software Foundation, Inc., Boston, MA) in ArcView 3.2 to determine the Overlap Coefficient (area overlapping between pairs of individuals as a percentage of the total union of the areas) between home ranges (95 percent UD), and core areas (50 percent UD) for each possible pair of chipmunks collared within the same trapping grid.

Burrow Use

We tracked radio-collared chipmunks to their burrow chambers after sunset between May and August of 2002 and 2003. Because we were constrained to locate burrow chambers also on an *ad hoc* basis, we only retained data from chipmunks with ≥ 30 days of burrow chamber use. We georeferenced and permanently marked all burrow chambers.

Results

Home-Range and Core-Area Size

We tracked 19 chipmunks in 2002 (11 males and 8 female) and 16 in 2003 (6 males, 10 females). Nontarget captures were limited to a single southern red-backed vole (*Clethrionomys gapperi*), grey squirrel (*Sciurus carolinensis*) and ovenbird (*Seiurus aurocapillus*). The final number of control chipmunks retained for complete home-range analyses was three males in 2002, and two males and three females in 2003. In the burned stands, the final number chipmunks was four males and four females in

Table 1.—Mean (SE) home-range size and mean (SE) core-area size between burn and control treatments for eastern chipmunks on the Fernow Experimental Forest, WV, 2002 and 2003.

Treatment	n	Home Range	Core Area
		-----------------ha-----------------	
Burn			
Male	6	0.39 (0.16)	0.04 (0.01)
Female	7	0.58 (0.14)	0.09 (0.02)
Control			
Male	5	0.55 (0.13)	0.08 (0.03)
Female	3	0.76 (0.10)	0.16 (0.06)

Table 2.—Mean (SE) overlap coefficients for control and burn treatments for chipmunk home ranges (95 percent utilization distribution) and core areas (50 percent utilization distribution), including male-male overlap, female-female overlap, and combined-sex (male-male, male-female, female-female) overlap on the Fernow Experimental Forest, WV, 2002 and 2003.

Treatment	n	Home Range	Core Area
Burn			
Male-male	4	0.60 (0.06)	0.40 (0.14)
Female-female	5	0.46 (0.04)	0.35 (0.08)
Combined-sex	23	0.53 (0.02)	0.37 (0.05)
Control			
Male-male	4	0.50 (0.06)	0.30 (0.09)
Female-female	3	0.54 (0.05)	0.15 (0.05)
Combined-sex	13	0.51 (0.03)	0.21 (0.03)

2002, and two males and two females in 2003. Overall fate of the 35 chipmunks radio-collared was as follows: three individuals were confirmed trap-related mortalities; two individuals' fates were unknown, but their radio collars were found intact; one individual was killed by a predator; 13 individuals were never recaptured after radio-collar transmitter failure; and 16 individuals were recaptured prior to transmitter failure. For both years combined, mean home-range size for males in the burn was 0.39 ha (SE = 0.16; Table 1) and 0.55 ha (SE = 0.13) in the control. Mean female home-range size in the burn was 0.58 ha (SE = 0.14) and 0.76 ha (SE = 0.10) in the control. Mean core-area size for males in the burn was 0.04 ha (SE = 0.01) and 0.08 ha (SE = 0.03) in the control. Mean female core-area size in the burn was 0.09 ha (SE = 0.02) and 0.16 ha (SE = 0.06) in the control. The small number of tracked chipmunk and lack of treatment replication prevented the use of interferential statistics.

Extent of Home-Range and Core-Area Overlap

For both years combined, mean male-male home-range overlap coefficient was 0.60 (SE = 0.06; Table 2) in the burn and 0.50 (SE = 0.06) in the control. Mean female-female home-range overlap coefficient was 0.46 (SE = 0.04) in the burn and 0.54 (SE = 0.05) in the control. Mean male-male core-area overlap coefficient was 0.40 (SE = 0.14) in the burn and 0.30 (SE = 0.09) in the

Table 3.—Mean (SE) number of burrows used per 30 days by chipmunks on the Fernow Experimental Forest, WV, 2002 and 2003.

Treatment	n	Burrows
Burn		
Male	6	1.33 (0.21)
Female	6	1.33 (0.21)
Control		
Male	6	1.33 (0.21)
Female	7	1.14 (0.14)

control. Mean female-female core-area overlap coefficient was 0.35 (SE = 0.08) in the burn and 0.15 (SE = 0.05) in the control. The combined sexes mean home-range overlap coefficient was 0.52 (SE = 0.02) in the burn and 0.51 (SE = 0.03) in the control. The combined sexes mean core-area overlap coefficient was 0.37 (SE = 0.05) in the burn and 0.21 (SE = 0.03) in the control.

Burrow Use

The final number of control chipmunks used for burrow analysis was four males and two females in 2002, and two males and five females in 2003. The final number of chipmunks used for burrow analysis in the burned stands was three males and two females in 2002, and three males and four females in 2003. Control males averaged 1.33 (SE = 0.21) burrows/30 days (Table 3) and control females averaged 1.14 burrows/30 days (SE = 0.14). Burn males averaged 1.33 (SE = 0.21) burrows/30 days and burn females averaged 1.33 burrows/30 days (SE = 0.21).

Discussion

Eastern chipmunks on the Fernow Experimental Forest continued to use forest stands treated with a spring prescribed fire. Marked individuals rarely were observed moving into adjacent unburned forest stands, and for those living on the periphery of a burn, no telemetry locations outside of the burned stand were recorded. Our home-range estimates derived from telemetry fell within the wide range of values for chipmunks from live-trapping studies within the eastern deciduous forests of North America (Blair 1942, Smith 1942, Manville 1949, Yerger 1953 and 1955, Forbes 1966, Dunford 1970, Forsyth and Smith 1973, Ickes 1974, Mares et al. 1976, Elliott 1978, Lacher and Mares 1996). Although unusual for most mammals (Harestad and Bunnell 1979, Swingland and Greenwood 1983), the lack of home-range contrast between male and female chipmunks also is consistent with previous research (Blair 1942, Bowers et al. 1990, Lacher and Mares 1996). Although chipmunks adjust home-range size according to resource availability (Mares et al. 1976, Getty 1981b, Mares et al. 1982, Mares and Lacher 1987, Bowers et al. 1990), the functional similarity of home-range and core-area sizes between burn and control areas that we observed indicates little substantial resource availability differential.

Although these fires killed much of the understory woody vegetation (< 2 m), especially red maple, striped maple and rosebay rhododendron (*Rhododendron maximum*) and the early emergent forbs and grasses that were already present, there was copious woody seedling and herbaceous plant growth by late spring and early summer following both fires. Aboveground fruiting bodies of fungi were observed routinely in the stands some weeks after the fires and throughout thereafter (but not quantified). It did appear that soft-mast production also was depressed within the burned stands during the first post-fire growing season in both burned stands (Rowan 2004). In the burn stands, individuals may have relied on remaining hard-mast caches or belowground resources (i.e., hypogeal fungi) until aboveground resources reappeared. The open ground in the burn treatments may have facilitated chipmunk foraging for seeds and arthropods (Ahlgren 1966, Sullivan and Boateng 1996, Ford et al. 1999). As an additional benefit, the nutritional content of forages and soft fruits in the burned areas may have exceeded that of prefire or unburned area values later in the growing season or subsequent growing seasons (Johnson et al. 1992).

Eastern chipmunks are known to have broadly overlapping home ranges (Blair 1942, Yerger 1953, Forsyth and Smith 1973, Ickes 1974, Elliott 1978, Getty 1980 and 1981a) and our results demonstrate that spring prescribed fires did not alter overlap among individuals. Studies of other rodents (genera *Clethrionomys* and *Microtus*) have shown that conspecifics maintain less overlap in times of low resource availability (Jones 1990) whereas high degrees of tolerance and overlap occurred when resource availability was high (Ostfield 1986, Ims 1987). Our chipmunk data suggests no increased territoriality and no additional competition for resources in the burn areas.

We found that both sexes used one to two burrow systems/30 days. Of the seven chipmunks that used two burrows, four individuals made permanent changes to the newer burrow. Three chipmunks switched to a new burrow for a few days (< 7 days) prior to returning to their previous burrow. Chipmunks quickly will overtake a "better" burrow if the original occupant dies or emigrates (Elliott 1978, Yahner 1978). We witnessed this phenomenon with two of our radio-collared animals. For example, a female that died following recapture to remove her radio collar had her burrow overtaken by a neighboring radio-collared male the following day. Animals that switched burrows temporarily may have moved to new burrows to escape ectoparasites (Yahner 1978). Some burrow chambers we found were within the mound portion of pit and mound topographic features near wind-thrown trees. However, most chambers we documented were not associated with any discernable microhabitat feature (Peterson et al. 1990).

Over the short term, spring prescribed fire in oak-dominated Allegheny hardwood stands on the Fernow Experimental Forest appeared to have no discernable impact on chipmunks. Although our inferences are limited by small sample sizes and the small geographic scope of our work, we believe the conclusions of this case study could be extended to other small mammal species with similar forage requirements and population dynamics in the central and southern Appalachian region following spring burning. Other small mammal species, such as the southern red-backed vole, that do not larder hoard and that must rely mainly on seeds (assuming burned ground does not enhance seed apparency) or emergent vegetation, might be temporarily negatively affected by spring prescribed fire (Beck and Vogel 1972, Merritt 1981), although this was not observed in similar southern Appalachian forest habitats with more intense spring burns (Ford et al. 1999).

If intense enough, prescribed burning conceivably could reduce the amount of downed coarse woody debris on the forest floor to the detriment of small mammals (Loeb 1996, Van Lear 1996, Ford et al. 1999, McCay and Komoroski 2004). However, we believe this did not occur because we noted few instances of larger coarse woody debris being consumed whereas numerous large pieces from collapsed snags or tree mortality were added. Similarly, Sanders and Van Lear (1988) noted that even intense fires consumed ≤ 40 percent of the volume of downed coarse woody debris in southern Appalachian mixed pine-hardwood clearcuts. We concur with the findings of Vreeland and Tietje (2002) that if volume of coarse woody debris already exceeded usable thresholds for small mammals, then light prescribed burns in the cool season will have little impact on most small mammals. Fire effects on parameters that we did not measure, such as reproductive success, remains unknown. Given the small extent of the burns and the lack of home range response, coupled with chipmunks' high reproductive capacity and high level of vagility, the demographic influences of these burns probably were minimal for the species. Future research being planned for the Fernow Experimental Forest[3] will provide a template to address the response of chipmunks, as well as other small mammal species, to repeated spring burning and/or fall burning when acorn crops are on the ground.

Acknowledgments

The funding for this study was provided by the USDA Forest Service Northeastern Research Station to the University of Georgia D.B. Warnell School of Forest Resources through Cooperative Agreement #01-CA-11242343. R. Rosier and R. Hovatter provided invaluable field assistance throughout the duration of this study.

---

[3] Adams, M.B., Edwards, P.J., Ford, W.M., Kochenderfer, J.A., Menzel, J.M., Rodrigue, J.L., Schuler, T.M., Wood. F. 2005. Fernow Experimental Forest: environmental impact statement. Final Report on file at U.S. Department of Agriculture, Forest Service, Northeastern Research Station, Newtown Square, Pennsylvania.

Literature Cited

Ahlgren, C.E. 1966. **Small mammals and reforestation following prescribed burning.** Journal of Forestry. 64: 614-618.

Aldous, S. 1941. **Food habits of chipmunks.** Journal of Mammalogy. 22(1): 18-24.

Allen, E. 1938. **The habits and life history of the eastern chipmunk, *Tamias striatus lysteri*.** Bulletin of the New York State Museum. 314: 1-122.

Anderson, M. 1978. **Optimal foraging area: size and allocation of search effort.** Theoretical Population Biology. 13: 397-409.

Barnes, T.A.; Van Lear, D.H. 1998. **Prescribed fire effects on hardwood advanced regeneration in mixed hardwood stands.** Southern Journal of Applied Forestry. 22: 138-142.

Beck, A.M.; Vogl, J. 1972. **The effects of spring burning on rodent populations in a brush prairie savanna.** Journal of Mammalogy. 53: 336-346.

Bergstrom, B.J. 1988. **Home ranges of three species of chipmunks (*Tamias*) as assessed by radiotelemetry and grid trapping.** Journal of Mammalogy. 69: 190-193.

Blair, W.F. 1942. **Size of home range and notes on the life history of the woodland deer-mouse and eastern chipmunk in northern Michigan.** Journal of Mammalogy. 23: 27-36.

Bowers, M.A.; Welch, D.N.; Carr, T.G. 1990. **Home range size adjustments by the eastern chipmunk, *Tamias striatus*, in response to natural and manipulated water availability.** Canadian Journal of Zoology. 68: 2016-2020.

Bowers, M.A.; Carr, T.G. 1992. **Home range shifts accompanying breeding in the eastern chipmunk, *Tamias striatus* (Rodentia: Sciuridae).** Zeitschrift für Säugetierkunde. 57: 288-293.

Brose, P.H.; Schuler, T.M.; Van Lear, D.H.; Berst, J. 2001. **Bringing fire back: the changing regimes of the Appalachian mixed-oak forests.** Journal of Forestry. 99: 30-35.

Brose, P.H.; Van Lear, D.H. 1998. **Responses of hardwood advance regeneration to seasonal prescribed fires in oak-dominated shelterwood stands.** Canadian Journal Forest Research. 28: 331-339.

Brose, P.H.; Van Lear, D.H.; Cooper, R. 1999. **Using shelterwood harvests and prescribed fire to regenerate oak stands on productive upland sites.** Forest Ecology and Management. 113: 125-141.

Castleberry, S.B.; Ford, W.M.; Wood, P.B.; Castleberry, N.L.; Mengak, M.T. 2001. **Movements of Allegheny woodrats in relation to timber harvesting.** Journal of Wildlife Management. 65: 148-156.

Dixon, K.R.; Chapman, J.A. 1980. **Harmonic mean measure of animal activity areas.** Ecology. 61: 1040-1044.

Dunford, C. 1970. **Behavioral aspects of spatial organization in the chipmunk, *Tamias striatus*.** Behaviour. 36: 215-231.

Elliott, L. 1978. **Social behavior and foraging ecology of the eastern chipmunk (*Tamias striatus*) in the Adirondack Mountains.** Smithsonian Contributions to Zoology. 265: 1-107.

Forbes, R.B. 1966. S**tudies of the biology of Minnesotan chipmunks.** American Midland Naturalist. 76: 290-308.

Ford, W.M.; Menzel, M.A.; McGill, D.W.; Laerm, J.; McCay, T.S. 1999. **Effects of a community restoration fire on small mammals and herpetofauna in the southern Appalachians.** Forest Ecology and Managment. 114: 233-243.

Forsyth, D.J.; Smith, D.A. 1973. **Temporal variability in home ranges of eastern chipmunks (*Tamias striatus*) in a southeastern Ontario woodlot.** American Midland Naturalist. 90: 107-117.

Getty, T. 1980. **The utilization of space by neighboring eastern chipmunks with overlapping home ranges.** Ecological Society of America Bulletin. 61: 134-135.

Getty, T. 1981a. **Territorial behavior of eastern chipmunks (*Tamias striatus*): encounter avoidance and spatial time-sharing.** Ecology. 62: 915-921.

Getty, T. 1981b. **Structure and dynamics of chipmunk home range.** Journal of Mammalogy. 62: 726-737.

Hackett, D.F., Trevor-Deutsch, B. 1982. **An evaluation of several grid-trapping methods by comparison with radio-telemetry in a home range study of the eastern chipmunk *(Tamias striatus).*** Biotelemetry Patient Monitoring. 9: 213-226.

Harestad, A.S.; Bunnell, F.L. 1979. **Home range and body weight - a re-evaluation.** Ecology. 60: 389-402.

Hooge, P.N.; Eichenlaub, B. 2000. **Animal movement extension to ArcView. Version 2.2.** Anchorage, AK: U.S. Geological Survey, Alaska Biological Science Center.

Ickes, R.A. 1974. **Agonistic behavior and the use of space in the eastern chipmunk, *Tamias striatus*.** Pittsburgh, PA: University of Pittsburgh. 235 p. Ph.D. dissertation.

Ims, R.A. 1987. **Responses in spatial organization and behaviour to manipulations of the food resource in the vole *Clethrionomys rufocanus*.** Journal of Animal Ecology. 56: 585-596.

Johnson, A.S.; Hale, P.E.; Osborne, J.S.; Anderson, O.F.; Ford, W.M. 1992. **Deer in pocosin habitat after catastrophic wildfire.** Proceedings of the Annual Conference of the Association of Southeastern Fish and Wildlife Agencies. 46: 118-127.

Jones, E.N. 1990. **Effects of forage availability on home range and population density of *Microtus pennsylvanicus*.** Journal of Mammalogy. 71: 382-389.

Lacher, T.E.; Mares, M.A. 1996. **Availability of resources and use of space in eastern chipmunks, *Tamias striatus*.** Journal of Mammalogy. 77: 833-849.

Loeb, S.C. 1996. **The role of coarse woody debris in the ecology of southeastern mammals.** In: McMinn, J.W.; Crossley, D.A., eds, Biodiversity and coarse woody debris in southern forests. Gen. Tech. Rep. SE-94. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 108-118.

Mahan, C.G.; Yahner, R.H. 1996. **Effects of forest fragmentation on burrow-site selection by the eastern chipmunk (*Tamias striatus*).** American Midland Naturalist. 136: 352-367.

Manville, R.H. 1949. **A study of small mammal populations in northern Michigan.** Miscellaneous Publication of the University of Michigan Museum of Zoology. 73: 1-83.

Mares, M.A.; Watson, M.D.; Lacher, T.E. 1976. **Home range perturbations in *Tamias striatus*.** Oecologia. 25: 1-12.

Mares, M.A.; Lacher, T.E.; Willig, M.R.; Bitar, N.A.; Adams, R.A.; Klinger, A.; Tazik, D. 1982. **An experimental analysis of social spacing in *Tamias striatus*.** Ecology. 63:267-273.

Mares, M.A.; Lacher, T.E. 1987. S**ocial spacing in small mammals: patterns of individual variation.** American Zooogist. 27:293-306.

Martin, A.C.; Zim, H.S.; Nelson, T.A. 1961. **American wildlife and plants. A guide to wildlife food habits.** New York, NY: Dover Publications, Inc. 500 p.

McCay, T.S.; Komoroski, M.J. 2004. **Demographic response of shrews to removal of coarse woody**

debris in a managed pine forest. Forest Ecology and Management. 189: 387-395.

McNab, W.H.; Avers, P.E. 1994. **Ecological subregions of the United States: section descriptions.** WO-WSA5. Washington, DC: U.S. Department of Agriculture, Forest Service. 267 p.

McShea, W.J. 2000. **The influence of acorn crops on annual variation in rodent and bird populations.** Ecology. 81: 228-238.

Merritt, J.F. 1981. ***Clethrionomys gapperi.*** Mammalian Species Account.146: 1-9.

Ostfield, R.S. 1986. **Territoriality and mating system of California voles (*Mictrotus californicus*).** Journal of Animal Ecology. 55: 691-706.

Peterson, C.J.; Carson, W.P.; McCarthy, B.C.; Pickett, S.T.A. 1990. **Microsite variation and soil dynamics within newly created treefall pits and mounds.** Oikos. 58: 39-46.

Rowan, E.D. 2004. **Effect of a spring prescribed fire on chipmunk home ranges and a woodland salamander community in a central Appalachian forest.** Athens, GA: University of Georiga. 87 p. M.S. thesis.

Sanders, B.M.; Van Lear, D.H. 1988. **Photos for estimating residue loadings before and after burning in southern Appalachian mixed pine-hardwood clearcuts.** Gen. Tech. Rep. SE-49. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Research Station. 21 p.

Schuler, T.M. 2004. **Fifty years of partial harvesting in a mixed mesophytic forest: composition and productivity.** Canadian Journal of Forest Research. 34: 985-997.

Schuler, T.M.; Miller, G.W. 1995. **Shelterwood treatments fail to establish oak reproduction on mesic forest sites in West Virginia – 10 year results.** In: Gottschalk, K.W.; Fosbroke, S.L.C., eds. Proceedings, 10th central hardwood forest conference; 1995 March 5-8; Morgantown, WV. Gen. Tech. Rep. NE-197. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 375-387.

Schuler, T.M.; Gillespie, A.R. 2000. **Temporal patterns of woody species diversity in a Central Appalachian forest from 1856-1997.** Journal of the Torrey Botanical Society. 127: 149-161.

Seaman, D.E.; Millspaugh, J.J.; Kernohan, B.J.; Brundige, G.C.; Raedeke, K.J.; Gitzen, R.A. 1999. **Effects of sample size on kernel home range estimates.** Journal of Wildlife Management. 63:739-747.

Silverman, B.W. 1986. **Density estimation for statistics and data analysis.** London, UK: Chapman and Hall. 175 p.

Smith, R.A. 1942. **The biology of a small mammal community in a central New York woodlot.** Ithaca, NY: Cornell University. 218 p. Ph.D. dissertation.

Steele, M.A.; Smallwood, P.D.; Spunar, A.; Nelsen, E. 2001. T**he proximate basis of the oak dispersal syndrome: detection of seed dormancy by rodents.** American Zoology. 41: 852-864.

Sullivan, T.P.; Boateng, J.O. 1996. **Comparison of small-mammal community responses to broadcast burning and herbicide application in cutover forest habitats.** Canadian Journal Forest Research. 26: 462-73.

Swingland, I.R.; Greenwood, P.J. 1983. **The ecology of animal movement.** New York, NY: Clarendon Press. 311 p.

Taylor, R.J. 1988. **Territory size and location in animals with refuges: influence of predation risk.** Evolutionary Ecology. 2: 95-101.

Tryron, C.A.; Snyder, D.P. 1973. **Biology of the eastern chipmunk, *Tamias striatus*: life tables, age**

distributions and trends in population numbers. Journal of Mammalogy. 54: 145-168.

Van Lear, D.H. 1996. **Dynamics of coarse woody debris in southern forest ecosystems.** In: McMinn, J.W.; Crossley, D.A., eds, Biodiversity and coarse woody debris in southern forests. Gen. Tech. Rep. SE-94. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 10-17.

Vreeland, J.K.; Tietje, W.D. 2002. **Numerical response of small vertebrates to prescribed fire in California oak woodland.** In: Ford, W.M.; Russell, K.R.; Moorman, C.E., eds. The role of fire in nongame wildlife management and community restoration: traditional uses and new directions. Gen. Tech. Rep. NE-288. Newtown Square, PA: U.S. Department of Agriculture, Forest Service: 100-110.

Wentworth, J.M.; Johnson, A.S.; Hale, P.E.; Kammermeyer, K.E. 1992. **Relationships of acorn abundance and deer herd characteristics in the southern Appalachians.** Southern Journal of Applied Forestry. 16: 5-8.

Whitaker, J.O.; Hamilton, W.J. 1998. **Mammals of the eastern United States.** Ithaca, NY: Cornell University Press. 583 p.

White, G.C.; Garrott, R.A. 1990. **Analysis of wildlife radio-tracking data.** San Diego, CA: Academic Press. 383 p.

Wolff, J.O. 1996. **Population fluctuations of mast-eating rodents are correlated with production of acorns.** Journal of Mammalogy. 77: 850-856.

Worton, B.J. 1989. **Kernel methods for estimating the utilization distribution in home-range studies.** Ecology. 70: 164-168.

Wrazen, J.A.; Svendsen. G.E. 1978. **Feeding ecology of a population of eastern chipmunks (*Tamias striatus*) in southeast Ohio.** American Midland Naturalist. 100: 190-201.

Yahner, R. H. 1978. **Burrow systems and home range use by eastern chipmunks, *Tamias striatus*: ecological and behavioral considerations.** Journal of Mammalogy. 59: 324-329.

Yerger, R.W. 1953. **Home range, territoriality, and populations of the chipmunk in central New York.** Journal of Mammalogy. 34: 448-458.

Yerger, R.W. 1955. **Life history note on the eastern chipmunk *Tamias striatus lysteri* (Richardson) in central New York.** American Midland Naturalist. 53: 312-323.

Rowan, E.L.; Ford, W.M.; Castleberry, S.B.; Rodrigue, J.L.; Schuler, T.M. 2005. **Response of eastern chipmunks to single application spring prescribed fires on the Fernow Experimental Forest**. Res. Pap. NE-727. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 10 p.

We used radiotelemetry to examine the effects of spring prescribed fire for preharvest oak (*Quercus* spp.) shelterwood management on eastern chipmunk (*Tamias striatus*) home-range attributes and burrow use on the Fernow Experimental Forest in the central Appalachian Mountains of West Virginia. Results for 21 chipmunks showed that prescribed fire had little discernable effect on home-range or core-area size, extent of conspecific overlap, or burrow use. Fire tolerance of this common forest rodent provides additional evidence supporting the use of prescribed burning to achieve vegetation management objectives in the central Appalachians where appropriate.

Key Words: burrow, central Appalachian Mountains, chipmunk, fire, home range, oak shelterwood, radiotelemetry

Printed on Recycled Paper

Headquarters of the Northeastern Research Station is in Newtown Square, Pennsylvania. Field laboratories are maintained at:

Amherst, Massachusetts, in cooperation with the University of Massachusetts

Burlington, Vermont, in cooperation with the University of Vermont

Delaware, Ohio

Durham, New Hampshire, in cooperation with the University of New Hampshire

Hamden, Connecticut, in cooperation with Yale University

Morgantown, West Virginia, in cooperation with West Virginia University

Parsons, West Virginia

Princeton, West Virginia

Syracuse, New York, in cooperation with the State University of New York, College of Environmental Sciences and Forestry at Syracuse University

Warren, Pennsylvania

"Caring for the Land and Serving People Through Research"