Modeling of Some Aspects of a Blue Grouse Population

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Parameters

I. Time period - The time period considered will be from May 1975 to April 1985 with a four month sub-interval from May thru August of 1975.

II. Location - The study area is a ½ mile by ¼ mile rectangle near the Taylor Ranch, lower Big Creek, Middle Fork of the Salmon River, in the Idaho Primitive Area.

III. Interactions - The interactions considered are those between blue grouse, predators of blue grouse and the habitat of the study area.

Interaction Table

From \ To	Blue Grouse	Predators	Habitat
Blue Grouse	*	*	
Predators	*	*	
Habitat	*		*

Introduction

A student wilderness honorarium provided me with the opportunity to study some features of blue grouse ecology at the University of Idaho, Taylor Ranch research facility.

Data were collected on, among other things, blue grouse productivity and the possible limiting effects of habitat and predation. This project is an attempt to incorporate some of my findings and also information from the literature into a computor model. The emphasis of this paper will be on some of the demographic characteristics of the blue grouse population in one of my study areas.

The modeling objectives are:

A. To calculate a value for the yearly potential rate of instantaneous increase for the blue grouse population (r)

B. To use the value of (r) to describe the growth of the population under an unlimited growth situation.

C. To describe the populations growth under the known limiting effect of the habitats carrying capacity.

D. To estimate the mortality due to inadequate habitat and predation and describe the observed mortality of chicks during the first four months.

E. To assume the habitat has improved, through human manipulation, increasing the first four month survival rate for chicks and reducing the mortality due to inadequate habitat - then describe mortality to chicks under this condition and compare the numbers of chicks present in the population at a given time to the number present without the habitat improvement.

Results

One nest containing nine eggs was found during the nesting period. G. C. Heebner (1956) studied blue grouse in the Cutty Mountains of Idaho and reported an average clutch size to be eight eggs. Since I only had a sample size of one clutch and Heebner's average clutch size is near the number of eggs in the nest I discovered I will use eight as an average clutch size for my calculations.

Through the marking of brood hens and the observation of a small number of unmarked hens on the study area I determined that there were ten brood hens and one lone female present on the study area. Zwickel (1975) reported a 50:50 sex ratio for the blue grouse he studied. Provided this sex ratio applies to the area I studied there would be a total of twenty-two blue grouse present at the start of the breeding season. Zwickel (1975) also reports a 31% annual mortality for adult blue grouse.

With this information it is possible to calculate the instantaneous rate of change (potential) as follows:

R = interval rate of change = Nt/No

Nt = (10 broods * 8 eggs/hen) + [(22 adults * .31) - 22] OR [22 - (22 * .31)]

= 80 + 15.18 = 95.2

∴ Nt/No = R = 95.2/22 = 4.3 = interval rate of change (potential)

Blue grouse have been reported to renest if the first clutch is destroyed but there are no accounts in the literature of a hen raising more than one clutch per year. Therefore twelve months or one year is a realistic base for the rate of change.

$r = \ln R$ = instantaneous rate of change (potential)

$$r = \ln 4.3 = \underline{1.459}$$

r = 1.459 is the value desired and will be used from now on as the growth rate for the population.

A computer program was run to determine the growth of this initial population under unlimiting environmental conditions for a ten year period from May 1975 to April 1985.

The equation used was:

$$Nt = NO * e^{(r*t)}$$

and the results are as follows

May 1975	– 22. grouse
April 1976	– 94.6 "
" 1977	– 403.48 "
" 1978	– 1,727.94 "
" 1979	– 7,399.98 "
" 1980	– 31,690.77 "
" 1981	– 135,717.10 "
" 1982	– 581,215.20 "
" 1983	– 2,489,080.00 "
" 1984	– 10,659,600.00 "
" 1985	– 45,650,240.00 "

The assumption of umlimited growth is obviously not valid in this instance. The evidence indicates to me that this blue grouse population was in fact stabalized at the habitats carrying capacity of twenty-two individuals. Several facts lead me to this conclusion (1) the habitat was in a stable condition (2) the population was essentially unexploited by man (3) although the grouse population had a high potential for increase only an average of two chicks per brood survived the first four months of life.

My next step was to explore the growth of the grouse population to the habitats carrying capacity. I assumed some natural or man made catastrophy reduced the 1975 breeding population to four individuals.

Two computor programs were run: one program in which r remained 1.459, and one in which a random number generator was used to assign the values of 1.3, 1.459 and 1.6 to r, each with 1/3 probability. The other given values and the equation used were as follows:

Initial SN = 4. = initial population size

cc = 22. = carrying capacity

Dt = 1.

SN = SN + r * SN * (1.-SN/cc) * Dt

The results of these programs are graphed in figure 1.

A prominent feature of the blue grouse population studied was the low rate of chick survival during the first four months of life. During this period the average brood size declined from eight chicks to an average of two chicks per brood at the end of four months. In order to model the decline I have divided this one-hundred and twenty day period into a first sixty days and a second sixth days. The first sixty days are a time in which the quality of the habitat is assumed to be the major cause of chick mortality. The quality of the habitat would be an index to food availability and also susceptibility to disease. During the second sixty days the chicks are larger and more visible. The hen is also much less protective in her defense of the chicks. Predation is assumed to be the primary cause of death during the second sixty days. The evidence I obtained seem to indicate that, of the two (habitat and predation), habitat quality was responsible for the death of a larger number of chicks than predation.

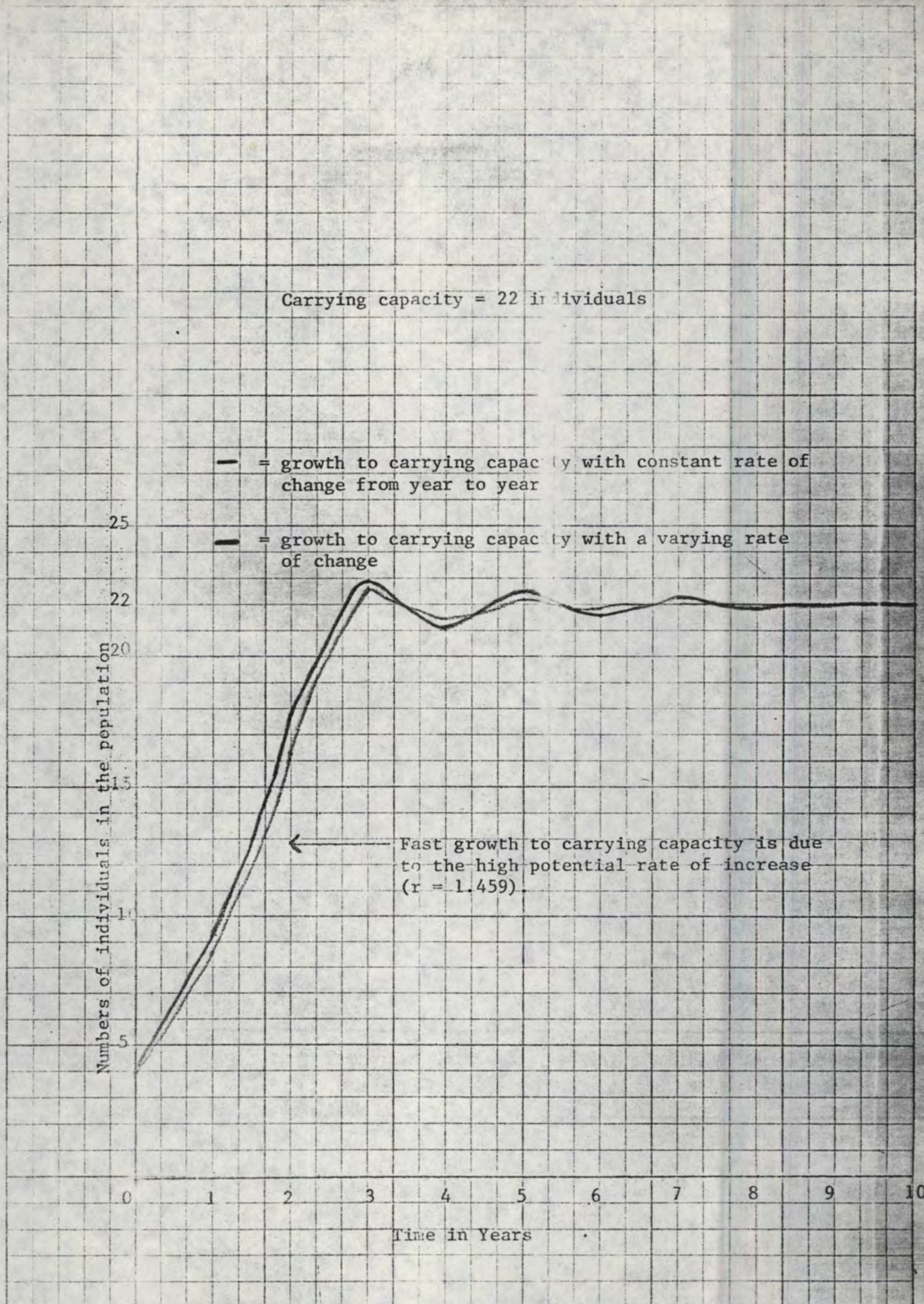

Figure 1. Population growth in a limiting environment.

The above information was incorporated into a computor model to describe the decline in the number of chicks in the grouse population over the first one-hundred and twenty days of life. The components of the model are as follows:

120 day interval survival rate = Nt/No =

$$\frac{10 \text{ broods} * 2 \text{ chicks/brood}}{10 \text{ broods} * 8 \text{ chicks/brood}} = \frac{20}{80} = .25$$

Interval rates of change are multiplicative therefore:

Day 1-60 Survival rate = .3 (due to poor habitat)

Day 60-120 Survival rate = .833 (due to predation)

Total (Day 1 - 120) Survival rate ÷ .3*.833 = .25

Interval Survival rate = Nt/No = R; and r = LnR

Therefore:

Day 1 - 60 instantaneous rate of change = r = Ln .3 = -1.2

Day 60 - 120 instantaneous rate of change = r = Ln .833 = -.183

Instantaneous rates of change are additive.

Given No = 80

Equations used are as follows:

For the first sixty days:

$$N_{days/60} = No * e^{(-1.2*days/60)}$$

For the second sixty days:

$$N_{days/60} = N_{60} * e^{(-.1838days/60)}$$

The results of this model are on figure 2 (blue line)

Habitat improvement has been used by many wildlife managers to increase the numbers of an animal species present in a population at a given point in time. Assuming the survival for the first one-hundred and twenty days is doubled (from .25 to .50) as the result of a habitat improvement program; what is the increase in blue grouse chicks present in the population on a given day during the first four months after hatching? To explore this situation the previous model was used with a few alterations.

Total (120 day) Survival rate = .50

Day 1 - 60: Interval survival rate increased due to habitat improvement = .71

Day 60 - 120: Interval survival rate decreased slightly because more grouse are available and this attracts more predators to the area = .71

$.71 * .71 = .50$

Day 1 - 60 instantaneous rate of change = r = Ln .71 = -.35

Day 60 - 120 instantaneous rate of change = r = Ln .71 = -.35

The equations from the previous model can now be used if the new values of r are substituted. (figure 2, red line)

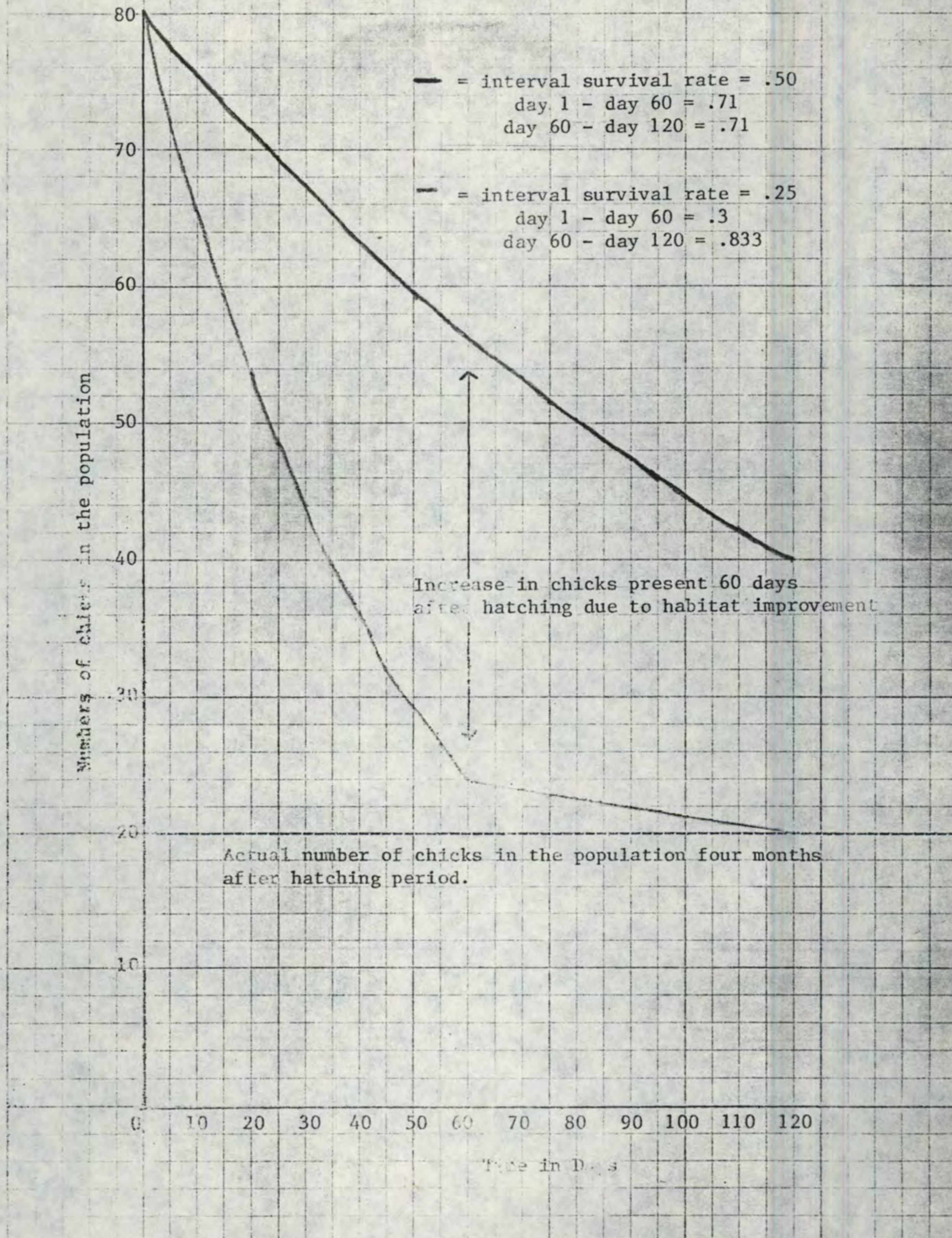

Figure 2. Chick mortality during the first four months.

Summary

A few demographic features of a blue grouse population have been examined with the aid of mathematical models. The models were verified by manipulating their components to produce outcomes which I found, through field and literature research, to be actual characteristics of a blue grouse population.

The potential rate of growth for the population was quite high but due to the limiting effects of the habitats carrying capacity this potential would only be realized if a drastic reduction in the populations numbers occurred; and then for only a few years. The low survival rate of grouse chicks during the first four months is a major feature of the populations dynamics. The one-hundred and twenty day interval was subdivided and values for the instantaneous rates of change (decline) attributed to habitat quality and predation. These values, when incorporated into the model, yielded results similar to those found in the field. The survival rate of chicks during their first four months of life was assumed to double as the result of a hypothetical habitat improvement program. The results of this improvement in chick survival were then compared with chick survival without the habitat improvement program on a daily basis.

Literature Cited

Heebner, Gordon C. 1956. A study of the Life History and Ecology of the Blue Grouse in West Central Idaho. Master thesis, University of Idaho.

Zwickel, Fred C. 1975. Autumn Structure of Blue Grouse Populations in North Central Washington. Journal of Wildlife Management. 39(3):461-468.