HUNT I AND II: COMPUTER-BASED DEER MANAGEMENT UNITS FOR UNIVERSITY AND IN-SERVICE EDUCATION

by
ROBERT H. GILES, JR.
Department of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061
A. BLAIR JONES, III
Department of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

ABSTRACT

A computer-based educational unit for university and inservice education is described. Students make selections from pre-punched decision cards and present these for computer analyses. They receive a printed output enabling them to improve their "play" of the game.

The units require management of deer in a southeastern U. S. county producing soybeans. The objective is to stabilize the deer population and minimize crop losses. Hunt I is a unit employed independently of past uses. After five uses of I, students are encouraged to use Hunt II which requires correcting past mistakes as well as playing against natural variation in variables. The program is in use in a course in integrated plant pest management and wildlife techniques.

INTRODUCTION

There are many applications of computer simulation and gaming in education (Bare 1972). A typical situation is that a student, after instructions, begins to play the educational game. He may respond to questions presented by the computer or in a manual by communicating with the computer using cards or a terminal (typewriter or cathode ray tube). The computer responds, giving answers, hints, or providing useful information. The student plays to win, either against a previous score, the computer, other students, or against nature.

Hunt I and II are such a game. Designed for use in a senior-level integrated pest management course taught at Virginia Polytechnic Institute and State University, the unit can also be used effectively in wildlife management and population dynamics courses, for inservice education, and even for layman education. For the latter, the educational objectives are quite different. The result desired is that questions are stimulated and an appreciation created of the complexities of deer management such that management decisions are left to those trained to deal with them.

These educational units incorporate into a realistic decision situation the problems of hunting control at a county level to minimize soybean crop losses to deer, a typical problem in many areas. The variables of the decision are habitat, acres and food supply, natality, age and sex structure, life expectancy, hunter harvest, illegal kill, crop production and price, and attitudes of crop buyers. The complexity of the calculations, the randomness, and the requirements for decision making under uncertainty are characteristics of the exercise that allow students to go beyond the learning experiences common to many university courses in agriculture, population dynamics, or environmental management. By successive plays of the game, students can be expected to improve their decisions. An improved decision is one that reduces the square of the difference between the population removal that resulted from their decisions and the desired or "school solution" population removal.

Programmed in FORTRAN IV, Hunt I and II are processed on an IBM 370 computer at an average cost of $0.20 per play. The programs are stored on disk so that students may use them at any time. Two pages of output are generated per student. One is retained by the student, one is presented to the instructor. Program documentation is available.

CONDUCT OF THE GAME

An instructor presents the game to a class of any size limited in the local situation only by the card decks provided and the grouping of students into teams. The game can be played with unlimited time or under the pressure of time, e.g. 15 minutes maximum. For best experience for the student, several plays should be done in each way in the above order. Students should get their pay-off or answers after each play and make changes based on the feedback provided.

After reading the situation statement, a one page document, students may ask questions for clarification. Any questions are valid, all should be answered to encourage learning. The game is developed as being between the computer and the student, not the instructor and student. The class or individuals may work together but must not use calculators or examine hidden variables. The computer will provide a correct answer from the information provided. Students examine the results of their decisions to improve their play of the game.

After the introduction, each student or team works alone with their instruction booklet and personal card deck to achieve the goal. A deck or packet of multi-colored cards is given to each student. Each deck has about 300 cards. The student draws a card from each section as specified in the instructions. When decision cards have been selected, each team turns in to the computer center these cards with the proper job control cards. Computer print-out answers are normally returned in less than 24 hours. Decision cards are re-entered into the playing deck and the student is prepared for the next play.

Hunt I and II are games that depend on the computer to store information about a population, about problems, and about student decisions, and then very quickly and accurately to calculate and to compare the results of the decisions with calculated correct answers. After the comparison a message is sent to the student. The message and the score it contains are the payoff.

Players will rarely win in the sense of exactly achieving the desired objective. The objective is to stabilize the population of deer at the maximum forage supply. This means a zero rate of change precisely at the ability of an area to meet the gross year-round energy needs of a population. Even though students will rarely win, they may try to improve after each play. That is, they should try to cause the difference between the actual and the desired residual population to decrease.

Students may play at their own speed. A sample of the output from one student's play is shown in Fig. 1.

THE ALGORITHM

The problem is to manage, through hunting, a county deer population and thus its impact on agriculture. The soybean producing county is 250,000 acres and in a unspecified mid-Atlantic state.

Proportions of the county that are rural and urbanized are specified by the student. The acres of potential deer range include the proportion of the rural area that produced natural forage and the proportion of the urban land that is available to deer. Potential range = percent rural acres + percent urban acres. Food production is considered only for the deer range, and is the weighted mean pounds of forage per acre. Total forage supply is calculated. Hunt I and II operate from the algorithm of range carrying capacity determined by the forage requirements for animals of specific weights. The basic relationship is

$$F = 0.15\ W^{0.75} \times 365 \text{ days}$$

(Whelan, unpub.) where F is the average kilograms of air-dried forage required annually and W is the mean weight in kilograms of each animal by age and sex class. Seasonal differences in forage needs are not accounted for in the game. Annual figures employed are assumed to represent sums of daily means.

For a population with specific age and sex-related weight classes, a population-specific forage requirement may be calculated. All calculations are based on *potentials* of an area to support deer.

Once the basic forage-consuming population is described, then a life table (Eberhardt 1969) provides the computational format for determining age ratios, weighted mean natality, survival and mortality, production in the next year, and adjusted sex and age ratios (adjusting to consume exactly the available forage). The concept of population stability (Giles et al. 1969) operates to proportion the population by sex, age, and natality to produce a population not only likely to consume just the right amount of forage but to have a zero rate of change.

Then mortality factors come into play. Natural mortality is accommodated in the age data and life table computations based on them. In addition to the hunting-caused mortality (discussed later), poaching loss is entered. This is a percentage selected at random (the student number is the random number generator seed) from a normal distribution with a mean of 10 and deviation of ±5. Crippling losses are accounted by the same process with percentage losses being 30 ± 5% of the reported legal harvest. These percentages are multiplied as proportions to determine total harvest.

Hunting success varies with the weather (Mechler 1969, Curtis 1970) and this is simulated by selection at random from a normal distribution with mean of 20% ± 5%. The situation is that when it is rainy and cold through the first 3 days of the season, the hunting success is reduced in the area by

HUNT I

Participant No. 7 Number of Play XZ
Years of Full-time Professional Wildlife Experience Zero Randl

The size of your mid-Atlantic-State county is 250,000 acres
Rural acres = 132500. Urban acres = 117500. Potential deer range = 128225. acres
Average food production throughout the county in pounds per acres is 35.
Annual pounds of available food is 8656057.

The natality of the population was 0.80; the adult sex ratio was 90:100
Age ratios in proportion of population:

Fawns	0.42
1.5	0.32
2.5-3.5	0.20
4.5+	0.06

The food supply for deer in your county would support a population like the one you described of not more than 7919. deer.

On the other hand, the same area will support a stable (R = 0) population of 7788.
The mortality factors working were: Loss to poachers — 0.05
Crippling loss — 0.22

The number of permits you issued was 20000.
Based on the weather, the percent hunter success was 18.
Your regulations accounted for a legal harvest of 3488. and a total kill of 4424.

Based on food available, the age structure of the population, and the life expectancy, the regulations should have allowed a total kill within 5% of 3343. (3176. to 3510.)

The difference between the supportable populations as described and a stable population supported on the same area is 131.

The previous calculations stopped the population at the limit of available food. If you had adjusted the kill, based as closely as possible to a stable population (R = 0), then you would have harvested within 5% of 2596. (2466. to 2726.)

You have overharvested the population. Too many deer were removed. Try again.
By being so liberal you are in real danger of mismanagement of user benefits from the population. The sportsmen are angry, far less cooperative in gate closing and fence abuse. One hunting dog owner is making marketing very difficult.
You missed an acceptable (within 5%) harvest by 914.
You missed an optimum harvest by 1081.
5% of the optimum harvest is 167.
The square of the difference is 1168561.

Try to keep the square of the difference at a minimum in future runs. Good Luck.

Fig. 1. A sample of the computer output resulting from the play of Hunt I.

about 5 percent. Rainy and cold opening days occur 1 year out of 10. Whether it will occur during the next season for which the student makes a decision is determined at random.

A permit hunting system is assumed. While rare in the East, the concept is valid and much used elsewhere. Whether permits are issued or not is irrelevent. Sophisticated game managers can calculate the exact harvest needed and the exact season type and length to achieve such a harvest (Giles and Conlin 1974 unpub. MS). The complications of season, weapon, fees, etc. are beyond the scope and purpose of this educational unit. The idea of permits integrates, for simplicity, these facets of a much more complicated decision.

Beyond this point of the computer program, comparisons are made between the decision to harvest and its results and desired conditions i.e. population stability. Statements are made providing students some realism and feedback for improved plays.

As a final output statement, an economic analysis of loss is printed if there are excessive deer (above the calculated carrying capacity) resulting from the student's decisions. The economic analysis is:

$$D = A \times C \times T \times Y \times M$$

Where D is the damage caused by excessive deer

Where A is 0.33 or one-third of the excess animals are assumed to forage out of their range onto cropland.

C is the pounds of soybean plants eaten per animal per day (1 large plant = 1 lb.)

T is the time of feeding on soybeans and is assumed to be 42 days (5 to 7 weeks)

Y is yield in bushels per plant. Based on computation of 154 pods/row foot producing 22 bu/ac. (60 bu. is very high), plant rows being 36 inches apart, row length being 208 ft. per acre, and there being about 35,000 plants per acre at 5 inch spacing, then the bushels per plant are 0.00063.

M is the current market price of soybeans in dollars per bushel. The initial value is $7.00

Hunt II is identical in all but computer output with Hunt I. After a student plays Hunt I five times, the computer provides not only a printed statement, but also one punched card. He is thereafter provided the opportunity to insert this card into his deck and to play the game in a continuous mode. This scheme provides the realistic situation that each year the population is a function, not only of forage but also of all previous decisions. An option is provided for variables to fluctuate at random, producing a simulation more like that of nature. The student may choose a card specifying whether discrete or random operation of the system is desired. For each play of Hunt II, a new random number seed is taken from the computer clock, providing a new situation for every student. Each new play of Hunt II results in a punched card which, entered in the next play of the game, provides information about the past situation. Hunt II output is in the format of Fig. 2 which was developed based on students' reactions. After 5 or 10 plays they did not want the more prosaic output, "just the facts" in a table.

Included in Hunt I and II is a record of the years of full-time professional experience which provides a means for feedback and simulator testing. With more experience, the student should perform better initially and converge on the right answer faster.

The column M/100F is the conventional sex ratio of males per 100 females. This and the number of permits are the only two decisions that are usually changed. In addition, the percentages, food production, age structure, sex ratio, and permits may be changed.

The column "existing population" is the number of deer for which food is available as a result of decision in that year.

The relative improvement, I, is the rate of the student's score change

$$I = (\text{Diff}^2_t - \text{Diff}^2_{t+1})/\text{Diff}^2_t$$

Students must key punch only one card: the number of permits they will issue. This was necessitated by the large number of cards that would otherwise be needed to provide the precision required by the discriminating student. Other decision cards to be employed are merely pulled from a pre-punched game deck.

The results of employing the game demonstrate that: (1) There is high student acceptance; (2) There is changed behavior of users toward complex decision making. Students become more conservative in their management decision making, return to information sources or seek advice, and share the game experience with other non-enrolled students and faculty; (3) Students attest to learning a new concept of ecological and economic interrelations; (4) Scores tend to improve. It takes at least "5-years" for a reasonably acceptable level of performance to be reached. Students can

HUNT II

Participant No. 7 Number of Play 20 Years of full-time Professional Wildlife Experience Zero Randl

Year	Birth Rate	M/100F	Life Expect.	Existing Population	Stable Population	Poaching Loss	Crippling Loss	Permits	Hunter Success	Legal Take	Total Kill	Desired Kill	Difference Squared	Improvement Rate Relative	Improvement Rate Average
17	0.8	90	3.0	7179	7061	0.05	0.22	11000	0.18	1918	2433	3031	357604	——	——
18	0.8	90	3.0	7179	7061	0.05	0.22	15000	0.18	2616	3318	3031	82369	0.77	0.38
19	0.8	75	3.0	7232	7061	0.05	0.22	14500	0.18	2529	3207	3315	11664	0.86	0.54
20	0.8	100	3.0	7149	7061	0.05	0.22	14750	0.18	2572	3263	2867	156816	−12.44	−2.70

Fig. 2. Output from Hunt II. The detailed text of Hunt I was eliminated based on student reactions. The length of the table increases in the number of plays.

become "hooked" on the game, playing it to win, rather than as a learning medium. This presents no significant problem and is easily corrected.

The educational units presented are an improved method for environmental education and are presently in use. Used in conjunction with other similar computer-based educational units, Hunt I and II can become modules in a complex and interactive educational program for total natural system management.

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LAW ENFORCEMENT SESSION

SOME DANGERS OF ENDANGERED SPECIES PROGRAMS

by

ROBERT H. CHABRECK

School of Forestry and Wildlife Management

Louisiana State University

Baton Rouge, Louisiana

Fossil remains in the earth's crust reveal that plant and animal communities have undergone gradual changes throughout the ages. Species or individuals which were unable to adapt to environmental changes were lost and replaced by those more adaptable. In prehistoric times, such losses were part of a natural series of events; however, whenever man arrived on the scene these events become more complex. As man advanced in numbers and wisdom he gradually dominated other living forms and the effects of his presence became more and more acute. In fact, the point may be nearing when man's activities will not only be a threat to the survival of other living things, but to his own existence as well.

Considerable attention has been focused on the extinction of species in historic times and the extinction rate is no doubt increasing with the increase in human population and technology. Approximately 120 species of mammals and 162 species of birds have become extinct since 1600, and about 290 forms of mammals, 300 birds, and 210 reptiles and amphibians are presently considered in danger of extinction. Of these, 71 species of mammals, 65 birds, and 19 reptiles are regarded as critically endangered and survival is doubtful unless strong protective measures are taken. The loss of invertebrate species during this period was no doubt many times greater than vertebrate forms.

The rapid decline of certain species and the increasing numbers becoming extinct are a concern of conservationists around the world. Because of this concern, two important pieces of legislation have been enacted by the U. S. Congress in recent years in an effort to provide added protection to species in danger of extinction. These were the Endangered Species Conservation Act of 1969 and the Endangered Species Act of 1973. Other legislation enacted which afford added protection to endangered species were the National Environmental Policy Act of 1970 and the Marine Mammal Protection Act of 1972.