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BOB-WHITE POPULATIONS AS AFFECTED BY WOODLAND MANAGEMENT IN EASTERN TEXAS

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Thoughtful eastern Texas sportsmen and landowners have often wondered why bobwhite quail continued to decrease on certain woodland tracts even in the absence of hunting. The answer, in part at least, is contained in the present bulletin. Bobwhite quail, like all other species of game, are dependent on favorable food and cover conditions at all times of year. Few of the birds are to be found in the thick woods, for favorable food conditions are absent, since the tall pines shade out many of the plants on which the quail depend. Nor are there very many bobwhites in logged off lands the first few years after cutting, as the best food plants have not had an opportunity to develop. The greatest number of quail are found in cutover tracts from the fifth to the ninth years after cutting, as the food and cover conditions are most favorable for bobwhites during this period. Vegetative type, however, is so important as to neutralize the age of growth influence in some soil areas. A satisfactory method of censusing quail was developed through the use of the Civilian Conservation Corps, so that it was possible to make fair comparisons between game bird populations at different times and in different places. The details of bobwhite quail populations as affected by woodland management are of unusual significance, not only to the management of forest land for bobwhites, but as indicating an important and valuable line of wildlife research work that should be followed up.

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BOB-WHITE POPULATIONS AS AFFECTED BY WOODLAND MANAGEMENT IN EASTERN TEXAS

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If the bob-white *(Colinus virginianus virginianus)* the only member of the quail family occurring in eastern Texas is to be maintained or increased, it will be necessary to direct woodland management to this end. (See Fig. 1).

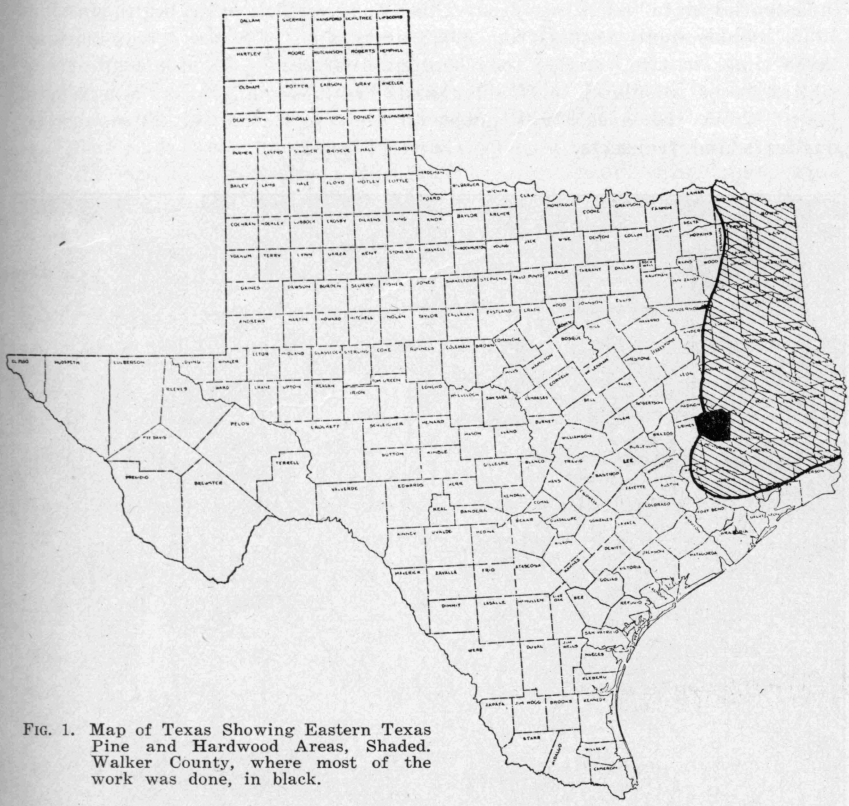

FIG. 1. Map of Texas Showing Eastern Texas Pine and Hardwood Areas, Shaded. Walker County, where most of the work was done, in black.

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Walker County, Texas, offers exceptional opportunities for study of the relationships of vegetation and wildlife populations on cutover areas of various ages. Extensive tracts of second-growth shortleaf and loblolly pine, cut at intervals since 1914 and subjected to rather uniform grazing and fire management practices, are available on a relatively large area of the same general soil type; also, there are several large blocks of second growth that were last cut between 1900 and 1905. In all of the fifteen areas studied, the soil consists of the Susquehanna fine sandy loam type characterized by a light colored sandy topsoil and a red subsoil of tight sandy clay. United States Weather Bureau records for 49 years show that the average annual precipitation in Huntsville, Walker County, Texas, is 43.39 inches.

Essential data resulting from this study, which was begun in June 1936, include quail counts from 5,323 acres (most of which was censused three times in two years); food content analyses of 56 stomachs of bobwhites from woodland in Walker and Trinity counties; a collection of plants from the area; and notes on the vegetation of a number of quadrats and transects.

FIG. 2. Virgin timber, possibly climax, in one of the last uncut tracts in eastern Texas. The principal trees are loblolly and shortleaf pine, southern red oak, and hickory. The vegetation in Polk, Tyler, and Hardin counties is exceptionally varied and luxuriant. The dead but standing pine (fourth from right) indicates the maturity of this stand. Photographed April 21, 1937, 15 miles west of Woodville, Tyler County, Texas. Texas Cooperative Wildlife Research Unit photo No. A892.

LOGGING PRACTICES AFFECT VEGETATION

The major causes of change in the forest vegetation are the opening of the forest crown and the elimination of root competition by the removal of timber, but from an ecological standpoint the numerous open tramways and brushed-out lanes are of considerable significance in that they make possible types of vegetation better suited to quail.

The method used in removing timber determines the extent of change in the vegetative community following logging. Early lumbering days in Texas saw common use of the highly destructive skidder cables. Fortunately the method in current use is less destructive. The lumber companies cut all straight pines that measure 6 or 8 inches or more in diameter at the base. They also take all sound oak, hickory, ash, sweet gum, and black gum that measure 12 inches or more in diameter at the base. The better stock goes to the sawmill; the poorer grades are used in making ties for the logging railroads and more recently pulpwood is being harvested to a diameter as small as 4 inches. Cutting is done by hand saws and axes and great two-wheeled mule- or ox-drawn carts are used to drag the logs to the loading zone beside the tram road. Each main tram has numerous spurs rarely more than a quarter of a mile apart, hence, few logs are dragged more than an eighth of a mile. The carts travel in narrow lanes from which the brush has been cleared. Soil disturbance is considerable in these lanes but damage to saplings of the area is limited to that caused by falling trees and by brushing-out the lanes. The standard right-of-way that must be cleared for a tram is 80 feet.

METHODS

Methods of Censusing Quail

A satisfactory drive method was developed for censusing quail coveys on large acreages of woodland using Civilian Conservation Corps enrollees. If there are few turns, fences, or deep streams to impede progress, a line of 20 to 40 men can census about 600 to 1,200 acres in 6 hours or less. The men were divided into squads of 6 and placed 12 yards apart. One man in each squad was designated as squad leader, although he held a place in the line. The section leader for the three squads kept the line straight and uniform and checked on records of each covey flushed, making sure it was not recounted. For each covey started, the squad leader recorded the exact time, estimated size of the covey, direction in which it flew, and general description of the place. Supervising the whole line, those in charge of the census kept accurate records of the time landmarks were passed and the length of each of the frequent stops. The end or middle man followed a road, tramway, fence, or a string of paper markers hung on bushes. Good supervision and organization were necessary for satisfactory results; furthermore, the drive method is unsatisfactory in rough or overbrushy country, where a proper line cannot be maintained.

After the drive method had been worked out, a check of its accuracy was made by the use of dogs. After nine coveys in a given woodland area had been located by the drive method, two bird dogs were taken to the exact locations where each covey had been found, but after careful circling of each area located only three of the nine coveys. A second drive census, however, showed all nine coveys close to the places where each had been found previously.

Bird dogs were tried, but it soon became evident that one dog and one man could not thoroughly work more than 100 acres of uniform woodland in an 8-hour day. In farmland, larger areas can be censused with dogs because the birds are concentrated in margins and limited areas of cover.

Efforts to check the accuracy of this census method touched questions of weather, spacing of men in line, marginal effects along roads and trams, and the value of censusing the same area twice. It was found that weather had little effect on the counts so long as rain was not actually falling. This was demonstrated on a 320-acre tract in the Flowing Springs area, Walker County, first censused on a warm, clear day and again a week later when a cold, damp, north wind was blowing. The difference in results was the minor sum of four individual quails. The count of coveys dropped from five to four, but this was accompanied by an increase in the size of one covey which probably indicated a combination of two groups. At first an arbitrary interval of 15 yards was used between men in the line. Since the flushing distance was always in excess of 15 yards before a line of noisy men, it appeared that in rather open woodland an interval of 25 to 30 yards would be close enough to flush every covey. The interval, however was reduced to 12 yards so that the lines could be held together better. In woodland having dense underbrush, a 6-yard interval is recommended, not because the cover might prevent coveys from being flushed, but because the smaller interval helps the men keep in line. Behavior of the men, rather than of the game, is the difficult problem! Whenever a flushed covey flew ahead of the line the birds scattered and most of them were not seen again. There was little danger of counting the same covey twice, because the skulking birds would not flush again unless nearly stepped on.

Margins of clearings were excluded from the woodland census areas because of their exceptional attractiveness to quail.

The nature of the census required that the line of men have something to guide them. In most areas, roads and logging tramways were convenient for this purpose. Records for the November 1936 censuses show that of 41 coveys found, 23 were nearer the outside end of the census line, while only 16 were near the road or tram. In the 1937 counts, on the other hand, many coveys were found on the trams.

The line of men was directed by means of whistle signals and voice

commands. Counts of the number of birds in each covey were recorded only as approximations, but the records of coveys for each area are believed to be nearly correct. Final compilation of results of these censuses is based on covey counts. Figures for the population density in acres per bird are derived from estimates of covey size or upon the average size of such coveys as could be accurately counted by the supervisor. At the end of each day, census cards made by squad leaders were used to compile a record of coveys found. When adjoining squads reported coveys for the same time and of the same general description, they were considered as one unless a leader definitely reported seeing two separate coveys.

By the end of 1939 approximately 50,000 acres in eastern Texas had been censused for quail by various agencies including the United States Soil Conservation Service, the Texas Game, Fish and Oyster Commission, and the Texas Cooperative Wildlife Research Unit.

WINTER FOODS OF BOB-WHITES

Seemingly food is a principal factor determining bob-white occurrence in cutover pine woodland, since cover is almost everywhere present in abundance. Food is likely to be scantiest in winter, and its availability at that season probably has much to do with quail density. To determine this, 56 crops and gizzards were collected in typical habitat in Walker and Trinity counties between December 1936 and March 1937. Table 1 summarizes the results of the analyses as to plant material, both by percentage of volume and by frequency of occurrence. Of significance is the fact that there are no important foods in the woodland which do not occur also in farm habitats. Pine and oak mast, ordinarily regarded as the most important food in woodland, constituted less than 5 per cent of the contents of the 56 crops. In all probability, however, mast is more available, or more used, in late fall and early winter than in late winter. Plant foods made up 99.67 per cent of the total food volume in the crops and gizzards, while only .33 per cent was composed of insects. Table 2 lists the forms identified.

A number of the plants most used for food by woodland bob-whites were those characteristic of the stages in cutover succession where quail were most abundant.

Table 1. Plant foods in 56 bob-white stomachs* taken in late winter, in Walker and Trinity counties, Texas

Name of Plant	Percentage by volume	Times occurring
Bush clover, *Lespedeza striata*	30.5	38
Doveweed, *Croton capitatus*	27.3	41
Green stuffs, including bur clover, chickweed, etc	9.7	21
Rhynchosia sp	6.6	21
Menodora heterophylla	4.2	5
Pines of at least 2 species, *Pinus* sp	3.0	3
Panic grasses, *Panicum* sp	2.7	21
Paspalum ciliatifolium var. stramineum	2.2	16
French mulberry, *Callicarpa americana*	2.1	17
Bush clover, *Lespedeza virginica*	1.7	10
Oaks of several species, *Quercus* sp	1.7	6
Buttonweed, *Diodia teres*	.9	5
Paspalum floridanum	.9	2
Milk Pea, *Galactia regularis*	.77	15
Poison ivy, *Rhus toxicodendron*	.77	5
Tick trefoil, *Desmodium sessilifolium*	.66	9
Dallis grass, *Paspalum dilatatum*	.50	12
Marsh elder, *Iva angustifolia*	.50	5
Gum-elastic, *Bumelia lanuginosa*	.37	3
Centrosema virginianum	.37	7
Sedges, *Cyperaceae*	.37	2
Tick trefoil, *Desmodium dillenii*	.35	3
Partridge pea, *Cassia fasciculata*	.25	3
Giant ragweed, *Ambrosia aptera*	.21	2
Unidentified	.16	2
Red haw, *Crataegus* sp	.11	2
Bush clover, *Lespedeza* sp	.10	4
Dock, *Rumex* sp	.09	1
Gromwell, *Lithospermum* sp	.09	2
Gaura sp	.07	5
Wild bean, *Strophostyles umbellata*	.05	3
Needlegrass, *Aristida intermedia*	.04	6
Crab grass, *Digitaria sanguinalis*	.03	2
Queen's-delight, *Stillingia sylvatica*	.03	1
Crotonopsis linearis	.03	1
Camphor weed, *Heterotheca subaxillaris*	.03	1
Crotonopsis sp	.03	1
Brachiaria ciliatissima	.03	1
Sensitive briar, *Cassia nictitans*	.02	1
Paspalum sp	.01	1
Vetch, *Vicia* sp	Trace	2
Nut rush, *Scleria ciliata*	Trace	1
Peppervine, *Cissus arborea*	Trace	1

*"Stomach" as used includes both gizzard and crop. For plant names reference is made to Cory and Parks (1937). For the structure of eastern Texas vegetation see Tharp (1926).

Table 2. Frequency of occurrence of insects in 56 bob-white stomachs taken in late winter, in Walker and Trinity counties, Texas

Name of insect	Times occurring
Leaf bettle, *Disonycha caroliniana*	3
Grasshopper, *Melanoplus scudderi*	3
Grasshopper, *Acrididae*	2
Leaf beerle, *Dibolia* sp	2
Ground beetle, *Carabidae*	1
Bug, *Chariesterus anterrator*	1
Grasshopper, *Melanoplus texanus*	1

EFFECTS OF TIMBER-CUTTING ON QUAIL HABITAT

The Pine-Oak-Hickory Association

The shortleaf-loblolly pine association contains also an abundance of oaks, gums, elms, hickories, and other broadleafed species. Differences

in moisture, acidity, and mineral content of the soil, and other conditions result in many variations in the plant community. Shortleaf and loblolly pines are rarely equally numerous in the same situations. Drier soils favor the shortleaf, and more moist soils the loblolly. Since existing conditions enable the two pines to dominate the other species, this plant community often is referred to as the shortleaf-loblolly type. A more descriptive term, however, would be pine-oak-hickory type. The following catalog of vegetation in this type is based upon observations in virgin stands of timber in Walker County.

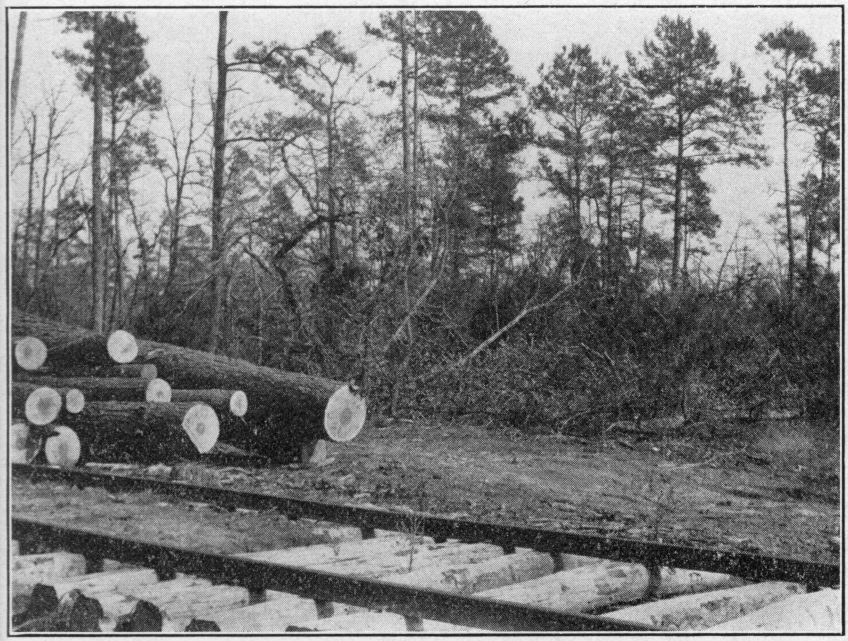

FIG. 3. Freshly cutover woodland showing piles of slash and trees left standing. The logs, ready to be loaded on flat cars, measure from 6 to 18 inches in diameter. Photographed January 4, 1937, 12 miles northwest of Huntsville, Walker County, Texas. Texas Cooperative Wildlife Research Unit photo No. A686.

The species first listed dominate in one place or another and are generally distributed.

Pinus echinata	shortleaf pine
Pinus taeda	loblolly pine
Quercus rubra	southern red oak
Liquidambar styraciflua	sweetgum
Quercus stellata	post oak
Quercus marilandica	blackjack oak
Ulmus alata	winged elm
Carya buckleyi	black hickory

Other trees frequently present include the following:

Quercus nigra	water oak
Nyssa sylvatica	black gum
Cornus florida	flowering dogwood
Carya glabra	pignut hickory
Quercus alba	white oak
Quercus velutina	black oak
Morus rubra	red mulberry
Fraxinus americana	white ash
Prunus mexicana	Mexican plum

Characteristic shrubs and vines are:

Callicarpa americana	French mulberry
Crataegus spathulata	hawthorn
Crataegus marshalli	hawthorn
Viburnum rufidulum	southern blackhaw
Myrica cerifera	wax myrtle
Quercus rubra	southern red oak (sprouts)
Vaccinium arboreum	tree huckleberry
Ilex vomitoria	yaupon
Ilex decidua	deciduous holly, (winterberry)
Forestiera pubescens	wild privet
Vitis cordifolia	frost grape
Vitis candicans	mustang grape
Vitis lincecumii	pine woods grape
Vitis rotundifolia	muscadine grape
Rhus copallina	dwarf sumac
Rhus glabra	smooth sumac
Rhus canadensis	aromatic sumac
Rhus toxicodendron	poison-ivy
Smilax pseudo-china	greenbrier
Smilax glauca	greenbrier
Berchemia scandens	rattan
Ascyrum hypericoides	St. Andrew's-cross
Cissus arborea	peppervine

Characteristic herbaceous species include:

Mitchella repens	partridgeberry
Uniola laxa	spikegrass
Stipa avenacea	blackseed needlegrass
Sporobolus clandestinus	dropseed
Panicum (many species)	panic grass
Paspalum ciliatifolium	paspalumgrass
Elephantopus carolinianus	elephantfoot
Viola triloba	violet

Although the pines are dominant in all virgin or mature second-growth upland forests observed in Walker and Polk counties, there is some doubt that they represent the climax formation. Pessin (1933, p. 11) referring to the mesophytic coniferous forests of the south, states that "hardwoods may ultimately take over the land if conditions for the coniferous forest become unfavorable either through heavy cutting or through some other factor . . . Biotic factors . . . in operation . . . make it impossible to predict . . . just what type of vegetation will occupy these flatwoods in the distant future." Billings (1937) found that abandoned fields in North Carolina first reverted to pine but later developed a climax hardwood formation about 120 to 150 years after the field was abandoned. He designates the pine type as sub-climax because litter from the pines increased moisture-holding properties of the soil and allowed hardwoods to develop and shade out pine seedlings. Warner (1926), discussing plant succession in eastern Texas, states that pines when once established can successfully compete with hardwoods on sandy soils. Seemingly in this case the pines actually constitute the climax vegetation. In explaining this he states, "The factors that operate to continue this dominance are (1) the poverty of the soil which prevents shading out of seedlings; (2) the lack of a well developed layer of leaf mold, due to its destruction by micro-organisms and frequently recurring ground fires; and (3) the structure of the soil that favors leaching and percolation of solutes favorable to deep feeding pine roots."

The changes in the succession of forest vegetation that follow timber-cutting are fundamentally responsible for the alterations in the population of bobwhites. Plant succession is affected by numerous variables. Some of the causes of variation in the character of second-growth are differences in (1) the composition of the virgin forest before cutting, (2) the burning and grazing history of the area before cutting, as well as (3) the burning and grazing that has occurred since. Soil moisture, soil acidity, and miscellaneous biotic factors may also affect succession.

Four Types of Cutover

Abandoned fields on all but the prairie soils in Walker County quickly revert to woodland. Since the succession that follows abandonment of fields is affected by fewer variables than that following timber-cutting, it also was studied for the purpose of recognizing the different stages. This method was used on the assumption that any species, characteristic of a particular association, will occur in the same relative position in secondary succession whether the disturbance which began the succession was timber-cutting and associated factors, or cultivation of the soil. It was found that in abandoned fields succession may be conveniently described in four stages: (1) weeds, (2) legumes and short grasses, (3) tall grasses and pine, and (4) near-mature pine. Because of the difficulties of succession analysis, the following table of components is but an arbitrary grouping that shows only the characteristic stages. Many of the plants that are listed for one stage occur also in the others.

Plant succession in cutover pine woodland shows a number of differences from that in abandoned fields. The differences in the two are the result of the different degrees of disturbance initiating the successions. In general the cutover pine woodland has been disturbed less than the cultivated fields. Where logging is conservative, the plant community may be set back only one or two stages; annual weeds may never appear in great numbers. The presence in fresh cutover of many woody shrubs and rootstocks, and some uncut trees, accounts for much of the apparent difference in the two successions. Along the trams and side lanes, succession is set back more than it is in cutover where only the larger trees have been removed. The cutover pine woodland succession may be considered in four stages: (1) sprouts, (2) early intermediate, (3) late intermediate, and (4) near-mature pine. These are the four types of cutover described.

Type I. Early Stage of Succession

In Abandoned Fields	In Cutover
Weed Stage (typical in areas 1 to 4 years old)	**Sprout Stage** (typical on areas 4 years old or less, see Figs. 4 and 5. Sprouts of oak, gum, elm and other hardwoods)
**Croton capitatus*.....doveweed	*Croton capitatus*.....doveweed
Heterotheca subaxillaris.....camphor-weed	*Heterotheca subaxillaris*.....camphor-weed
Erigeron canadensis.....horseweed	*Plantago virginica*.....plantain
Iva ciliata.....rough marshelder	*Plantago aristata*.....bracted plantain
Cassia fasciculata.....partridge-pea	*Cirsium horridulum*.....bull thistle
**Ambrosia artemisaefolia* var. *elatior*.....ragweed	*Polypremum procumbens*.....polypremum
**Digitaria sanguinalis*.....crabgrass	*Vicia ludoviciana*.....vetch
Panicum dichotomiflorum.....panic grass	*Strophostyles helvola*.....trailing wild-bean
Diodia teres.....buttonweed	*Trifolium carolinianum*.....Carolina clover
	Also, *Callicarpa americana*, French mulberry, weakened from exposure to the sun but common everywhere and many shrubs and trees not disturbed by the timber cutting.

Type I contains a fair population of quail. In 1936 it supported a covey to 140 acres. It lacks a balanced supply of food and satisfactory grass for roosting and nesting cover.

*Frequently occurs in later stages.

Type II. Second Stage of Succession

In Abandoned Fields		In Cutover	
Legume—Short Grass Stage (typical on areas 5 to 9 years old)		**Early Intermediate Stage** (typical on areas 5 to 9 years old. See Figs. 6 and 7)	
Trifolium carolinianum	Carolina clover	*Pinus* spp. (seedlings become noticeable)	pines
Lespedeza striata	common lespedeza	*Croton capitatus*	doveweed
Lespedeza procumbens	bush clover	*Aristida longiseta*	red three awn
Strophostyles helvola	trailing wild-bean	*Aristida purpurascens*	arrowfeather
**Galactia volubilis*	milk-pea	*Cynodon dactylon*	Bermuda grass
Galactia regularis	milk-pea	*Digitaria sanguinalis*	crabgrass
**Centrosema virginianum*	butterfly-pea	*Digitaria filiformis* var. *villosa*	crabgrass
Desmodium sp.	tick trefoil	*Axonopus compressus*	carpetgrass
Vicia ludoviciana	vetch	*Panicum anceps*	panic grass
Aristida longiseta	red three awn	*Panicum dichotomiflorum*	panic grass
Aristida purpurascens	arrowfeather	*Desmodium* spp. (several species)	tick trefoil
Festuca octoflora	six weeks fescue	*Acalypha gracilens*	three-seeded mercury
Cynodon dactylon	Bermuda grass	*Lespedeza striata*	common lespedeza
Axonopus compressus	carpetgrass	*Helenium tenuifolium*	bitterweed
**Eupatorium compositifolium*	dogfennel	*Rudbeckia hirta*	black-eyed-susan
Helenium tenuifolium	bitterweed	*Monarda punctata*	sandyland-sage
Cerastium viscosum	mouse-ear chickweed	*Eupatorium compositifolium*	dogfennel
Monarda punctata	sandy-land sage	Besides the few mature trees there are scattered thickets of fast-growing oaks, hickories, elms, and gums. *Callicarpa americana* is abundant.	
Ambrosia psilostachya	perennial ragweed		

This second type contains the highest density of quail found. In 1936 it supported one covey to 77 acres. This seems to be due to the abundance of such valuable foods as doveweed and common lespedeza together with sufficient cover.

*Frequently occur in later stages.

Type III. Third Stage of Succession

In Abandoned Fields	In Cutover
Tall Grass—Pine Stage (typical on areas 10 to 15 years old)	**Late Intermediate Stage** (typical on areas 10 to 15 years old. See Figs. 8, 9, 10)
Andropogon virginicus.....broomsedge	*Callicarpa americana*.....French mulberry
Andropogon ternarius.....beardgrass	*Andropogon virginicus*.....broomsedge
Andropogon scoparius.....little bluestem	*Andropogon ternarius*.....beardgrass
Paspalum ciliatifolium.....paspalum	*Andropogon scoparius*.....little bluestem
Panicum anceps.....panic grass	*Eupatorium compositifolium*.....dogfennel
Gymnopogon ambiguus.....gymnopogon	*Centrosema virginianum*.....butterfly-pea
Eragrostis sp.....lovegrass	*Paspalum ciliatifolium*.....paspalum grass
**Pinus taeda*.....loblolly pine	*Galactia volubilis*.....milk-pea
Diospyros virginiana.....persimmon	*Galactia regularis*.....milk-pea
	Pine saplings begin to overtop deciduous species. Oak, elm, gum, and hickory saplings are dense and tall but not mature enough to bear fruit.

This third type contains a declining population of quail due to decreasing food and increasing density of broomsedge and brush. In this type the quail population varied between 95 and 134 acres per covey in 1936 and 1937.

*Frequently occurs in later stages.

Type IV. Mature or Near-Climax Stage

In Abandoned Fields	In Cutover
Near-Mature Pine Stage (typica in areas 15 years old and older)	**Near-Mature Stage** (typical on areas more than 15 years old. See Fig. 11
Pinus taeda.....loblolly pine *Pinus echinata*.....shortleaf pine *Callicarpa americana*.....French mulberry *Uniola laxa*.....spikegrass *Panicum* sp.....(shade tolerant) panic grass Flora in reforested old fields lacks variety because the pines pioneer rapidly and the hardwoods are slow to become re-established.	Seed Bearing Trees *Pinus echinata*.....shortleaf pine *Pinus taeda*.....loblolly pine *Quercus rubra*.....southern red oak *Quercus stellata*.....post oak *Quercus marilandica*.....blackjack oak *Carya buckleyi*.....black hickory *Liquidambar styraciflua*.....sweetgum *Ulmus alata*.....winged elm *Callicarpa americana*.....French mulberry *Crataegus spathulata*.....hawthorn *Crataegus marshallii*.....parsleyleaf hawthorn *Viburnum rufidulum*.....southern blackhaw *Cornus florida*.....flowering dogweed *Rhus glabra*.....smooth sumac *Rhus toxicodendron*.....poison-ivy *Rhus canadensis*.....aromatic sumac *Ascyrum hypericoides*.....St. Andrew's-cross Herbaceous Species *Uniola laxa*.....spikegrass *Panicum* spp. (woods type).....panic grass *Aristida purpurascens*.....arrowfeather *Stipa avenacea*.....blackseed needlegrass *Sporobolus clandestinus*.....dropseed *Penstemon laxiflorus*.....pentstemon *Aristolochia reticulata*.....snakeroot *Elephantopus carolinianus*.....elephantfoot *Salvia lyrata*.....lyreleaf sage *Baptisia nuttalliana*.....false-indigo *Euphorbia corollata*.....flowering spurge *Stillingia sylvatica*.....queen's delight

Type IV has only one covey to 350 to 500 acres because trees have crowded out important food-producing herbaceous plants.

Long before a woodland reaches the climax, it may be termed nearly mature, as far as its effects upon occupation by quail are concerned. Most of the woody species are then of fruiting age and few herbaceous annuals remain; the grasses present are all shade-tolerant species.

Although grazing has widespread effects on the woodland association, the details of its relationships to succession have not been studied. Succession in cutover as outlined above was determined on areas free of fences and open to public grazing. Scrub cattle and a few hogs range everywhere; scattered bands of goats also are present in eastern Texas. It is known that grazing serves to keep the woodland understory open; selective grazing of such favorites as legumes, magnolias, red mulberry, and bays certainly cause some reduction in the abundance of these species. Increased numbers of goats, sheep or cattle would accentuate these undesirable changes in the forest.

FIG. 4. Cut 3 years before, this area contained one covey of bobwhites to 140 acres which is the average for areas cut less than 5 years. The dry stalks in the foreground are doveweed, *Croton capitatus;* the grass is arrowfeather [or three awn], *Aristida purpurascens* and crabgrass, *Digitaria sanguinalis.* Blossoms of blackberry, *Rubus trivialis,* are in view on the right. Photographed February 21, 1937, 14 miles west northwest of Huntsville, Walker County, Texas. Texas Cooperative Wildlife Research Unit photo No. A746.

Effects of Fire on Normal Plant Succession

Hot fires in freshly cut slashings cause many changes in normal plant succession. Records on five areas, burned 1 to 14 years before, indicate

some of the more obvious effects of burning. Almost all pines are destroyed. Hardwoods are killed to the ground but sprout from the rootstocks, sending up several stems in the place of each one burned. A dense thicket of oaks and hickories without pines is the most evident feature of an old burn. Species eliminated or reduced by burning include pines, violets, woods-type panic grasses, and French mulberry.

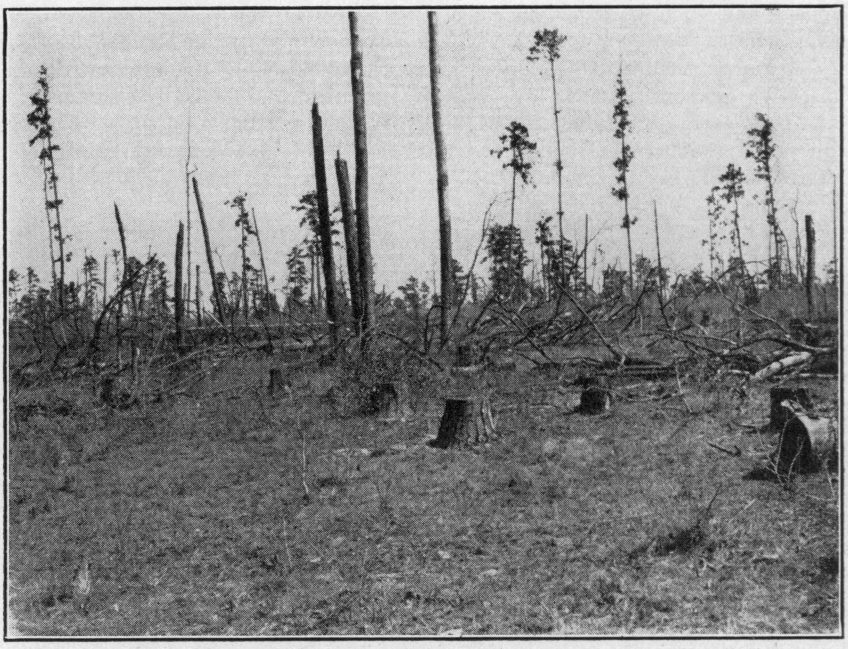

FIG. 5. A 3 year-old burned cutover that contains very little quail food. Its chief value to quail is its margin. The grass includes species of three awn, *Aristida*, and beardgrass, *Andropogon*. Because most of the trees are dead this area will remain open for 20 years or more. Photographed March 10, 1937, 14 miles west northwest of Huntsville, Walker County, Texas. Texas Cooperative Wildlife Research Unit photo No. A767.

The following species seem to be favored by a hot slash burn:

Funaria	moss
Polypremum procumbens	polypremum
Axonopus compressus	carpet grass
Cynodon dactylon	Bermuda grass
Muhlenbergia capillaris	muhlenbergia grass
Eragrostis spectabilis	purple lovegrass
Oxalis stricta	yellow woodsorrel
Houstonia minima	bluets
Trifolium carolinianum	Carolina clover
Rubus trivialis	blackberry
Euphorbia maculata	spotted spurge

Euphorbia cordifolia	carpet spurge
Specularia perfoliata	Venus-looking glass
Acalypha gracilens	three-seeded mercury
Silene antirrhina	sleepy catchfly

Burning disturbs the succession more than timber cutting, but less than clearing or cultivation. Although none of the details of fire succession in eastern Texas have been worked out, it is evident that most burns 1 to 10 years old contain less quail food than the adjoining unburned cutover woodland. This does not apply to longleaf pine areas. Burns do have considerable value for quail after succession in the surrounding woodland crowds the birds out. The burned areas remain open longer and therefore are the last haven of the quail. In burns older than 10 years usually grass and brush cover and some food suitable for quail are abundant.

FIG. 6. Early intermediate cutover type (5 to 9 years old) contains the highest numbers of quail occurring in woodland. Stumps 7 years old are partly decayed and the sap wood may be kicked off with ease. Photographed February 21, 1937, 15 miles west-northwest of Huntsville, Walker County, Texas. Texas Cooperative Wildlife Research Unit photo No. A745.

The effect of slash burns in pine woodland on grazing as well as on quail and other game and fur-bearing species is a problem warranting attention.

QUAIL CARRYING CAPACITY OF WOODLAND

Four Types

Early settlers in Walker County found quail in all parts of the uncut climax woodland. Although quail were most abundant on the small farms and prairies, the climax pine woodland with its rather open understory apparently supported more quail than are now present in the mature second-growth. Censuses have revealed that at least a few coveys occur in cutover woodland of all ages. Indeed, these counts are the most significant finding of the research here reported on, as through them the value to quail of all ages of second-growth woodland has been quantitatively determined.

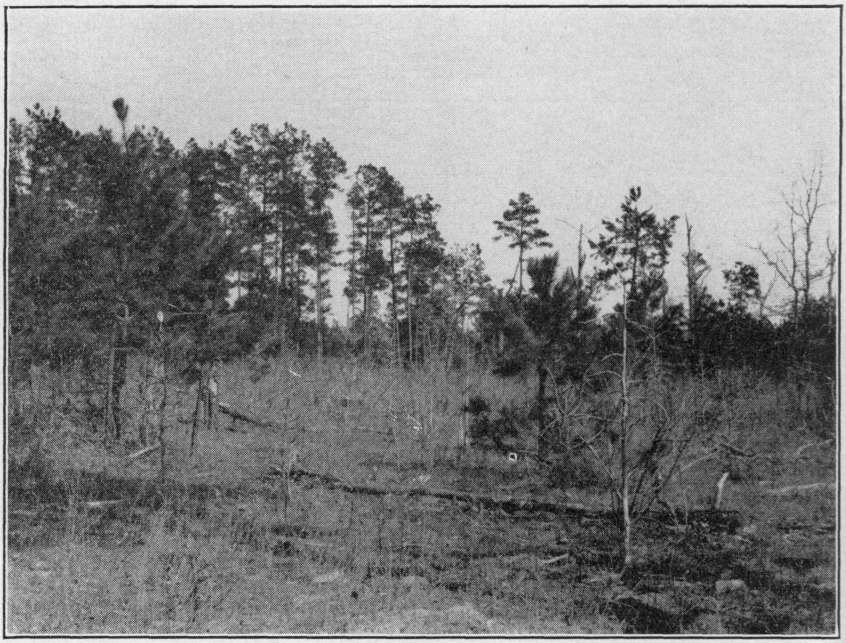

FIG. 7. Early intermediate type of cutover lumbered off 8 years before. Doveweed, *Croton capitatus*, in the foreground is beginning to give way to the surrounding oak and pine saplings. A covey of bob-whites headquarters near this place. Grazing is heavy. Photographed February 21, 1937, 11 miles northwest of Huntsville, Walker County, Texas. Texas Cooperative Wildlife Research Unit photo No. A744.

Figure 12 and Tables 3* and 4 give the results of counts on 8,738 acres, 4,357 of which were made in 1936 and the remainder in 1937. The drive method was applied to an aggregate of 12,873 acres of woodland. Some

*Numbers in the "Area" column refer to the same tracts, of course, although not all were counted both years.

spring counts and rechecks in bad weather are not included in the tables; also, results for two small areas are excluded.

In comparing Tables 3 and 4 it will be noted that the acreage censused was slightly greater in 1936 than in 1937. The areas are listed according to the number of years that had elapsed since they were logged, and they are also classified as to stage of succession. Although "acres per bird" figures are given, the "acres per covey" figures because of the method of counting are much more reliable.

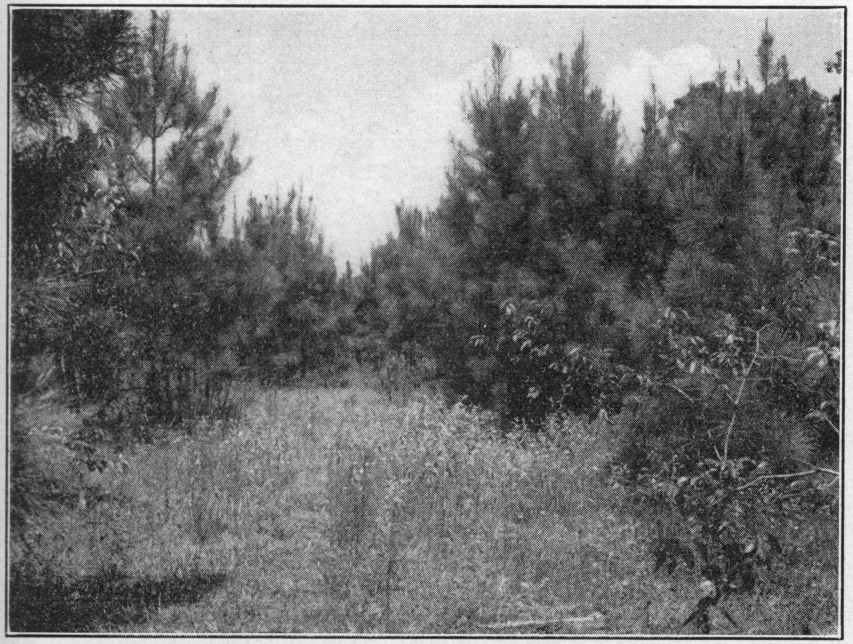

FIG. 8. This tramway in late intermediate type of cutover (10 to 15 years old) still harbors some doveweed, *Croton capitatus*, and crabgrass, *Digitaria sanguinalis*. A few coveys still persist along such tramways and in small clearings, but the pine saplings are rapidly crowding them out. Photographed August 17, 1936, 11 miles south southwest of Huntsville, Walker County, Texas. Texas Cooperative Wildlife Research Unit photo No. A334.

Table 3. Results of the 1936 quail census in cutover woodland

Stage in Succession	Area	Years since cut	Acres	Coveys	Birds	Acres per bird	Acres per covey	Type Averages	
								Acres per bird	Acres per covey
Type I	1	2	143	1	12	11.9	143	14.5	140.6
	2	2	432	3	26	16.6	144		
	3	3	194	1	8	24.2	194		
Type II	4	7–8	803	10	124	6.5	80.3	6.1	76.8
	5	9	733	10	127	5.7	73.3		
Type III	6	12	583	11	104	5.6	53	9.6	95.0
	7	12	304	1	14	21.7	304		
	8	15	348	1	11	31.6	348		
Type IV	9	23	368	1	3	122.6	368	90.6	498.5
	10	33	629	1	8	78.6	629		
			4,537	40	437				

These figures have been corrected for margins and clearings in the several places where the census areas were not entirely typical. Note, however, the relatively high quail population of area 6, although according to "years since cut" it belongs with Type III. For discussion of this instance, see text, p. 26.

Table 4. Results of the 1937 quail census in cutover woodland

Stage in Succession	Area*	Years since cut	Acres	Coveys	Birds	Acres per bird	Acres per covey	Type Averages	
								Acres per bird	Acres per covey
Type I	2	3	432	0	0	5.4	80.2	9.0	134.3
	3	4	642	8	119				
Type II	4	8.9	803	9	85	9.4	89.2	9.4	89.2
Type III	5	10	733	4	54	13.5	183.2	11.1	134.0
	6	13	571	7	79	7.2	81.6		
	7	13	304	1	12	25.4	304.0		
Type IV	8	16	348	2	24	14.5	174.0	28.7	358.0
	9	24	368	0	1	368.0			
			4,201	31	374				

These figures have been corrected for margins and clearings in the several places where census areas were not entirely typical.

*Numbers refer to same areas censused in 1936. Note that certain areas have changed in type in the one year between the censuses. Whether or not chance or a true type change is involved here cannot be conclusively demonstrated without more extensive counts; although all available evidence suggests a change in type.

FIG. 9. A typical view of the pine saplings, oaks, and understory of French mulberry, *Callicarpa americana*, of the late intermediate stage (10 to 15 years old) when quail are being crowded out. Photographed August 13, 1936, 11 miles south-southwest of Huntsville, Walker County, Texas. Texas Cooperative Wildlife Research Unit photo No. A324.

Of special interest are areas 4 and 5. These two plots, totaling 1,536 acres, are in one continuous strip approximately one-quarter mile wide and 9½ miles long. Area 4, when it was 7 and 8 years old, contained slightly fewer quail than area 5 which was then 9 years old. The next year area 5, then 10 years old, dropped 60 per cent in number of coveys, while area 4 dropped only 10 per cent. These reductions occurred during a period when the county-wide loss of numbers of coveys was about 30 per cent and the loss on all woodland areas censused was only 15 per cent. Evidently this sudden decrease of quail in 10-year cutover marks the end of the most satisfactory age-type. This result of the census substantiated studies of the vegetation which had indicated that the 10th year closely marks the beginning of the domination of herbaceous plants by trees.

Results for area 6 seem to disprove this conclusion, but the explanation of the high population on this section (located along the Midway road 10 miles north of Huntsville) is that the soil is somewhat less favorable to tree growth than that of the other areas and in many places supports only an open stand of scrubby post oaks. Also, some 70 acres of the area had been severely burned and were more open than they otherwise would have been. Perhaps area 6 should have been listed with Type II

rather than Type III; such instances of overlapping as a result of local conditions are to be expected. Another area (No. 7, 304 acres) of the same age of cutover was censused in a more typical soil type where the vegetation is much more dense and only one covey was found.

FIG. 10. The most dense understory occurs in the late intermediate type when the pine saplings are just beginning to overtop and shade out some of the oak and sweetgum saplings. The quail population here is one covey to about 300 acres. Photographed February 21, 1937, 6 miles south of Huntsville, Walker County, Texas. Texas Cooperative Wildlife Research Unit photo No. A737.

This area (7) contained a small clearing which was part of a 50-acre farm that was abandoned at the time the timber surrounding it was cut. Pines and sweet gums had almost retaken the fields. Perhaps the covey in this area should be credited to the old field and not to the woodland. This covey had been flushed at least six times in the woods, however, and twice it was more than a quarter of a mile from the field. Two pairs of quail were found in the census area during the summer of 1936 and neither was closer than ¼ of a mile to the clearing. Such clearings are so characteristic of the sandyland areas of eastern Texas, where worn out farms quickly return to woodland, that it was decided to classify the covey in area 7 as occurring in the woodland habitat.

Area 8 was not cut so severely as most woodland tracts and as a consequence had a more open stand of mixed pine saplings, near-mature

pines, and mature oaks. The numerous open spots may account for the presence of quail. The increase of one covey in 1937 is not accounted for here.

The one covey found in area 10, which was second-growth pine woodland nearly mature enough to be logged again, was in the edge of a 2 or 3 acre opening supporting some doveweed where the soil had been disturbed apparently by hogs. Area 10 is an excellent example of mature woodland; all tracts of this age, however, have clearings. In poor soil it has been the custom to abandon fields continually and clear new ones. On most eastern Texas farms a complete change of fields is made in less than 10 years. This results in many small, open spots throughout the pine woodland.

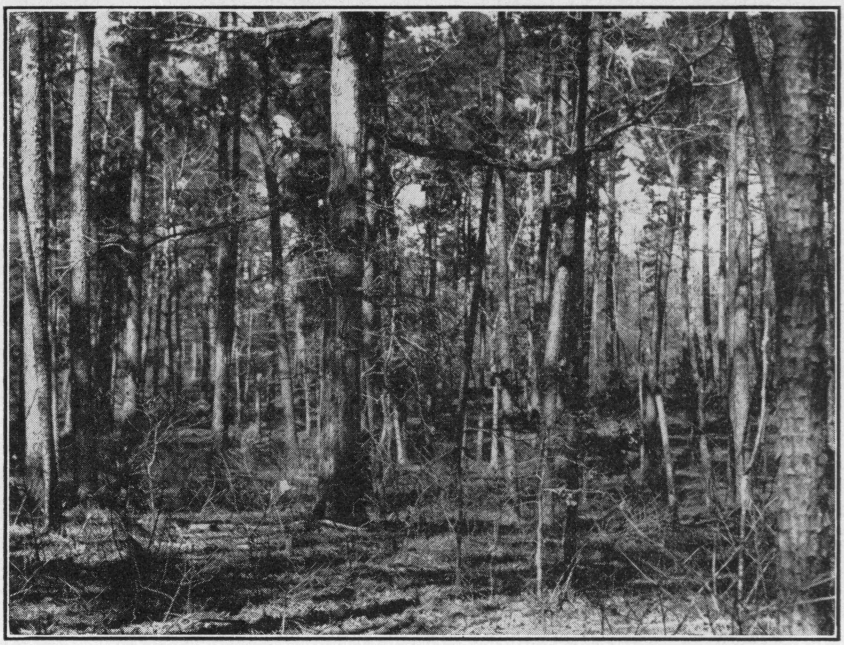

FIG. 11. Mature woodland in winter. Food and ground cover for quail are insufficient here for more than one covey in 500 or 600 acres. Photographed February 21, 1937, 3 miles southeast of Huntsville, Walker County, Texas. Texas Cooperative Wildlife Research Unit photo No. A743.

The 1937 average of 358 acres per covey in near-mature woodland represents two census areas cut 16 to 24 years before. The 1936 count for the same age-class, which averaged 498 acres per covey, included 629 acres cut 33 years ago. In order to strike a fair average in 33 year-old cutover it would have been necessary to census considerable additional land. Therefore, the 1936 average was assumed to be as accurate as it was practicable to make. The two areas censused in 1937 are more open

than most woodland 15 to 40 years old; therefore, the 1936 average of about 500 acres to the covey in near-mature woodland probably is closer to the normal for this age class. Obviously in order to strike a fair average in the various ages of cutover it would have been desirable to census several thousand acres more in each. It is realized that part of the recorded variability is due to errors in sampling as shown in this discussion. However, it is felt that the trends shown are in general representative of actual conditions.

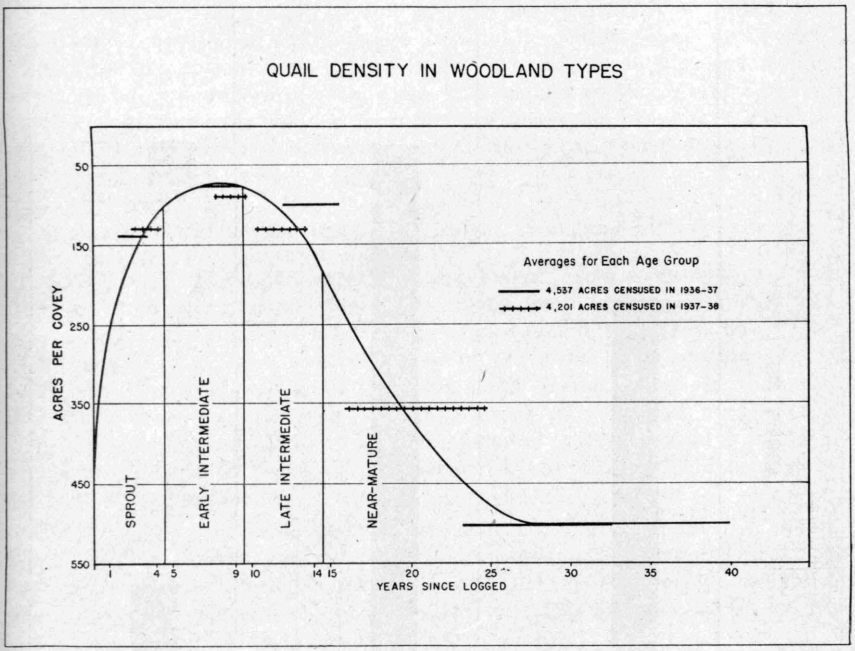

FIG. 12. Summary of all Censuses Showing Relative Density of Quail in Four Types of Woodland.

The graphic summary of all censuses (see Fig. 12) shows that as a rule the abundance of quail reaches a high point about the 8th year and begins a distinct decline about the 10th after lumbering. This peak divides the curve into two parts, the first reflecting that from one to nine years after timber is cut, quail are on the increase; and the second that after that they are on the decline. Two less distinct divisions may be recognized about the fourth and fourteenth years. All these divisions trace back to the stages of vegetative succession.

Perhaps the most useful results of this study are the recognition of the periods after lumbering when quail increase or decrease, and the descriptions of vegetative conditions associated with the observed increase

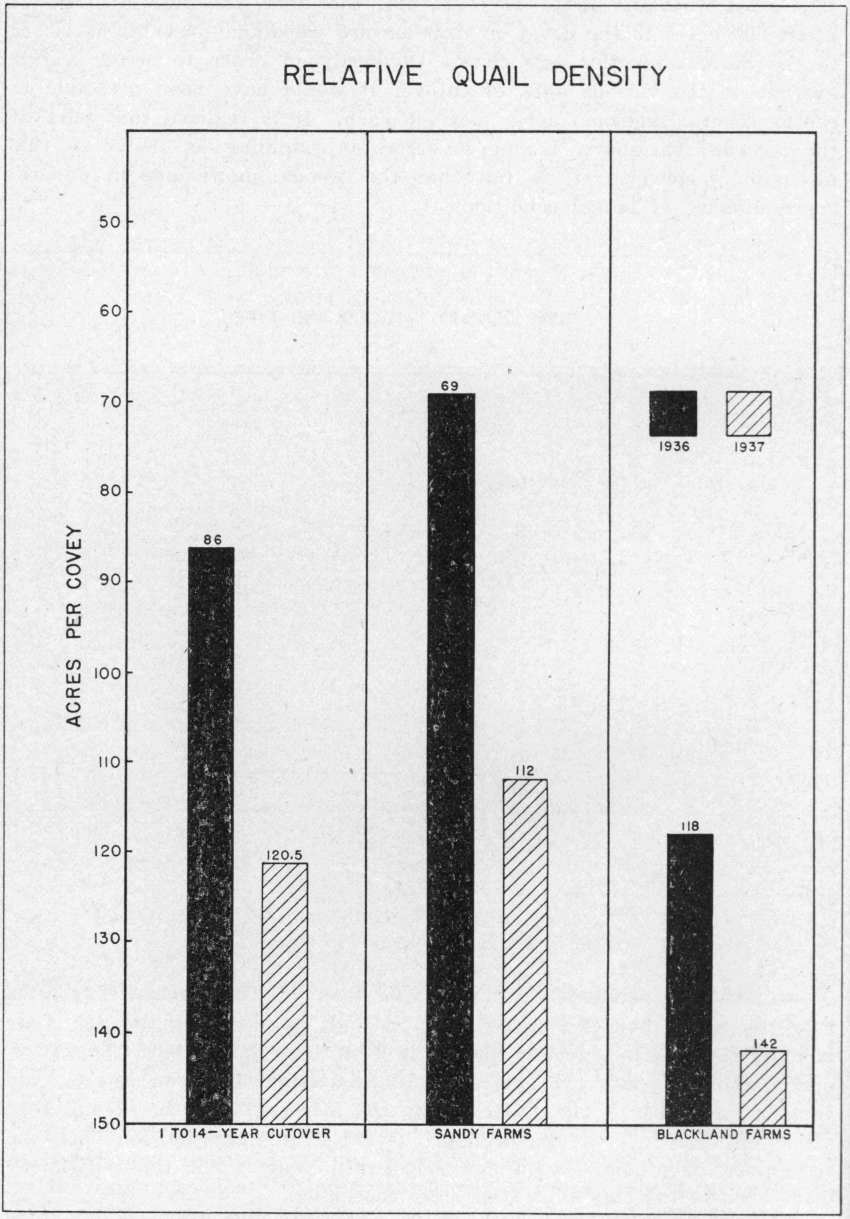

FIG. 13. Relative Density of Quail on 1-to-14 year Cutover Lands, in Sandy Land Farms, and in Blackland Farms.*

or decrease. Management of woodland habitat for quail in Walker County doubtless should aim to maintain the herbaceous vegetation typical of 5 to 9 year old cutover land.

Vegetative Type More Significant Than Age of Cutover

The census results show a definite correlation of quail abundance with age of cutover, based on the gradual but definite change of vegetative conditions. Such change does not always proceed uniformly in cutover of identical age. Although typical 15-year-old cutover is too thick for quail, tracts of timber of that age invariably contain open spots that support the vegetation of an earlier stage. A covey in such a spot should be credited to the vegetative conditions rather than to the age of cutover. Of 15 coveys found in cutover more than 9 years old, all but 3 were in spots where the vegetation was typical of the early intermediate (5 to 9 years) type.

Comparative Value for Quail of Cutover Woodland and Farmland

In Walker County 1,458 acres of sandy land farms and pastures, and 1,890 acres of blackland pastures and farms were censused in 1936 and 1937. Figure 13 shows the relative abundance of quail on these two types of farms and in average woodland 1 to 14 years old. The woodland contains only slightly fewer quail than the sandy farms, but more than the blackland farms. In the pine woodland areas only 20 per cent of the land is cleared for cultivation. The remainder is in second-growth varying in age up to 40 or 45 years. Woodland more than 45 years old usually is ready to be cut again.

The wooded areas in Walker County contain a greater total of quail than do all the farms, for the following reasons: (1) woodland occupies four times as much area as farmland, and (2) approximately one third of the wooded area has been cut out in the past 15 years and is, therefore, in a stage of succession favorable to the birds.

The Value of Burns to Quail

The woodland areas censused covered parts of 6 distinct burns. The vegetation of old burns is dominated by scrub oaks that sprout from roots after the fire. Grazing usually is heavy on recent burns and as a result quail food plants and grasses rarely are abundant after the first year or two. Some species, however, such as blackberry, do prosper. Slash burns are extremely hot and pines rarely survive; hence, such burns contrast sharply with surrounding unburned woodland and may be recognized readily even when 25 or more years of age.

The value of burns less than 10 years old and more than 30 acres in extent is due largely to their margins. Quail and other birds make good use of the edges of burns where they find a variety of foods and ideal dusting spots in close proximity to favorable escape cover. Most burns

older than 10 years are of value to quail as the only open spaces in the fast-growing woodland. Here the birds find grassy ground cover for nesting and roosting, as well as some food plants, remnants of the herbaceous developmental vegetation crowded out of the unburned woodland.

MANAGEMENT OF PINE WOODLAND FOR QUAIL

The major problem in sound quail management in the pine-oak woodland is the control of brush and trees, not of grass, as in the longleaf type. Stands of woody vegetation may provide satisfactory cover but often are deficient in year-round food supply. As shown by the censuses, quail prefer to remain in or near areas having suitable food plants, similar to those in recent fallow fields, outstanding among which is doveweed. As the pine saplings and hardwood brush spring up, the weeds and grasses most valuable to quail are gradually crowded out. The major objective of management of pine woodland for quail is the maintenance of well-distributed spots or strips of early succession vegetation, so that the bob-whites may have an adequate food supply—cover in most instances is ample.

Extensive Management

The practicability of various methods for management of quail depends on the size of the area and the funds allotted to the work. Lumber companies might maintain a rather steady supply of quail over large woodland tracts merely by cutting the timber in strips or blocks on a rotation basis, logging a fourth of the total area every 10 to 12 years. This would make available to quail at all times developmental or early intermediate stages of vegetation. There would be the further advantage of having stands of woodland 30 to 40 years old as well as younger growth within easy reach of the quail. At certain seasons, acorns, pine mast, and various fruits would provide a variety of desirable foods. The lumberman ordinarily cuts timber in solid blocks so that ties and rails may be removed when the job is done. Trucks could easily replace railroads in logging many tracts, and would make possible more conservative cutting. Rotation of timber cutting would be of great benefit to quail, deer, and squirrels, as well as to many other forms of wildlife and the forest itself. Fire hazards would be reduced by the strips of uncut woodland separating cutover areas and seeding of pines and other trees would take place more readily if mature seed trees were nearby.

Intensive Management

For best results, a quail management program on cutover woodland should be started on areas cut only 1 or 2 years before; although any area cut less than 9 years should make some response. Any of the five methods recommended below will help but in some cases it may not be practical to utilize more than one or two of the suggestions.

Headquarters Food and Cover Patches

These consist of fenced plots one quarter to 2 acres in size. They should be located about 300 yards apart along trams or roads, in the edges of fields, and in small clearings, and should include a clump of blackberry, rattan, myrtle, yaupon, or other year-round cover. The amount of plowing and planting to be done in the fenced plots depends on funds available for the work. Where grazing is heavy, merely fencing the plots will increase quail food. If possible, the open parts of the plots should be plowed each spring after a favorable rain. Unless the plot is on virgin soil, the cultivation will produce a vigorous stand of doveweed and other native quail foods without planting. If these desirable natives have not pioneered in the plot, hand-picked seeds of doveweed, partridge-pea, and any other locally important quail foods should be planted. Sesban and common lespedeza which may be purchased from commercial seed houses also are recommended. Other plants often used for quail plantings are benne, rattail millet, Egyptian wheat, redtop, and field-peas. If cultivated and fertilized these plants yield good supplies of food; but there is some question as to how readily the birds learn to use them, and also as to how resistant they are to damage by insects and weather. In general, primary reliance may well be placed on the native food plants. It is important that quail food patches provide food in late winter when the birds need it most. Two results may be expected of the food and cover patches. They will improve the food and cover supply for quail and also serve as covey headquarters; certain old fields in woodland hold coveys for years because they provide a combination of suitable cover and food in one place. The net result of the establishment of headquarters food and cover patches will be more quail and easier hunting.

Brush Cutting

More intensive methods of managing pine-oak woodland for quail include brush cutting, plowing, and burning. Although cutting of brush by hand is effective, it is slow and laborious; mechanical means are much faster. Treedozers and heavy rollers are used in the southeastern United States. These are constructed of heavy brush-cutting blades mounted on huge revolving drums and hauled by tractors. Other forms of brush cutters also have proved their usefulness. The amount of brush cutting depends upon local conditions, but the minimum objective should be to keep open the 80-foot tramways. Where the vegetation is too thick, brush cutting in conjunction with strip plowing or spot burning will further improve conditions for quail.

Plowing

Plowing is the best known method of setting back the plant succession far enough to cause doveweed and associated quail food plants to increase abundantly. Along tramways, roads, and ditches, shallow plowing or disking every 2 years will maintain a supply of some of the most valuable

quail food plants, provided bushes and trees do not shade the plowed spots, or consume the soil water through their spreading roots. Brush cutting will facilitate protection of these plowed strips.

Burning

Burning spots of slash to provide small clearings has not been attempted in Walker County, although where such burns have occurred accidentally, quail usually have benefited to some extent. In the narrow triangular area formed wherever a tramway branches, it is fairly easy to control a slash burn. As a precaution, the borders of the trams should be plowed unless they are completely bare of grass and litter. Not more than 10 acres should be burned in one spot. The third side of the area to be burned should be protected by a plowed fire lane from which all slash has been removed. No fires should be set on windy days, and all such spot burns should be watched until entirely out. It is safest to burn at night when the movement of air is less, and when dew is present. One should test the conditions (wind, dew, inflammability, etc.) under complete control on a small spot before extending the burning to a larger area. The proper season is January, February and March.

On quail preserves in the cutover longleaf areas of Georgia, one-third of the grass land is burned each year. The fires are controlled by plowed strips. After the burn is two years old, plowing will greatly improve its value for quail. Stumps and downlogs will prevent uniform plowing, but a man with a mule and a singletree plow can disturb most of the exposed soil and stimulate a bumper crop of quail food with no planting whatever.

Grazing

Most Walker County woodland was unfenced (1937) and therefore open to uncontrolled grazing. The census areas did not provide an opportunity to note the effects on quail of moderate grazing as compared with heavy, unregulated grazing. Vegetation studies in a few protected woodland areas in the county have indicated that many important quail foods, such as the legumes and certain grasses, do not mature seed if grazing pressure is more than moderate. The condition of herbaceous vegetation on several places observed suggests that for the best interests of quail, grazing pressure should not exceed one cow to 30 acres on cutover less than 15 years old. On older tracts of second-growth the grazing allotment should not exceed one cow to 40 acres.

Complete protection from grazing along with fire exclusion is not entirely beneficial to quail. This was shown on the Old Colony experimental area where, as a result of protection from all grazing for 2 years, reforested fields developed rank vegetation unfavorable to quail. In the Big Thicket section of Polk County, residents say that grazing is a factor second only to fire in keeping woody undergrowth thinned out. For the first several years, however, second-growth does not require any thinning, and cattle apparently are of little service to quail. The explanation of

the slow increase of quail in areas cut from 1 to 3 years previously is that the herbaceous vegetation is late in getting started. It is likely that protection of these newly cut areas from all grazing for 2 or 3 years would enable the herbaceous vegetation to become established more rapidly, with resulting accelerated increase in quail. For intensive game management, careful regulation of grazing is essential.

Any plowed, burned, or planted plot maintained for the benefit of quail should be protected from livestock. Although doveweed is not taken by cattle, all of the common legumes and most of the grasses are preferred forage. In fact, most quail food plants are eaten by livestock. If production of quail food is the primary objective, it is best to fence out cattle, sheep, and goats. If plowing, or burning, is impracticable, it is desirable to use enough livestock to prevent the formation of dense roughs of broomsedge and other grasses. Where woodland tracts are fenced (no intensive management of quail should be attempted without fences) well regulated, moderate grazing by livestock is entirely compatible with quail management. The term "well regulated, moderate grazing" implies that no grazing will be allowed until the herbaceous vegetation has become established well enough to cover most of the open ground, and that all grazing shall be regulated by the condition of key quail foods which are palatable to cattle. Among these plant indicators are vetch, trailing wild beans, lespedeza, bur clover, milk-pea, and tick trefoil. From ¼ to ½ of this desirable vegetation should make seed for the best interests of both quail and livestock. If grazing to that extent does not suffice to keep undesirable roughs in check, they should be controlled by burning or in some other way. Grazing, like burning, is a two-edged sword, and from the game management standpoint may easily become excessive.

Control of Predators

Apparently predation is of secondary importance in limiting the quail population of Walker County. The evidence on the relations of hawks, owls, and armadillos to quail does not suggest that reducing these species would result in increased numbers of the birds. Housecats and stray dogs do not belong in the fields and should be dispatched if feral. High populations of foxes on quail management areas should be avoided. Individual Cooper's or sharp-shinned hawks may hunt a covey of quail persistently, and in such cases elimination of these hawks might benefit the quail, but since most hawks and owls prey upon quail competitors and enemies most of the time they are distinctly beneficial in maintaining a proper balance. Skunks, opossums, and raccoons are valuable fur animals and the little damage they may do to the quail population is balanced by their economic value; moreover the losses they cause probably are negligible. If the effort sometimes spent in destroying predators were devoted to improving the habitat for quail, far more satisfactory quail populations would be obtained.

Regulation of Hunting

Considerable illegal quail hunting is reported during the open season on mourning doves in September and October. The six weeks open season on quail from December 1 to January 16, in itself, allows for the taking of as many birds as the population warrants. By making the two hunting seasons concurrent, a considerable saving of quail probably would result.

Quail in woodland afford difficult sport. The hunter must shoot quickly and accurately in order to get his birds. It is likely that a higher percentage of cripples occurs in woodland than anywhere else. This factor should be considered in determining the amount of hunting that may safely be done on a given tract. Pre-season censuses of coveys should provide the basis for determining how many birds may be taken from an area. Recognized authorities agree that it is not wise to harvest more than 33 per cent of an individual covey in any one year. This leaves 67 per cent to make up for crippling and natural losses and to insure sufficient breeding stock for the following season.

None of the quail hunting in Walker County woodland, so far as known, is regulated in any way. Each hunter gets what he can. No hunter knows how many birds other hunters have removed from the covey. Large coveys found late in the season are hunted intensively, even though they may represent aggregated remnants of several over-shot coveys. A few hunters are shameless "game hogs". The regulation of hunting as well as of burning and grazing, is essential for successful maintenance of the birds.

Restocking

Where quail are entirely lacking from good habitat some stocking may be required. As a rule, however, all the good natural areas are occupied and those that are not inhabited are usually so unsuitable that introduced quail have little chance of succeeding. On the other hand, where native quail are well scattered, even though not numerous, improvement of habitat without artificial restocking will result in satisfactory increases. Restocking is risky and expensive, and should be unnecessary. In most parts of Walker County and neighboring areas there is a sufficient seedstock. The problem is to improve conditions so that they will permit bob-whites to increase, then to regulate the hunting so the population can be maintained.

SUMMARY

Report is made on the effects of woodland management on quail populations in a nearly typical eastern Texas county in the shortleaf-loblolly pine-hardwood type. Material reported upon includes quail population figures for 5,323 acres, most of which was censused 3 times in 2 years; analyses of the contents of quail stomachs and crops; a collection of

plants; notes on a number of temporary quadrats and transects and on 5 permanent quadrats; and records of extensive field observations.

A successful drive method of censusing coveys of quail on large tracts of woodland was developed, using Civilian Conservation Corps enrollees in squads of 20 to 40 moving abreast. The accuracy of this method was tested by making counts of the same area under different conditions of weather and with varying intervals between the men in the line. Marginal effects of roads and tramways were taken into account, as was also the value of counting the same area twice.

Opening the woodland by cutting pine timber starts a series of changes in vegetation which in relation to quail may be conveniently considered in the following four types:

In Type I herbaceous species make steady increases each year along with sprouts and seedling trees. Weed-type herbaceous species are most vigorous in Type II. In Type III, broomsedge and associated grasses reach a climax and then weaken as the brush thickens. In Type IV, sapling pines begin to overtop and dominate other species.

The density of quail in cutover areas reaches a peak about the eighth year (76.8 acres per covey) and begins to decline about the tenth year. For the first 4 years after cutting the average acreage per covey is about 140.6 acres; from the tenth to fifteenth years it is 95, and for older tracts of woodland about 500 acres per covey.

Recommendations for management of quail in the cutover shortleaf-loblolly pine-hardwood type include plowing and brush clearing in spots and along trams, protection from heavy grazing and overshooting, little or no restocking of quail or control of so-called predators except locally as needed, some burning of slash under certain carefully regulated conditions, optional planting of feed patches, and careful regulation of hunting.

Favorable environmental change could be induced by land owners under a rotational system of harvesting timber. They could favor the interspersion of various timber age-classes that is essential to continuous quail production. Foresters should give consideration to such silvicultural practices as will be compatible with both timber and wildlife management.

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