Fell-and-burn Regeneration in the North Georgia Piedmont: Effects on Wildlife Habitat and Small Mammals[1]

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Abstract: The fell-and-burn site preparation technique is an effective means of regenerating low-quality hardwood stands to pine-hardwood mixtures in the Southern Appalachian Mountains. In this region, pine-hardwood mixtures offer a compromise between the benefits of hardwood management to wildlife and the economic benefits of pine management. However, the fell-and-burn technique has not been tested in the Piedmont and other regions. This study compared the effects of several variations of the fell-and-burn technique on small mammal communities and wildlife habitat in the upper Piedmont of Georgia during the first year following treatment. Results indicate that high-severity fires may damage site quality. All site preparation treatments produced more forage biomass and richer, more populous small mammal communities than did unharvested controls. Unburned, felled sites supported more forage biomass and more species of small mammals. Burning without felling resulted in the highest forb production, while felling and burning supported the most diverse plant community and highest numbers of small mammals.

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The fell-and-burn site preparation technique has proven successful as an inexpensive means to regenerate low-quality stands to more economically productive pine-hardwood mixtures in the southern Appalachian Mountains (Phillips and Abercrombie 1987). Complete descriptions of the technique are given by Abercrombie and Sims (1986) and Phillips and Abercrombie (1987). Briefly, the technique involves a commercial clearcut followed by spring felling of residual stems (>2 m in

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height) and summer broadcast burning. Pines are planted the following winter at a 3 x 3-m or wider spacing. Researchers anticipate that the technique will produce results in the upper Piedmont similar to those observed in the mountains. However, differences in vegetation, animals, climate, soil, and topography may make refinements to the technique necessary. Previous studies in the Piedmont have shown that the fell-and-burn technique allows successful hardwood regeneration (Geisinger et al. 1989), but reduces competition enough to allow pine seedlings to become established (Waldrop et al. 1989).

Benefits or detriments to wildlife have not been documented. It has been supposed that use of fell-and-burn methods would benefit certain game species because mast production is continued that would otherwise be lost through conversion to pine monoculture. However, there has been little consideration of effects on small mammals, insects, and herpetofauna in treated stands. For these reasons it is important to determine the effects of the technique on all components of the existing communities before promoting its use in the Piedmont.

Methods

Study Area

Study areas were located in the Upper Piedmont Plateau region of North Georgia, on the Dawson Demonstration Forest in Dawson County. Soils were fine sandy loams of the Fannin and Tallapoosa series. Annual temperature and precipitation average 15.5 C and 150 cm, respectively. During 1989, when this study was conducted, temperature was 0.8 C below normal, and precipitation was 31 cm above normal.

Prior to harvest, stand ages ranged from 45 to 55 years. Site indexes averaged 18 m (range 15 to 20 m) for shortleaf pine (*Pinus echinata* Mill.) at 50 years. Stands consisted primarily of low-quality hardwoods dominated by upland oaks (*Quercus spp.*) and small numbers of shortleaf pine, loblolly pine (*P. taeda* L.), and Virginia pine (*P. virginiana* Mill.). Basal area averaged 9.3 m^2/ha. Aspects ranged from 180 to 230 degrees, and slope averaged 16.2 percent (range 10.0 to 22.0).

The study was established in a randomized complete block design with 4 treatments replicated in 3 blocks. Treatments were selected to examine variations of the fell-and-burn site preparation technique and included: 1) felling of unmerchantable residuals only, 2) summer broadcast burning without felling, 3) felling and burning, and 4) an unharvested control. Each treatment area was approximately 1 ha. Stands were harvested during February 1988 by a commercial logging operation. Residual stems were felled by chainsaw crews in May 1988. Site preparation burns were conducted on 3 July 1988, 3 days after a rain of 2 cm. At the time of burning, moisture content of 10-hour timelag fuels (measured with fuel moisture sticks) was 11 percent. Relative humidity was 55 percent and wind speeds were less than 8 km/hour. Strip headfire was the most common firing technique. However, backing fires were used over large areas to protect other studies in adjacent stands.

Habitat Analysis

Procedures for habitat analysis were modified from U.S. Fish and Wildlife Service Habitat Suitability Index (HSI) models (Mengak et al. 1989). Prior to harvest, 10 to 20, 0.04-ha vegetation plots were established along a transect within each treatment area. Plots were spaced at varying distances along the transect to best utilize the available area, avoid overlap, and maintain a southerly aspect. Permanent small-mammal trapping stations also were established at each plot center. Sampling was conducted during 3 sampling periods in 1989. Periods were chosen to evaluate habitat at the lowest level of vegetation production (1 Jan to 31 Mar), the peak of production (1 May to 31 Jul), and the end of the growing season (1 Sep to 30 Nov). Groundcover estimates (by species) were obtained using a 35-mm ocular tube (James and Shugart 1970). Estimates were made at 1-m intervals along 2 10-m transects within each sample plot. Transects were centered on the trap station.

Above ground forage biomass was determined by clipping the current year's growth of all plants in a 1 x 1-m plot, randomly located within each 0.04-ha plot to a height of 1.5 m; forage was weighed in the field. Clipped material was separated into 3 categories: woody, forbs, and grasses. Moisture content of forage biomass was determined in the laboratory after drying in a forced air oven at 60 C for 72 hours.

Trapping

Trapping of small mammals took place during the 3 periods when vegetation was sampled. Traplines were prebaited for 5 nights using closed traps baited with peanut butter. Then, sampling was conducted for 5 consecutive nights during each trapping period. Four trap types were used in each treatment area: Victor rat traps, Victor mouse traps, Museum special traps, and pitfalls with drift fences. All traps were rebaited each day during the prebaiting and trapping periods. Trapping design was identical for all periods.

One snap trap of each type was placed within 2 m of each randomly-located trap station. Trapping stations were marked with 1-m sections of rebar in order to establish permanent trap locations. Pitfalls were randomly located on each site by overlaying a grid on the site map and using a random number table to determine their coordinates. A modification of the trap design described by Williams and Braun (1983) was used. Each drift fence consisted of 3 5-m x 51-cm legs of aluminum flashing that met at a common point centered on the pitfall, with 120 degrees between each pair of legs. Flashing was set in a ditch 8 to 10 cm deep. These ditches were then packed with soil and the fences supported with wooden stakes. At the center of the fences, a 19-liter plastic bucket was buried flush with the ground. Buckets were kept one-third to one-half full of water to drown captured animals and were covered with a lid when not in use. All traps were checked daily during trapping periods.

Vegetation and trapping data were used to calculate Shannon diversity (H′), evenness (J), and species richness (S) for each trapping period. Shannon diversity was calculated as $H' = -\Sigma P_i$ (ln P_i) where (P_i) is the proportion of the ith species in the population (Shannon and Weaver 1949). This function measures the uncertainty in predicting the identity of any randomly selected individual based on the total number of species in the sample (S) and the number of individuals (*N*), or the proportion of that species to the whole sample (P_i) for each species represented in the sample. (J) is a measure of the evenness of the distribution of individuals within the species present, and is calculated as $J = H'/(\ln S)$ (Pielou 1977). Species richness (S) was the number of plant or animal species sampled.

Insects were collected in 10 randomly located 600-ml pitfalls on each site. Traps were used for biomass collection only since numbers of terrestrial insects can be overestimated when species are individually singled out for identification (Southwood 1978). Traps were kept one-third to one-half full of equal parts of water and ethylene glycol to keep the insects flexible. Traps were emptied daily during the 5-day period when small-mammal trapping took place. All insects were identified to family, dried in a forced-air oven at 60 C for 72 hours, and weighed.

All habitat and trapping data were summarized for each site and treatment type. Analysis of variance was used to test for differences between treatments, blocks, and collection periods. Differences were tested for significance at the 0.05 level of probability.

Results and Discussion

Vegetation

Biomass.—All site-preparation treatments produced higher forage biomass than unharvested controls (Fig. 1). Both woody and grass forage production one growing season after harvest were significantly higher on the fell-only site-preparation treatment than all other treatments due to the longer growth period and relatively undis-

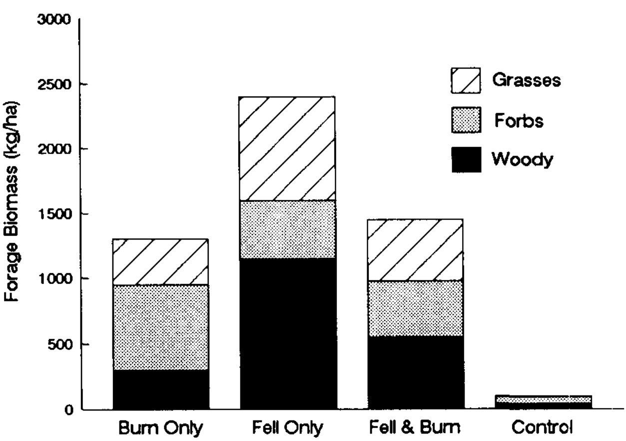

Figure 1. Forage biomass production by species group and treatment, Dawson County, Georgia, 1989.

turbed litter layer. However, the litter layer tended to inhibit forb establishment by blocking access to the soil and limiting the penetration of sunlight.

Total production was inhibited in the burn-only and fell-and-burn treatments where slow-moving backing fires, which tended to remain stationary in areas of heavy fuel concentration, created conditions of high severity (Wells et al. 1979) where the duff layer was consumed and mineral soil was exposed. Van Lear and Kapeluck (1989) found that 3.6 cm of topsoil had eroded from study sites during the 9 months following burning on these sites. Stored seeds and seeds invading from adjacent areas likely were washed away. Many stumps failed to sprout after burning because the cambial layer was consumed. Grass production also was reduced by burning as compared to the fell-only treatment. Forb production responded more favorably to burning and was significantly higher on the burn-only sites than on fell-only sites. Without felling, fuel loading was not as high and burns tended to be less severe, allowing greater grass and forb production than the fell-and-burn treatment.

Plant Diversity.—Site preparation treatments produced few changes in the plant species richness (S) between treatments. Even though site-prepared areas supported a different group of species and the total number of species was higher than in unharvested controls, the mean number of species per sample plot was not significantly different (Fig. 2). Shannon diversity (H′) was unaffected by treatment during periods 1 and 3 (Table 1). However, differences were observed during period 2 when the vegetation was at peak production and groundcover was maximum. At this time, H′ was greater in all site prepared areas than in unharvested controls and significantly greater in the fell-and-burn treatment areas. Evenness (J) of vegetation was not significantly different among treatments.

On unburned sites, a few woody and grass species (<15) maximized their growth at the expense of the forbs. Burned sites supported somewhat larger numbers of species, but in relatively small proportions. Species groups in burned treatment areas were separated by microsites that resulted from differences in fuel loading and fire severity. These microsite differences were most noticeable in fell-and-burn

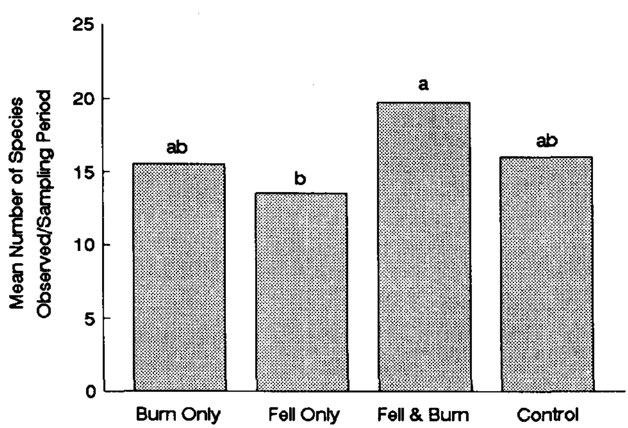

Figure 2. Plant species richness by treatment in Dawson County Georgia, 1989. Treatments with the same letter are not significantly different at the 0.05 level.

Table 1. Shannon diversity (H′) for vegetation by treatment and sampling period, Dawson County, Georgia. 1989.

	Period		
Treatment	1 Jan–31 Mar 1989	1 May–31 Jul 1989	1 Sep–31 Nov 1989
No fell, burn	1.259a[a]	2.964ab	2.315a
Fell, no burn	1.432a	3.293ab	2.476a
Fell and burn	1.239a	3.659a	2.597a
Unharvested control	1.871a	2.579b	2.596a

[a]Values followed by the same letter within a column were not significantly different at the 0.05 level.

treatment areas. Felled stems served as fuels to hold the fire in some areas longer than others and thus created localized areas of high severity. Control sites supported different species than site prepared areas. Several species present on the control sites were absent on the treated sites because of their inability to survive under open conditions or their inability to compete with early successional herbaceous species and woody sprouts. A complete listing of species by treatment was given by Evans (1990).

Small Mammals

Species richness (S) of small mammals was increased by all site preparation treatments and was significantly greater than unharvested controls in fell-only treatment areas (Fig. 3). This increase in S is probably a response to the type and total amount of forage biomass available to the animals as well as the amount of suitable cover and its proximity to a food source. Both forage biomass and groundcover were maximized on the fell-only sites (Fig. 1). Shannon diversity (H′) for small mammals was not significantly different between site-preparation treatments (Table 2). All

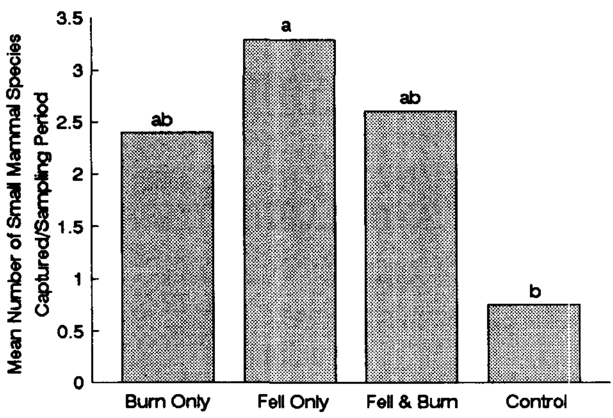

Figure 3. Species richness of small mammals by treatment in Dawson County, Georgia, 1989. Treatments with the same letter are not significantly different at the 0.05 level.

Table 2. Shannon diversity (H′) for small mammal populations by treatment and sampling period, Dawson County, Georgia, 1989.

Treatment	Period: 1 Jan–31 Mar 1989	1 May–31 Jul 1989	1 Sep–31 Nov 1989
No fell, burn	0.000a[a]	0.616a	1.085a
Fell no burn	0.322a	1.233a	0.833a
Fell and burn	0.000a	0.777a	1.020a
Unharvested control	0.000a	0.231a	0.000b

[a]Values followed by the same letter within a column were not significantly different at the 0.05 level.

site-preparation treatments yielded higher evenness values (J) during the second and third periods as a result of slightly higher H′ values. J of small mammal populations was significantly higher on burned treatments than control sites during the third sampling period (Table 3).

Mean number of individuals (*N*) utilizing a given area was significantly higher on all site-preparation treatments than controls (Fig. 4). The combination of felling and burning produced significantly higher *N* values than all other treatments. These high *N* values were the result of early successional species colonizing the most severely burned sites. Not all small mammal species increased in response to disturbance. The most common species trapped were those best adapted to an early successional environment such as white-footed mice (*Peromyscus leucopus*) (Table 4). This finding agrees with a number of other studies that show an increase in *Peromyscus spp*. following fire (Ahlgren 1966, Krefting and Ahlgren 1974, Hingtgen and Clark 1984). This increase in *Peromyscus spp.* was most pronounced during the first 2 sampling periods, but was still evident during the third sampling period. By that time, most of the habitat was sufficiently developed to support a larger number of species with more varied food habits and cover requirements. Due to severe burns

Table 3. Evenness (J) of small mammals by treatment and sampling period, Dawson County, Georgia, 1989.

Treatment	Period: 1 Jan–31 Mar 1989	1 May–31 Jul 1989	1 Sep–31 Nov 1989
No fell, burn	0.000a[a]	0.661a	0.842a
Fell no burn	0.449a	0.620a	0.619ab
Fell and burn	0.000a	0.651a	0.0847a
Unharvested control	0.000a	0.333a	0.000a

[a]Values followed by the same letter within a column were not significantly different at the 0.05 level.

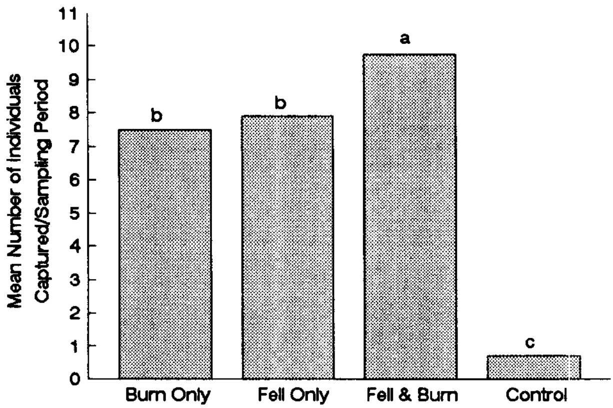

Figure 4. Mean number of small mammal individuals captured by treatment in Dawson County, Georgia, 1989. Treatments with the same letter are not significantly different at the 0.05 level.

Table 4. Relative abundance (%), and number of individual animals (*N*) by species, Dawson County Georgia, 1989.

Species		*N*	Abundance (%)
Mammals			
White-footed mouse	(*Peromyscus leucopus*)	152	63.9
Cotton rat	(*Sigmodon hispidus*)	19	7.9
Cotton mouse	(*P. gossypinus*)	15	6.3
Golden mouse	(*Ochrotomys nuttallii*)	13	5.5
House mouse	(*Mus musculus*)	6	2.5
Least shrew	(*Cryptotis parva*)	6	2.5
Pine vole	(*Microtus pinetorum*)	2	0.8
Southeastern shrew	(*Sorex longirostris*)	1	0.4
Eastern cottontail rabbit	(*Sylvilagus floridanus*)	1	0.4
Southern flying squirrel	(*Glaucomys volans*)	1	0.4
Total		216	90.8
Non-mammals		22	9.2
Grand Total		238	100.0

in some areas, many microhabitats remained in an early successional stage for the entire growing season and were suitable only for species like *Peromyscus spp.* that could successfully exploit them. Other species could move from one area to another in order to exploit seasonally abundant food sources, as was seen by Briese and Smith (1974).

Insects

Total insect biomass decreased somewhat as a result of all site preparation treatments (Fig. 5). Burned sites averaged 1.3 kg/ha, while unburned and control sites averaged 1.2 and 1.5 kg/ha, respectively. Recovery of insect production was quite rapid and by the third sampling period all treatments were higher in insect

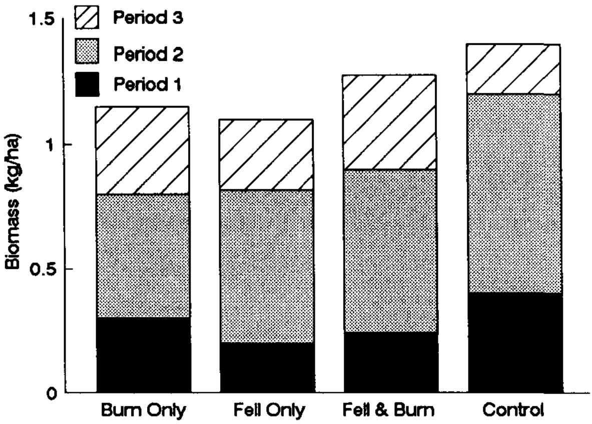

Figure 5. Insect biomass production by treatment, Dawson County, Georgia, 1989.

biomass production than controls. During period 3, insect biomass was significantly higher on the fell-and-burn sites than in controls. The orders Coleoptera, Lepidoptera, and Orthoptera contributed >70 percent of the biomass, but Diptera, Hemiptera, Homoptera, and Hymenoptera also were collected.

Conclusions

Forage biomass production was greater on all site-preparation treatment areas than in unharvested controls. Also, site-prepared areas supported richer plant communities and higher numbers of small mammals than controls. In this study, felling of residual stems without burning resulted in the most productive plant communities because it did not suffer from the heavy erosion associated with both burning treatments.

Even though severe burns produced adverse affects to site quality, the short-term effects on wildlife habitat and small mammals appear to be positive. If site-preparation burning can be conducted in a manner to minimize erosion, the fell-and-burn technique may prove to be the best of the site-preparation treatments tested for small mammal habitat. This treatment was preferable to the burn-only treatment since it resulted in greater plant biomass and plant species richness. Variable fire patterns due to uneven fuel loading created microsite differences that may have caused the increase of plant species richness. Also, areas that were felled and burned had significantly higher numbers of small mammals utilizing the area than all other treatments.

The fell-and-burn technique is a relatively inexpensive method to regenerate pine-hardwood mixtures but its application in the Piedmont requires additional study. Effects on wildlife, water quality, and soil as well as on stand regeneration and development are currently being studied. As Van Lear and Kapeluck (1989) have shown, burning prescriptions on Piedmont sites must be modified if erosion is to be controlled. Species composition and soil characteristics of Piedmont sites are different from those of mountain sites, and it may be necessary to modify fell-and-burn techniques because of those differences. Finally, this study addressed only the early successional habitat changes that resulted from this technique. The impact of this type of site preparation on wildlife as the stands continue to develop is yet to be determined.

Literature Cited

Abercrombie, J.A., Jr. and Daniel H. Sims 1986. Fell and burn for low-cost site preparation. Forest Farmer 46(1):14–17.

Ahlgren, C.E. 1966. Small mammals and reforestation following prescribed burning. J. For. 64:614–618.

Briese, L.A. and M.H. Smith. 1974. Seasonal abundance and movements of nine species of small mammals. J. Mammalogy 55:615–629.

Evans, T.L. 1990. Effects of fell-and-burn site preparation on wildlife habitat and small mammals in the upper Piedmont of Georgia and South Carolina. M.S. Thesis, Clemson Univ., Clemson, S.C. 52 pp.

Geisinger, D.R., T.A. Waldrop, J.L. Haymond, and D.H. Van Lear. 1989. Sprout growth following winter and spring felling with and without summer broadcast burning. Pages 91–95. *in* T.A. Waldrop, ed. Proceedings of pine-hardwood mixtures: a symposium on management of the type. Atlanta, Ga. USDA For. Serv. Gen. Tech. Rep. SE-58.

Hingtgen, T.M. and W.R. Clark. 1984. Small mammal recolonization of reclaimed coal surface-mined land in Wyoming. J. Wildl. Manage. 48:1255–1261.

James, F.C. and H.H. Shugart, Jr. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727–736.

Krefting, L.W. and C.E. Ahlgren. 1974. Small mammals and vegetation changes after a fire in a mixed conifer-hardwood forest. Ecology 55:1391–1398.

Mengak, M.T., D.C. Guynn, Jr., and D.H. Van Lear. 1989. Ecological implications of loblolly pine regeneration for small mammal communities. For. Sci. 35:503–514.

Phillips, D.R. and J.A. Abercrombie, Jr. 1987. Pine-hardwood mixtures–a new concept in regeneration. South. J. Applied For. 11:192–197.

Pielou, E.C. 1977. Mathematical ecology. John Wiley and Sons. New York, N.Y. 385pp.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. The Univ. N.C. Press, Chapel Hill. 1183pp.

Shannon, C.E. and W. Weaver. 1949. The mathematical theory of communication. Univ. Illinois press, Urbana, Ill. 177pp.

Southwood, R., Sir. 1978. Ecological methods: with particular reference to the study of insect populations. John Wiley and Sons. New York, N.Y. 391pp.

Van Lear, D.H. and P.R. Kapeluck. 1989. Fell and burn to regenerate mixed pine-hardwood stands: an overview of effects on soil. Pages 83–90 *in* T.A. Waldrop, ed. Proceedings of pine-hardwood mixtures: a symposium on management of the type. Atlanta, Ga. USDA For. Ser. Gen. Tech. Rep. SE-58.

Waldrop, T.A., F.T. Lloyd, and J.A. Abercrombie, Jr. 1989. Fell and burn to regenerate mixed pine-hardwood stands: an overview of research on stand development. Pages 75–82 *in* T.A. Waldrop, ed. Proceedings of pine-hardwood mixtures: a symposium on management of the type. Atlanta, Ga. USDA For. Serv. Gen. Tech. Rep. SE-58.

Wells, C.G., Campbell, R.E., DeBano, L.F., Lewis, C.E., Fredriksen, R.L., Franklin, E.C., Froelich, R.C. and Dunn, P.H. 1979. Effects of fire on soil: a state-of-knowledge review. U.S. Dep. Agric., Forest Service, Washington, D.C. Gen. Tech. Rep. WO-7. 34pp.

Williams, D.F. and S.E. Braun. 1983. Comparison of pitfall and conventional traps for sampling small mammal populations. J. Wildl. Manage. 47:841–845.