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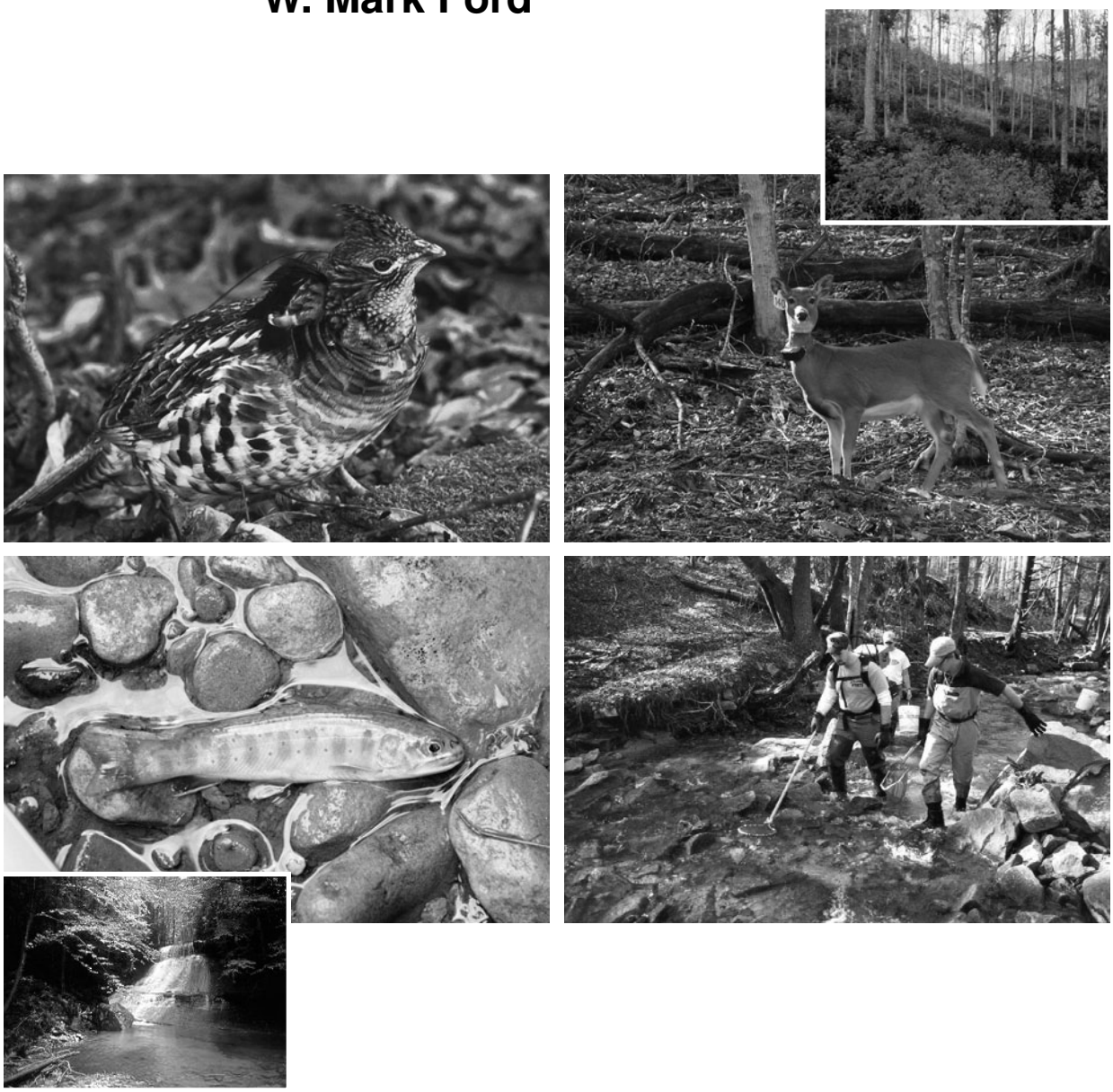
Ten Years of Research on the MeadWestvaco Wildlife and Ecosystem Research Forest: An Annotated Bibliography

Patrick D. Keyser
W. Mark Ford



Abstract

Contains 90 citations and annotations of publications and final reports that describe research conducted on or in association with the MeadWestvaco Wildlife and Ecosystem Research Forest in West Virginia from 1994 through 2004.

The Authors

PATRICK D. KEYSER is a senior wildlife biologist and project administrator, MeadWestvaco Corporation, Rupert, WV 25984

W. MARK FORD is a research wildlife biologist, USDA Forest Service Timber and Watershed Laboratory, Parsons, WV 26287

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Forward

The MeadWestvaco Wildlife and Ecosystem Research Forest was established on June 17, 1994 by the former Westvaco Corporation to provide an area that could serve as a living laboratory to study the interactions of modern industrial forestry with the whole of the ecosystem and its ecological processes within the Appalachian landscape. The Westvaco Wildlife and Ecosystem Research Forest became one of the few privately owned ecological research areas in the United States managed as a working forest. Following the merger of Westvaco Corporation and Mead Corporation in 2002, the area became known as the MeadWestvaco Wildlife and Ecosystem Research Forest (MWERF). Research and management activities at the MWERF have been and continue to be directed by a panel of scientists and professional natural resource managers from the Federal and state government, academia, industry, and private conservation organizations.

Located on 3,413 ha in southwestern Randolph County, West Virginia, the MWERF is in the Allegheny Mountains and Plateau Physiographic province of the Appalachian Mountains in east-central West Virginia. The MWERF encompasses most of three entire watersheds of the Upper Middle Fork drainage, Birch Fork, Rocky Run, and Kittle Creek (Figure 1). The elevation of the forest ranges from 734 m along the Middle Fork to 1180 m at the crest of Rich Mountain. Topography consists of steep side slopes with broad, plateau-like ridgetops and narrow valleys with small, high-gradient streams. Soils are acidic and well-drained Inceptisols and Ultisols of the Gilpin-Dekalb-Buchanan Association formed over the Pottsville Sandstone Group. The MWERF is characterized by a cool, humid climate with evenly distributed precipitation (>160 cm) with much of the winter precipitation occurring as snow.

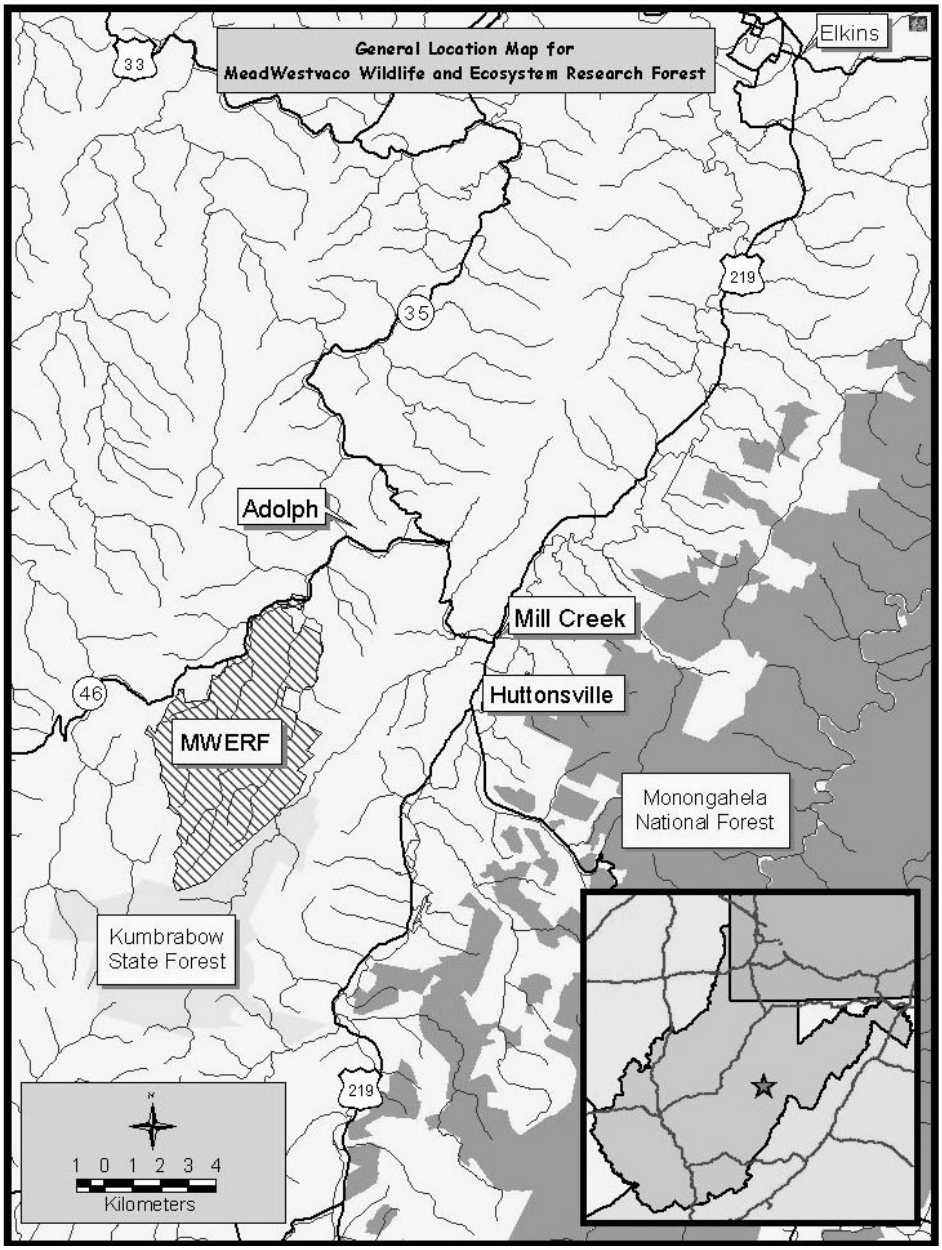


Figure 1.—Location of the MeadWestvaco Wildlife and Ecosystem Research Forest, Randolph County, West Virginia.

Much of the MWERF is dominated by a northern hardwood-Allegheny hardwood type containing: American beech, yellow birch, black cherry, Fraser magnolia, red maple and sugar maple. Those species, along with cove hardwood and mixed mesophytic community types consisting of yellow-poplar, northern red oak, basswood, cucumber magnolia, sweet birch and white ash are found at the lowest elevations. Montane red spruce-eastern hemlock stands occur at the upper elevations and within sheltered frost pockets on the MWERF above 925 m. Overstories dominated by eastern hemlock with dense understories of dense rosebay rhododendron occur along the forest's watercourses. An artifact of high white-tailed deer herbivory pressure, much of the understory vegetation throughout the MWERF consists of a striped maple shrub layer and a dense hay-scented fern groundcover.

Formerly hunting grounds of the Shawnee and Seneca tribes, the wooded mountains of the area remained largely unpopulated prior to the mid- to late-19th century, though many of the larger river bottoms, were settled as early as the late 18th century by Europeans of Scotch-Irish, German and English descent. Widespread logging of the area's forests began in the early 1900s, but as late as 1931, the West Virginia Geological Survey reported finding virgin timber on what are now parts of the MWERF. Most of the MWERF originally was logged between 1916 and 1928 by a combination of horse skidding and standard-gauge railroad. Selective logging for sawtimber continued up to and after Westvaco's acquisition of the tract in the early 1970s. Accordingly, most of the residual forest was aged 70-90 years at the time of the research forest dedication. That, combined with the intervening stand entries, has created forest conditions with complex structure and abundant canopy gaps. Numerous skid trails, abandoned haul roads, and old railroad grades add to the spatial heterogeneity of the MWERF.

Currently, MeadWestvaco manages the MWERF through study-specific manipulations and harvests in the context of an even-aged regeneration program designed to achieve an acceptable forest regulation and foster a desirable shade-intolerant species mix. Initial research efforts on the MWERF focused on descriptive ecology whereas current and future phases of research are utilizing the planned and ongoing forest manipulations to examine stand-level forest management relationships to the biota and ecological processes. For example, many present research efforts on the MWERF are linked to the Appalachian Landscape Ecology Project that utilizes the MWERF and surrounding lands in a comprehensive multi-frequency disturbance regime in large landscape-level blocks with 20-, 40-, and 80-year forest rotations. Herein are provided abstract summaries for all the reported research from published abstracts, theses, dissertations, project final reports, and peer-reviewed scientific journal articles for the first 10 years of the MWERF for research conducted there or in association with the area's program. This work has represented studies on traditional forest and wildlife management topics, as well as more wide-ranging issues in ecology and forest biology.

Citations

1. Campbell, T.A. 2003. **Movement ecology of white tailed deer in the central Appalachians of West Virginia.** Athens, GA: University of Georgia. 162 p. Ph.D. dissertation.

From 1999-2002, baseline data on white-tailed deer movement was collected to assess the feasibility of using localized management to enhance forest regeneration. Clover traps were used to capture 343 deer on the MWERF. Radiotelemetry of 148 female and 43 male deer showed that adult female winter home range size was larger than either summer or fall range. Female deer were highly philopatric with fawn and yearling female dispersal less than 5 percent. Yearling male annual mortality rates for human-induced and natural mortality were 0.63 and 0.12, respectively, whereas for yearling females this was 0.09 and 0.05. This was characteristic of a population shaped by moderate fawn recruitment and excessive harvest of yearling male deer. A sample of 810 l-m^2 plots in clearcuts and adjacent forests indicated that mature forest had less woody browse than clearcut plots and elevation and distance to mature forest were more important than site index in predicting browsing pressure. A reduction in female deer through liberalized harvest to promote forest regeneration and maximize biodiversity in this region is recommended. Locally, the behavior and ecology of female white-tailed deer on the MWERF meet the a priori assumptions necessary to apply localized management.

2. Campbell, T.A.; Laseter, B.R.; Ford, W.M.; Miller, K.V. 2004. **Movements of female white-tailed deer (*Odocoileus virginianus*) in relation to timber harvests in the central Appalachians.** Forest Ecology and Management. 199: 371-378.

We compared home range and core area size and overlap, of white-tailed deer movements before, during and after timber harvests. Of 83 adult females that were radio-collared, home range and core area size or overlap did not differ between control and treatment deer spatially associated with timber harvests.Treatment deer were located outside their pre-harvest home ranges more often and were located closed to clearcuts than in other time periods than control deer. Recently clearcut habitats less than 6 years past harvest were used in greater proportion than availability. Lack of significant changes in movements during and after timber harvests suggests habitat management aimed at attracting deer away from areas with low regeneration success or towards higher browse supplies would likely be unsuccessful in the central Appalachians.

3. Campbell, T.A.; Laseter, B.R.; Ford, W.M.; Miller, K.V. 2004. **Topographic home ranges of white-tailed deer in the central Appalachians.** Southeastern Naturalist. 3: 645-652.

Seasonal topographic diversity between male and female white-tailed deer home ranges were compared using percentage increase from planimetric to topographic areas as a measure. Pooled mean percent increase for home range size was 3.1 percent and there were no significant differences in the percentage increases between sexes or among seasons. For most comparative purposes, the simpler practice of plainmetric home range size analysis probably is sufficient.

4. Campbell, T.A.; Laseter, B.R.; Ford, W.M.; Miller, K.V. 2004. **Feasibility of localized management to control white-tailed deer in forest regeneration areas.** Wildlife Society Bulletin. 32: 1124-1131.

The feasibility of using localized management as proposed by the rose-petal hypothesis as a tool to control deer herbivory in regeneration areas was assessed by examining seasonal home-range and core-area size and site fidelity of 148 radio-collared female white-tailed deer at the MWERF. Adult female home-range size in winter exceeded that of summer of autumn. Female deer displayed high site fidelity. Dispersal was low for female fawns and no yearling or older deer dispersed from their observed home range. Female white-tailed deer at the MWERF meet a priori assumptions necessary for localized management.

5. Campbell, T.A.; Laseter, B.R.; Osborn, D.A.; Ford, W.M.; Bush, P.B.; Miller, K.V. 2001. **Unusual summer movements of white-tailed deer in the central Appalachians: is it in the water?** In: 24th annual meeting of the Southeast Deer Study Group; 2001 February 17-20; St. Louis, MO. Jefferson City, MO: Missouri Department of Conservation: 14-15.

Numerous sallies of white-tailed deer individual and social groups were observed outside of their normal home range boundaries on the MWERF in response to localized mineral. Mean distance of sallies was 3.5 km and the directionality was not random, but toward natural gas wells that produced effluent. Sally duration ranged from one day to nearly a month. Motion-activated video cameras revealed that deer were present at these wells for 49 min/day, and consumed well outflow during 71.4 percent of visits. Water samples collected at the two wells had Na concentrations of 785.5 ppm and 23.2 ppm, respectively, whereas control wells with no observed deer activity had Na concentrations between 0.2 and 0.6 ppm. Data suggests that deer will travel up to 6.8 km in pursuit of Na, thus validating the premise that deer use of mineral licks depends on their distribution and availability across the landscape.

6. Campbell, T.A.; Laseter, B.R.; Osborn, D.A.; Ford, W.M.; Miller, K.V. 2002. **Localized management of white-tailed deer within forest regeneration areas of the central Appalachians.** In: 5th international Deer Biology Congress; 2002 August 25-30; Quebec City, PQ. Quebec City, PQ: Quebec Ministry of Fish, Wildlife and Parks: 37.

Localized management proposes that a semi-permanent elimination of white-tailed deer can be achieved through the "surgical" removal of a deer social group(s) for approximately a decade. However, this hypothesis has only been tested in a highly philopatric, low-density and un-hunted deer herd in New York and these findings are contrary to traditional ideas of deer dispersion patterns in the eastern United States that suggest deer will find and colonize areas of reduced social pressure when population densities are high. On the MWERF, 175 female white-tailed deer were outfitted with radio-collars to identify social groups and estimate range overlap among social groups. During January and February of 2002, 51 deer were removed within a 1.2 km^2 area, encompassing two forest regeneration areas of northern hardwood forest type. Over the remaining winter, spring and summer months of 2002, none of the extant radio-collared deer dispersed into the localized removal area.

7. Campbell, T. A.; Laseter, B.R.; Osborn, D.A..; Ford, W.M.; Keyser, P.D.; Miller, K.V. 2003. **Can restricting hunter access reduce the harvest of yearling male white-tailed deer?** In: 26th annual meeting Southeast Deer Study Group; 2003 February 23-26; Chattanooga, TN. Nashville, TN: Tennessee Wildlife Resources Agency: 16-17.

Restricting hunter access during antlered buck seasons has been suggested as a means to reduce harvest of male deer in efforts to increase male age structure. Due to limited hunter access on the MWERF, it was hypothesized that philopatric yearling males would have higher survival rates than those that emigrated from the area onto adjacent lands where hunter access was less restricted. Of 32 radio-collared yearling males, 60 percent dispersed from their natal ranges, traveling a mean distance of 6 km with a range of 2 to 21 km. Annual survival of both philopatric and emigrating yearling males was less than 25 percent with hunting being the primary mortality agent. Only three yearlings remained on the MWERF and survived to 2 years of age, suggesting that limiting hunter access alone is not an effective tool to reduce the harvest of yearling males.

8. Campbell, T.A.; Laseter, B.R.; Ford, W.M.; Miller, B.F.; Osborn, D.A.; Miller, K.V. 2004. **Using incidental deer sightings to index sex and age ratios.** In: 27th annual meeting Southeast Deer Study Group; 2004 February 22-24: Lexington, KY. Frankfort, KY: Kentucky Department of Fish and Wildlife Resources: 24.

From June 1999-May 2002, the sex and age of all deer observed during on the MWERF were recorded. Of 11,100 observations, sex and age were recorded for 7,927 deer sightings. As expected, monthly variation in ratios was high. Annual cycles within both ratios were apparent. Buck to doe ratios increased from June-November, then declined sharply in December. Fawn-to-doe ratios increased from June-March, then declined moderately from April-May. Observational data may provide useful indices of sex and age ratios, although high variability indicates that timing of observations is critical and must be standardized.

9. Carter, T.C.; Menzel, M.A.; Owen, S.F.; Edwards, J.W.; Menzel, J.M.; Ford, W.M. 2003. **Food habits of seven species of bats in the Allegheny plateau**

and ridge and valley of West Virginia. Northeastern Naturalist. 10:83-88.

Fecal pellets from 159 bats captured on the MWERF and Monongahela National Forest were analyzed to determine food habits by species. Diets of northern myotis and eastern red bats were dominated by both Coleoptera and Lepidoptera., whereas big brown bats ate primarily Coleoptera and hoary bats ate primarily Lepidoptera. Diets of silver-haired bats were composed of Lepidoptera and Diptera. Diets of little brown myotis and eastern pipistrelles consisted of an even proportion of six orders: Coleoptera, Hemiptera, Lepidoptera, Homoptera, Diptera, Hymenoptera, and Tricoptera. The food habits of these seven species of bats in the central Appalachians did not differ notably from diet of each species reported from other regions of the eastern United States.

10. Castleberry, N.L. 2000. **Food habits of the Allegheny woodrat (*Neotoma magister*).** Morgantown, WV: West Virginia University. 98 p. M.S. thesis.

Seasonal food habits of the Allegheny woodrat in the Ridge and Valley and Allegheny Plateau physiographic provinces of West Virginia and Virginia were described using microhistological techniques. Twenty-two food items comprised the majority of diets in both provinces. In the Allegheny Plateau, the top five food items were fungi, blueberries, acorns, wood ferns, and lichens. In the Ridge and Valley, woodrats ate primarily blackberry (*Rubus* spp.) leaves, fungi, greenbrier leaves, acorns, and oak leaves. Oak mast was used more heavily in every season in the Allegheny Plateau than in the Ridge and Valley. Between year differences are attributed to poor mast availability in 1997 and good availability in 1998. Woodrat diets did not differ in terms of diet diversity between unmanaged and managed forest landscapes in the region.

11. Castleberry, N.L.; Castleberry, S.B.; Ford, W.M.; Wood, P.B.; Mengak, M.T. 2002. **Allegheny woodrat (*Neotoma magister*) food habits in the central Appalachians.** American Midland Naturalist. 147: 80-92.

Within the core of the Allegheny woodrat's distribution in the central Appalachians, food habits and food resource availability are poorly understood. We collected fecal material from known individuals between November 1997 and December 1998 and used microhistological techniques to describe seasonal food habits in the oak-dominated forests of the Ridge and Valley and the northern hardwood forests of the Allegheny Plateau physiographic provinces. Green vegetation, hard mast, soft mast, and fungi were present in Allegheny woodrat diets in both provinces in all seasons. Presence of fungi and soft mast within the diet was higher and more seasonally widespread in the Allegheny Plateau because of more mesic forest conditions and more extensive early successional forest habitat than in the Ridge and Valley. Presence of hard mast in the diet mirrored acorn production and availability in both provinces in 1997 and 1998. Significant acorn use on the Allegheny Plateau, where oak-dominated forest stands are rare, highlights the importance of hard mast to Allegheny woodrats.

12. Castleberry, S.B. 2000. **Conservation and management of the Allegheny woodrat in the central Appalachians.** Morgantown, WV: West Virginia University. 166 p. Ph.D. dissertation.

The Allegheny woodrat occurs throughout the Appalachian Mountains, where it forms isolated colonies in rock outcrops, cliffs and caves. Populations among the northern and western peripheries of the range have experienced drastic declines in the past 20-30 years. Study objectives were to examine the impacts of forest management practices on movements, home range, and habitat use and to determine genetic structure and levels of gene flow within and among Allegheny woodrat populations. Results from radiotelemetry work suggest that timber harvesting has minimal impact on woodrat movements, home range, and habitat use in situations where intact forest is retained adjacent to colonies. Furthermore, timber harvesting did not influence microhabitat selection, as woodrats foraged in areas with diverse understory vegetation regardless of harvest method. Eleven polymorphic microsatellite DNA markers were developed to examine woodrat genetic variation at two spatial scales, geographically distinct regional populations and subpopulations within regional populations. There was significant genetic differentiation in woodrat populations at both spatial scales with a significant relationship between geographic

and genetic distance that suggests isolation by distance as a mechanism for differentiation. Individual colonies or aggregations of geographically proximate colonies function as populations and should be considered conservation units for management.

13. Castleberry, S.B.; Wood, P.B.; Van der Maath, N.L.; Ford, W.M.; Mengak, M.T. 1999. **Foraging movements of Allegheny woodrats in West Virginia.** In: 55th annual Northeast Fish and Wildlife Conference; 1999 April 11-14; Manchester, NH. Concord, NH: New Hampshire Fish and Game Department: 9.

Radiotelemetry was used to locate foraging Allegheny woodrats to determine the effects of two silvicultural methods on summer foraging movements and home range size on or near the MWERF. The silvicultural methods were clearcut/deferment harvests and sawtimber harvests whereas unharvested colony sites served as controls. Preliminary analysis revealed that among all harvest types, the mean home range size of males was approximately three times larger than that of females at 9.0 and 3.4 ha, respectively. For sexes combined, mean home range size at both clearcuts/deferments of 5.4 ha and sawtimber harvests of 10.5 ha was greater than at unharvested areas of 1.7 ha. This suggests that woodrats forage farther from their dens in harvested forests compared to unharvested forests.

14. Castleberry, S.B.; King, T.L.; Wood, P.B.; Ford, W.M. 2000. **Microsatellite DNA markers for the study of Allegheny woodrat (*Neotoma magister*) populations and cross-species amplification in the genus *Neotoma*.** Molecular Ecology. 9: 824-826.

The Allegheny woodrat is currently considered threatened, endangered, or at-risk throughout its range purportedly due to the direct or indirect effects of human-fragmented landscapes. To strengthen long-term population stability and reduce the need for further protection through the regulatory process, an effective conservation program for this at-risk species will require unambiguous, objectively defined units of management that discern evolutionarily important lineages. As an initial step towards addressing this research need, thirteen polymorphic microsatellite DNA markers were developed and examined for amplification success using Allegheny woodrats collected from Randolph and Greenbrier counties, West Virginia and Bath County, Virginia. Alleles observed per polymorphic locus ranged from 3 to 14 and averaged 6.8 alleles per locus. Direct count heterozygosities ranged from 0.231 to 0.846 and averaged 0.510. Cross-species amplification was investigated in seven additional *Neotoma* species. Six loci amplified in all species and two loci were polymorphic in all seven species.

15. 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.

To examine the impacts of timber harvesting on Allegheny woodrat behavior, 37 adults were radio-tracked during summer 1998 and 1999 in clearcut, diameter-limit, and intact forest stands in and near the MWERF. Home range size and foraging movements generally were greatest at diameter-limit sites and smallest in intact forests in 1998, following a poor mast crop. There were no differences among harvest methods in 1999 when mast was abundant. When hard mast was scarce, woodrats increased foraging movements and home range size to locate mast or sufficient alternative foods. Results suggested that clearcutting has minimal impact on woodrat movements, home range, and habitat use if sufficient intact forest is retained adjacent to colonies. Harvesting methods that selectively remove important mast-producing species may represent the greatest disturbance to Allegheny woodrats from forest management.

16. Castleberry, S.B.; King, T.L.; Ford, W.M.; Wood, P.B. 2001. **Microsatellite DNA analysis of Allegheny woodrat population structure.** In: 81st annual meeting of the American Society of Mammalogists; 2001 June 16-20; Missoula, MT. Missoula, MT: University of Montana: 102.

Eleven polymorphic microsatellite DNA markers were developed to examine Allegheny woodrat genetic variation and woodrat genetic structure was examined at two spatial scales. The markers detected considerable genetic variation with an average heterozygosity of 62 percent and an average of 10.4 alleles per locus. All

statistical tests indicated significant genetic subdivision at the population and subpopulation levels. Subpopulations conformed to Hardy-Weinberg expectations in 98.9 percent of comparisons; allele frequency differed among subpopulations in 99.3 percent of comparisons. Gene flow estimates were low and individual colonies or aggregations of geographically proximate colonies function as populations.

17. Castleberry, S.B.; Wood, P.B.; Ford, W.M.; Castleberry, N.L; Mengak, M.T. 2002. **Summer microhabitat selection by foraging Allegheny woodrats (*Neotoma magister*) in a managed forest.** American Midland Naturalist. 147:93-101.

Allegheny woodrat microhabitat characteristics were compared among clearcut, diameter-limited, and intact forest stands in the Allegheny mountains of West Virginia to determine effects of timber removal woodrat habitat selection. Microhabitat variables were measured within 0.04 ha plots centered on foraging locations identified using radiotelemetry. Differences in microhabitats among timber harvest methods were related to overstory characteristics, including total number of trees, canopy cover and overstory diversity. There were no observed differences in microhabitat variables between foraging and random plots within any harvest method and differences between foraging and random plots related to understory plant diversity. This suggests that Allegheny woodrats tolerate a wide range of macrohabitat conditions, but habitat selection is primarily determined by microhabitat factors.

18. Castleberry, S.B.; King, T.L; Wood, P.B.; Ford, W.M. 2002. **Microsatellite DNA analysis of population structure in Allegheny woodrats (*Neotoma magister*).** Journal of Mammalogy. 83:1058-1070.

Eleven polymorphic microsatellite DNA markers were screened to investigate patterns and processes of genetic variation in Allegheny woodrats at two spatial scales, geographically distinct populations and subpopulations within populations. The microsatellite markers detected considerable genetic variation and diversity and subpopulations conformed to Hardy-Weinberg expectations in 98.9 percent of comparisons. Allele frequency differed among subpopulations in 99.3 percent of comparisons. There was significant genetic subdivision at the population and subpopulation levels. Theoretical estimates of gene flow were low among subpopulations, suggesting that effective dispersal is limited among subpopulations separated by as little as 3 km. A significant range-wide relationship between geographic and genetic distance at both scales suggests isolation by distance as a mechanism for the observed differentiation. The relationship between genetic distance and geographic distance among the 19 subpopulations within the central Appalachians was significant. Woodrat colonies or geographically proximate aggregations of colonies function as populations and should be considered distinct conservation units for management.

19. Castleberry, S.B.; Castleberry, N.L; Wood, P.B.; Ford, W.M.; Mengak, M.T. 2003. **Fleas (Siphonaptera) of Allegheny woodrats in West Virginia with comments on ectoparasite host specificity.** American Midland Naturalist. 149: 209-212.

Previous research has indicated fewer host-specific ectoparasites on woodrats of the eastern United States as compared to western woodrat species. Allegheny woodrat flea parasites were examined in the core of the species' distribution to further elucidate patterns of ectoparasite host specificity in the East. Of 346 fleas collected from 62 Allegheny woodrats, all but one were identified as *Orchopeas pennsylvanicus*. The single exception was a male *Epitedia cavernicola*, that represented only the second record of this species from West Virginia. Unlike the eastern woodrat, that hosts a variety of generalist flea parasites, Allegheny woodrats in were host to only two flea species, both of which are host specific to woodrats.

20. Clayton, J. 2001. **Middle Fork River limestone treatment of acid mine drainage.** Elkins, WV: West Virginia Division of Natural Resources, Wildlife Resources Section. 39 p.

Three studies were conducted on limestone treatment of the acid-mine drainage and atmospheric acid deposition inputs into the Middle Fork River. These included: (1) a pilot limestone sand treatment of selected tributaries, (2) design and implementation of limestone sand treatment of all the major tributaries for full treatment, and (3) studies on the effects of treatment on tributary and river chemistry and biology. Following the success of the pilot instream limestone sand treatments in 1993

and 1994, full treatment was initiated in 1995 that involved the addition of 7,951 tons of limestone sand at 41 treatment sites on 27 tributaries of the Middle Fork River. Thereafter, 2,500 tons was added annually to replace limestone dissolved in the neutralization process. The treatment has resulted in a dramatic improvement in the water quality of the river and its tributaries that were being impacted by both acid mine drainage and acid precipitation. The entire 62 km of the Middle Fork have been improved sufficiently to restore a fishery, including brook trout.

21. Collins, R.J. 2004. T**he effects of prescribed fire, canopy gaps and deer herbivory on forest species composition: implications for succession theory.** Pittsburgh, PA: University of Pittsburgh. 213 p. Ph.D. dissertation.

Surface fires, canopy gaps and white-tailed deer herbivory are three important processes that act as "filters" differentially affecting plant species during ontogeny. Three major processes that control the realized species composition to produce successional trajectories in forests were examined through experimental manipulation using surface fires, created canopy gaps and white-tailed deer exclusion. Where deer are absent, the "Shade Tolerance Model" explained the development of pioneer communities after surface fires in canopy gaps. Where deer are present, however, the "Herbivory Model" explained the development of late successional communities after surface fires in canopy gaps. The third model, "Initial Floristics", which is widely applied across eastern deciduous forests, did not explain successional trajectories after any disturbance.

22. Collins, R.J.; Carson, W.P.; Long, Z. 2000. **The role of fire, canopy gaps, and deer browsing on forest regeneration in second growth stands: pretreatment results.** In: Proceedings of the 21st Tall Timbers fire ecology conference; 2000 April 14-16; Tallahassee, FL. Tallahassee, FL: Tall Timbers Research Station: 197.

Dendrochronological and palaeobotanical studies show that species composition in many eastern deciduous forests is changing at unprecedented rates. Two notable examples are the increase of red maple saplings along with a decrease of northern red oak saplings. Three likely explanations for the shifts in species composition are disruptions in natural fire regimes, over browsing by large deer populations, and changes in understory light environments. Preliminary data from the MWERF and Monongahela National show that oaks fail to reach sapling size and red maple saplings dominate. Further, analyses on understory light levels show that northern red oak seedlings occur at low densities in stands with high leaf area index and high canopy closure.

23. Collins, R. J.; Carson, W.P. 1998. **Species composition in eastern deciduous forests: a multiple factor approach to pattern analysis and hypothesis building.** In: 83rd annual meeting, Ecological Society of America; 1998 August 2-8; Baltimore, MD. Washington, DC: Ecological Society of America: 79.

A widely accepted theory states that understory light levels determines woody species composition through species-specific shade tolerances. Individuals of all tree species greater than 20 cm tall, light as leaf area index, canopy closure, and canopy heterogeneity and stand characteristics such as site index and slope were measured in sixty-four 20 m by 20 m plots in mature stands on the MWERF. Sugar maple and northern red oak had the same sharp threshold of leaf area index above which no seedlings occur. Although other canopy layers are dominated by the late successional sugar maple in the seedling layer, the pioneer black cherry dominates. These results suggest that species composition in the seedling layer may not be based on shade tolerance alone. Through path analysis, multi-factor models were created and used to build testable hypotheses that describe relative relationships of forest stand dynamics.

24. Collins, R.J.; Carson, W.P. 2000. **Effects of fire, deer herbivory, seed predation and canopy gaps on forest regeneration: a large-scale experimental approach.** In: Yaussy, D.A., comp. Proceedings of the workshop on fire, people and the central hardwoods landscape; 2000 March 12-14; Richmond KY. Gen. Tech. Rep. NE-274. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station: 124.

Fire, deer, seed predation and canopy gaps were experimentally manipulated in 128 400 m^2 research plots in West Virginia and the survival, growth and

recruitment of 28,000 tagged woody seedling, sapling and canopy trees were monitored. The fires were intense and top-killed up to 100 percent of small saplings and up to 60 percent of large saplings; however canopy tree mortality was only 4 percent and not different from controls. Fires strongly influenced the species composition of emergent seedlings. Three-way interactions of fire, deer, and canopy gaps have emerged as important factors affecting growth and survival of seedlings.

25. Collins, R.J; Carson, W.P. 2000. **The role of fire, deer herbivory and canopy gaps on tree species composition: Implications for Succession Theory.** In: 85th annual meeting Ecological Society of America; 2000 August 6-10; Snowbird, UT. Washington, DC: Ecological Society of America: 14.

Successional theories and models for second growth eastern deciduous forests predict that species composition should shift over time from pioneer, shade-intolerant species to late-successional shade-tolerant species. To understand the mechanisms that control forest composition and succession sixty-four 400 m^2 subplots were established where 17,000 woody seedlings, saplings and overstory trees were tracked where fire, browsing by deer, and canopy gap formation were manipulated. Sprouts on standing dead trees were three times taller inside deer-proof fences compared to spouts in unfenced plots. Northern red oak seedling height increased by 60 percent in fenced gaps and decreased by 20 percent in unfenced gaps. Black cherry showed the same pattern. Fires promoted grape and pin cherry germination.

26. Collins, R.J; Carson, W.P. 2001. **Is shade tolerance a fixed species trait? Evidence for shifting tolerance with herbivory.** In: 86th annual meeting Ecological Society of America; 2001 August 5-9; Madison, WI. Washington, DC: Ecological Society of America: [pages unknown].

Successional models for eastern deciduous forests use species specific shade tolerances to predict forest dynamics. These models assume that species specific shade tolerances are fixed across biotic gradients. Fire, browsing by deer and gap formation were experimentally manipulated in sixty-four 400 m^2 plots where the survival, growth and recruitment of 17,000 permanently marked individuals were followed. American beech, a very shade tolerant species, had consistently high survival across non-fire treatments. However, black birch, intermediate in shade tolerance, was ranked last in shade tolerance in controls but jumped to second in the shade tolerance ranking with high survival in the absence deer herbivory. Sugar maple, a very shade tolerant species, had poor survival across treatments. Hence models based solely on shade tolerance may fail to predict forest dynamics or be based on the wrong mechanism.

27. Collins, R.J.; Carson, W.P. 2002. ***T*he fire and oak hypothesis: incorporating the effects of deer browsing and canopy gaps.** In: Van Sanbeek, J.W.; Dawson, J.O.; Ponder, F.; Loewenstein, E.F.; Fralish, J.S., eds. Proceedings, 13th central hardwood forest conference; 2002 April 1-3; Urbana-Champaign, IL. Gen. Tech. Rep. NC-234. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station: 44-63.

A century of fire suppression has altered tree species composition and is a commonly cited for the region-wide decline in oak abundance. Other explanations include alterations in canopy gap regimes and deer browsing that operate in conjunction with fire suppression. Canopy tree survival and sapling sprouting response for 14 species collected during the second growing season following fires and the third growing season following gap creation and fence construction showed that fires lowered survival of small canopy trees but had no effect on large canopy trees. Small red maple canopy trees had lower survival than other species. Fire increased and deer browsing decreased the proportion of top-killed saplings that sprouted. Gaps, however, had no significant effect on sprouting. Deer browsing after fire reduced diversity in the sprouting community and created understories dominated by striped maple. Northern red oak saplings were not fire tolerant and did not produce tall sprouts following fire.

28. Collins, R.J.; Carson, W.P. 2003. **Do succession models predict the right pattern for the wrong reason: shade vs. herbivore tolerance?** In: 88th annual meeting Ecological Society of America; 1998 August 3-8; Savannah, GA. Washington, DC: Ecological Society of America: [pages unknown].

White-tailed deer populations are at historically high levels in many areas. By neglecting the effects of browsing, successional models may either fail to predict successional trajectories or make the correct prediction for the wrong ecological reason. In the absence of deer herbivory, the "Shade Tolerance Model" correctly predicted the dominance of shade-intolerant species after both fire and canopy gap formation in experimental manipulated plots. In the presence of deer, shade-tolerant species dominated after disturbances. The "Stage-Dependant Model" did not consistently predict dominant species. Herbivory changes successional trajectories by truncating succession and preventing pioneer species from dominating after disturbance.

29. Dellinger, R.L.; Wood, P.B.; Keyser, P.D. 2003. **Songbird abundance and nesting success on landscapes of differing harvesting intensities on an industrial forest.** In: 10th annual meeting Wildlife Society; 2003 August 6-10; Burlington, VT. Bethesda, MD: The Wildlife Society: 104.

Songbird abundance, richness, and nesting success in landscapes managed were quantified under three harvesting intensities representing three levels of forest disturbance on the MWERF during 2001-2003. These levels approximated a harvesting rotation of 20, 40, or 80 years. Forest interior birds were the most abundant habitat guild in 2001-2002, followed by interior-edge and lastly edge species indicative of a forest in predominately mature age classes. In 2001, forest interior species were less abundant in the 80-year rotation compartments than other treatments, and interior-edge species had different abundances among all three treatments, highest in the 40-year rotation and lowest in the 80-year. Survival rates for all 22 species nest-monitored in 2001 were highest in the 40-year rotation compartments and lowest in the 20-year rotation. Nest survival in 2002 of 11 focal species was highest in the 40-year rotation compartments but lowest in the 80-year rotation.

30. Dobony; C.A. 2000. **Factors influencing ruffed grouse productivity and chick survival in West Virginia.** Morgantown, WV: West Virginia University. 97 p. M.S. thesis.

Productivity measures, chick mortality, and factors influencing chick survival of ruffed grouse were examined at the MWERF and the Westvaco Dutch Run Tract in the Ridge and Valley of southeastern West Virginia during 1998 and 1999. The proportion of hens that attempted to nest, their overall nest success, and clutch size were similar between age classes, between sites, and between years. Depredation was the major cause of nest failure, and 30 percent of the nests monitored were disturbed or destroyed mostly by raccoon and black rat snake. Less than 30 percent of radio-collared grouse chicks (< 3 days old) survived 5 weeks post-hatch. Most mortality occurred within the first week post-hatch decreasing thereafter. Avian and mammalian predation rather than exposure accounted for the majority of mortality.

31. Dobony, C.A.; Edwards, J.W. 2001. **A new flight-interception trap for arthropod sampling.** Entomology News. 112: 217-220.

A flight-interception trap was designed to assess arthropod abundance and biomass as part of a ruffed grouse study at the MWERF. Traps were constructed of acrylic plexiglass and were relatively inexpensive and durable. The design was efficacious in sampling airborne insects and some terrestrials of multiple orders and families.

32. Dobony, C.A.; Edwards, J.W.; Ford, W.M.; Allen, T.J. 2001. **Nesting success of ruffed grouse in West Virginia.** Proceedings of the annual conference of Southeastern Association of Fish and Wildlife Agencies. 55: 456-465.

The nesting success of ruffed grouse was examined at two sites in West Virginia during 1998 and 1999. Nests of radio-collared female grouse were located and the proportion of females that nested, nest success (proportion of hens successful in hatching one chick), clutch size, hatching success, and hatch dates was determined. The proportion of hens that attempted to nest, nesting success, and average clutch size and hatching success was similar between age classes, sites, and years. Depredation was the major cause of nest failure. Nests monitored with video cameras revealed raccoons and black rat snakes were the most common nest predators. Nesting success and nest depredation rates in West

Virginia were found to be comparable to other portions of the range, but re-nesting rates were less.

33. Edwards, J.W.; Ford, W.M.; Wood, P.B.; Menzel, M.A.; Johnson, J.B.; Owen, S.F.; Menzel, J.M.; Chapman, B.R.; Miller, K.V. 2001. **Survey of forest bat communities on the Monongahela National Forest and Westvaco Wildlife and Ecosystem Research Forest with emphasis on the Indiana bat.** Elkins, WV: U.S. Department of Agriculture, Forest Service, Monongahela National Forest. 119 p.

Mist nets were set at 38 locations associated with stream or pool habitats for a combined total of 343 net-nights during the periods 3 June - 11 August 1998, and 23 May - 27 July 1999 on the MWERF and Monongahela National Forest. This effort yielded 420 captures of 10 bat species common to north-central West Virginia. Acoustical sampling during the same time period at 11 stations resulted in 1691 bats being detected. Bat activity was highest in association with riparian habitats. Large-bodied bats such as hoary bats were recorded more frequently in open habitats such as recently harvested leave-tree or deferment cuts than intact forests with closed canopies.

34. Ford, W.M.; Odom, R.H.; Preston, D.P. 1996. **Westvaco's Wildlife and Ecosystem Research Forest: an industry approach to long-term cooperative ecological research.** In: 7th annual Southern Appalachian Man and the Biosphere conference; 1996 November 6-8; Gatlinburg, TN. Knoxville, TN: Southern Appalachian Man and the Biosphere Program: 21-22.

As part of Westvaco Corporation's ecosystem-based, multiple use approach to forest management, the Westvaco Wildlife and Ecosystem Research Forest was established as a living laboratory to study the interactions of modern silviculture with the ecology of the Appalachian landscape. The area is located in the Allegheny Mountains of West Virginia and contains three, 400 ha of middle to upper-elevation terrestrial forest communities, approximately 20 km of permanent freshwater streams and a variety of riparian, rock-outcrop and bog habitat types. Dominant forest overstory types include cove and mixed mesophytic hardwoods, northern hardwoods, and montane boreal spruce communities. The Research Forest has been disturbed by logging and other activities and continues to be managed for production of timber, fiber and other commodity products. Pretreatment baseline survey work is being conducted to answer the question, "What's out there?" As management activities proceed, studies are in progress or planned to focus on biological responses to timber harvesting. Finally, as responses to various treatments are understood, studies will explore ways to adaptively manage the landscape to produce acceptable levels of forest products, biological diversity and resource conservation within this forested landscape. An important element of work is the integration of research data and results with Westvaco's land classification efforts and Forest Resources Information System. Allocating corporate resources to more productive land and customizing management prescriptions based on significant variation in the land base are only to important values obtained from land classification; ecological research that is also based on identifiable landscape units is more comparable from place to place and therefore more useful within a physiographic region when discussing various aspects of biodiversity.

35. Ford, W.M.; McCay, T.S.; Menzel, M.A.; 2002. **Influence of elevation and forest type on shrew community assemblage and species distribution in the central and southern Appalachian Mountains.** In: International colloquium on the Biology of the Soricidae II; 2002 October 14-18; Rector, PA. Pittsburgh, PA: Carnegie Museum of Natural History: 17.

Shrew community data from 303 sites across the upper Piedmont, Blue Ridge, northern Ridge and Valley, southern Ridge and Valley, Cumberland Plateau and Allegheny Mountains and Plateau sections of the central and southern Appalachian Mountains was analyzed to describe regional distributions and to identify macro-environmental factors important to shrews at the community and species scales. Nine species were documented with a low of three in the southern Ridge and Valley section to a high of eight in the Blue Ridge section where the Appalachian, Austral, and Boreomontane fauna elements converge. Regionwide, shrew species richness was related to increasing elevation and was higher in mesic forest types than in xeric types.

Conformity to expected distribution of shrew body-size (small, medium and large) appropriate for the central and southern Appalachian species pool showed no relationship to elevation gradients. However, xeric forest types conformed to a balanced assemblage of size classes less than expected. Among individual species, presence of masked shrew and smoky shrew was associated strongly with increasing elevation and mesic forests, whereas presence of southeastern shrew and southern short-tailed shrew showed an opposite trend with elevation and forest type.

36. Ford, W.M.; Dobony, C.A.; Edwards, J.W. 2002. **Shrews in managed northern hardwood stands in the Allegheny Mountains of West Virginia.** Proceedings of the annual conference of Southeastern Fish and Wildlife Agencies. 56: 374-384.

To assess shrew response to clearcutting northern hardwood forests in the Allegheny Mountains of West Virginia, a pitfall trapping survey was conducted during the late spring and early summer of 1998 and 1999 across a chronosequence of northern hardwood stand-ages, from recently clearcut to those > 60 years old at the MWERF. Capture frequency of masked shrews, smoky shrews, and northern short-tailed shrews did not differ among stand-ages. Shrew captures were influenced more by differences in weather conditions between years and pitfall type. Masked shrew and smoky shrew captures were correlated positively with daily precipitation and negatively with maximum daily temperature in 1999, a severe drought year. Pitfalls placed along natural cover such as downed woody debris and emergent rock captured more masked shrews and smoky shrews than did pitfalls placed in the open forest floor.

37. Ford, W.M; Rodrigue, J.L. 2001. **Soricid abundance in partial overstory removal harvests and riparian areas in an industrial forest landscape of the central Appalachians.** Forest Ecology and Management. 152: 159-168.

To assess the response of soricids to partial overstory timber harvest and to investigate the importance of riparian areas to soricids, pitfall trapping surveys were conducted during the summers of 1996-1998 in the Westvaco Ecosystem Research Forest. Of species collected in sufficient numbers to analyze statistically across treatments, the relative abundance of masked shrews, smoky shrews, and northern short-tailed shrews did not differ among harvest sites and control sites for any year, either pre-harvest or post-harvest. Uncut, control sites had higher relative abundances than did riparian sites for masked shrews in 1996 and for smoky shrews in 1997. Collections of all species were correlated poorly with most microhabitat variables. Rock shrews were restricted to uncut upland sites at higher elevations with large amounts of emergent rock.

38. Ford, W.M.; Stephenson, S.L.; Menzel, J.M; Black, D.R.; Edwards, J.W. 2004. **Habitat characteristics of the endangered Virginia northern flying squirrel (*Glaucomys sabrinus fuscus*) in the central Appalachian Mountains.** American Midland Naturalist. 152:430-438.

Eleven ecological variables thought to be important for assessing the habitat of the endangered Virginia northern flying squirrel were compared at 11 occupied and nine unoccupied sites within northern hardwood-montane conifer forests in the central Appalachians of West Virginia. Forest stands at sites occupied by northern flying squirrels had significantly higher relative importance values of montane conifers such as red spruce and little or no presence of northern red oak than did sites that were believed unoccupied. Probabilities derived from logistic regression analyses indicated that sites were considered occupied when relative importance values of montane conifers in forest stands exceeded approximately 35 percent. Additionally, patchily distributed hypogeal fungi combined with the much reduced and altered forest habitat in the region help explain the rarity of northern flying squirrels in the central Appalachians.

39. Gribko, L.S.; Hohn, M.E.; Ford, W.M. 1999. **White-tailed deer impact on forest regeneration: modeling landscape-level deer activity patterns.** In: Stringer, J.W.; Loftis, D.L., eds. Proceedings, 12th central hardwood forest conference; 1999 February 28-March 2; Lexington, KY. Gen. Tech. Rep. SRS- 24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 176-185.

White-tailed deer herbivory has been identified as a major impediment to the survival and growth of forest regeneration in the northeastern United States.

As a supplement to direct control of deer densities through hunting, it may be possible for land managers to manipulate habitat and browsing pressure through carefully planned timber harvest. A method to relate deer habitat use patterns to regeneration condition and complexity across large landscapes was developed at the West Virginia University Forest and the Westvaco Wildlife and Ecosystem Research Forest. Fecal pellet group counts were conducted on geolocated 1.72 m radius circular plots at an intensity of approximately one plot per 2.4 ha. Deposition patterns were modeled using geographic information systems technology and a spatial statistics technique known as two-dimensional ordinary point kriging. Variography revealed spatial contagion in the university forest that could be accurately modeled with a resulting interpolated probability map for long-term monitoring of deer activity patterns. Results on the Westvaco forest indicated that sampling intensity was too coarse to allow modeling of strong localized dependence in the data.

40. Hartman, K.J.; Sweka, J.A. 2001. **Development of a bioenergetics model for Appalachian brook trout.** In: Proceedings of the annual conference of the Southeastern Association of Fish and Wildlife Agencies. 55: 38-51.

A bioenergetics model for brook trout was developed to evaluate the potential impact of thermal changes on Appalachian streams. Growth and final weight were closely estimated, however, consumption was slightly underestimated. This bioenergetics model suggests that given unlimited food, brook trout growth may be possible over the range of environmental temperatures supporting the species. However, under more restricted rations typical of Appalachian headwater streams such as on the MWERF only modest growth is possible between 3.5 and 20º C. These restrictions may have serious implications for thermal alterations upon brook trout regionally and may suggest that energetically, over-winter may be a critical time.

41. Haulton, G.S. 1999. **Ruffed grouse natality, chick survival, and brood micro-habitat selection in the southern Appalachians.** Blacksburg, VA: Virginia Polytechnic Institute and State University. 110 p. M.S. thesis.

Ruffed grouse natality characteristics were calculated for three regions in the southern Appalachians (Ridge and Valley, Alleghany Plateau, and Ohio River Valley). Nesting rate, pooled over all regions, was 83.6 percent in 1997 and 79.7 percent in 1998. In the 2-year period, the Alleghany Plateau reported the highest nesting rate whereas the Ohio River Valley reported the lowest rate. Overall hen success rates were 81.5 percent in 1997 and 56.9 percent in 1998. Yearling hen success rates were as high as or higher than adults. The re-nest rate was lower than previously reported for the southern Appalachians. First-week chick survival estimates ranged from 0.18 to 0.32 in 1997 and from 0.45 to 0.48 in 1998. Late brood season survivorship values were considerably lower than from more northern portions of ruffed grouse range. Microhabitat characteristics were compared at known brood locations with randomly selected locations to determine which characteristics are selected by hens and broods. In the first 6 weeks of the brood season, hens and broods selected sites with tall, complete, vegetative ground cover under well developed canopies with ample arthropods, fruit, and forage.

42. Hood, S.M. 2001. **Vegetation responses to seven silvicultural treatments in the Southern Appalachians one year after harvesting.** Blacksburg, VA: Virginia Polytechnic Institute and State University. 133 p. M.S. thesis.

The vegetation responses to seven silvicultural treatments one growing season after harvesting were examined on seven sites in the southern Appalachian mountains of Virginia and West Virginia. Treatments included: (1) control; (2) understory control by herbicide; (3) group selection; (4) high-leave shelterwood; (5) low-leave shelterwood; (6) leave tree; and (7) clearcut. Vegetation richness and cover increased with increasing harvest intensity. Local species extinctions were similar in the control and disturbed treatments. Regional-scale differences in site location were more important in explaining the presence of a species than were environmental characteristics. Within a region, species primarily were distributed along a light/litter weight gradient and secondarily along a soil properties and nutrient gradient.

43. Johnson, A.N. 2002. **Determining the genetic distances between sub-populations of *Aneides aeneus* in the Westvaco Wildlife and Ecosystem Research Forest.** Huntington, WV: Marshall University. 62 p. M.S. thesis.

The green salamander is a plethodontid that often inhabits cliffs and rocky outcrops which are moist but not wet and shaded. Seventeen tissue samples were retrieved from five sites within the Westvaco Wildlife and Ecosystem Research Forest for the purposes of determining the extent of gene flow between those five separate populations. The polymerase chain reaction was used to amplify approximately 940 base pairs of the ND4 NADH dehydrogenase region of mitochondrial DNA (mtDNA). Tree topologies, rooted by an outgroup from North Carolina, showed no consistent grouping by individual populations. Linear regression analysis showed a significant correlation between genetic distances and geographical distances of the samples both within the forest and extending to the North Carolina specimen, though this correlation was not significant for populations within one kilometer of each other possibly indicating gene flow at that scale or less.

44. Keyser, P.D.; Wigley, T.B.; Haas, C.A.; Wood, P.B.; Ford, W.M.; Edwards, J.W.; Guynn, D.C.; Loehle, C. 2003. **Square pegs and round holes: understanding landscape ecology in heavily forested systems, the Appalachian Landscape Ecology Project.** In: 10th annual meeting of Wildlife Society; 2003 August 6-10; Burlington, VT. Bethesda, MD: Wildlife Society: 162.

The prevailing paradigm for understanding forest wildlife ecology and management issues has shifted from the stand to the landscape scale. However few ecological studies incorporate such design features or seek specifically to answer landscape-level questions in temperate forest ecosystems. Beginning in 2000, the Appalachian Landscape Ecology Project (ALEP), was initiated in a heavily forested landscape on and adjacent to the MWERF that allows for evaluation of landscape-level effects of forest disturbance and associated population processes appropriate to such a context. The ALEP involves a 40-year time frame, a rigorous but simple experimental design, and investigations of multiple taxa, all at a relatively large spatial scale.

45. Knapp, S.M. 1999. **Effects of timber harvesting on terrestrial salamander abundance and behavior.** Blacksburg, VA: Virginia Polytechnic Institute and State University. 121 p. M.S. thesis.

The short-term effects of seven silvicultural treatments on terrestrial salamander populations were examined at four sites in southwest Virginia and West Virginia. The three silvicultural treatments with the most canopy removal had significantly fewer salamanders than the control postharvest. No differences were found among treatments in age class distribution, the percent of females that were gravid, or average clutch size. Instantaneous rates of salamander activity ranged from 1.3 to 11.7 percent of the population redbacked salamanders and slimy salamanders respectively. Timber harvest caused up to a twofold increase or decrease in activity rates. There was evidence for bias in the night census method, but differences were not consistent enough to suggest general bias corrections. In concurrent lab work, poorly fed salamanders were observed out of simulated burrows less than well-fed salamanders suggesting risk-averse behavior.

46. Knapp, S.M.; Haas, C.A.; Harpole, D.N.; Kirkpatrick, R.L. 2003. **Initial effects of clearcutting and alternative silvicultural practices on terrestrial salamander abundance.** Conservation Biology. 17: 752-762.

Using a randomized, replicated design, the short-term effects of timber harvest on terrestrial salamanders were examined in the southern Appalachian Mountains of Virginia and West Virginia. All treatments with canopy removal had significantly fewer salamanders than the control treatment, but salamander abundances on alternative treatments with partial or less canopy removal as a percent of treatment area did not differ significantly from clearcuts. There were no significant differences between treatments in the proportion of females that were gravid or in the average number of eggs in gravid females. The initial declines in terrestrial plethodontid abundance caused by timber harvesting may be minimized across the landscape by concentrating high-intensity timber harvesting in small areas of a few hectares.

47. Langdon, C.A. 2001. **A comparison of white-tailed deer population estimation methods in West**

Virginia. Morgantown, WV: West Virginia University. 119 p. M.S. thesis.

Five methods of estimating white-tailed deer density were compared and the effects of baiting were evaluated on deer movement at the Westvaco Wildlife and Ecosystem Research Forest in during 2000 and 2001. Deer density estimates were derived from pellet group counts, spotlight distance sampling, spotlight mark-resighting, automated camera surveys, and automated camera mark-resighting among summer, fall, winter, and spring. Deer density estimates from pellet group counts were the least precise, but were least costly. Spotlight distance sampling yielded relatively precise estimates, as did spotlight mark-resighting when the number of marked deer exceed 15; spotlighting was moderately expensive. Automated camera surveys produced the most precise deer density estimates whereas camera mark-resighting was fairly precise; costs were very high. Significant differences among density estimates occurred within seasons. Sex and age ratios observed were highest in fall and spring, respectively; within-season sex, age, and marking ratios observed via automated cameras were generally higher than those observed during spotlighting. Telemetry data and resightings of marked deer indicated that the area an automated camera surveyed was 39 ha. Baiting during automated camera surveys did not significantly affect deer movement.

48. Langdon, C.A.; Edwards, J.W.; Crum, J.M.; Ford, W.M. 2001. **A comparison of white-tailed deer population estimation methods in West Virginia.** In: 24th annual meeting of the Southeast Deer Study Group; 2001 February 17-20; St. Louis, MO. Jefferson City, MO: Missouri Department of Conservation: 21.

White-tailed deer density was estimated by pellet-group counts, spotlight counts, and automated camera estimates during 2000 on approximately 809 ha of forest and cut over areas at the Westvaco Wildlife and Ecosystem Research Forest. Automated camera estimates were derived using both antlered to antlerless ratios and a known marked deer population.

49. Langdon, C.A.; Edwards, J.W.; Crum, J.M.; Ford, W.M. 2002. **Evaluating the effectiveness of different deer population estimation techniques in the central Appalachians.** In: 25th annual meeting of the Southeastern Deer Study Group; 2002 February 17-20; Mobile, AL. Montgomery, AL: Alabama Division of Wildlife and Freshwater Fisheries: 30-31.

Three white-tailed deer population estimation methods were evaluated on the Westvaco Wildlife and Ecosystem Research Forest: pellet-group counts, spotlight counts, and automated camera surveys during four sampling periods in 2000-01 on approximately 2,000 ha of forest and cutover areas. A marked deer population allowed mark-resight estimates using spotlighting and automated cameras. Density estimates ranged from 21.5 to over 210.6 deer/mi^2. Estimates were generally highest in the summer and lowest in the spring. Pellet group count estimates were inconsistent with those derived from other methods, as were spotlight mark-resight estimates calculated from few observations of marked deer. Automated camera surveys produced the most precise estimates, but were far more expensive than other methods. Buck:doe and fawn:doe ratios observed by spotlighting and automated cameras were highest in the fall and winter, respectively.

50. Laseter, B.R. 2004. **Sociospatial characteristics and genetic structure of white-tailed deer in the central Appalachians of West Virginia.** Athens, GA: University of Georgia. 102 p. Ph.D. dissertation.

The sociospatial characteristics and genetic structure of female white-tailed deer inhabiting a forested environment in the central Appalachian Mountains were examined using an extensive telemetry data set for 127 female white-tailed deer captured during the winters of 1999-2002 on the MWERF. Genetic measures were used to evaluate spatial and genetic relationships. Female white-tailed deer do not distribute themselves randomly across the MWERF, but are clumped into groups of spatially tolerant individuals. Although patterns of inter-relatedness observed are consistent with matriarchal social structure reported in previous studies, higher population density may affect the composition of deer groups removed in spatially-based localized management efforts. Overall, the rose-petal model of deer population expansion applies to the MWERF, but high population density forces overlap among matriarchal groups and therefore may limit the effectiveness of localized management efforts.

51. Laseter, B.R.; Campbell, T.A.; Osborn, D.A.; Miller, K.V.; Ford, W.M. 2002. **Spatiotemporal characteristics of female white-tailed deer in the central Appalachians of West Virginia.** In: 25th annual meeting of the Southeastern Deer Study Group; 2002 February 17-20; Mobile, AL. Montgomery, AL: Alabama Division of Wildlife and Freshwater Fisheries: 34.

Across their range, white-tailed deer form matrilineal groups, composed of older females and their female descendants. In migratory herds, researchers have used summer and winter range commonalities to delineate these matrilineal groups. In the central Appalachians of West Virginia, deer are nonmigratory and seasonal ranges are less discrete than in migratory herds. Radiotelemetry data collected from May 1999 to June 2001 for 63 female deer was examined for spatial overlap. Groups were delineated based on cluster analysis of degree of home range overlap. Average home range size did not change seasonally and average female group size did not differ between seasons. This suggests that while biologically meaningful female groups likely exist in the central Appalachians, they cannot be defined via traditional approaches, such as shared seasonal ranges.

52. Laseter, B. R.; Campbell, T.A.; Osborn, D.A.; Miller, K.V.; Ford, W.M. 2002. **Social groups of female white-tailed deer: how much seasonal movement occurs in the central Appalachians.** In: 5th international Deer Biology Congress; 2002 August 25-30; Quebec City, PQ. Quebec City, PQ: Quebec Ministry of Fish, Wildlife and Parks: 63.

A total of 11,847 radiotelemetry locations collected from May 1999 to June 2001 for 63 female deer on the Westvaco Wildlife and Ecosystem Research Forest were examined. Average home range size differed between winter and summer months but was not highly significant. Additionally, average female group size was smaller in winter than summer but also was not highly significant. These results suggest that in the absence of discrete seasonal ranges, average home range size and group size might not adequately reflect seasonal social group dynamics in the central Appalachians.

53. Laseter, B.R.; Campbell, T.A.; Osborn, D.A.; Miller, K.V.; Ford, W.M. 2003. **White-tailed deer browse preferences in clearcuts in the central Appalachians of West Virginia.** In: 26th annual meeting of the Southeastern Deer Study Group; 2003 February 23-26; Chattanooga, TN. Nashville, TN: Tennessee Wildlife Resources Agency: 23-24.

Clear-cutting is a silviculturally appropriate method when regenerating commercially and ecologically valuable species, especially in the context of typically mast-poor northern hardwood stands of the central Appalachians. Nine regeneration areas ≤ 5 years old were sampled to compare availability and use of woody browse. A total of 731,993 twigs was recorded and 126,427 of those were browsed. Nine of the 21 species were classified as high-use whereas 12 were classified as low-use species relative to their availability. Blackberry and greenbrier were the most important browse species in these regeneration areas, followed by pin cherry, black cherry and black birch. Observed high use of black cherry, a low-preference species for deer, underscores the potentially significant ecological impacts associated with high deer density relative to ecological carrying capacity. This suggests that selective browsing by deer could have significant implications for forest regeneration in the central Appalachians.

54. Laseter, B.R.; Campbell, T.A.; Miller, B.F.; Osborn, D.A.; Miller, K.V.; Ford, W.M. 2004. **Female white-tailed deer: are there really social groups in the central Appalachians?** In: 27th annual meeting of the Southeastern Deer Study Group; 2004 February 22-24; Lexington, KY. Frankfort, KY: Kentucky Department of Fish and Wildlife Resources: 33.

More than 20,000 radiotelemetry locations collected from May 1999 to December 2001 for 120 female deer were examined on the MWERF. Social groups were delineated based on cluster analysis of degree of annual home range overlap. For each group, additional cluster analyses, visual inspection of individual core areas and over 1,400 direct visual observations aided in characterization of spatial relationships within groups. Analysis of group and individual activity centers indicated no predictable relationship between age and position within each group when analyzed annually and seasonally. Average home range size did not differ among age classes. This confirmed that discrete spatial groups do exist in nonmigratory herds, however spatial arrangement

within groups may differ from that reported in migratory herds.

55. Lengowski, L.S. 1995. **A documentation of human use on the Westvaco Research Forest.** Elkins, WV: Davis and Elkins College. 89 p. Senior thesis.

Prior to European settlement, the area that is now the Westvaco Wildlife and Ecosystem Research Forest was hunting grounds for the Seneca and Shawnee Indians. Limited settlement began in the late 1700s, primarily of people with German, English and Scotch-Irish backgrounds. One hundred years later, Swiss emigrants settled the area near Adolph in the 1880s. The logging era began with the extension of the railroad up the Middle Fork River in the early 20th century to service the Ellamore Mill. All of the virgin timber on the area had been cut by 1928 by the Moore-Keppel Company. Westvaco purchased the land in the 1970s. White-tailed deer were absent on the area by the early 20th century, though brook trout were know to be common prior to logging activities.

56. Lindley, B.A. 1999. **Natural History of the Northern Spring Salamander *Gyrinophilus porphyriticus porphyriticus* at the Westvaco Wildlife and Ecosystem ResearchForest in Randolph County, West Virginia.** Huntington, WV: Marshall University. 87 p. M.S. thesis.

The objective of this study was to determine the natural history of the northern spring salamander. Four sites on three streams were divided into two 25 m transects. All sites were examined once each month from August 1997 through November 1998. No single environmental factor limited the distribution of the northern spring salamander. There were differences among sites for pH, water temperature, and stream depth and width. Larvae were observed in lower water depths when compared to the average stream depths at each stream. No egg masses were found. Metamorphosis occurred mostly in the summer based on larvae observed. Size classes of larvae indicated an age range of 4 to 7 years. Only one recapture out of 80 marked individuals was observed.

57. Loehle, C.; Wigley, T.B.; Mitchell, M.S. 2002. **Assess the scientific basis for standards/practices at multiple spatial scales, east - Project NCSSF 2002-A.5.** Washington, DC: National Council for the Science of Sustainable Forestry. 22 p.

Forestry practices can have important influences on functions of forest, such as the support of biological diversity. By altering forest structural features at the stand scale habitat for selected wildlife species can be enhanced or diminished. Likewise, forest habitat attributes at larger spatial scales are also potentially related to biodiversity. The effects of spatial attributes of forest structure at several different scales were analyzed retrospectively for four areas including the Westvaco Wildlife and Ecosystem Research Forest. At the landscape scale, roads could not be shown to produce a consistent negative effect on richness of birds, reptiles, amphibians, or herpetofauna. At the plot level, bird richness increased with road density within all neighborhoods and with increased proximity to roads. In the species-area analysis, riparian zones were not consistently richer than zones farther from water for birds, reptiles, amphibians, or herpetofauna. At the plot level, bird richness was not related to distance of sample points to the nearest water. Measures of habitat related to Montreal Process indicators were determined to be related to many measures of biological diversity. However, no single indicator of landscape condition will predict all aspects of biodiversity.

58. Logan, M.N. 2003. **Brook trout (*Salvelinus fontinalis*) movement and habitat use in a headwater stream of the central Appalachian Mountains of West Virginia.** Morgantown, WV: West Virginia University. 62 p. M.S. thesis.

Brook trout habitat use, home range, and movement patterns were evaluated in an Appalachian headwater stream during spring and other high flow events. Brook trout were implanted with radio tags to track their movement for approximately 30 days during late spring 2002 and early spring 2003. Results showed that brook trout used pools as their primary habitat and that large woody debris was used as cover more than expected by chance. Other variables, such as water depth and velocity, were artifacts of pool use. Results also showed that brook trout were very mobile, capable of moving hundreds of meters daily.

59. Lorber, J.H. 2003. **Effects of alternative silvicultural practices on oak regeneration in the**

southern Appalachians. Blacksburg, VA: Virginia Polytechnic and State University. 139 p. M.S. thesis.

Regeneration in oak-dominated stands following silvicultural clearcut, commercial clearcut, leave-tree, shelterwood and group-selection was examined on four sites in the mountains of Virginia and West Virginia. Oak regeneration dominance varied by site, but did not vary by silvicultural treatment; all resulted in relatively low numbers with treatments unable to overcome site-specific limitations to successful oak regeneration. The greatest reduction in oak importance occurred on the intermediate and high quality sites. At the microhabitat level, important predictors for oak regeneration were understory and overstory oak component in the pre-harvest stand, post-harvest light and soil nitrogen levels.

60. Mengak, M.T.; Castleberry, S.B.; Ford, W.M.; Rodrigue, J.L.; Castleberry, N.L. 2002. **Longevity record for a wild Allegheny woodrat (*Neotoma magister*) in West Virgini**a. Virginia Journal of Science. 53: 167-170.

On 8 August 1997, a juvenile female woodrat was caught and ear-tagged. She was caught 24 times in the same outcrop from 1997 through 2002. A conservative estimate of her age on 25 January 2002 was 1,734 days.

61. Menzel, J.M. 2003. **An examination of the habitat requirements of the endangeredVirginia northern flying squirrel (*Glaucomys sabrinus fuscus*) by assessing nesting sites, habitat use and the development of a habitat model.** Morgantown, WV: West Virginia University. 122 p. Ph.D. dissertation.

Characteristics of nest trees used by Virginia northern flying squirrels were compared within randomly selected trees during summer and fall of 2000 and 2001 by tracking 13 northern flying squirrels to 59 nest trees. The squirrels used an average of 3.6 nest trees per month, switching trees frequently. Sixty-nine percent of the nests were in cavities and 31 percent were leaf nests. Wide variation in nest tree characteristics suggests that selection is not as specialized as previously thought. Radiotelemetry and GIS analysis also were used to determine the home range size and habitats utilized by northern flying squirrels. Using the adaptive kernel method, male squirrels had a mean home-range size of 64.1 ha and females had a mean home range of 17.0 ha. Compositional analysis showed that northern flying squirrels prefer spruce (*Picea* spp.) and spruce-mixed northern hardwood forests in West Virginia. Habitat characteristics that were significant in predicting the presence of northern flying squirrels included: (1) elevation over 1036 meters; (2) northern aspects; and (3) spruce and mixed spruce northern hardwood stands.

62. Menzel, J.M.; Ford, W.M.; Edwards, J.W.; Menzel, M.A. 2004. **Nest tree use by the endangered Virginia northern flying squirrel in the central Appalachian Mountains.** American Midland Naturalist. 151: 355-368.

The characteristics of nest trees used by Virginia northern flying squirrels in West Virginia were compared with randomly selected trees in 2000 and 2001 by tracking squirrels to 59 nest trees. The squirrels used an average of 3.6 nest trees per month, switching trees frequently. Sixty-nine percent of the nests were in cavities and 31 percent were leaf nests. Yellow birch and Fraser magnolia were selected for nest trees more than expected based on availability. Nest trees generally were larger and taller than surrounding trees and many were located near linear openings such as trails. Overall there was a wide variation in nest tree characteristics indicating more generalized denning habits than previously believed.

63. Menzel, M.A.; Owen, S.F.; Ford, W.M.; Edwards, J.W.; Wood, P.B.; Chapman, B.R.; Miller, K.V. 2002. **Roost tree selection by northern long-eared bat (*Myotis septentrionalis*) maternity colonies in an industrial forest of the central Appalachian Mountains.** Forest Ecology and Management. 155: 107-114.

Seven lactating northern myotis were tracked to 12 roost trees used by maternity colonies ranging in size from 11 to 65 individuals in the central Appalachians of West Virginia. Lactating females switched among roosts on average every 5 days. Roosts were located in nine trees species, with 11 roosts in tree cavities and one under exfoliating bark. Eight of the roosts were located in snags; the other four were located in cavities in living trees. Black locust snags were selected more than expected based on their occurrence in the forests surveyed. All roosts were located in or below the forest canopy suggesting that solar exposure may not be as critical for

maternity colonies of this species unlike other bats at northern latitudes in North America. These data show that short-lived, early successional species such as black locust may provide suitable roosting habitat for northern long-eared bats in managed Allegheny hardwood stands in the central Appalachians.

64. Odom, R.H.; Ford, W.M.; Edwards, J.W.; Stihler, C.; Menzel, J.M. 2001. **Modeling Virginia northern flying squirrel habitat in the central Appalachians.** Biological Conservation. 99: 245-252.

Occurrence patterns and habitat data for the Virginia northern flying squirrel were examined in the central Appalachian Mountains of West Virginia to develop a predictive habitat model. Topographic conditions (elevation, landform index, surface curvature, slope gradient and aspect) and proximity to coniferous cover were evaluated for three study areas where flying squirrel presence has been documented via nest box surveys. Virginia northern flying squirrel presence was strongly associated with proximity to conifer cover but not to any other habitat variables tested. Logistic regression analyses showed that current habitat relationship data are insufficient to delineate potential habitat with a reasonable degree of confidence. More detailed microhabitat and macrohabitat relationship studies of the Virginia northern flying squirrel beyond information gathered from traditional nest-box surveys will be necessary for successful management and eventual recovery of this endangered species.

65. Owen, S.F. 2000. **Impacts of timber harvest in the central Appalachians hardwood region on bat foraging and roosting behavior.** Athens, GA: University of Georgia. 52 p. M.S. thesis.

Anabat II bat detectors were used to determine bat foraging habits in industrial forest lands on the Allegheny Plateau of West Virginia, and to compare activity levels in five habitats that differed in structural complexity. These habitats included clearcuts, deferment harvests, sawtimber harvests, mature forests with intact canopies, and mature forests with canopies disturbed by windthrow. Over 155 recording nights and 898 calls, total foraging activity levels and bat species composition differed among the habitat types. High activity levels of myotids were recorded in mature stands with intact and disturbed canopies. High activity levels of big brown, silver-haired and hoary bats occurred in deferment harvests. Low levels of all species, including the myotids were recorded in clearcuts and sawtimber harvests. Twenty pregnant or lactating northern myotis were radio-tagged and followed to 43 different roost trees used by maternity colonies that ranged in size from 7 to 88 individuals. Of measured 23 characteristics, only roost height, dbh, snag basal area, snag abundance and overstory density differed between roost and random trees. Black locust and black cherry were used more frequently than expected based on their abundance across the landscape. Intensively managed Allegheny hardwood forests in the apparently provide adequate roosting habitat for the northern myotis.

66. Owen, S.F.; Menzel, M.A.; Ford, W.M.; Chapman, B.R.; Miller, K.V.; Edwards, J.W.; Wood, P.B. 2001. **First summer record of a female Indiana bat, *Myotis sodalis*, in West Virginia.** The Journal of the Elisha Mitchell Scientific Society. 117: 132-134.

A post-lactating female Indiana bat was caught on 11 July 1999 on the Westvaco Wildlife and Ecosystem Research Forest. Morphometric features were as follows: mass, 6 g; forearm length, 31 mm; tragus length, 5 mm; ear length, 13 mm; and foot length, 8 mm; keeled calcar and inconspicuous toe hairs. The specimen was captured in a mist net set over an ephemeral pool at an elevation of ~ 900 m.

67. Owen, S.F.; Menzel, M.A.; Ford, W.M.; Edwards, J.W.; Chapman, B.R.; Miller, K.V.; Wood, P.B. 2002. **Roost tree selection by maternal colonies of northern long-eared myotis in an intensively managed forest.** Gen. Tech. Rep. NE-292. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 6 p.

Radio transmitters were attached to 20 pregnant or lactating northern myotis. Forty-three maternity colony roost trees were located in intensively managed hardwood forests in the Allegheny Mountains of east-central West Virginia. Maternity colonies ranged in size from 7 to 88 individuals. Roost trees selected by maternity colonies differed from randomly located roost trees in that they were taller, smaller in diameter, surrounded by more live overstory trees and snags, and surrounded by a higher

basal area of other snags. Black locust and black cherry were used as day roosts more frequently than expected based on their abundance across this landscape.

68. Owen, S.F. 2003. **Ecology and management of raccoons within an intensively managed forest in the central Appalachians.** Morgantown, WV: West Virginia University. 93 p. Ph.D. dissertation.

From the fall of 2000 through the spring of 2003, the spatial movements and den site selection of 30 raccoons (13 female and 17 male) were monitored within an intensively managed forest. Home range (95 percent adaptive kernel method) and core-home range (50 percent) size differed by gender but not season. Males maintained larger home ranges (394 ha) than females (244 ha). There were no gender or season specific differences in habitat selection at the home range level and home range composition did not differ from available habitat composition. However, habitat composition did differ between the core-home range and 95 percent home range levels. Habitat composition differed between seasons. Raccoons selected riparian areas and regeneration harvests during summer, whereas intact and diameter-limit stands were selected during fall. Fifty-five percent and 92 percent of all active locations were located below 900 m and 1000 m respectively. Restructuring rabies vaccination bait-drops to include an elevational threshold of 1000 m and distance threshold of 400 m within permanents streams would reduce treatment area by 36 percent, while maintaining > 70 percent contact with raccoons in the area. The 175 diurnal den sites documented included cavity trees, rock dens, log piles, slash piles, and various exposed limbs. Overall, den selection differed between genders and seasons, and among den type used. Female raccoons often selected cavities in large trees as maternal den sites. Though raccoons are highly adaptable, the continued loss of large diameter trees without replacement in short rotations may pose a future impact to raccoon recruitment and survival. The occurrence of raccoon roundworm was negative in the area, suggesting that at present, raccoons are not exposing Allegheny woodrats to this parasite.

69. Owen, S.F.; Menzel, M.A.; Edwards, J.W.; Ford, W.M.; Menzel, J.M.; Chapman, B.R.; Wood, P.B.; Miller, K.V. 2003. **Bat activity in harvested and intact forest stands in the Allegheny Mountains.** Northern Journal of Applied Forestry. 21: 54-159.

Anabat acoustical monitoring devices were used to examine bat activity in intact canopy forests, complex canopy forests with gaps, forests subjected to diameter-limit harvests, recent deferment harvests, clearcuts and unmanaged forested riparian areas in the Allegheny Mountains of West Virginia. Eight species of bats, including the endangered Indiana bat. Most bat activity was concentrated in forested riparian areas. Among upland habitats, activity of silver-haired bats and hoary bats was higher in open, less cluttered vegetative types such as recent deferment harvests and clearcuts. These results suggest that bat species in the central Appalachians partially segregate themselves among vegetative conditions based on differences in body morphology and echolocation call characteristics. From the standpoint of conserving bat foraging habitat for the maximum number of species in the central Appalachians, emphasis should be placed on protecting forested riparian areas.

70. Owen, S.F.; Menzel, M.A.; Ford, W.M.; Chapman, B.R.; Miller, K.V.; Edwards, J.W.; Wood, P.B. 2003. **Home-range size and habitat use of the northern myotis (*Myotis septentrionalis*).** American Midland Naturalist. 150: 352-359.

Home range size and habitat use of nine female northern myotis was examined within an intensively managed forest in the central Appalachians of West Virginia. Mean home range size using the 95 percent adaptive kernel method was 65 ha northern myotis used recent diameter-limit harvests and road corridors more than expected based on availability of these habitats. Intact forest stands and more open deferment harvested stands were used less than expected, although intact forest stands still constituted the overall majority of habitat used. Partial timber harvests that leave a relatively closed canopy appear to promote or improve northern myotis foraging habitat in heavily forested landscapes. However, the long-term ecological impacts on bats and other biota from this silviculturally unacceptable practice are unclear.

71. Owen, S.F.; Edwards, J.W.; Ford, W.M.; Crum, J.M.; Wood. P.B. 2004. **Raccoon roundworm in raccoons**

in central West Virginia. Northeastern Naturalist. 11: 137-142.

No evidence of raccoon roundworm in 25 raccoons sampled by fecal floatation and necropsy methodologies was detected at the Westvaco Wildlife and Ecosystem Research Forest. However, *Capillaria* spp. eggs and Strongyloides spp. eggs were documented in fecal samples. The low prevalence of raccoon roundworm in an area believed to contain a significant population of Allegheny woodrats would support conservation measures to continue to monitor for raccoon roundworm or raccoon-Allegheny woodrat interaction in the region.

72. Pacurari, D.I.; Gribko L.S.; Yuill, C.B.; Warner, T.A.; Wilson, T.H. 1999. **Optimal spatial resolution for Appalachian hardwood forest images.** In: 4th international Airborne Remote Sensing conference and 21st Canadian Symposium on Remote Sensing. Ottawa, ON: Ottawa, ON. Canadian Aeronautics and Space Institution: H-36.

The optimal spatial resolution through analysis of the spatial autocorrelation and the semivariance of optical remote sensing images of Appalachian hardwoods was determined with with airborne multispectral digital camera systems. The images had a very high spatial resolution of 0.18 m pixel size and consisted of measurements of spatial autocorrelation made on spatial profiles of the imagery and of measurements of semivariance made on matrix files (images). As a control, measurements were made in 181 plots, each 400 m^2, where trees were measured for dbh and crown diameter. The optimum value of spatial resolution was 6.4 m. The relationship between dbh and crown diameter at the field plots suggested an average crown diameter of 6.9 m. Therefore, images could be produced with images with optimal resolution of high accuracy without requiring images of overwhelming size.

73. Pacurari, D.I. 2000. E**valuation of the use of remotely sensed images to speciate mixed Appalachian forests.** Morgantown, WV: West Virginia University. 128 p. M.S. thesis.

Advancements in technology have led to development of various new sensors and platforms. Among them, the airborne digital camera has potential for use in detailed forest vegetation management. The ability to speciate mixed Appalachian hardwood forests using the Airborne Data Acquisition and Registration (ADAR) System 100 was determined, along with optimal spatial resolution and scale of the acquired images of 200 ha of the Westvaco Wildlife and Ecosystem Research Forest. The optimal spatial resolution for central Appalachian hardwood plots is between 6 and 7 m and corresponds to the average crown size. However, it is unlikely that a tree crown will be covered by a single pixel that is equal to the size of the tree crown. Upscaled image that produced correct species composition had 1.8 m resolutions. Lastly, three sets of image mosaics were used to tree species composition. A color-infrared image with 0.5 m resolution produced the best results, with an overall accuracy of 73.1 percent and a Kappa statistic of 0.69.

74. Pacurari, D.I.; Gribko, L.S.; McNeel, J.F.; Warner, T.A.; Yuill C.B. 2001. **Determination of an optimal spatial resolution of remotely sensed images for mixed Appalachian forests.** In: 3rd international conference on Geospatial Information in Agriculture and Forestry; 2001 November 5-7; Denver, CO: Washington DC: U.S. Department of Agriculture, Agricultural Research Service and Natural Resources Conservation Service. [no pagination].

The Airborne Data Acquisition and Registration System 1000 was used for acquisition of digital images over a study area of 200 hectares of the Westvaco Wildlife and Ecosystem Research Forest. The images used had very high spatial resolution, with a 0.18 m pixel size. It was determined that the optimal spatial resolution was between 6 and 7 m, corresponding to the average tree crown size on the area. To optimize accuracy classification, mosaic images were upscaled using the Maximum Likelihood classifier. The species composition derived from classifications of increasingly upscaled images was compared with ground data. The coarsest upscaled image for which all species that were mapped at the finer resolution could still be identified was the 1.8 m pixel image. For upscaled images with pixel sizes larger than 1.8 m, a smaller number of species could be detected.

75. Rogers, A.M. 1999. **Ecology and natural history of *Rana clamitans melanota* in West Virginia.**

Huntington, WV: Marshall University. 131 p. M.S. thesis.

Fourteen study sites were sampled with aquatic funnel traps and D-frame net sweeps in the plateau and mountain region of West Virginia to determine differences in green frog larval period. Larval stage classes 25 and 26, the first free living stages, were absent from the plateau region from February to April, but were present in the mountain region. Pre-transformation larval stages, 40 through 44, were found from May through October, and peaked in July. Stage class abundance shifted from stages 27 and 34 in the May/June data set to stages 25 and 46 in the July/August data set. Breeding activity was found to be a month later in the mountain regions than previously reported and data suggested that the mountain populations may have a 2-year larval period. Froglet dispersal began in June and peaked in August. In spring, water pH was lowest at high elevation sites above 1200 m and in smaller habitat such as ditches and temporary pools. Significant differences in water temperature between the months of May and June, July and August, and September and October indicate that green frog activity is affected by water temperature.

76. Schuler, T.M.; Ford, W.M.; Collins, R.J. 2002. **Successional dynamics and restoration implications of a montane coniferous forest in the central Appalachians, USA.** Natural Areas Journal. 22: 88-98.

In a pilot study designed to better understand second-growth spruce structure, trees and downed coarse woody debris in an isolated montane red spruce forest were inventoried and compared to old-growth forest communities of similar composition. At this relict forest, stand initiation occurred in the early 1920s following a period of watershed-wide timber harvesting. Live tree basal area, snag density and total fallen log volume were similar to old-growth values. However, snag basal area, height of dominant and co-dominant red spruce and maximum red spruce dbh were significantly less than would be expected in old-growth forests of similar composition. Red spruce comprised greater than 40 percent of dominant crown class trees and often was a main canopy emergent. However, eastern hemlock had the highest relative importance value in the stand. Stocking was147 percent of full threshold and was correlated with slow growth rates for red spruce and eastern hemlock. Growth and yield simulations indicated current conditions would support a thinning in smaller size classes that could accelerate individual tree growth rates and decrease time required to attain additional old-growth structural characteristics valuable for the management of endangered species such as the Virginia northern flying squirrel.

77. Sharp, E.P. 2003. **Watershed and streamside management zone characterization in the Allegheny Plateau of West Virginia.** Blacksburg, VA: Virginia Polytechnic and State University. 190 p. M.S. thesis.

Streamside management zones (SMZ) and watersheds were characterized before and after harvest with different SMZ widths and harvesting intensities in the Allegheny Plateau of West Virginia. The major overstory tree species found were sugar maple, yellow poplar, American beech, basswood, sweet birch, yellow birch, white ash, red maple, and snags. The overall average streamwater temperature was 13º C. Highest daily temperature occurred in the mid-afternoon and lowest temperatures occurred just before sunrise. Streamwater quality was good, with near neutral pH, low nitrogen content, and high dissolved oxygen. Uniform soil loss equation erosion estimates predicted an erosion rate of 2.9 Mg/ha/yr in the SMZ. However, sediment rods showed an overall accumulation of soil in the SMZ, averaging 173 Mg/ha/yr. This equated to an average watershed loss of 10.9 Mg/ha/yr. In-stream and SMZ large woody debris volume was approximately equal at 28 and 33 m^3/ha. Large woody debris was more decayed in the SMZ than in-stream large woody debris.

78. Smith, R.D.M. 2003. **Raptor assemblage, abundance, nesting ecology, and habitat characteristics under intensive forest management in the central Appalachian Mountains.** Morgantown, WV: West Virginia University. 106 p. M.S. thesis.

Raptor abundance and diversity were examined in three treatments (20-, 40-, and 80-year harvest rotations) on an industrial forest in the central Appalachian Mountains. eventeen species were detected and there were no differences in abundance among treatments for all raptors. Forest species were detected more often than

edge species, and red-shouldered hawk (*Buteo lineatus*) was the most abundant. Barred owls were detected most often using nocturnal playback techniques, although other owl species were detected. Fourteen nesting attempts of five species were monitored. For three Buteo species, mammals were the most common prey delivered to the nest. At current levels of disturbance, forest raptors are able to survive and successfully breed on this industrial forest.

79. Smith, B.W.; Dobony, C.A.; Edwards, J.W.; Ford, W.M. 2004. **Observations of long-tailed weasel, *Mustela frenata*, hunting behavior in central West Virginia.** Canadian Field-Naturalist. 117: 313-315.

Using infrared video-surveillance systems during 1999-2000, two attempts by long-tailed weasels were observed depredating female ruffed grouse and their clutches of eggs. Neither female was captured despite weasel attacks on multiple nights, but all eggs from one nest were either consumed or cached over a 2-night period.

80. Sweka, J.A.; Hartman, K.J. 2001. **Influence of turbidity on brook trout reactive distance and foraging success.** Transactions of the American Fisheries Society. 130: 138-146.

Videographic techniques were used to study brook trout foraging behavior in an artificial stream. Three brook trout were tested during each sampling period, creating a competitive situation under which a more accurate measure of reactive distance could be made. Treatment turbidity levels ranged from 0 to 43 nephelometric turbidity units. The reactive distance of brook trout decreased curvilinearly with increasing turbidity. The probability of a brook trout's reacting to a given prey item was correlated with reactive distance and also decreased with turbidity. However, turbidity had no influence on the probability of attack given a reaction, the probability of capture given an attack, or the probability of ingestion given capture. In natural streams, invertebrate drift densities typically increase with turbidity as flows increase, but this increase may not be enough to compensate for the decreased ability of brook trout to detect drifting prey.

81. Sweka, J.A.; Hartman, K.J. 2001. **Fall and winter brook trout prey selection and daily ration.** Proceedings of annual conference of the Southeastern Association of Fish and Wildlife Agencies. 55: 8-22.

Patterns of invertebrate drift and brook trout feeding seen during warmer times of the year were compared to post-spawning fall and winter for brook trout in the central Appalachians. The general diel pattern of invertebrate drift and salmonid feeding found during spring and summer months in other studies was less obvious during the post-spawning fall and winter for brook trout. Total invertebrate drift density did not follow a diel pattern. Brook trout diet compositions was not correlated to the composition of invertebrate drift and brook trout may feed from the benthos more frequently than previously suspected for stream salmonids. There appeared to be no diel effect on brook trout feeding. Brook trout daily ration during the fall and winter were extremely low and may have been below maintenance ration during the fall.

82. Sweka, J.A.; Hartman, K.J. 2001. **Effects of turbidity on prey consumption and growth in brook trout and implications for bioenergetics modeling.** Canadian Journal of Fisheries and Aquatic Sciences. 58: 386-393.

Brook trout were held in an artificial stream to observe the influence of turbidity on mean daily consumption and specific growth rates. Turbidity had no significant effect on mean daily consumption, but specific growth rates decreased significantly as turbidity increased. Brook trout in turbid water became more active and switched foraging strategies from drift feeding to active searching. This switch was energetically costly and resulted in lower specific growth rates in turbid water as compared with clear water. Abiotic factors, such as turbidity, can have implications for the accuracy of predicted growth by bioenergetics models.

83. Sweka, J.A. 2003. **Aquatic-terrestrial linkages in appalachian streams: influence of riparian inputs on stream habitats, brook trout populations, and trophic dynamics.** Morgantown, WV: West Virginia University. 198 p. Ph.D. dissertation.

Aquatic-terrestrial linkages and habitat and food resources influences on brook trout were examined in central Appalachian streams. Large woody debris was experimentally added to eight streams in the Middle Fork River watershed to determine if stream habitat

heterogeneity and prey abundance could be increased. The large woody debris additions effect on stream channel morphology varied among streams, but showed little overall change by 3 years post-manipulation. Brook trout populations fluctuated over time, but did not show a consistent increase following additions. Invertebrate drift did not increase following the addition of large woody debris. Likewise, prey consumption by brook trout was not influenced by the additions, but diet composition showed a significant shift by the second year post-habitat manipulation. The diet proportion comprised of the shredder functional feeding group increased. Brook trout tended to prefer prey that entered the drift from the surface and terrestrial invertebrates comprised a large portion of the annual prey consumed. However, study duration was insufficient to detect significant changes in stream habitat and brook trout populations due to the large woody debris additions.

84. Terry, T.M. 2004. ***Glaucomys sabrinus fuscus* habitat and nest box use in West Virginia with management recommendations for Kumbrabow State Forest.** Morgantown, WV: West Virginia University. 83 p. M.S. thesis.

The characteristics of 31 nest sites (22 cavity, eight leaf; one undetermined) from four radio-collared Virginia northern flying squirrels were examined at Kumbrabow State Forest and the MWERF during the summers of 2002–2003. The nest trees used were similar to random trees within use areas. Compared to random trees, nest sites were in areas with more overstory trees and snags for both sexes. Home ranges for two radio-collared Virginia northern flying squirrels estimated using a 95 percent adaptive kernal method were 3.4 ha for a female 24.7 ha for a male. The female's 95 percent adaptive kernel home range was 3.4 ha with a core use (50 percent) area of 0.3 ha. The female used cover types proportional to their availability and the male used areas closer to streams and grassy edges than was available. Both avoided deciduous forest. The efficiency of nest boxes to generate biological data also was evaluated. Overall long-term capture rates were at less than 2 percent, suggesting that naturally occurring nest sites may not be limiting and boxes may underestimate species presence. Currently, 1,359 ha of Kumbrabow State Forest adjacent to the MWERF is predicted to be marginal (possibly occupied) to optimal habitat. With restoration efforts, spruce-dominated habitats highly suitable for Virginia northern flying squirrels could be increased.

85. Van der Maath, N.L.; Castleberry, S.B.; Wood, P.B.; Ford, W.M.1999. **Activity patterns and behavior of Allegheny woodrats around communal latrine sites.** In: 55th annual Northeast Fish and Wildlife Conference; 1999 April 11-14; Manchester, NH. Concord, NH: New Hampshire Fish and Game Department: 8.

Allegheny woodrat activity patterns and behavioral and social interactions were studied using infrared videography around latrine sites at the Westvaco Wildlife and Ecosystem Research Forest. The pelage of all known individuals at each site was uniquely marked for identification on video. Between 31 July and 13 September 1998, a total of 81 camera nights or 648 camera hours was recorded. Woodrat activity begins approximately half an hour after dusk and continues throughout the night with a peak around midnight. Many woodrats observed used these latrine area for travel and never stopped. Those stopping appeared to be examining the area to identify previous users. Other activity observed included fighting, defecation, and grooming.

86. Waldron, J.L. 2000. **Ecology and sympatric relations of crevice salamanders in Randolph County, West Virginia.** Huntington, WV: Marshall University. 107 p. M.S. thesis.

Using mark-recapture, the ecology of three species of sympatric plethodontid salamanders: green salamander, mountain dusky salamander and slimy salamanders on rock outcrops at the Westvaco Wildlife and Ecosystem Research Forest. By examining activity patterns, vertical stratification, and habitat preference no difference between the height and depth of crevices or crevice microhabitat inhabited by the three species was observed. Mountain dusky salamanders occupied higher portions of the outcrops than did slimy salamanders and the seasonal activity patterns and surface abundances of green salamanders and mountain dusky salamanders differed. Attempts to document dispersal movements of green salamanders was unsuccessful, though movement for one female between two outcrops was observed.

87. Weakland, C.A. 2000. **Effects of diameter-limit and two-age timber harvesting on songbird populations on an industrial forest in central West Virginia.** Morgantown, WV: West Virginia University. 150 p. Ph.D. dissertation.

The short-term effects of diameter-limit and two-age timber harvesting on the abundance and nest survival of songbirds and the specific landscape-level and microhabitat-level features of a recently fragmented industrial forest that affect songbird abundance were determined. Songbird abundance was quantified using fixed-radius point counts and nest survival was documented on 40 ha nest searching plots at the Westvaco Wildlife and Ecosystem Research Forest 1 year before and 1 to 2 years after partial harvesting. For most songbird species present prior to harvest, abundances changed little following diameter-limit harvesting. Interior-edge species and total abundance of songbirds were more abundant in diameter-limit harvested areas. The abundance of most songbird species present prior to two-age harvesting also changed little after the harvest. Interior-edge species had higher abundance in two-age harvested areas. The dark-eyed junco and veery and the scarlet tanager and overbird were found more frequently in nonfragmented landscapes than those fragmented by regeneration harvests or by diameter-limit harvests, respectively. Timber harvesting in this landscape is not having short-term deleterious impacts on most songbirds.

88. Weakland, C.A.; Wood, P.B.; Ford, W.M. 2002. **Response of songbirds to diameter-limit cutting in the central Appalachians of West Virginia, USA.** Forest Ecology and Management. 155: 115-129.

The effects of diameter-limit harvesting on songbird populations at the Westvaco Wildlife and Ecosystem Research Forest was examined pre- and post-harvest. Results indicate that the abundances of most songbird species present before the harvest were not affected by the timber removal either 1 or 2 years after harvesting. Several species responded positively to the harvest, and nest survival on harvested plots was higher after harvesting than before harvesting. On the forest, only the largest diameter trees were removed, and intermediate and subcanopy trees remained standing, keeping the stand structurally diverse. Songbirds may respond to this management in a more positive manner than clearcutting, and landowners may be more willing to use this technique than single-tree selection. It appears that this alternative technique may not affect most forest-dwelling songbirds in the central Appalachians and may be a viable management strategy for retaining forest bird communities in the face of large-scale harvesting.

89. Whitaker, D.M. 2003. **Ruffed grouse (*Bonasa umbellus*) habitat ecology in the central and southern Appalachians.** Blacksburg, VA: Virginia Polytechnic Institute and State University. 205 p. Ph.D. dissertation.

Through the Appalachian Cooperative Grouse Research Project, researchers tracked more than 1,500 radioed ruffed grouse at 10 study sites from 1996-2002 to provide data on home range variation and habitat selection. Clearcuts formed the cornerstone of ruffed grouse habitat in the region. In oak-hickory forests, nutritional constraint strongly influenced habitat use. Home ranges doubled following poor hard mast crops, and at these times ruffed grouse increased use of alternate foraging habitats. Females and broods made extensive use of mesic bottomlands and forest edges that support abundant soft mast and herbaceous forages in the oak-hickory type. Ruffed grouse inhabiting mixed mesophytic forests were insensitive to hard mast, did not select bottomlands, reduced use of forest edges, and increased use of clearcuts. The greater abundance of yellow birch, black cherry and aspen buds, relieves nutritional stress on ruffed grouse inhabiting this forest type. Ruffed grouse attempt to balance competing strategies of maximizing either survival or condition, and the expression of this tradeoff was mediated by forest composition.

90. Williams, L.A. 2004. **Amphibian population and community characteristics, habitat relationships, and first-year responses to clearcutting in a central Appalachian industrial forest.** Blacksburg, VA: Virginia Polytechnic and State University. 166 p. M.S. thesis.

Baseline data on amphibian species richness, relative abundance, and habitat use for a long-term landscape ecology study on the MWERF was provided. From results of area-constrained daytime searches, nine regression models to predict amphibian relative abundance were developed. Distance to perennial or

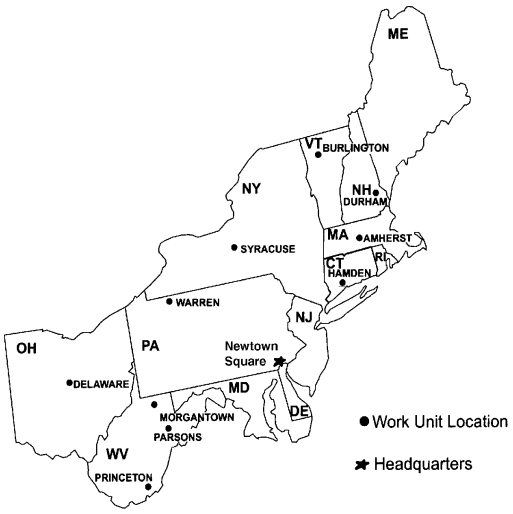
ephemeral streams or perennial ponds, the amount of available rocks along transects, and site index were the three most important habitat variables in models were responsible for 24-32 percent of the inherent variation in population relative abundance. Other habitat variables that were significant in models were year, percent canopy cover, the amount of available highly decomposed woody debris, percent woody stems (<7.5 cm dbh), soil pH, and percent herbaceous vegetation. Relative abundances showed positive relationships with all significant habitat variables with the exception of year and percent woody stems. Amphibian species richness declined from pre-harvest to post-harvest, but species diversity showed little change. Overall relative abundance declined significantly pre-harvest to post-harvest with coverboard sampling and night plot sampling. At coverboard stations, relative abundance declined significantly from pre-harvest to post-harvest at a distance of 5-10 m and 40-50 m away from adjacent mature forest.

Scientific names of plants and animals listed in the text.

Allegheny woodrat (*Neotoma magister*)
American beech (*Fagus grandifolia*)
Aspen (*Populus* spp.)
Barred owl (*Strix varia*)
Basswood (*Tilia americana*)
Big brown bat (*Eptesicus fuscus*)
Blackberry (*Rubus* spp.)
Black cherry (*Prunus serotina*)
Black locust (*Robinia pseudoacacia*)
Black rat snake (*Elaphe obsoleta*)
Blueberry (*Vaccinium* spp.)
Brook trout (*Salvelinus fontinalis*)
Cucumber magnolia (*Magnolia acuminata*)
Dark-eyed junco (*Junco hyemalis*)
Eastern hemlock (*Tsuga canadensis*)
Eastern red bat (*Lasiurus borealis*)
Eastern woodrat (*Neotoma floridana*)
Fraser magnolia (*Magnolia fraseri*)
Grape (*Vitis* spp.)
Greenbrier (*Smilax* spp.)
Green frog (*Rana clamitans*)
Green salamander (*Aneides aeneus*)
Hay-scented fern (*Dennstaedtia punctilobula*)
Hickory (*Carya* spp.)
Hoary bat (*Lasiurus cinereus*)
Indiana myotis (*Myotis sodalis*)
Little brown myotis (*Myotis lucifugus*)
Long-tailed weasel (*Mustela frenata*)
Masked shrew (*Sorex cinereus*)
Mountain dusky salamander (*Desmognathus ochrophaeus*)
Northern myotis (*Myotis septentrionalis*)
Northern red oak (*Quercus rubra*)
Northern short-tailed shrew (*Blarina brevicauda*)
Northern spring salamander (*Gyrinophilus porphyriticus*)
Ovenbird (*Seiurus aurocapilla*)
Pin cherry (*Prunus pensylvanica*)
Raccoon (*Procyon lotor*)
Raccoon roundworm (*Baylisascaris procyonis*)
Redbacked salamander (*Plethodon cinereus*)
Red maple (*Acer rubrum*)
Red-shouldered hawk (*Buteo lineatus*)
Red spruce (*Picea rubens*)
Rock shrew (*Sorex dispar*)
Rosebay rhododendron (*Rhododendron maximum*)
Ruffed grouse (*Bonasa umbellus*)
Scarlet tanager (*Piranga olivacea*)
Silver-haired bat (*Lasionycteris noctivagans*)
Slimy salamander (*Plethodon glutinosus*)
Smoky shrew (*Sorex fumeus*)
Southeastern shrew (*Sorex longirostris*)
Striped maple (*Acer pensylvanicum*)
Sugar maple (*Acer saccharum*)
Sweet birch (*Betula lenta*)
Veery (*Catharus fuscescens*)
Virginia northern flying squirrel (*Glaucomys sabrinus*)
White ash (*Fraxinus americana*)
White-tailed deer (*Odocoileus virginianus*)
Wood fern (*Dryopteris* spp.)
Yellow birch (*Betula alleghaniensis*)
Yellow poplar (*Liriodendron tulipifera*)

Keyser, P.D.; Ford, W.M. 2005. **Ten years of research on the MeadWestvaco Wildlife and Ecosystem Research Forest.** Gen. Tech. Rep. NE-330. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 27 p.

Contains 90 citations and annotations of publications and final reports that describe research conducted on or in association with the MeadWestvaco Wildlife and Ecosystem Research Forest in West Virginia from 1994 through 2004.



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

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

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