the unparalleled interest and efforts shown by sportsmen, game officials, biologists, law enforcement personnel, and many others. Without such support an account of this kind would not have been possible.

THE EFFECTS OF ARASAN-ENDRIN TREATED PINE SEED ON BOBWHITE QUAIL, GRAY SQUIRREL AND TURKEY[1]

By William J. Hamrick

Arasan-endrin[2] coated pine seed has been recommended to repel birds and rodents for direct seeding to establish a stand of forest trees. The recommended rate of treatment per 100 pounds of seed was 10 pounds of Arasan-75 and two pounds of endrin 50W (one per cent effective endrin), with Flintkote's C-13-HPC asphalt emulsion or Dow Latex 512-R recommended as a sticker to bond the repellents to the seed. Aluminum powder could be added at the rate of one cup per 100 pounds of seed (Mann and Derr, 1961). Recommended rates of seeding were one pound of slash or loblolly seed per acre or three pounds of longleaf seed per acre (Martin, 1959). Seeding dates, as recommended by Martin (1959), were late February or early March in central and North Alabama and December, January or February in South Alabama.

Kerr (1959) stated that about 75,000 acres were direct-seeded in the south in 1959. There has been some indication that animal depredation on treated seed remains a problem, at least under certain conditions. The use of treated seed as food by wildlife, along with the acreage involved and the known toxic properties of endrin, has caused some concern as to the possible adverse effects of this technique on game species.

The objectives of this study were to determine the toxicity and repellent qualities of Arasan-endrin treated pine seed, as used for forest reseeding, to wildlife. Specific objectives were to determine:

1. The lethal dosage of such treated seed for bobwhite quail (*Colinus virginianus* L.), gray squirrels (*Sciurus carolinensis* L.) and turkeys (*Meleagris gallapavo* L.).
2. The repellent qualities of treated pine seed in respect to the above wildlife species.

During the study some information was obtained on repellent qualities concerning cotton rats (*Sigmodon hispidus* Say and Ord) and chipmunk (*Tamias striatus* L.).

PROCEDURE AND RESULTS

The Arasan-endrin treated seed used in this study were obtained from a commercial seed supplier. The treatment was that recommended and used for reseeding to establish a stand of forest trees. The treatment was two per cent Endrin 50W, eight per cent Arasan 42-S and aluminum coloring. Arasan 42-S, an aqueous liquid containing four pounds of thiram (Arasan) per gallon is easy to apply, is as effective in protecting pine seed as the older formulations and provides a more durable coating (Derr, 1963a). Derr (1963b) also stated: "Application of two gallons per 100 pounds of seed (dry-weight basis) provides approximately the same amount

[1] A contribution of the Alabama Cooperative Wildlife Research Unit, Auburn University, the Alabama Department of Conservation, the U. S. Bureau of Sport Fisheries and Wildlife and the Wildlife Management Institute, cooperating. Presented at Technical Game Sessions of the 22nd Annual Conference of Southeastern Association of Game and Fish Commissioners, October 1968.

[2] Arasan or thiram is tetramethyl thiuram disulfide. Endrin is 1,2,3,4,10,10 hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4, 5, 8-endo-endo-dimethanonaphthalene.

of active repellent as the recommended 10 pounds of Arasan 75 per 100 pounds of seed". The seed of slash pine (*Pinus Elliottii* Engelm.) was used.

Bobwhite Quail

Procedure

Thirty-six pen raised bobwhite quail, 16 females and 20 males, were utilized in this study. These birds were approximately nine months of age. Quail were housed in cages constructed of one-inch-mesh hardware cloth, so that each 45" x 15" x 18" cage consisted of three adjoining 15" x 15" x 18" compartments. Cages were housed in a three-sided shed near the Cooperative Wildlife Research Unit deer pens, and were placed on a wooden rack approximately three feet above ground level. Studies with quail were conducted during March, April and May of 1964. Water was provided in one-half-pint wide-mouth jars wired into a corner of each cage. Supplemental feed was provided in the form of commercial game bird ration.

Force feeding.——Ten quail, five females and five males, were force fed one treated seed. Force feeding was accomplished by gently forcing the bird's beak open, holding the bird's head to have the neck as straight as possible, and using forceps to place a seed into the opening of the esophagus. The bird was allowed to relax for a short interval, while still in hand, and then visually checked to see that the seed had been swallowed. Six quail, four females and two males, were forced fed one untreated seed as checks.

Free-choice feeding.——Ten quail, four females and six males, were offered a mixture of 30 ml treated seed and 30 ml untreated seed for 24 hours. No supplemental feed was provided during this period. Thirty ml of untreated seed was considered as being sufficient to feed a bird for 24 hours without starving it into eating treated seed. Eight birds, two females and six males, were offered 30 ml of untreated seed as checks. No supplemental feed was provided during this period.

It was thought that offering the treated and untreated seeds mixed would most nearly simulate conditions in the field where artificially-seeded treated seed would be commingled with any natural foods present at the time of seeding. However, in case of question, three male quail were offered 25 ml treated seed and 30 ml untreated seed, with the two types of seed in separate containers. This feeding was for 24 hours, with no supplemental feed provided during this period. No checks were used.

Two male bobwhite quail were placed in cages that had been lined with roofing paper in the bottom and extending six inches up the sides. These birds were offered a choice of 25 ml of aluminum colored seed (with no Arasan or endrin) and 25 ml of uncolored and untreated seed, in separate containers. The volume of each type seed remaining, was measured at the end of a 24 hour period. No supplemental feed was provided during this period.

Three quail, that were originally used as check birds in force feeding tests, were later utilized in free-choice feeding tests. At least a month time lapse was allowed in each case.

Results

Force feeding.——One treated slash pine seed was a lethal dosage for quail. All ten birds, five females and five males, force fed one treated seed died. All exhibited symptoms similar to those described for endrin poisoning (Rudd and Genelly, 1956): "loss of weight, loss of appetite, tremors, muscular spasms and convulsions leading to coma characterize external symptoms". Other symptoms, noted for quail in this study, were: staggering; feathers fluffed; wings sagging; and loose, watery droppings. Tremors appeared in birds as soon as three hours after being force fed one treated seed. None of the check birds exhibited ill effects.

The average observed time from force feeding until death was 53.4 hours for female birds, with the minimum and maximum time being 41 and 66 hours. The average observed time from force feeding until death was 59.8 hours for males, with the minimum and maximum time ranging from three hours (for two birds) to 128 hours. One possible explanation for this wide range of time, for male birds, is the difference in size of individual seeds; therefore, causing a difference in the amount of

seed surface-area exposed to the treatment material. It would not seem likely that the early deaths, of the two birds, were due to injury in handling, since all check birds showed no ill effects. However, injury in handling is a possible explanation. Other explanations are variation in weight of the quail and/or variation in resistance to the treatment material.

Free-choice feeding.——Of the ten quail, four females and six males, offered a mixture of 30 ml treated and 30 ml untreated seed, all females and one male died. All exhibited symptoms similar to those of birds force fed treated seed. The surviving five males exhibited definite symptoms of poisoning, but did not go into the convulsions and coma stage.

One check bird exhibited symptoms of poisoning and later died. Close examination of the cage revealed three treated seed on the cage support, thus being available to this bird. This quail was in a cage adjoining that of a bird being offered treated seed. Undoubtedly, the treated seed were scratched onto the cage support by the bird receiving treated seed. After this incident an empty cage compartment was allowed between the treatment and check birds. All other check birds exhibited no ill effects.

The elapsed time from placement of the mixture of treated and untreated seed in the cage until death was observed was 96 hours for the male quail. The average time for the four female quail was 141.8 hours, with a minimum and maximum time of 46 to 190 hours.

Of the three male quail that were offered 25 ml of treated seed and 30 ml untreated seed, in separate containers, two died. Both of these exhibited the previously described symptoms. The elapsed times, from placement of the seed in the cage until death was observed, were 76 and 262 hours. The surviving bird also showed the typical symptoms except for the convulsions and coma stage preceeding death.

Of the two quail offered a choice between aluminum colored (but otherwise untreated) seed and normal-colored untreated seed, for 24 hours; one consumed 7.5 ml uncolored seed and 7.0 ml aluminum colored seed while the other consumed 2.5 ml uncolored seed and 2.0 ml aluminum colored seed.

See table 1 for a summary of treatments and results.

Gray Squirrels

Procedure

Sixteen wild gray squirrels were live-trapped for use in the study. These squirrels were housed in cages identical to those used for bobwhite quail. Studies were conducted during March, April and May, 1964. Water was provided in one-half-pint wide-mouth jars wired into a corner of each cage. Supplemental feed was provided in the form of shelled yellow-corn and pecans. No problems were experienced with this rather limited diet during the short time of confinement (34 days maximum).

Squirrels were held at least five days before being subjected to treatment. Seven of the sixteen squirrels trapped died (presumably of shock) within 72 hours. Death from shock was almost always predictable by the squirrels behavior during the first 24 hours. All squirrels surviving the first 72 hours appeared to have adjusted to the caged environment.

Seven squirrels were used in attempting to ascertain the lethal dosage of treated seed. These seven squirrels consisted of one adult male, one adult female, two subadult males and three subadult females. Squirrels were aged using the tail pelage characteristics technique described by Sharp (1958). These squirrels were offered a known number of treated seed. Roofing paper trays were placed under the cages to catch dropped seed. The number of ungnawed seed were counted and subtracted from the total offered, giving the number of seed eaten or gnawed. No supplemental food was provided during the period while the treated seed were being offered.

Two squirrels, one adult male and one subadult female, were offered 25 ml of treated seed and 25 ml untreated seed. These seed were offered in separate containers, for 24 hours, with no supplemental feed provided during this period.

Results

Of the seven squirrels, offered a known number of treated seed, five died. These five gnawed an average of 85 seed. This varied from a low of 30 seed to a high of 135 seed. The amount of treatment material each individual was exposed to probably varied. Observation indicated that some individuals were more adept at cutting through the seed coat to get to the edible inner portion. This would cause the time an individual squirrel spent in contact with each seed to vary and therefore, probably cause a variation in exposure to treatment material. The two squirrels that did not die damaged 84 and 133 seed respectively. Both exhibited tremors and an apparent reduced vitality but were still alive two weeks after treatment.

The two squirrels, an adult male and a subadult female, offered a choice of treated and untreated seed, showed a preference for the untreated seed. However, treated seed were also eaten. One of these squirrels, the adult male, died 96 hours after treatment. This squirrel and the one surviving both exhibited symptoms of poisoning.

See table 2 for a summary of treatment and results.

TABLE 1

Treatment and results of feeding tests of Arasan-Endrin treated slash pine seed to quail.

Treatment	*Number of birds*	*Number exhibiting symptoms of poisoning*	*Number dead*
Force fed one treated seed	5 males	5	5
	5 females	5	5
Force fed one untreaded seed	2 males	—	—
	4 females	—	—
Offered a mixture 30 ml treated seed and 30 ml untreated seed for 24 hours	6 males	6	1
	4 females	4	4
Offered 60 ml untreated seed for 24 hours (check birds)	6 males	1	1*
	2 females	—	—
Offered 25 ml treated seed and 30 ml untreated seed for 24 hours	3 males	3	2

*This bird had access to treated seed, scratched onto the cage-support by a bird in the adjoining cage that was being offered treated seed.

TABLE 2

Treatment and results of feeding tests of Arasan-endrin treated slash pine seed to gray squirrels*

Treatment	*Sex and age of squirrel*	*Number of seed gnawed*	*Mortality occurred*
Offered known number of treated seed	Adult male	88	yes
	Adult female	105	yes
	Subadult male	136	yes
	Subadult female	133	no
	Subadult female	68	yes
	Subadult male	30	yes
	Subadult female	84	no
Offered 25 ml treated seed and 25 ml untreated seed in separated containers	Adult male	——	yes
	Subadult female	——	no

*All squirrels exhibited symptoms of poisoning.

Cotton Rats and Chipmunk

Procedure

Cotton rats were numerous and were often observed in a fence-row near the building housing the cages for this study. It was anticipated that these cotton rats would perhaps bias the information on squirrels by damaging seed spilled or dropped into the roofing paper trays under the squirrel cages. For this reason, treated seed were placed on a tray and the tray placed on the ground, near the above mentioned fence-row. These seed were exposed at dusk and taken up soon after dawn. The seed were offered for seven nights, during March, 1964.

One chipmunk was live-trapped while capturing squirrels, during April, 1964. This chipmunk was caged and provided with water. Treated seed were offered late in the afternoon on the day of capture.

Results

Gnawed seed indicated that small rodents were utilizing the treated seed, offered near the fence-row adjacent to the building housing the cages for this study. On the day after these seed were made available a cotton rat was observed exhibiting severe tremors. This animal was barely able to evade capture. No cotton rats were seen in the immediate vicinity after the second day and no seed were damaged after the third night.

The one chipmunk, offered treated seed, was found dead the next morning (12 hours). Four seed had been gnawed. It is possible that it died of shock; however, since it did gnaw some seeds, it seems unlikely that it died of shock. Experience, with gray squirrels, indicated that once an individual started eating, it had adjusted to the caged environment.

Turkeys

Procedure

Twelve pen-reared wild-stock turkey hens were obtained for this study. These turkeys were housed in four adjoining 12' x 24' pens, with the sides and top constructed of one-inch-mesh hardware cloth. Pens were on Upper State Game Sanctuary near Jackson, Alabama. Supplemental feed was provided in the form of commercial game bird ration and scratch grain. Water was provided in open containers. Studies with turkeys were conducted from April, 1965 through August, 1966.

Turkeys were leg-banded for individual identification and force fed varying numbers of treated seed in an effort to determine the lethal dosage. Since a large number of treated seed (up to 36) were fed to some individuals, seed were placed in gelatin capsules and the capsules were moistened to facilitate the force feeding process.

Force feeding.——Three turkeys, each were force fed four, six and eight treated seed, with two birds force fed eight untreated seed as checks. Two turkeys were force fed 12 and 15 treated seed, with two force fed 15 untreated seed as checks. One bird was force fed 24 treated seed, three were force fed 30 treated seed and one was force fed 36 treated seed. No checks were used in the higher dosages, as no injuries or other ill effects due to handling had occurred from past force feedings.

Due to a limited number of turkeys available, all birds used as checks were later used for force feeding or free-choice feeding tests. Also, birds receiving sublethal dosages in force feeding tests were later used in free-choice feeding tests. Due to the use of gelatin capsules, in force feeding tests, these birds should not have acquired any aversion to the treated seed.

Free-choice feeding.——Nine turkeys, two of which had not been previously force fed treated seed, were offered a mixture of treated and untreated seed. These seed were offered for 48 hours. Approximately one pint of each type of seed was offered per bird. No supplemental feed was offered during this period.

Results

Force feeding.——Of the ten turkey hens force fed treated seed, three died. Two of these birds were fed 30 treated seed; the other 36 treated seed. One bird force fed

30 treated seed survived for three months, until the study was terminated. The observed time lapse, from force feeding until death, was 24 hours for the bird fed 36 seed and 48 and 96 hours for the two fed 30 treated seed.

Free-choice feeding.——None of the turkeys offered a mixture of treated and untreated seed died within a reasonable time lapse. One bird, previously force fed four treated seed, died 43 days after being offered the mixture of treated and untreated seed. Although treatment may have been a contributing factor, it was not considered the direct cause of death. This bird appeared to be the weakest in the flock and was observed as being the lowest on the peck order.

No obvious symptoms of poisoning were observed in turkeys; however, the six turkeys force fed sublethal dosages of treated seed and surviving until the study was terminated averaged five pounds and two ounces in weight, while the two birds not force fed treated seed but offered treated and untreated seed, averaged seven pounds and nine ounces. This was an average difference of two pounds and seven ounces.

See table 3 for a summary of treatments and results.

TABLE 3

Treatment and results of feeding tests of Arasanendrin treated slash pine seed to adult turkey hens.

	Number of birds	*Mortality Occurred*
Force fed four treated seed	1	0
Force fed six treated seed	1	0
Force fed eight treated seed	1	0
Force fed eight untreated seed	2	0
Force fed 12 treated seed	1	0
Force fed 15 treated seed	1	0
Force fed 15 untreated seed	2	0
Force fed 24 treated seed	1	0
Force fed 30 treated seed	3	2
Force fed 36 treated seed	1	1
Offered one pint treated seed and one pint untreated seed for 48 hours	2	0
Offered one pint treated seed and one pint untreated seed for 48 hours	7*	1**

*Previously used in force feeding tests.

**This one bird, previously force fed four treated seed, died 43 days after being offered a choice of treated and untreated seed. This was probably not a direct result of treatment.

DISCUSSION AND CONCLUSIONS

Discussion of Results

Bobwhite Quail

In force feeding tests all quail force fed one treated seed died. This was predictable. DeWitt, *et al.* (1963) established the LD50 for adult bobwhite quail, fed 10 ppm of endrin in the diet, as 1 mg/kg. The average treated slash pine seed contained a computed dosage of approximately 0.35 mg of effective endrin. For an average-sized, adult quail this would be a dosage in excess of 1.5 mg/kg of effective endrin.

There was a great deal of difference in the observed time, from feeding until death, between force feeding and free-choice feeding tests; with quail in free-choice feeding tests surviving, on the average, twice as long as those in force feeding tests. This difference could possibly be explained by excitement and a corresponding acceleration of the rate of body metabolism on the part of birds that were force fed. However, this does not explain the fact that all birds surviving free-choice feeding

tests exhibited symptoms similar to those exhibited by birds, before death occurred, in force feeding tests. This would indicate that a bird could possibly obtain a lethal dosage and could certainly obtain a sublethal dosage by tasting and rejecting treated seed; for chlorinated hydrocarbons are readily absorbed through mucous membranes. The effect of the aluminum color was apparently almost negligible as a feeding-deterrent to quail.

Gray Squirrels

Squirrels were susceptible to poisoning from treated seed. The degree of susceptibility would probably vary with the availability of a natural food supply.

No exact lethal dosage figure can be presented for squirrels, as the number of seed gnawed and probably the amount of treatment material ingested from each seed varied. For treatment squirrels that died, the average number of treated seed gnawed was 85. Eighty-five seed would contain approximately 29.7 mg of effective endrin. The amount of endrin actually ingested would be less than (probably less than half) this amount.

Cotton Rats and Chipmunk

Cotton rats will eat treated seed under natural conditions. An abundant population of cotton rats was apparently exterminated and certainly was greatly reduced by having access to treated seed. It is very doubtful that these animals were forced into eating the treated seed due to a lack of other food; although food availability may have been a factor.

Turkeys

The pen-raised wild-stock turkey hens utilized in this study had a lethal dosage of approximately 30 treated seed. This would be a dosage of approximately 10.5 mg of effective endrin or, approximately 2.5 mg/kg for a 4.1 kg (nine pound) bird.

Since no symptoms were observed in turkeys it is unknown if seed were eaten in free-choice feeding tests. Work with other animals in this study indicates that the treatment involved may be what Neff and Meanly (1956) describe as a conditioned repellency. If not a conditioned repellency it is an aversion developed through tasting and rejecting treated seed. This would make it very probable that some treatment material would have been ingested, if only in minute quantities (when compared to the weight of the bird) that were absorbed through the mucous membranes of the mouth while tasting and rejecting treated seed.

General Discussion

The animals most affected by direct seeding of treated seed would be bobwhite quail, probably gray squirrels, and other seed-eating small mammals and birds. The direct affects of the seeding site preparation on the habitat has not been evaluated. However, the extent to which each species would be affected by treated seeding could be governed by several factors: (1) the availability of natural foods; (2) the type of site preparation and stage of vegetative succession of the seeded area; and (3) the size of the area seeded. Generally, a reseeded area will be quite open as in a clear-cut area or a severely burned over area. Gray squirrels would probably utilize only the edges of such an area, especially if the area is of considerable size. On the other hand, quail, turkeys, small ground-dwelling rodents and seed-eating birds have the ability to utilize, and are often attracted to extensive, relatively open areas.

There is little doubt that quail, small (quail-size and smaller) birds, small rodents and probably gray squirrels would incur some direct mortality from the utilization of treated seed on a seeded area. This direct mortality is of concern, but may not be the chief concern. Most small birds and small mammals have a high reproductive capacity and ability to populate or to repopulate an area; unless mortality is complete over an extensive area or unless other factors enter into the picture.

One factor that could be anticipated is the possibility of animals obtaining a sublethal dosage of endrin, during the process of learning to avoid the treated seeds, having a lowered reproductive capacity. This is a common phenomenon associated with sublethal dosages of chlorinated hydrocarbons. Also, the physical condition of

these animals would be lowered, and this would occur just prior to the reproductive season. This could limit the ability of a population to recover and could quite easily bias any follow-up study of the cause of a lowered population.

Another factor of this nature is increased predation on game animal populations. It is very probable that animals receiving a sublethal dosage of treatment material would have an increased susceptibility to predation. The chief defense of most prey species is the ability to remain completely immobile, thus avoiding detection. The characteristic tremors would erase this ability. Also, the animals are reduced in vigor by the effects of sublethal dosages. This would further reduce the ability of affected animals to escape predators. This agrees with conclusions reached by Hill (1962) concerning quail subjected to sublethal dosages of Kepone. The possibility that small rodents would be virtually wiped out in treatment areas would place an increased amount of pressure, from predators, on desired animal populations. This could be a problem even if the desirable populations were otherwise unaffected.

Another factor that is of concern is pesticide residues in the environment. Any practice contributing to this growing problem should receive careful study. Chlorinated hydrocarbon pesticides are particularly important because they persist long in the environment and accumulate in the tissues of animals (Dustman, 1966). This fact when associated with the use of game animals for food is of increasing concern. Buckley (1963) states: "The health hazard of eating game meat has caused concern to some people, since residues (of pesticides) in these animals may exceed legal tolerance set for domestic meat animals".

SUMMARY

This study was undertaken to determine the toxicity and repellent qualities of Arasan-endrin treated pine seed, as used for forest reseeding, in relation to wildlife. Specific objectives were to determine: (1) the lethal dosage of such treated seed for bobwhite quail, gray squirrels and turkeys, and (2) the repellent qualities of treated pine seed in respect to the above wildlife species.

During the study some information was obtained on repellent qualities, of treated seed, to cotton rats and chipmunks.

Aluminum-colored slash pine seed treated with two per cent Endrin 50W and approximately eight per cent Arasan 42-S were used in the study.

Pen-reared bobwhite quail and pen-reared wild-stock turkey hens were force fed treated seed to determine a lethal dosage. Wild-trapped squirrels were offered a known number of treated seed and ungnawed seed counted to determine the average lethal dosage of such seed. Caged quail, squirrels and turkeys were offered a choice of treated and untreated seed, to test repellency. One chipmunk was offered treated seed only. Treated seed were made available to a wild population of cotton rats, that were a potential problem since they were abundant near the building where caged study animals were housed.

The lethal dosage of treated seed for quail was one seed. All quail force fed one treated seed died. The lethal dosage for turkeys was 30 treated seed and the average lethal dosage for squirrels was 85 seed, gnawed.

Of 13 quail offered a choice of treated and untreated seed seven died. The six surviving exhibited symptoms of poisoning. One of two squirrels offered a choice of treated and untreated seed died, and the one surviving exhibited symptoms of poisoning. Turkeys, in the free-choice feeding tests, exhibited no symptoms of poisoning.

A local wild population of cotton rats, that were given access to treated seed, was apparently exterminated. Gnawed seed indicated usage. One cotton rat was observed that exhibited symptoms of severe poisoning and was barely able to avoid capture. The chipmunk given treated seeds gnawed four and was observed dead 12 hours after the seed were offered.

It was concluded that small rodents and seed-eating small birds could be adversely affected by having access to treated seed.

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AN EVALUATION OF A RESEEDING VETCH, CLANTON TICK-CLOVER, AND A LOW-TANNIN SELECTION OF SERICEA LESPEDEZA AS QUAIL FOOD AND COVER PLANTS[1]

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INTRODUCTION

The need for better quail food and cover plants is widely recognized. This paper describes experiments with three plants that were thought promising.

Two plants tested were perennial legumes, Clanton tick-clover (a strain of *Desmodium perplexum*) and a low-tannin selection of sericea *(Lespedeza cuneata)* and one was a reseeding annual legume, a hybrid vetch resulting from a cross between *Vicia sativa* and *Vicia cordata.*

[1]A contribution of the Alabama Cooperative Wildlife Research Unit, Auburn University, Game and Fish Division of the Alabama Department of Conservation, the U. S. Fish and Wildlife Service and the Wildlife Management Institute, cooperating. Presented at the 22nd Annual Conference of the Southeastern Association of Game and Fish Commissioners.

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