a fall juvenile-adult ratio of approximately 3 to 1 (Table 3). Certain other recommendations are as follows:

(1) Landowners should be encouraged to harvest more of the quail produced each year. The fear of over shooting quail coveys can be minimized by realizing that many unshot coveys persist through the winter season in rough areas where hunters do not hunt. These quail will move to unoccupied ranges to produce young during the following year.

(2) Additional covey ranges must be added to an area if an appreciable increase in the quail production is to be expected. The high development of the study area did not increase the carrying capacity because of the limited amount of range. It was believed, however, that sufficient food and cover were available on the study area throughout the year to have supported another covey.

(3) A similar study should be run on an area where hunting pressure is high and the data collected should include that of other factors such as diseases, climate, etc., that effect the quails' survival.

## SUMMARY

Studies on quail mortality, mobility and daily and seasonal activities were initiated during the fall of 1962 on a study area containing approximately 10 acres of open land. The open area was maintained in a high state of development as a quail range. No hunting was permitted on the area and the surrounding areas were not hunted for a radius of approximately one mile.

Observations of the two coveys of quail inhabiting the area were made from tall blinds with the use of binoculars and a spotting scope during the period of March through September. Data were collected on the quail coveys during the period of October through February with the use of bird dogs and by trapping and banding.

The greatest loss of quail occurred during April, May and June of each year. The causes of the losses, be it mortality or a shift in the population, could not be determined.

Approximately 16 per cent (about 5 out of 30) of the adults occupying the range at the start of the two mating seasons concerned (1962 and 1963) spent the remainder of the spring and summer months in small covey groups on the study area without mating. These adults joined the broods of the year during October and November. Only two coveys of quail were known to utilize the area although sufficient food and cover were believed available to support another covey throughout the study period.

Trapping and banding results were negligible due to failure to attract quail into the traps after the study area was highly developed.

Seasonal ranges were found to vary slightly during the fall and winter as compared to the spring and summer season. Quail coveys utilized the developed open land more during the spring and summer than they did in the fall and winter. The daily range approximated that of the seasonal range on the highly developed study area. In no case were the resident coveys found to move over 100 yards from the outer edge of the 10-acre open portion of the study area.

# SOME EFFECTS OF WEATHER ON COTTONTAIL REPRODUCTION IN ALABAMA

BY EDWARD P. HILL III

(A Contribution from Federal Aid in Wildlife Restoration Project-Alabama W-36-R)

In the many good publications on cottontail *(Sylvilagus floridanus)* reproduction, relatively little has been reported comparing specific weather data with the commencement, continuity, and duration of the breeding season. The purpose of the first portion (Part I) of this paper is to present an analysis of some of the effects late winter temperatures appear to have on commencement and synchronization of cottontail breeding in Alabama. The second portion (Part II) contains evidence of some effects of summer drought on reproduction by penned rabbits.

## PART 1

## SOME APPARENT EFFECTS OF LATE WINTER TEMPERATURES ON COMMENCEMENT OF COTTONTAIL BREEDING IN ALABAMA

Various authors have indicated that there are one or more environmental factors that determine the breeding season in rabbits.

Hammond and Marshall (1925) suggested that temperature and/or diet are probably responsible for setting the limits of the breeding season of domestic rabbits.

Kline (1962) noted that Iowa cottontails vary from one year to another in the commencement of breeding activities. Bassonette and Csech (1939) through regulation of the photoperiod, produced testicular growth and breeding in *(S. transitionalis)*, but had relatively little success in producing young before April. Eche (1955) stated that there were probably several external stimuli which control length of the rabbit breeding season, the most important of which appear to be a component of green vegetation. Elder and Finerty (1943) indicated that the seasonal development in the reproductive system of the male cottontail is correlated with changes in gonad stimulation activity of the pituitary gland. They suggested that cytological changes in the pituitary gland may be associated in some way with an inherent glandular rhythm or with the effect of external environmental factors such as temperature or length of daylight. Wight and Conaway (1961) in noting the delaying effects of snow and cold temperatures on the commencement of cottontail breeding, stated:

> "In view of the generally accepted hypothesis that lengthening photoperiod is the mechanism responsible for governing the onset of breeding in most mammals, it is important to record an observation of the influence of weather on this mechanism."

Conaway and Wight (1962) suggested that there is an overall external synchronizing stimulus which brings all female members of a population into what may be termed a pre-estrus condition at about the same time. Variable population and environmental factors may then determine whether or not each female will actually achieve estrus and breed. They suggest that females failing to breed regressed from the pre-estrus condition and that an interval of from 14 to 16 days was required before a second pre-estrus occurs.

### *Procedures and Results*

Annual six-day rabbit hunts conducted on Wheeler National Waterfowl Refuge near Decatur, Alabama during February afforded an excellent opportunity to collect reproductive information near the beginning of the breeding season. Checking stations were operated (1960-1965) at two locations convenient to hunters. Female reproductive tracts were examined to determine the extent of breeding and approximate date of conception according to Schwartz (1942) and Sadler (1963).

Average temperatures for the first 10 days of February were computed (1962-1965), from weather summaries recorded at Decatur, Alabama. Temperature departures from the longtime means of February 1-10 were then computed. These were compared visually with pregnancy rates through February 10. Temperature departures and pregnancy rates are presented in the following table:

Table 1. Pregnancy rates of cottontail rabbits and departures from longtime mean temperatures for the first 10 days of February on Wheeler National Waterfowl Refuge (1962-1965).

| | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|
| Per cent pregnant prior to February 10 | 25.0(64) | 12.5(64) | 6.8(73) | 45.1(51) |
| Temperature departure from longtime mean (February 1-10) | +4.0 F. | —5.7 F. | —4.0 F. | —5.0 F. |

Numbers in parentheses are sample size.

The 1965 temperature was colder than the longtime mean, however, a wave of warm temperature centered on February 10 was accompanied by a major onset in conception. The occurrence of this phenomenon revealed the need for a closer comparison of the pregnancy rates with daily temperatures in order to better understand the effect of short-term warming periods.

Departures from longtime daily means were then computed and are presented graphically in Figure 1. Conception dates are included for comparison. The conception that accompanied the temperature range and distribution of February 1-10, 1965, demonstrated perhaps more than the other three years, the influence of temperature on the commencement of cottontail breeding.

Differences in the effect of temperature on the commencement of breeding were also demonstrated within the latitude of the state. Samples of rabbits taken from north and south Alabama in 1960, 1964, and 1965 indicate higher rates of pregnancy in the southern areas. The following table shows these differences:

Table 2. Pregnancy rates of cottontail rabbits collected in north and south Alabama in 1960, 1964, and 1965.

| Year | Area | Date collections were started[1] | Per Cent Pregnant |
|---|---|---|---|
| 1960 | North | February 16 | 19.1(94) |
| 1960 | South | February 16 | 90.1(11) |
| 1964 | North | February 15 | 6.8(73) |
| 1964 | South | February 15 | 49.1(55) |
| 1965 | North | February 22 | 67.3(52) |
| 1965 | South | February 22 | 100.0(14) |

[1] Conceptions used in pregnancy rates occurred at least one day prior to the date collections were started. Numbers in parentheses are sample sizes.

The abnormally warm temperatures occurring in Alabama between December 21, 1964 and January 2, 1965 afforded an exceptional opportunity to observe effects of temperature on cottontail breeding. The temperature during this period was 10 degrees warmer than the longtime mean.

Fourteen females were collected from counties of south Alabama in January 1965. Six of these had conceived, three occurring in late December and three occurring in late January. The three conceptions of December 19, 25, and 27 are the earliest known in Alabama by this author. It is possible that December conceptions could have been common throughout south Alabama in 1964, however, no evidence of a full term December conception was found in 22 females collected in south Alabama in February 1965. The earliest conception found by Majors (1952) was approximately January 14. Of 601 female cottontails collected in Alabama during December, January, and February (1960-1965), no other December conceptions were found.

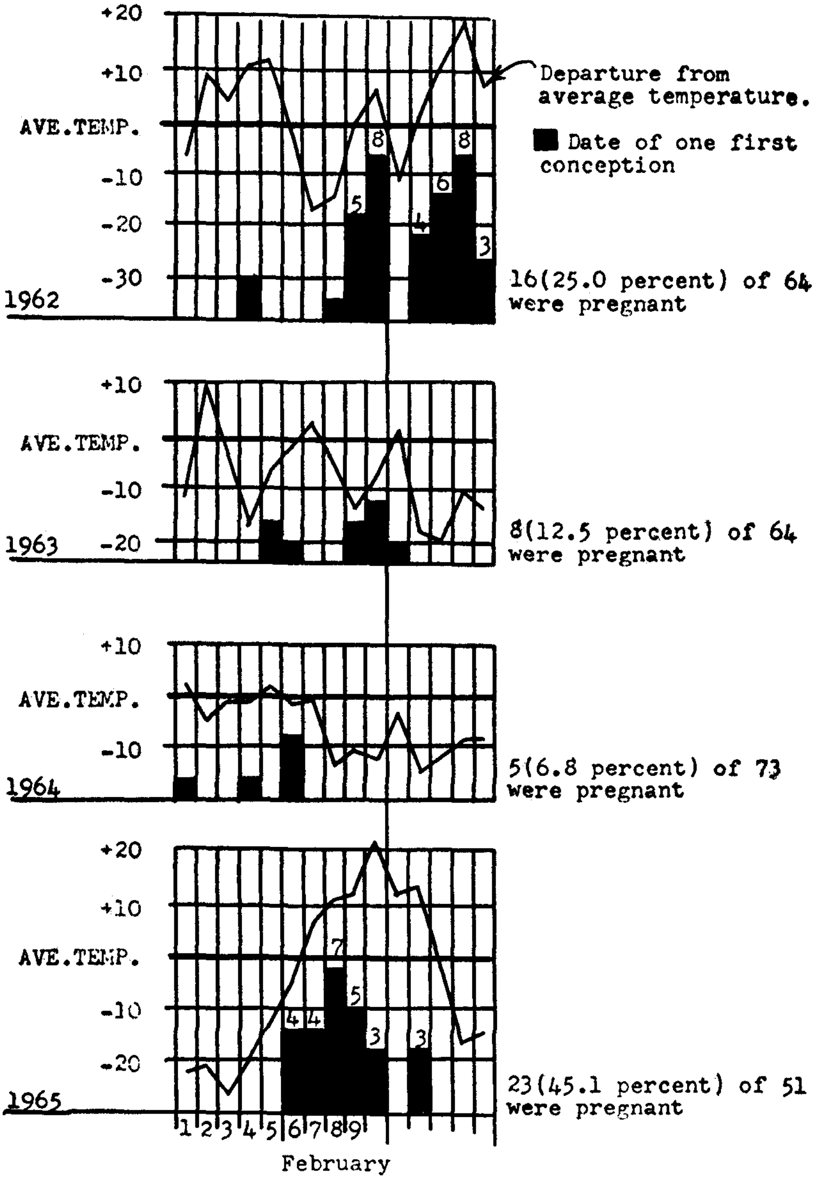


**Figure 1.** Relationship between first conceptions in cottontail rabbits and February temperature on Wheeler National Waterfowl Refuge—1962-1965.

*Discussion and Conclusions*

It would be erroneous to refer to the three conceptions in December 1964 as the onset of breeding, as the general onset occurred about February 10, 1965. Therefore, for the purpose of this paper a distinction is made between the first few conceptions of the year and the general onset or commencement of breeding.

In view of the varying pregnancy rates found among years and between locations in the same year, it can be said that the time of the first few conceptions and the general onset of the cottontail breeding season in Alabama may vary from year to year and within populations during the same year.

It appears that the frequency and extent of late winter periods of warm and cold temperatures determine this variation. Colder than normal temperatures such as occurred in north Alabama in 1963 and 1964 seem to delay the general onset of breeding while warmer than normal temperatures such as occurred in 1962 and for a short period in 1965, seem to be associated with an earlier general commencement of breeding.

Assuming for the present, that temperature is the primary factor controlling the onset of breeding, one can only theorize as to how it would be manifested in the rabbit to hasten or postpone breeding. The male cottontail, like many male mammals in breeding condition, probably breeds when the opportunity avails itself. The immediate conceptions following parturation through most of the breeding season would tend to substantiate this and indicate that breeding is usually controlled by the female. Since the male appears to be in breeding condition earlier than the female, one might conclude that late winter temperatures control the onset of breeding indirectly by influencing the receptiveness of the female.

There is the possibility that diet as well as temperature are equally important in controlling the general onset of the cottontail breeding season, and that one or both of these may be the "overall external synchronizing stimulus" described by Conaway and Wight (1962) that brings all females into a pre-estrus condition at nearly the same time.

As discussed later in Part II, green succulent vegetation appears to be a limiting factor on reproduction later in the breeding season. In central and south Alabama, crimson clover, winter wheat, and various other cover crops are often available throughout the winter. Failure of rabbits to breed before February under these conditions would support the postulation that temperature rather than diet controls the first few conceptions and the general onset of the breeding season. The availability of green vegetation in pens and enclosures containing cottontails did not result in early breeding. Therefore, temperature rather than diet is considered by the author as the primary factor controlling the onset of breeding.

No inference is made that temperature affects breeding after the onset. The cottontail breeding season in Alabama usually terminates in late August while mild temperatures persist into mid October. Therefore, it can be said that temperature has little or no effect on the termination of cottontail breeding season in Alabama.

Lending support to the line of thought that temperature controls the onset of cottontail breeding, is the pattern for delayed breeding with cooler temperatures as one moves north through Alabama, and the fact that an extended wave of warm temperature such as occurred in February 1965, can produce synchrony throughout the state.

To further explain the latter portion of this statement, reconsider the hypothesis by Conaway and Wight (1962) describing the synchronized pre-estrus conditions which occur at 14 to 16-day intervals. Since the onset of breeding is usually delayed with increased latitudes, one could assume that the pre-estrus periods, although synchronized within local populations, would also show a gradient delay with increasing latitude.

If gradient delays in the pre-estrus periods occur each year, one of three or more conditions would have to be met for synchrony to occur throughout the state as it did in 1965. One choice is that there was, in 1965, contrary to other years, a synchronized pre-estrus throughout the state and breeding occurred during a coincident wave of warm temperature. This would indicate that temperature is the stimulus controlling the pre-estrus condition.

Another choice is that there was, as in other years, a gradient delay in pre-estrus periods through Alabama, and although breeding occurred at the same time, the rabbit population in south Alabama had undergone at least one additional pre-estrus period while the population in north Alabama could well be in its first pre-estrus period. In this case, temperature would appear to have delayed the onset in north Alabama.

A third choice is that there was a gradient delay in pre-estrus periods through Alabama and the time factor (delay) between latitudes came into alignment under the influence of temperature or other environmental stimulus. If this were the case, it would appear that temperature could alter the interval between pre-estrus periods or alter the gradient delay between latitudes or both.

Either of these choices would, due to the apparent influence of temperature, tend to support the hypothesis that temperature controls the onset of breeding.

The general onset of breeding in Alabama may or may not be highly synchronized. This appears to be dependent to some extent on the temperature gradient and size of the area sampled. Since the extent of synchrony is determined by the rate at which the stimulus, temperature or other, brings about conceptions, it seems that the degree of synchrony would be correlated with the intensity and duration of the stimulus.

It is reasonable that the pronounced synchrony reported in the mid-west is a result of the small temperature gradient accompanying comparatively large changes of latitude. The more abrupt temperature change accompanying the winter to spring transition could also affect the degree of synchrony. This change is less abrupt in Alabama, particularly in the southern counties where later winter frontal activity is moderated by the Gulf of Mexico.

## PART II

## SOME EFFECTS OF SUMMER DROUGHT ON REPRODUCTION BY PENNED RABBITS

The effect of drought on rabbit reproduction has been noted by several workers. Myers and Poole (1961) working with *(Oryctolagus cuniculus)* in Australia, found indications that females can drop back into a state of diosetrus temporarily during the breeding season whenever conditions militate against ovulation and pregnancy. Evidence was also given which indicated that reproduction was greatly affected by rainfall when lactation terminated in females eating dry foods. This effect was demonstrated in last-born litters of the season when the nestlings, irrespective of the density of the population or the apparent health of the female, lost weight and starved.

Ingles (1941) after studying the audubon cottontail *(S. auduboni)*, suggested year-round breeding by this species in the irrigated valleys of California is perhaps due to the year-round supply of green vegetation. He also indicated that the breeding season in other areas where woody plants are utilized in winter, is more limited. Fitch (1947) found breeding by the audubon cottontail limited to late fall, winter, and spring months—the growing season when green forage is abundant. Mossman (1955) found that the period of infertility in *(S. bachmani)*, the brush rabbit, coincided with the dry season in west-central California.

Sheffer (1947) working with cottontails in 1/16-acre pens found that drought caused a termination of reproduction by July 1st.

### *Procedures and Results*

Five 50′ x 50′ pens located on the Zack Abney farm near Prattville, Alabama were stocked with two or three females and one male cottontail during 1963 through 1965. In addition to water and fertilized natural grasses, other foods such as commercial pellets, plantings of oats, winter wheat, crimson clover, millets, and cow peas were provided as forage.

After the commencement of the breeding season, each pen was systematically searched to locate nests. Littering sequences were established in each pen, and records were made of litter sizes, birth dates, predation, and mortality. Young were removed to holding pens at about 20 to 30 days of age. Pregnancy rates were calculated each day during the three-year period starting with the conception dates of the first litters.

Noticeable decreases in the pregnancy rate at the time when reproduction should have been at a peak occurred each year. Decreases of 33 per cent in May 1963, 88 per cent in May and June 1964, and 86 per cent in May 1965 occurred and are shown graphically in Figures 2, 3, and 4, respectively. The most obvious cause of these

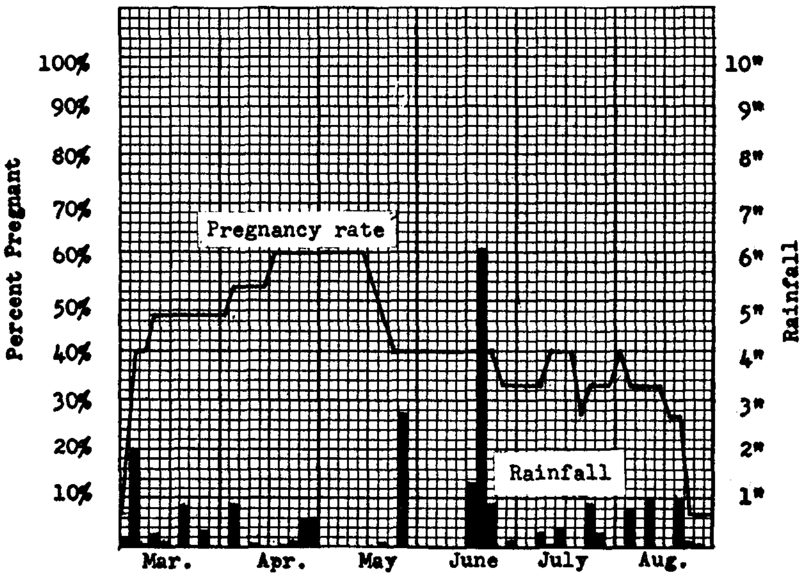


Figure 2. Relationship between rainfall and pregnancy rates of cottontail rabbits in 50′ x 50′ pens in 1963.

decreases appeared to be lack of adequate rainfall as demonstrated by the wilted condition of the vegetation in the pens. There was a limited recovery in the pregnancy rate following rains in 1964.

A detailed examination of the rainfall data from Auburn University experimental farm located ¾ mile south of the study area revealed that periods of dry weather occurred in May 1963 and 1964, and in April and May 1965. These periods of dry weather can be seen in Figures 2, 3, and 4. The bars on each graph represent rainfall that occurred during a three-day period.

In order to show a relationship between the severity of the drought and the extent of decreases in reproduction, a modification of methods described by Ward and others (1959) was utilized to determine the number of drought days. They listed maximum available moisture holding capacities and rates of evapotranspiration for the various soils and regions of Alabama. Each day the amount of daily evapotranspiration was subtracted from the available moisture in the soil. Any rain that fell was added to the available soil moisture not to exceed the maximum available moisture holding cacapity. Drought days occurred when the available soil moisture was depleted by evapotranspiration.

The maximum available moisture holding capacity for the soil of

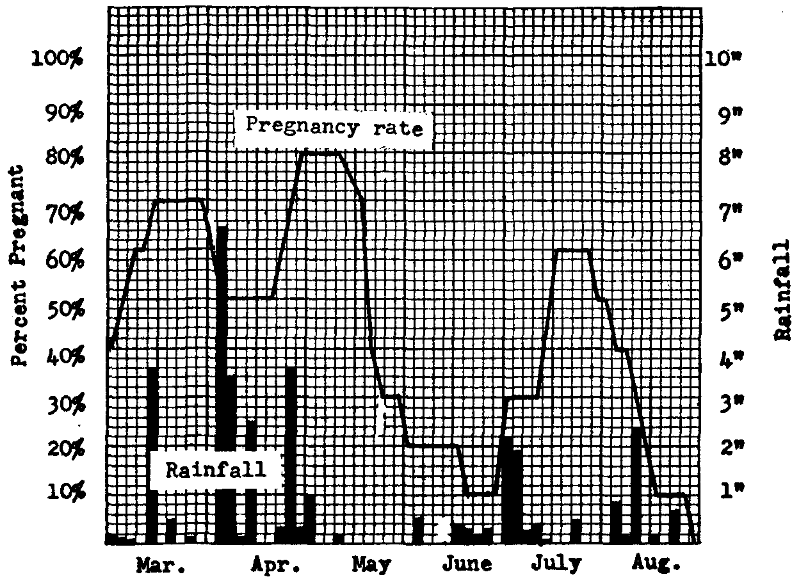


Figure 3. Relationship between rainfall and pregnancy rates of cottontail rabbits in 50′ x 50′ pens in 1964.

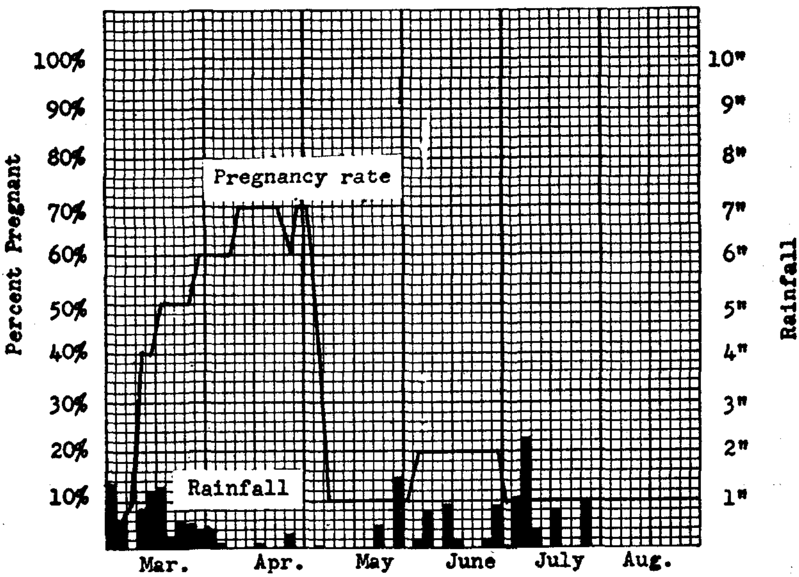


Figure 4. Relationship between rainfall and pregnancy rates of cottontail rabbits in 50′ x 50′ pens in 1965.

the study area is approximately one inch of water for the first foot of soil. The estimated standard rates of evapotranspiration for the soil and vegetation of the study area given by Ward (1959) were .130″ per day in April, .160″ per day in May, .185″ per day in June, .162″ per day in July, and .158″ per day in August.

Due to the influence of wind velocities and cloud conditions on the daily evapotranspiration rate, a more conservative estimate of the drought day was adopted. After the soil was saturated (maximum available moisture) a time lapse of 10 days was allowed before the first drought day was counted. This procedure, plus the method used by Ward (1959) to account for additional rain was used in computing the number of drought days per month.

Thirteen (13) drought days occurred in May 1963, 15 in May and three in June 1964, and 13 in April and 20 in May 1965. Ward (1959) reported that seven drought days is the minimum number to be expected in the soils of the study area from May 15 to June 5 in five out of ten years.

*Discussion and Conclusions*

It was concluded that extended drought interferes with cottontail rabbit reproduction in 50′ x 50′ pens. The continuous availability of water and commercial pellets had no apparent effect in preventing the decrease in pregnancy rates, and suggests that green vegetation is necessary for continuous reproduction.

Although no summer collections of wild cottontails were made during drought years, night censuses on a 26-acre enclosure adjacent to the 50′ x 50′ breeding pens in 1963 and 1964 indicated that there were fewer juveniles during the year of greater drought.

The censuses were conducted along the same route during July of each year. In 1963, sixty-three (63) rabbits were counted, 20 (31.7%) which were judged as juveniles. During the 1964 census, 39 rabbits were counted, 5 (12.8%) which were judged as juveniles.

Admittedly, these data are only as reliable as the census technique. The results, however, tend to parallel those of the breeding pens.

In view of the apparent effects of drought on rabbit reproduction in Australia, and the apparent effect of drought on reproduction in penned cottontails in Alabama, there is strong evidence suggesting that the continuity of reproduction in wild cottontail populations in Alabama can be interrupted by extended periods of summer drought.

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# FLORIDA'S EXALTED DOVE HUNTING

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of Game & Fish Commissions

ABSTRACT

Public dove hunting has become very popular among sportsmen in Florida. Since 1961, a program adopted from the "Williamston Plan" of 1929 has provided an orderly harvest with accurate harvest records on an equitable economically self-supporting basis. Through cooperative lease contracts with landowners, the fields are opened to public hunting for a $2.00 daily permit fee. The Florida Game and Fresh Water Fish Commission selects fields and plants grain food to concentrate dove populations. More each year public dove fields help supply hunting for hunters who otherwise might not have an opportunity to hunt.

A public hunting program can provide hunting for sportsmen who would otherwise not have an opportunity to hunt. Such programs have for this reason gained rapid popularity among sportsmen in several states.

Most controlled dove hunting programs are patterned after a controlled hunting system called the "Williamston Plan" developed in 1929 (Wight 1931). The idea originated in Michigan as a cooperative agreement between landowners, sportsmen, and conservationists from the University of Michigan who were interested in providing an orderly harvest with thorough harvest records. It was financed by receipts from hunting permit sales. Similar systems have been credited with creating good sportsmen-landowner relationships (Hicks 1938). Controlled public hunting in Florida began with the establishment of Gulf Hammock Wildlife Management Area in 1949. The idea has grown into a system of 54 public hunting areas. Its evolution through 1952 is described by Frye (1952).

Since the inclusion, in 1960, of "normal agriculture plantings" in the hunting methods permitted for migratory birds, public dove hunting programs have rapidly expanded. These programs are designed by various state game and fish agencies to provide increased dove hunting opportunities on an orderly, equitable basis. Though each state designed its own program to regulate both resident and migrant game, most of them amount to adaptations of the Williamston Plan.

In 1961, the Florida Game and Fresh Water Fish Commission initiated a public dove field program on five fields located in Bay, Franklin, Hillsborough and Wakulla counties. Each year the program has continued to gain popularity and support from sportsmen. Fields located on both public and private land, usually near big cities, are made available through cooperative lease agreements between the Commission and landowners. The size of each field is dependent on many variables, but most range from 125 to 500 acres. The Game Management staff selects and plants the fields. A daily fee of $2.00 per hunter is charged.

Except in the northern one-third of the state, little grain is grown. In portions of central and south Florida public dove fields sown with