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The eastern wild turkey (*Meleagri gallopavo silvestris*) is common throughout the Ozark National Forest and is an important species to sportsmen and wildlife enthusiasts. The Land and Resources Management Plan (LRMP) for the forest suggests the importance of the species by proposing it as the "featured species" on 37% of the forest (USDA Forest Service, 1986). Management guidelines outlined in the LRMP include establishment of "four well-distributed 1 to 5-A openings per 640-A habitat unit" with "improved wildlife forage species on at least one opening per habitat unit, where natural forage is inadequate". Provision of wildlife openings in a manner consistent with these guidelines has required considerable capital expenditure by the USDA Forest Service over the 10-year period covered by the LRMP.

Provision of forest openings to improve turkey habitat has long been advocated (Stoddard, 1935; Holbrook and Lewis, 1967; Shaffer and Gwynn, 1967). Openings are of particular importance to poults during summer providing relatively high concentrations of insects and seeds required for growth (Martin and McGinnes, 1975). The types of openings provided for turkeys on public and private forests may vary however from clearcuts, to openings maintained in native herbaceous cover, to food plots planted in grasses or grass-legume mixes. Relative costs involved in establishing and maintaining each type of opening vary considerably. Further, few data are available to assess the relative values of openings for meeting the needs of turkeys and other wildlife species (Hurst, 1978; Krusac and Michael, 1979; Healy and Nenno, 1983).

No studies of this type have been conducted in the Ozarks. The objectives of this study were to (1) assess the relative amounts of herbaceous biomass, preferred seeds, and insects provided during the summer by each of 3 types of forest openings used on the Ozark National Forest, (2) investigate the extent to which turkeys use each type of opening, and (3) compare the relative costs of providing openings by each method.

Study Areas.--The 9 openings selected for this study are located in the Pleasant Hills District of the Ozark National Forest in Johnson Co., AR. Regional topography varies from rolling hills to steep mountains, but the study sites were on relatively flat ridge tops and benches. Soils are loamy and stony at the surface, moderately erodible, and better suited to forest management than more intensive uses. These soils are rated from good to fair for production of native herbaceous plants and fair to poor for production of cultivated grasses and legumes (Garner et al., 1977).

Forests are dominated by white oak (*Quercus alba*), black oak (*Q. velutin*), southern red oak (*Q. falcata*), various hickories (*Carya* spp.), and shortleaf pine (*Pinus echinata*) on upland sites. Ground cover tends to be sparse with lowbush blueberry (*Vaccinium pallidum),* poison ivy (*Toxicodendron radicans*) and greenbriers (*Smilax* spp.) sometimes forming thick cover (Pell, 1984). Common species that invade clearings after disturbance include goldenrods (*Solidago* spp.), beggarweeds (*Desmodium* spp.), ragweed (*Ambrosi* spp.), blackberries (*Rubus* spp.), and persimmon (*Diospyros virginiana*).

Wild turkeys were common throughout the study area. Local population densities varied with quality of habitat, but approximated 6 birds/km^2 (USDA Forest Service, 1980). Populations have increased dramatically during the past 20 years in part due to a successful trap-transplant program conducted by the Arkansas Game and Fish Commission.

To compare the amounts of seeds and invertebrates produced in different types of forest openings, we selected 9 openings for study. These included 3 clearcuts, 3 cultivated food plots, and 3 openings created by using herbicide to kill trees (hereafter called herbicide openings). All openings were within 15 km of each other, with similar site index, age, topography, and turkey density. Clearcuts were 5-8 ha in size and were 1-2 years old when sampled; slash had been left on each site, and no site preparation had occurred prior to sampling. Food plots were 1 ha in size and had been disked, seeded, and fertilized in September of the previous year. The seed mix included wheat, ryegrass, ladino clover, and orchard grass. Food plots were fertilized with 1400 kg/ha (250 lbs/A) of 12-24-12 fertilizer. Herbicide openings were 1 ha in size and had been created 2 years prior to the study using hexazinone (Velpar L liquid) applied at a rate of 19L/ha (2 gal/A). The herbicide had been applied in May by a biologist using a backpack sprayer and had resulted in a nearly complete root-kill of woody vegetation. Hexazinone is commonly applied in the spring to facilitate root absorption when more rainfall is expected (Brooks et al., 1992).

Sampling.--Total herbaceous biomass and the biomass of preferred seeds were measured in each opening during the first 2 weeks of June. Herbaceous biomass was estimated in each opening by clipping 18 randomly-selected 1-m^2 plots at ground level. Clippings were separated by species, air-dried to constant weight, and weighed. Seeds of those species known to be utilized by turkeys were stripped by hand and weighed. For purposes of this study, preferred seeds included those of wheat, ryegrass, panic grasses (*Panicum* spp.), paspalums (*Paspalum* spp.), crabgrass (*Digitaria sanguinalis*), sprangletop (*Leptochloa panicoides*), sedges (*Carex* spp.), beggarweeds, ragweeds, and lespedezas (*Lespedeza* spp.).

Invertebrates were sampled twice weekly in each opening from mid-June through August using a 40 cm-diameter sweep net. Each sample consisted of 150 sweeps conducted along three 100-m transects uniformly distributed parallel to the long axis of each opening. Samples were collected only on calm days with no precipitation. No attempt was made to sample invertebrates in the litter or soil. Invertebrates were preserved in ethyl-acetate, then counted, oven-dried, and weighed. Mean biomass and number of invertebrates per sample were used as indices of invertebrate abundance (Healy and Nenno, 1983).

The relative use of each opening by turkeys was estimated using track plots. Tracks were counted in 1m x 2m rectangular plots established at a density of 10 plots/ha. We made track plots by removing all vegetation and litter, and raking the surface to a soft, smooth texture. Plots were inspected twice each week from June through August. The percentage of days that turkey tracks were observed in each opening was an index of use. The mean herbaceous biomass, seed biomass, and invertebrate abundance and biomass produced by each type of opening were compared using ANOVA with Tukey's mean comparison test to find differences of means. Percent use data were arcsine transformed prior to the ANOVA test. All tests were conducted at $\alpha = 0.05$.

The production of herbaceous biomass was greatest in the food plots and herbicide openings which averaged 290 and 225 g/m^2, respectively (Table 1). Herbaceous biomass was significantly lower in clearcuts ($p = 0.003$). Dense stands of wheat, ryegrass, and orchard grass were produced on two of the food plots, accounting for the majority of biomass on these sites. The third food plot was dominated by ladino clover with some orchard grass, wheat, and fescue (*Festuca* spp.). This plot was on a ridge which received little precipitation during May and June resulting in sparse stands of grasses and less herbaceous biomass than the others.

Herbicide openings were dominated by a wide variety of grasses, forbs, and woody plants including goldenrods, beggar's tick (*Bidens frondosa)*, beggarweeds, ragweed, partridge pea (*Cassia fasciculata*), pokeberry (*Phytolacca americana*), lowbush blueberry, and blackberries. Most of the plants on these sites were herbaceous annuals that had germinated and grown after the application of herbicide. These were complemented by some woody stems that had resprouted from plants which were not killed by the herbicide treatment. The vegetation in the 3 clearcuts was dominated by woody vegetation, much of it sprouts from cut stems. Herbaceous vegetation was more sparse and patchy on these sites and was dominated by native brome grasses (*Bromus* spp.) and various forbs.

Food plots generally produced the largest quantity of preferred seed and produced significantly more seed than clearcuts ($P = 0.04$; Table 1). However, seed production in the food plots was variable depending on site conditions. Production was highest in food plots #1 and #2 where wheat and orchard grass contributed greatly to total biomass. However, the food plot dominated by clover produced only sparse stands of grasses and little seed relative to the others. Consequently, although seed production was high in 2 of 3 food plots, the mean production of preferred seeds was not significantly greater in food plots compared to herbicide openings. Herbicide openings produced between 10.5 and 13.7 g/m^2 of a wide variety of preferred seeds (Table 1).

Table 1. Total herbaceous biomass, seed biomass, and invertebrate biomass produced in 3 types of forest openings on the Ozark National Forest, AR.

		Total herbaceous biomass (g/m^2)		Seed biomass (g/m^2)		Invertebrate biomass (g/transect)		Invertebrate abundance (no./transect)	
Type of Opening	N	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
Food Plot	3	289.7^a	25.2	51.3^a	17.9	6.0^a	2.1	354.3^a	128.7
Herbicide opening	3	225.3^a	25.1	12.3^{ab}	0.9	6.3^a	0.9	336.0^a	55.6
Clearcut	3	104.3^b	17.2	5.3^b	2.3	2.3^a	0.9	99.0^b	37.4

Means followed by different letters differ significantly at $\alpha = 0.05$.

Seed biomass as a proportion of total herbaceous biomass was greatest in the food plots where preferred seeds were approximately 18% of total biomass. In contrast, herbicide openings produced similar levels of herbaceous biomass, but seeds comprised only 5% of the total biomass. The native plants which predominated in the herbicide openings did not produce the large seeds and seedheads which are typical of the cultivated varieties of wheat and orchard grass planted in food plots.

Invertebrate abundance and biomass fluctuated dramatically between sampling periods and sites. We found no significant difference in invertebrate biomass ($P = 0.16$) or abundance ($P = 0.13$) among treatments (Table 1). However, a significant positive correlation existed between total herbaceous biomass and invertebrate biomass in the 9 plots ($r = 0.68$; $P = 0.04$). Food plots and herbicide openings with abundant vegetation generally contained abundant invertebrates. Clearcuts with their sparse patches of herbaceous vegetation typically produced only about 1/3 the abundance of invertebrates found in the other types of openings.

Eight of 9 openings were used by turkeys during this 3-month study; no evidence of turkeys was found in 1 clearcut. Food plots and herbicide openings were used more frequently than clearcuts ($P = 0.03$). Turkey tracks were found in food plots during 34% of the surveys, in herbicide openings during 33% of the surveys, and in clearcuts during 9% of the surveys. The use of openings was highly correlated with total herbaceous biomass ($r = 0.89$; $P = 0.001$), invertebrate biomass ($r = 0.87$; $P = 0.002$), and invertebrate abundance ($r = 0.89$; $P = 0.001$), but less correlated with seed biomass ($r = 0.63$; $P = 0.07$). Use of openings declined as summer progressed; most tracks and sightings of hens and poults were recorded between June 1 and July 15. By August, turkeys were rarely using any of the openings.

Numerous studies suggest that forest openings enhance turkey habitat (Stoddard, 1935 Blackburn et al., 1975; Martin and McGinnes, 1975; Pack et al., 1980). Openings provide a number of benefits to turkeys, but probably have the greatest influence on the survival and growth of young poults, particularly during the first month of life (Healy and Nenno, 1983). Openings with adequate herbaceous vegetation provide necessary food and cover during the first critical weeks when survival rates are lowest (Hurst and Stringer, 1975; Pack et al., 1980).

Seed production was particularly high in food plots planted to wheat and orchard grass when adequate precipitation was available. However, herbicide openings also produced large quantities of seeds and a broader diversity of seeds from native plants than food plots. This diversity may be beneficial to turkeys if it provides a broader range of nutrients or reduces the probability of crop failure due to weather or disease. Clearcuts provided relatively little food in the first 2 years after cutting, and the patchy distribution of herbaceous vegetation provided less protective cover for turkey broods. These results are consistent with those of a West Virginia study that concluded that unmanaged grass-forb openings provided as much food for poults as managed grass-legume food plots (Healy and Nenno, 1983).

Turkeys used forest openings more frequently when they provided abundant herbaceous vegetation and seeds. Sightings of turkeys and their tracks were common in food plots and herbicide openings. The dense stands of grasses and forbs in these openings provided the critical protective cover and foods needed by poults and adults in early summer (Pack et al., 1980). Use was most heavy in early summer coinciding with the time that broods are most dependent on forest openings for insects. Presumably the use of openings declined later in the summer as diets shifted towards more plant matter and food requirements could be met in other plant communities (Blackburn et al., 1975; Hurst and Stringer, 1975; Healy and Nenno, 1983).

Healy and Nenno (1983) recommended managing for early brood habitat by using the simplest, most cost-effective technique that maintains the herbaceous community. In the Ozarks it appears that both food plots and herbicide openings provide sufficient quantities of herbaceous biomass, preferred seeds, and invertebrates to be readily used by turkeys. However, herbicide openings provide several advantages that food plots do not. First, the cost and effort of establishing herbicide openings is less. Wildlife openings can be created using hexazinone at a cost of approximately $140/ha. The costs of planting, fertilizing, and maintaining grass-legume food plots are 6-8 times higher (G. Leeds, USDA Forest Service, pers. comm.). Second, herbicide openings can be created and maintained without heavy equipment, reducing soil disturbance and compaction. Third, food plots must be situated on roads to provide access by farm vehicles, but herbicide openings can be established away from roads, reducing disturbance (including poaching) at these sites and expanding the opportunity to create openings in optimal locations to meet management goals. Finally, herbicide openings provide a large number of snags which benefit a variety of snag-dependent and cavity-dwelling wildlife species. The abundance of woodpeckers in these openings was evident throughout the summer.

The Forest Service recently eliminated the use of hexazinone to manage vegetation on national forests. Different herbicides can dramatically alter the composition of the redeveloping plant community and shift species composition in ways that may be beneficial or detrimental to wildlife depending on their habitat requirements (Brooks et al., 1992). A study conducted in Georgia indicated that hexazinone-treated sites produced more desirable food plants for bobwhite (Colinus virginianus) and white-tailed deer (Odocoileus virginianus) than sites treated with picloram and triclopyr or imazapyr. Additional research should be conducted to assess the relative habitat value of forest openings created using alternative herbicides in the Ozarks.

While maintained openings in forested landscapes have traditionally been used to enhance habitat for many wildlife species, concerns exist that these openings may contribute to forest fragmentation and be detrimental to forest-interior species (Overcash et al., 1989). The extent to which openings contribute to forest fragmentation is influenced by their size, vegetative composition, and spatial distribution. It is not the purpose of this paper to evaluate the optimal size or distribution of managed openings. However, it is important to note that the ONF has become more heavily forested in the past 50 years due to natural succession, the planting of pines in former open habitat, fire suppression, and the acquisition of private land. Further, it is likely that open habitat will continue to decline on the ONF since the Forest Service eliminated clearcutting and replaced it with alternative harvest methods which maintain greater forest canopy. In this context, the continued maintenance of forest openings will become increasingly important as a means to enhance habitat for a wide variety of game and nongame species, and the use of suitable herbicides to create these openings appears to be a cost-effective alternative to managed food plots.

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