COLLEGE OF NATURAL RESOURCES

Utah State University
Logan, Utah 84321

TO: Irene Burns
FROM: Frederic H. Wagner
SUBJECT: Information on Title of Conference
DATE: June 20, 1972

Annual Meeting of the Rocky Mountain and Southwestern
Division of the American Association for the Advancement of Science,
April 21-24, 1971; Tempe, Arizona

MASTER

The entire content of this paper is fiber reclaimed from metropolitan solid waste.

WOULD YOU PLEASE GIVE US A MORE COMPLETE INFORMATION
ON TITLE OF CONFERENCE?

THANK YOU
TECHNICAL INFORMATION CENTER
OAK RIDGE, TENN. 37830
ATTN: REGULATION & APPRAISAL SECTION
IRENE BURNS

RECEIVED

JUN 19 1972

COLLEGE OF
NATURAL RESOURCES

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

RECEIVED BY TIC FFR 14 1972

Changes In Jackrabbit Mortality Rate and Density Level
As a Function of Coyote Predation¹

L. Charles Stoddart
Department of Wildlife Resources
Utah State University
Logan, Utah

MASTER

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Introduction

A study of the dynamics of the jackrabbit population in the Utah portion of Curlew Valley has been in progress since 1962. One purpose has been to measure population density changes and determine which environmental factors are responsible for the changes.

It is of particular interest that annual rates of change in density have varied. There are three parameters which determine rate of density change: mortality rate, natality rate, and rate of net movement in or out of the study area. If the rate of density change varies, one or more of the three parameters must also vary. The purpose of this paper is to describe the observed parameter changes which have caused the variation between years in rate of density change and discuss the relationship of these parameter changes to two environmental factors: (1) coyote per rabbit ratio, and (2) rabbit density.

Results and Discussion

Densities were estimated in March and October (Fig. 1) of each year by a method which utilized results from 70 1-mile line transects and an absolute count over a 1-square-mile area. We observed a continuous decrease in density

¹Presented at the 1971 meeting of the Southwestern and Rocky Mountain Division of A.A.A.S. Tempe, Arizona. The research herein reported was supported by U.S. Atomic Energy Commission Contract No. AT(11-1)-1329, Frederic H. Wagner, Principal Investigator.

from 1963 to a low in October, 1967 of about 30 rabbits per square mile. This decline was followed by continuous increase from 1967 to October, 1970 when the density was estimated at 265 rabbits per square mile.

The observed increase from 1962 to 1963 is not consistent with our explanation for the population trend in subsequent years. It may have resulted from error in our procedure of collecting and/or processing data since it occurred during the early stages of our study. However, if the increase is real it is likely only a temporary reversal of a general decline since subjective reports from local people in the area indicate rabbit densities were considerably higher in 1959 and 1960 than in 1963. Because of this inconsistency, the 1963 data were not used in some of the following figures.

We chose a large study area (about 350 square miles) so that movement, i.e. ingress and egress, would not significantly affect numbers, and density change would be a function of mortality and natality rates only.

Natality rates were calculated from autopsy results of monthly collections of rabbits. The rates have been expressed in two ways (Fig. 2): (1) the average number of young produced per female surviving the breeding season, and (2) average number of young produced per female alive on January 1 preceding the breeding season. The difference between the two lines in Figure 2 results from mortality of adult females in the population during the breeding season.

Three points warrant mention: (1) Year-to-year variation in natality rate as indicated by the top line in Figure 2 is relatively small. There is only a 50 percent difference between the low of 12.2 in 1966 and the high of 18.9 in 1967. (2) There is not a consistent relationship between natality rate of surviving females (Fig. 2, top line) and rate of density change. For example the population decreased in 1967, the year with highest production per surviving female, and increased in 1970 when production was considerably lower. (3) Because

of variation between years in female mortality rate (see below) during the breeding season, a much better relationship exists between rate of density change and fetus production per January 1 female (Fig. 2, bottom line). Here the three years showing highest production (1968, 69, and 70) are the three years of population increase (Fig. 1).

Three mortality rates were calculated each year (Fig. 3): (1) March-October mortality of adults was estimated by simply dividing the October density of adults (determined by multiplying the October population density estimate by percentage adults in the October collection) by the previous spring density. (2) October-March mortality of the total population was calculated, again, by dividing March density by previous October density. (3) Juvenile mortality rate from birth to October was estimated by comparing calculated natality with the number of juveniles actually observed during the October census (estimated by multiplying the October density by percentage juveniles in the October collection).

Observed variation in mortality rates between years (Fig. 3) is considerably more extreme than observed variation in natality rates. There is an 860 percent range in summer adult mortality from the low of 9 percent in 1968 to the high of 87 percent in 1964. It is this variation that has caused the inconsistent relationship between the two plots of natality rates in Figure 2.

In contrast to the natality rates (see above), there is a close relationship between mortality rates and annual, October-October, rates of density change (Fig. 4). Eighty five percent of the variation in October-October density change is explained by changes in mortality rate of adults from October-October (calculated by combining the summer adult and winter population mortality rates) and juveniles from birth to October.

Since variation in mortality was apparently responsible for much of the variation in annual rates of density change, we then explored the relationship

of density change to mortality factors. For this analysis the October-October density change was divided into an October-March change and March-October change.

October-March change in density was plotted as a function of the independent variable, coyote-per-rabbit ratio (Fig. 5). The coyote-per-rabbit ratio was calculated for each October-March period by dividing the mean coyote density for the period by the mean rabbit density for the period. Coyote densities used are estimates made by Frank Clark who is studying the coyote population in Curlew Valley. Linear regression analysis of the data indicates that about 90 percent of the variation in October-March density change can be explained by variation in the coyote-per-rabbit ratio.

During the March-October period the population was divided into two age classes, adults and juveniles, and the two classes examined separately.

March-October adult mortality was plotted, again, against the coyote-per-rabbit ratio (Fig. 6). The second-order equation explains about 72 percent of the observed variation in adult mortality.

Finally, birth-October mortality (represented here by a 10-day survival rate) of juveniles was plotted as a function of two independent variables: (1) coyote-per-rabbit ratio, and (2) mean rabbit density from March-October (Fig. 7). Mean rabbit density in this model represents one or more density-dependent mortality factors such as reduction in postnatal care by females, disease, or starvation of juveniles. At present we do not know what the factor or factors are, but we do know that juvenile mortality has been increasing with rabbit density independently of the coyote-per-rabbit ratio. This increase is evident in 1969 and 1970 (Fig. 7) when mortality rates were higher than could be accounted for by the existing coyote-per-rabbit ratio.

Since March-October adult mortality is well correlated with the coyote-per-rabbit ratio and juvenile mortality to the coyote-per-rabbit ratio and

rabbit density, we used these two independent variables in a model to describe the observed March-October change in density (Fig. 8). This model adds strength to our thinking that natality rates have had little effect on the variation in rates of density change during the course of the study. Though March-October covers the period of reproduction in the jackrabbit, the model explains 97 percent of the variation in rate of density change with no provision for changes in natality.

We can now construct a model for October-October density change by combining the models for October-March and March-October density change in the equation:

$$N_{t+1} = N_t(1 + \% \text{ March-October change})(1 + \% \text{ October-March change}) \dots\dots 1$$

where N_{t+1} is the October density and N_t the previous October density. The density changes indicated by the model (Equation 1) can be compared with the observed data (Fig. 9). This comparison or fitting of the model to the observed data is analogous to the fitting of any regression equation to observed data except in this case the model is composed of two regression equations combined, as indicated, in Equation 1.

The data presented above suggest that when coyote-per-rabbit ratios are relatively high, coyotes have affected the mortality rates of adults and juveniles to a considerable degree. There are other sources of evidence which suggest that the coyotes, because of their numbers and feeding behavior, in fact are responsible for considerable mortality in the rabbit population.

(1) A mortality study was conducted in 1967 and 1968 using radio telemetry to follow animals to their death and to locate them soon after death for the purpose of determining the causes of mortality. Mortality rates of the telemetered animals were consistent with those measured demographically so it was assumed

that the mortality factors were also consistent with those operating on the rest of the population. Of those animals found dead about 2/3 were killed, in our opinion, by coyotes.

(2) From the food habits study of Frank Clark, it was estimated that a coyote kills on the average about 1/2 rabbit per day. By multiplying this kill rate by the number of coyotes in the area, the number of rabbits killed by coyotes can be estimated. In most years this number corresponds well with estimates from the demographic studies of the total number of rabbits lost on the area.

The exceptions occur in the summers of 1969 and 1970 when the loss of juveniles, as discussed above, was too great to be accounted for by mortality due to coyote predation.

Conclusion

We have observed jackrabbit density changes to be highly dependent on mortality rates, and mortality rates in turn to be functions of coyote predation. Jackrabbit densities go down when the coyote-per-jackrabbit ratio is high and go up (at least when rabbit densities are relatively low as during most years of this study) when coyote-per-jackrabbit ratios are low.

Since we have not studied the population during the initiation of a decline we do not know what factors may operate to start the decline. One possibility is the coyote population itself. Because of increasing mortality of juvenile rabbits as a function of rabbit density, the coyote density may increase to the point where coyotes exert, through predation, enough pressure to initiate a decrease in rabbit numbers. Alternatively, it may be that disease, food shortage, or a combination of these and other unknown factors initiate the decline.

Whatever the factors are, we believe that once the coyote-per-rabbit ratio becomes relatively high, i.e. in the range of those ratios observed during the first years of the study, rabbit density levels will be profoundly affected by coyote predation.

Fig. 1

Fig. 2

NUMBER OF FETUSES PER FEMALE

Fig. 3

PERCENT ANNUAL POPULATION CHANGE, OCTOBER - OCTOBER

Fig. 4

Fig. 5

PERCENT SUMMER ADULT
MORTALITY

Fig. 6

Fig. 7

Fig. 8

Fig. 9