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A LAND MANAGEMENT MODEL FOR RUFFED
GROUSE AND TIMBER REVENUES

presented by

Gretchen A. Hayslip

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of the requirements for

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A LAND MANAGEMENT MODEL FOR
RUFFED GROUSE AND TIMBER REVENUES

By

Gretchen Ann Hayslip

A THESIS

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ABSTRACT

A LAND MANAGEMENT MODEL FOR
RUFFED GROUSE AND TIMBER REVENUES

By

Gretchen Ann Hayslip

This paper introduces an interactive computer model for forest landowners who want to manage their land for ruffed grouse (Bonasa umbellus).

The model identifies grouse activity centers based upon the types and ages of the vegetation present on the user's land as needed by grouse for food, shelter and reproduction. It predicts the number of grouse present on the user's land without habitat management. The model predicted a range of grouse numbers that include the numbers of grouse estimated by actual field surveys.

The model then recommends the blocks of land to be cut and predicts the number of grouse that will reproduce on the landowner's property if they follow the computer generated cutting plan. It also shows the landowners the revenues they will recieve from cutting timber on their land. Landowners are given the opportunity to try their own cutting plans for comparison with the computer recommended plan.

ACKNOWLEDGEMENTS

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INTRODUCTION

Many landowners would like to know how to better manage their land for ruffed grouse (Bonasa umbellus) and to be able to predict timber revenue/grouse trade-offs. Private citizens own land for numerous reasons, including recreation, hunting, fishing, aesthetics, and timber revenues to name a few. According to the National Survey of Fishing, Hunting and Wildlife-Associated Recreation 2,309,000 people hunted for grouse in 1980 (USFWS, 1982a, p.23); 166,500 in Michigan (USFWS, 1982b, p.9). However, landowners are often reluctant to harvest timber on their land. The reasons behind this include the belief that leaving a forest alone will maximize its benefits, ignorance of the necessary treatments, and a general mistrust of both loggers and timber harvesting procedures.

This paper introduces an interactive computer model for landowners and shows them how to manage their land for grouse and timber revenue/grouse trade-offs. The model first predicts the number of grouse on the user's land without any habitat management. It predicts the grouse starting at present, and continues to predict the population at ten-year intervals for as long as users desire to manage their land. Then it prescribes a grouse-oriented tree harvesting strategy and predicts the number of grouse and timber revenues that will result from this strategy. Comparing grouse numbers with and without habitat management demonstrates to landowners the advantages of managing their woodlot. Further, this model provides landowners with a tool to see how harvesting timber on their land will affect their grouse population before they actually cut any trees.

The landowners are also given the opportunity to try out their own cutting plans in the model. Then the users can compare the grouse numbers, revenues and present values from cutting the timber according to their own cutting plan with the results of the computer generated cutting strategy.

LITERATURE REVIEW

Mature ruffed grouse spend their entire lives in a small area, being a non-migratory species. Therefore, good grouse habitat must contain the required food and shelter for the species in a relatively small area. Michigan's grouse range is generally located in the northern half of the lower peninsula, the upper peninsula, and throughout pockets of forest in the agricultural areas in the southern part of the state (Palmer, 1963). Each area occupied by a grouse pair contains an activity center, defined as a "central area of intensive activity in the proximity of one or more drumming logs used by a single male grouse" (Gullion, 1967, p.89). If a young adult male tries to occupy an activity center already defended by another male, he must challenge, move on or die. Hens mate only once a season and raise their broods without any assistance from the male. After a three week incubation period, hens lay an average of ten eggs in a clutch (Gullion, 1972). Soon after the eggs have hatched, the hen leads her brood from the nest and neither the hen, nor her brood, return to the nesting site. If the first clutch of a hen is lost, the hen may renest. Gullion (1972) expects no more than three or four chicks of a brood of ten will survive the summer.

Ruffed grouse are browsers whose diet consists of the buds, fruits, leaves, and twigs of various shrubs, herbs, and trees. A primary characteristic of good grouse habitat is a diversity of plant species (Bump et al., 1947). The larger the number of required vegetation types within an area, the greater the number of grouse that can be expected in that area.

Brood Cover

Generally, hatching begins during the last week in May and continues until the second week in July, with the peak being the first week in June (Kubisiak, 1978). In Alberta, Rusch and Keith (1971b) found the average number of eggs per nest to be eleven, while in Minnesota Gullion (1972) found an average of ten. During the first ten days following hatching broods may move considerable distances while remaining in either upland hardwoods or brush areas. Following this time period broods settle into a more definte range for the remainder of their brood life. Survival rates for the entire twelve week brood period are 51 percent according to Rusch and Keith (1971b). The diet of young grouse is mostly insects, but by the middle of July it has changed to plant material (Bump et al., 1947). Ruffed grouse broods require an interspersion of feeding and shelter areas with frequent access to herbaceous vegetation. Ruffed grouse use dense sucker stands of aspen (Populus spp.) less than ten years old for brood cover (Gullion, 1972). According to Bump et al. (1947), the cover most frequented by broods were overgrown areas deficient in conifers, patches of aspen, birch (Betula spp.) or alder (Alnus spp.), second growth hardwoods and recently cut over areas. Females with broods spend most of their time from mid June to early August in lowland and aspen areas. On the Sandhill Wildlife area, Wisconsin, 94 percent of all broods were flushed in either aspen stands or within 100 meters of an aspen stand (Kubisiak, 1978).

Winter, Nesting, and Breeding Cover

Male ruffed grouse display intensely territorial social behavior. Drumming by males in spring is an announcement to females and a warning to other males. Males usually establish individual territories during their first fall and winter. Rusch and Keith (1971b) give some evidence that some young males are non-territorial and that the proportion of these non-territorial males is inversely related to population density in the Rochester, Alberta area. Once territories are established, the birds become sedentary and spend most of their time within a quarter mile radius. Drumming activity is most intensive during the spring but some logs are closely attended throughout the summer. Fall drumming log attendance approaches spring activity levels (Gullion, 1967).

The surrounding vegetation is the most important factor in the selection of drumming sites. In Minnesota, Gullion and Marshall (1968) found few losses from predation occur on the drumming log itself, rather the losses occur in the proximity of the log, the activity center. It is believed that predators learn to attack the grouse while they are on their way to or from the perennial drumming log. Palmer (1963), Boag and Sumanik (1969), and Rusch and Keith (1971a) indicate that male ruffed grouse select sites with a high density of woody stems and a sparce canopy of low shrubs. Drumming male grouse display a strong preference for aspen according to many authors including Kubisiak, (1978); Boag and Sumanik, (1969); and Gullion, (1972). Gullion and Marshall (1968) found that the survival of grouse declined as the frequency of tall pine trees (Pinus spp.) increased within the Cloquet forest area, Minnesota. The larger proportion of kill found by Rusch and Keith (1971a) in both the spruce (Picea spp.) forest and near the spruce-aspen edge in Alberta, indicates that coniferous cover may be detrimental to ruffed grouse. The selection of a drumming site with a lower density of shrubs and a higher density of stems of young trees, affords protection from raptors and early detection of ground predators.

In general, ruffed grouse live in the portion of North America where temperatures are below zero for extended periods and snow is on the ground for much of the winter. Where deep soft snow is available, grouse spend the coldest parts of the winter in burrow-roosts several inches below the snow surface. Therefore, snow depth and quality is an important factor affecting grouse populations. If snow conditions are not suitable for burrowing, it could result in either increased predation, or a worsening of the general body condition of the grouse.

Female ruffed grouse prefer areas lacking in coniferous cover for nesting, in particular pole stage aspen (Gullion, 1972). According to Bump et al. (1947) females also prefer second growth hardwoods for nesting.

Winter Food

For the Connecticut Hill study area, New York, Bump et al. (1947) found that ruffed grouse are attracted to coniferous areas in the winter. Dorney (1959) in Wisconsin, Gullion (1970) in Minnesota, and Berner and Gysel (1969) in Michigan, did not find such a distinct attraction to conifers in the winter. According to Dorney (1959), grouse prefer northern hardwoods areas for roosting. Flower buds of aspen are the most important source of winter food for grouse (Gullion, 1972). Dorney (1959) found ironwood (*Caprinus spp*.) to be the principal winter food of grouse, however in this area of northern Wisconsin, aspen is rare. Soft snow is used for roosting and furnishes protection from winds and cold temperatures. Grouse obtain most of their food from upland tree species, so the presence of soft snow allows the birds to feed and roost in the same general area.

Other Factors Influencing Grouse Populations

Predation

In Minnesota, Gullion and Marshall (1968) found that the ground level food resources in most Cloquet forest habitats appeared equally satisfactory for adult grouse, but some forest habitats provide better cover for raptors, primary predators of ruffed grouse. Grouse have cryptic coloration, so that the best grouse cover occurs where the bird can maintain continuous surveillance of their surroundings. A canopy of deciduous trees provide the best cover to protect grouse against predation (Gullion, 1972).

Hunting

According to several authors (Bump et al., 1947; Gullion and Marshall, 1968; and Palmer and Bennett, 1963) the general effect of man's hunting on grouse populations is not detrimental. In Michigan, Palmer and Bennett (1963) found that populations on both hunted and unhunted areas declined by approximately 50 percent from late September to mid December. The more grouse that hunters harvest early in the season the less grouse remain available to predators later in the season.

Cycles

Ruffed grouse and snowshoe hare (*Lepus americanus*) are considered the principle prey species involved in the ten-year cycle of northern forested regions. The chronologies of the fluctuations in these species have been similar, with a tendency for grouse to be the first to peak and the first to decline (Rusch and Keith, 1971b). The periodic fluctuations are not so much the result of accelerated losses among grouse as they are a failure to recruit young birds each season (Gullion, 1970). Most hypotheses on ten-year cycles consider intrinsic factors, such as territorial behavior and genetic quality, to be more important in the determination of grouse population numbers than extrinsic factors such as climate, food, predation, and disease. Both in Alberta (Rusch and Keith, 1971b), and in Minnesota (Gullion, 1970) , predation is the most important proximal source of grouse mortality. In the Rochester area, Alberta, the increased survival of young grouse, and thus an increase in the numbers of grouse, seemed to be a function of lowered rates of predation on grouse (Rusch and Keith, 1971b). It is believed that these extrinsic factors, while critical sources of mortality, involve losses of surplus birds that would have died anyway. However, two facts which imply that extrinsic factors may have some effect upon the cyclic fluctuations in ruffed grouse numbers are the synchrony of fluctuations throughout much of the ruffed grouse range, and the large numbers of grouse lost through predation. More recent theories include the decreased digestability of tree buds due to an increase in the presence of phenols resulting from increased consumption by high numbers of grouse (Gullion, unpublished report at the Ruffed Grouse Society Workshop, Michigan State University, 1983.)

Need for the Model

This model is desgined for use by private forest landowners. Many private woodlot owners do not practice good management for a variety of reasons including the belief that leaving a forest alone will maximize its benefits, ignorance of the necessary treatments and a general mistrust of both loggers and timber harvesting procedures (Koelling and Kidd, 1982). In a Minnesota study, only five percent of the respondents stated that a forest management plan had been made for all or any part of their land (Ellefson et al., 1982). Another ten percent of the landowners responded that they planned to prepare a management plan within the next five years and an additional 25 percent indicated that they might prepare a plan in the future (Ellefson et al., 1982). In Maine, Zeichick and O'Keefe (1983) also reported that many woodlots are totally unmanaged, or managed indifferently.

MATERIAL AND METHODS

This model identifies ruffed grouse activity centers based upon the types and ages of the vegetation present on a piece of land. The landowners input information used by the model concerning their land.

The land map, prepared by landowners, consists of an 8 column by 16 row grid, or 128 blocks, with each block representing a 2.5 acre section of land. For each 2.5 acre block, the type and age of the vegetation within the block must be determined. Figure 1 lists the vegetation types and related age classes. Hardwood trees are divided into two types. The first type, lowland hardwoods, include white ash (Fraxinus americana), soft maple (Acer spp.), elm (Ulnus spp.), and cottonwoods (Populus deltoides). The second type, upland hardwoods, includes black walnut (Juglans nigra), black cherry (Prunus spp.), red oak (Quercus spp.), beech (Fagus spp.) and yellow birch. The conifer type consists of pine, spruce, white cedar (Thuja occidentalis), and fir (Abies spp.). Alder, dogwood (Cornus spp.), winterberry (Ilnex spp.) and other shrub species constitute the brush type.

VEGETATION TYPE	AGE CLASSES (IN YEARS)
ASPEN	0-10
LOWLAND HARDWOODS	11-20
UPLAND HARDWOODS	21-30
SWAMP CONIFERS/PINES	31-40
FIELDS	41-50
BRUSH	51-60
MARSH	61-70
WATER (PONDS AND LAKES)	71-80+

Figure 1. Vegetation types and related age classes used by model

Landowners enter the vegetation type and related age class for each block of their land. The landowners are asked the age of the vegetation on their land, as opposed to site index, stem density, or other measures, because it is probably the least difficult for them to determine. Users also input the total footage of rivers, streams and/or roads on their property. They also decide how many years they want their land to be managed, between 30 and 80 (in multiples of 10).

Prediction of Grouse Populations

For this model three conditions must be present in order for a breeding pair of grouse to be present on the land. First, aspen greater then 21 years of age are required for winter food. Second, either upland hardwoods 21-60 years old, conifers 21-30 years old, 11-20 year old aspen, or lowland hardwoods 21-50 years old are needed to provide winter, nesting and breeding cover. Third, either aspen or lowland hardwoods up to ten years old, upland hardwoods up to twenty years old, or brush of any age must be present for brood cover. Other authors, including Gullion (1972) and Dorney (1959), have demonstrated the use of these vegetation types by ruffed grouse for this region of the country.

Activity centers predicted by this model are due to any one of three factors: the juxtaposition of vegetation types; openings produced by fields, marshes, lakes, and/or ponds; and borders caused by rivers, roads and/or streams. First, however, the four squares of land surrounding each block are checked to see if they contain an activity center. Due to male ruffed grouse territoriality, activity centers can not be within ten acres of one another. If the surrounding squares do not contain activity centers, the model then checks the type and age of the vegetation within each block to determine if it meets any of the three conditions previously stated. If within the block itself, or the square above it, to the right of it, or diagonally to the right of it, these three vegetative conditions are met, then an activity center will exist. The total acreage of fields, marsh, lakes, and/or ponds divided by 40, results in the number of activity centers due to openings. For every quarter mile of river, road and/or stream present on the land, another activity center is calculated. The total number of activity centers is determined by adding up the centers due to vegetation, openings and borders. However, no more than one activity center can be expected per ten acres due to grouse territoriality (Gullion, 1972). Therefore, if the total number of activity centers is calculated to be larger than one per ten acres, this number is reduced.

The model gives a range for both the number of spring breeding pairs and fall populations. The fall population is estimated to contain within each activity center the breeding pair plus three to four chicks. If all of the activity centers calculated for the land are due to vegetation, the total number of birds will range between five and six times the number of activity centers. In the case of zero activity centers, 0-1 pairs and 0-6 total birds will be predicted for the land, because of the natural variability of grouse populations. If the total number of activity centers is greater than the number of pairs due to vegetation, then the number of grouse determined to be present will be between the number of pairs due to vegetation (and this number multiplied by five birds) and the total number of pairs (and this number multiplied by six birds). However, if there are zero activity centers calculated due to vegetation, but the total number of centers is greater than zero, the number expected will lie between zero pairs (zero birds) and the total number of pairs (this number times six birds). The reason behind this is that although the land contains enough openings and/or borders to support a breeding pair, if it does not provide sufficient food and cover, grouse may not be present on the land. The model also projects future grouse populations on the land entered by landowners, in ten-year increments.

Recommending a Timber Harvesting Plan

After the model predicts the grouse population without any management, it prescribes a cutting plan for the landowners to follow in order to maximize the grouse population on their land. Timber is harvested in 2.5 acre blocks at ten year intervals starting with the present year and continuing as long as the landowners desire. The three vegetation types cut; aspen, lowland hardwoods and upland hardwoods, provide the most productive habitat for ruffed grouse in this region of the country. Other tree and shrub species produce grouse but less is known about their management. The grouse population on the land, as altered by the cutting plan, is predicted starting with year ten and continues in ten year increments for as long as the landowners desire. The cutting procedure recommended by the computer harvests timber on the landowner's property to achieve an interspersion of age classes. The details as to which blocks of land are recommended to be cut is presented in the subroutine MGMT section. In addition the computer shows the revenues the landowners recieve if they follow the recommended cutting plan.

Calculating Timber Revenues

Before the model determines revenues from the acres of timber cut, the landowners are given the opportunity to change, if desired, the prices used for mature aspen, lowland hardwoods, upland hardwoods, and/or swamp conifers/pines. The prices the model uses are representative of prices found in the northern half of the lower peninsula of Michigan for medium stocked, medium productive sites determined from an average of 1983 stumpage prices from Timber Mart North (1983). The model lists revenues from those acres cut within the past ten years only, and the net present value of revenues generated up until this point in time. Equation (1) is used to calculate the net present value:

$$\text{Net Present Value} = \frac{R}{(1 + i)^t} \qquad (1)$$

Where: R = timber revenues
i = interest rate
t = time (years)

The goal of the prescribed cutting plan is to maximize the grouse population on the user's land. However user's may want to consider maximizing their revenues, altering their cash flow patterns, maximizing their present value or some combination. After the model gives it's management recommendations and the expected number of grouse and revenues for the user's land, landowners have the opportunity to enter their own cutting plan. In the cutting plan generated by the model, swamp conifers/pines are not cut because they are not as beneficial for grouse as the other tree types. However, landowners may decide to cut them on their land, so the revenues and net present values generated from swamp conifers/pines are listed for the cutting plan entered by landowners.

Program MAIN

This program accepts a piece of land as an input, predicts the number of grouse on the land at present and produces grouse-maximizing cutting plan. Landowners may enter a cutting plan of their own which will also be evaluated for the change in grouse population and timber revenues. Any name beginning with the characters A-Z is assumed to be an integer. LAND, dimensioned 16 (rows) by 8 (columns), is the two-digit vegetation-age code for the land within each square. CENTRS denotes whether or not an activity center is present on each block.

No activity centers occur in the first row or last column due to a lack of surrounding vegetation. This is a function of the manner in which adjacent blocks are checked in the subroutine MGMT.

LNDCPY is a copy of the LAND matrix. AGES represents the age of the vegetation within each block. TRECUT, is the number of blocks cut of each of three types of vegetation (aspen, lowland hardwoods and upland hardwoods), eight age classes of vegetation and for each quarter of the management plan. TOTCUT gives the total number of blocks cut of each of the three vegetative types and eight age classes. YRTEMP, ACRES and PRICE all have real number values. Both RESPND and ANSWER are three characters in length. The common blocks LANDS, PARAMS and SECTOR represent variables used elsewhere in the program. LOCALE, dimensioned 16 (rows) by 8 (columns), is the location of each block within the grid map. For example, the blocks in the first row have the values 1-8 and 9 is the first block in the second row.

First, the LAND, AGES, and CENTRS matrices are initialized to zero and the LOCALE matrix is set from 1 to 128 (Table 1a, lines 7-14). Then the users are asked if they want a printed copy of the instructions; if RESPND equals yes, then the subroutine INTRO is called. The subroutine MAPKEY is called to remind the users of the age and the vegetation codes that are to be entered for both those who requested a copy of the instructions and those who did not. LCOUNT, the number of blocks of land that are of vegetative types used by grouse (aspen, lowland hardwoods, upland hardwoods, swamp conifers/ pines, and brush) is set equal to zero. The users are then prompted to enter the two-digit vegetation-age code for each LOCALE. The computer reads this as BLOCK. If BLOCK equals -1, the users have finished entering their land. IF BLOCK is less than -1, between 01 and 09, or greater than 89, the computer tells the users that the number that they have entered, for the block in question, is not valid, and it asks them to enter another number.

TYP equals LAND divided by ten, and AGE is the remainder. If the type of vegetation is one of those listed as being used by grouse (TYP = 1,2,3,4, or 6) then one is added to LCOUNT (Table 1b, lines 19-29). N is set equal to I (the number of rows) minus one, and M equals eight. The users then enter the number of feet of streams, rivers and/or roads on their property, the computer reads this as RIVNRD.

ACRES, the number of acres of land used by grouse, equals LCOUNT multiplied by 2.5. MAXGRS, the maximum number of activity centers expected on the land due to grouse territoriality, equals ACRES divided by ten. The landowners then enter how many years they want to manage their land, and the computer reads this as YEARS. YRTEMP equals YEARS divided by ten. YEARS is reset equal to YRTEMP multiplied by ten and rounded off to the nearest integer, making YEARS a multiple of ten. The subroutine NOMGMT is called to predict the breeding pairs of grouse without any habitat management (Table 1b, lines 52-55).

Next, PRICE is set for each of the eight age classes and four of the vegetative types (aspen, lowland hardwoods, upland hardwoods, swamp conifers/pines). The computer shows the users the prices for mature stands (AGE = 8) of the three vegetation types used in the subroutine MGMT and asks if they would like to change this price. If RESPND equals yes, the users enter their own prices and the computer reads these numbers as PRICE for the vegetation type and at AGE = 8. Now the subroutine MGMT is called to prescribe a tree harvesting plan (Table 1d, lines 9-13).

The computer asks the landowners if they have a cutting plan of their own they would like to enter. If ANSWER equals yes, the users are shown the price for mature swamp conifers/pines and asked if they want to change this price. If RESPND equals yes, the users enter a price and the computer reads it as PRICE (4,8). The subroutine OWNCUT is called to evaluate their cutting plan. Finally, the computer calls the subroutine ENDING to print the closing remarks.

Table 1a. Program MAIN

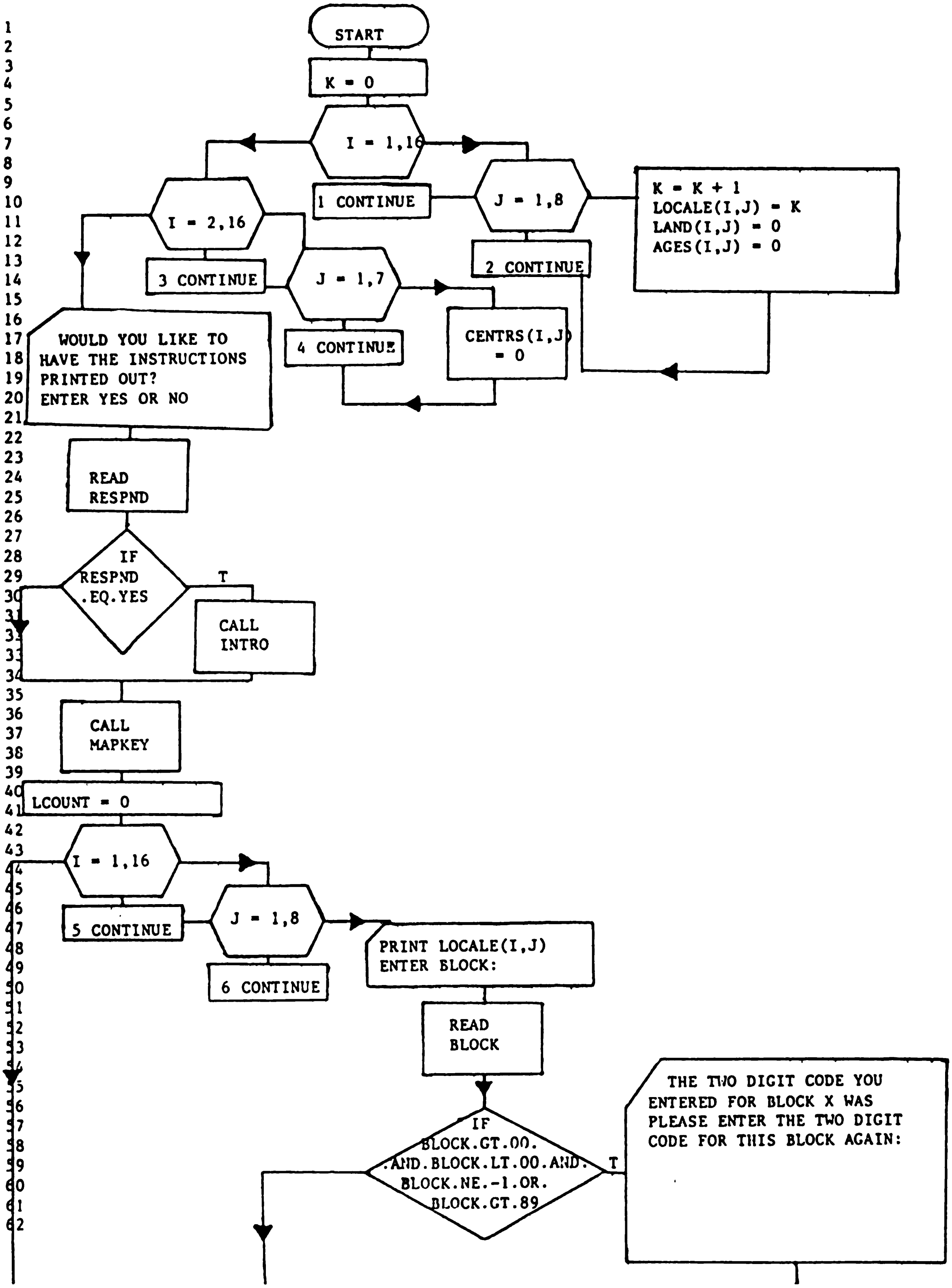


Table 1b. Program MAIN (cont'd)

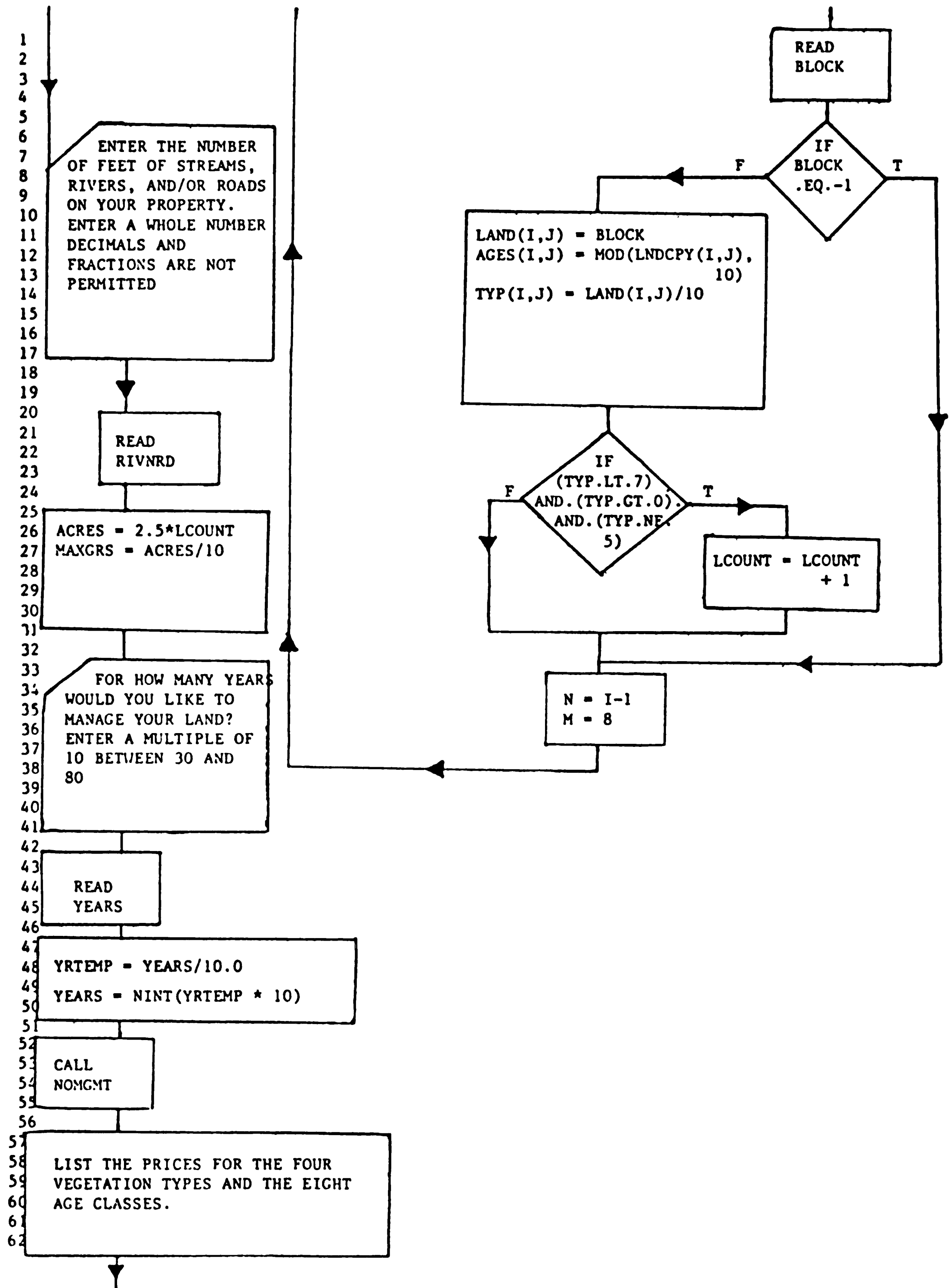


Table 1c. Program MAIN (cont'd)

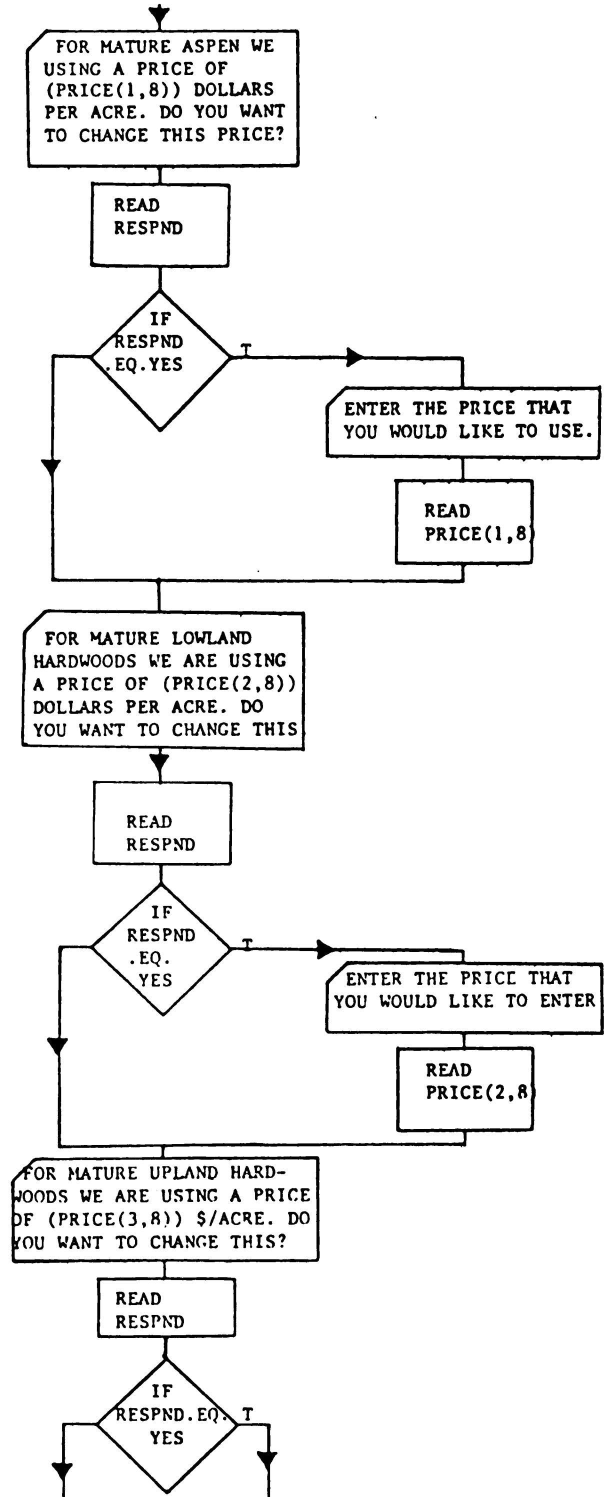
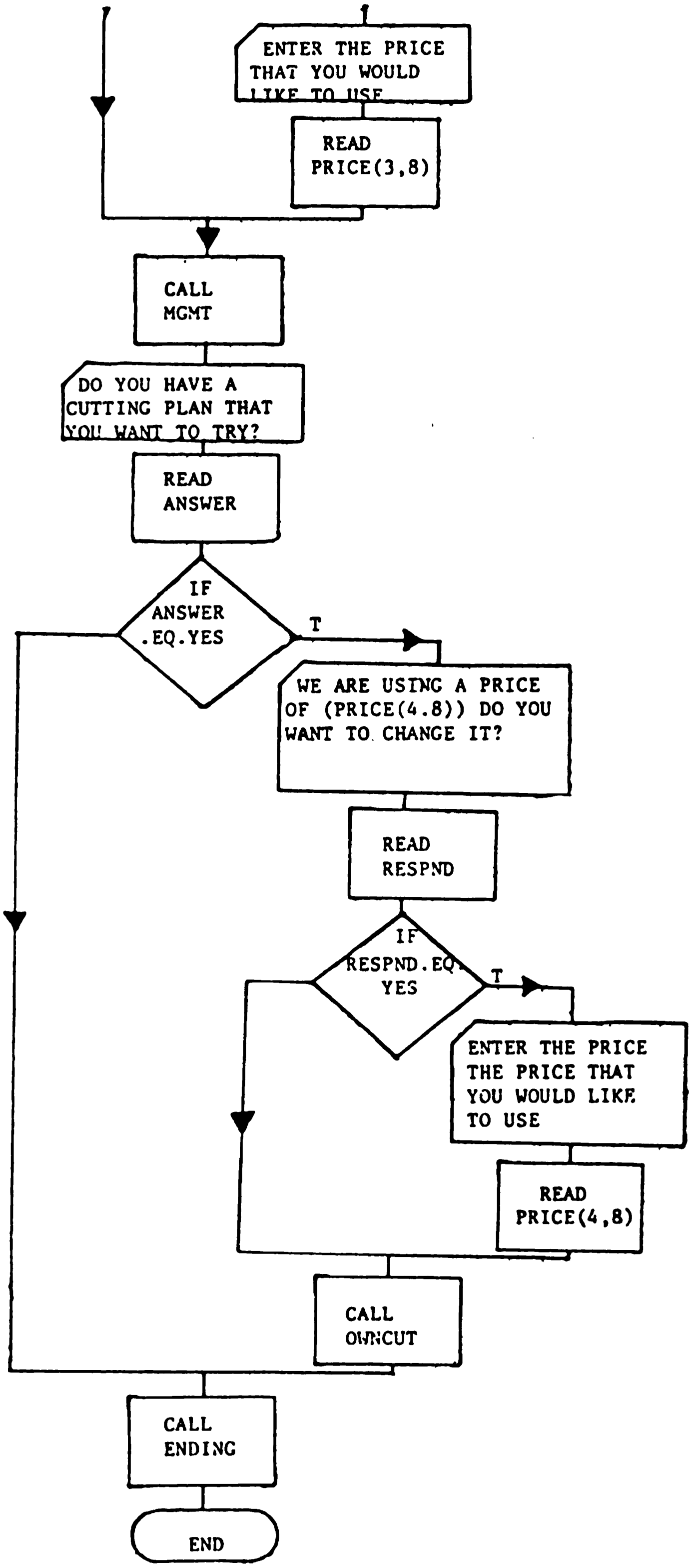


Table 1d. Program MAIN (cont'd)

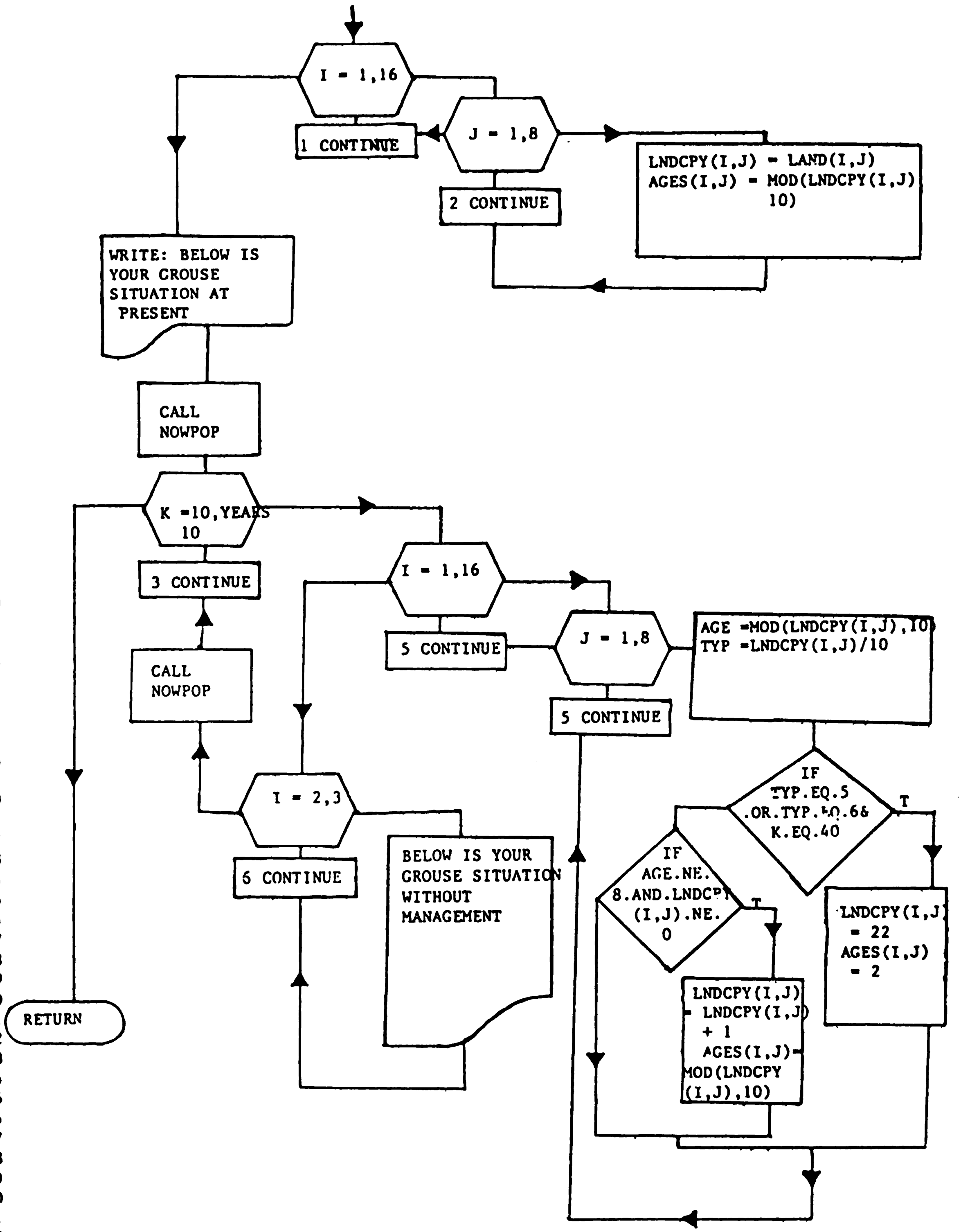


Subroutine NOMGMT

This subroutine predicts the number of breeding grouse pairs on the user's land if there is no habitat management. Any name beginning with the characters A-Z is assumed to be an integer. LAND, dimensioned 16 by 8, was entered in the main program and represents the vegetative type and age of each block of land. The CENTRS (activity centers) array is dimensioned 16 by 7, and was initialized to zero in the main program. LNDCPY is a copy of the LAND matrix, dimensioned 16 by 8, for manipulation. AGES, also dimensioned 16 by 8, indicates the age of the vegetation of the block of land. Of the items in the common block /LANDS/, only LAND, LNDCPY, CENTRS, AGES, and YEARS are used in this subroutine.

First, this subroutine makes copies of the original LAND and AGES matrices for manipulation (Table 2, lines 4-11). It then calls subroutine NOWPOP which predicts the grouse population at present on the land entered. The next step is to convert any brush and/or fields over 40 years old to lowland hardwoods 11-20 years old. Then the age of the vegetation present is increased by ten years, unless there is no vegetation present, or unless the age is 80 (Table 2, lines 46-54). NOWPOP is called again to predict the grouse population on the newly aged land. The conversion of brush and/or fields to lowland hardwoods, the aging of the vegetation on the land, and the prediction of the grouse population, are repeated for the number of years indicated in the main program.

Table 2. Subroutine NOMGMT



Subroutine MGMT

This subroutine calculates the number of activity centers on the land, prescribes a cutting plan within each manageable vegetation type, and calculates the change in the number of activity centers due to the cutting plan. Current revenues, acres cut in the past ten years, total acres cut and the net present value of the timber revenues will be listed.

Any name beginning with the characters A-Z is assumed to be an integer. GO is a logical statement that decides if there are years left to manage the land. LAND, CENTRS, LNDCPY, and AGES are all defined and dimensioned as they were in previous subroutines. TRECUT, dimensioned 3 by 8 by 8, represents the number of acres cut in each age class of aspen, lowland hardwoods and upland hardwoods for every ten year period. The first number, 3, stands for the three vegetation types; the second number, 8, denotes the age class of the vegetation; and the third number, 8, represents the particular time period of the management plan during which the vegetation was cut. TOTCUT, dimensioned 3 by 8, is a running total of all acres cut in each of the three vegetation types and eight age classes, irrespective of the time period they were cut. Of the items in the common block /LANDS/, LAND, LNDCPY, CENTRS, AGES, YEARS, TRECUT, and TOTCUT are used in this subroutine.

First, the computer sets both the TRECUT and TOTCUT arrays to zero. Then a copy is made of the LAND matrix (LNDCPY) for manipulation. The value AGES is the remainder of LNDCPY divided by ten, and it represents the age of the vegetation on each block (Table 3a, lines 27-33). Next, KOUNT is set equal to YEARS. YEARS, the number of years the land is to be managed, was entered in the main program. Q, representing the time period or quarter of the cutting plan, is given the value of two. The quarters are the time period of the cutting plan and may range from 1 to 8, with each quarter representing a ten year period. For example, the first quarter (Q = 1), denotes years 0-10. The cutting starts in the first quarter, but the variable Q is not used until after the second quarter or time period. During the first quarter, the odd row and odd column squares of LNDCPY are cut if of the types and ages designated in the subroutine CKNCT by calling this subroutine (Table 3a, lines 48-53). Subroutine CKNCT evaluates the types and ages of the vegetation and decides which blocks to cut. It keeps track of what types of vegetation and ages of vegetation were cut, and the quarter that they were cut in. Subroutine CKNCT cuts vegetation if it is either aspen, lowland hardwoods or upland hardwoods and over ten years of age.

TYP, the vegetation type of the block, is LNDCPY divided by ten. AGE is the remainder of LNDCPY divided by ten. Both TYP and AGE are defined within each DO loop that does any cutting, including the subroutine CKNCT. Next, any aspen, lowland hardwoods and upland hardwoods 51 to 70 years of age are cut in the odd row and even column squares of LNDCPY. These values are stored in the TRECUT and TOTCUT arrays (Table 3b, lines 21-32). Then the even row, odd column squares of the same ages and types as before are cut and stored (Table 3b, lines 45-55). Up until this point all of the cuts that have been made were in the first year of the management plan, or in Q = 1. Now the first round of cutting is complete.

KOUNT, the variable that tells how many years are left to manage the land, is decreased by ten. PLOTTR is called to make a map to show the user where to make the first set of cuts. Next, PRNTRE is called to print out acres of each type cut in the past ten years, the revenues from these acres, the total of all acres of each type cut and the net present value of the revenues. Then AGEIT is called to age all of the land, including those blocks just cut. To show the effect of cutting upon the grouse population, NOWPOP is called to give the grouse situation after ten years (Table 3c, lines 48-52).

Now the second round of cutting begins. First the odd row, even column squares of LNDCPY are cut, if they are of the designated type and age, by calling CKNCT. Then the even row, odd column squares of 51-60 year old aspen, lowland hardwoods and upland hardwoods are cut. This completes the cutting that is to be done in the second quarter (Q = 2) or year 10. Timber is harvested in the beginning of each quarter. PLOTTR and PRNTRE are called to print out the map and listing of acres and revenues. AGEIT is called to age the land ten more years, then NOWPOP gives the grouse population after twenty years. KOUNT is decreased by ten (Table 3d, lines 50-53).

Now the third round of cutting begins. From this point on the users may enter from between 30 and 80 years as the length of time they desire their land to be managed. One is now added to Q, which was set to two earlier in the program, so we are now in the third quarter (Q = 3) or year twenty. The logical GO will be true when there are still years left to manage. The even row, even column squares of land are cut, if they are of the designated type and age, by calling CKNCT (Table 3e, lines 5-10). PLOTTR and PRNTRE are called again. KOUNT is decreased by ten, and Q is increased by one. AGEIT is called to age the vegetation ten years. NOWPOP gives the grouse situation on the land after (YEARS - KOUNT) number of years of management (Table 3e, lines 34-38).

Now, if KOUNT equals zero, there are no more years left to manage. If KOUNT does not equal zero the computer continues with the subroutine. In the fourth round of cutting, the fourth quarter (Q = 4) or year 30, the even row, odd column squares are cut by CKNCT. PLOTTR and PRNTRE are called, KOUNT is decreased by ten, and Q is increased by one as in earlier rounds. AGEIT is called to age the vegetation ten years (Table 3f, lines 14-18). At this point, any brush and/or fields of any age are converted to lowland hardwoods 11-20 years old. NOWPOP is then called to determine the grouse situation on the land. If KOUNT does not equal zero, then the fifth round (Q = 5) begins.

In year 40, the fifth quarter, the odd row, odd column squares of land are cut by calling CKNCT. In the sixth round (Q = 6) or year 50, if KOUNT does not equal zero, the odd row, even column squares are cut by calling CKNCT (Table 3f, lines 44-48). The seventh round (Q = 7) or year 60 goes back to what was done in the third round, cutting the even row, even column squares of land by calling CKNCT (Table 3g, lines 5-10). In the eighth round (Q = 8) or year 70, if KOUNT does not equal zero, CKNCT is called to cut the even row, odd column squares. In each round the trees are cut at the beginning of the quarter and the grouse situation is predicted at the end of the quarter.

Table 3a. Subroutine MGMT

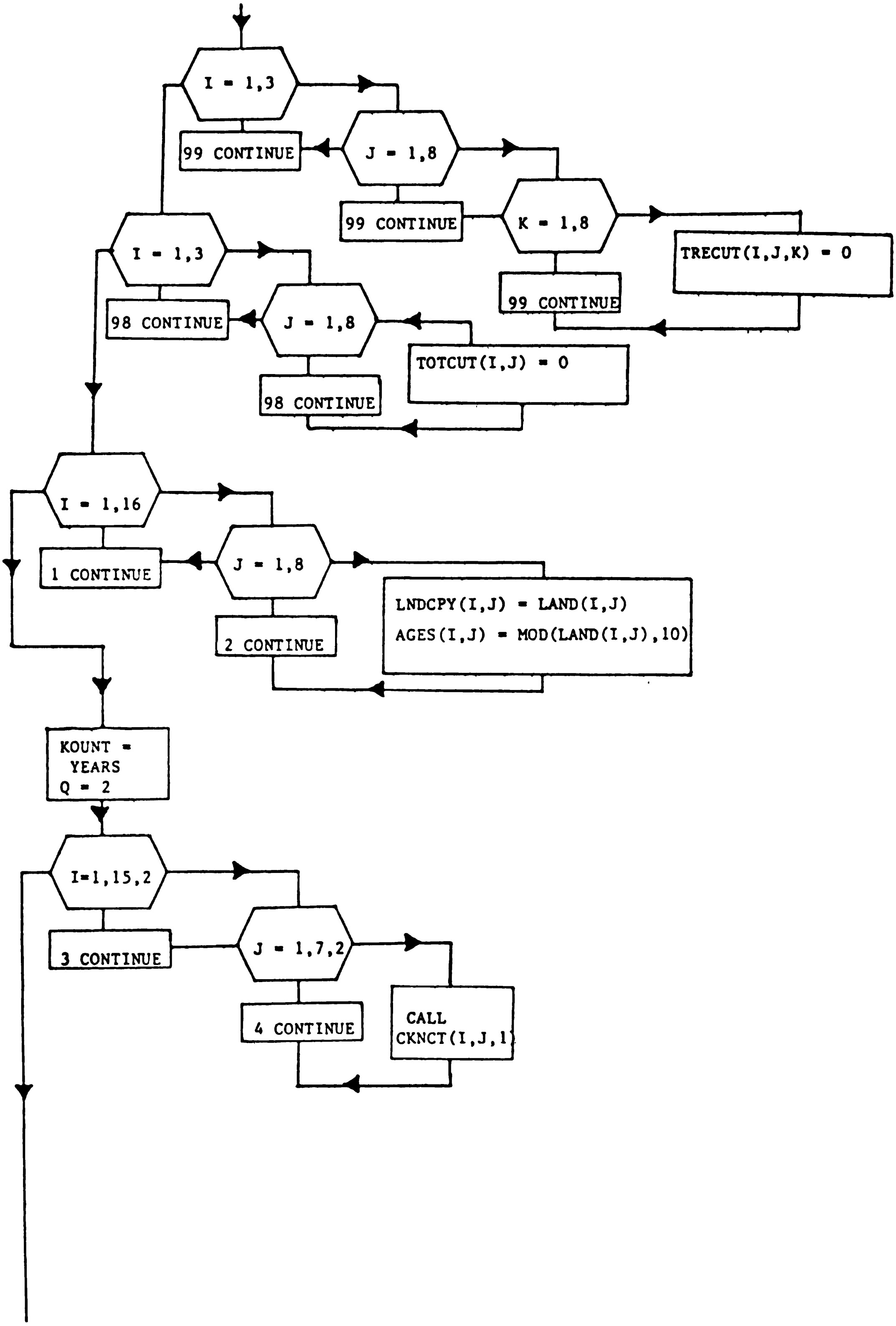


Table 3b. Subroutine MGMT (cont'd)

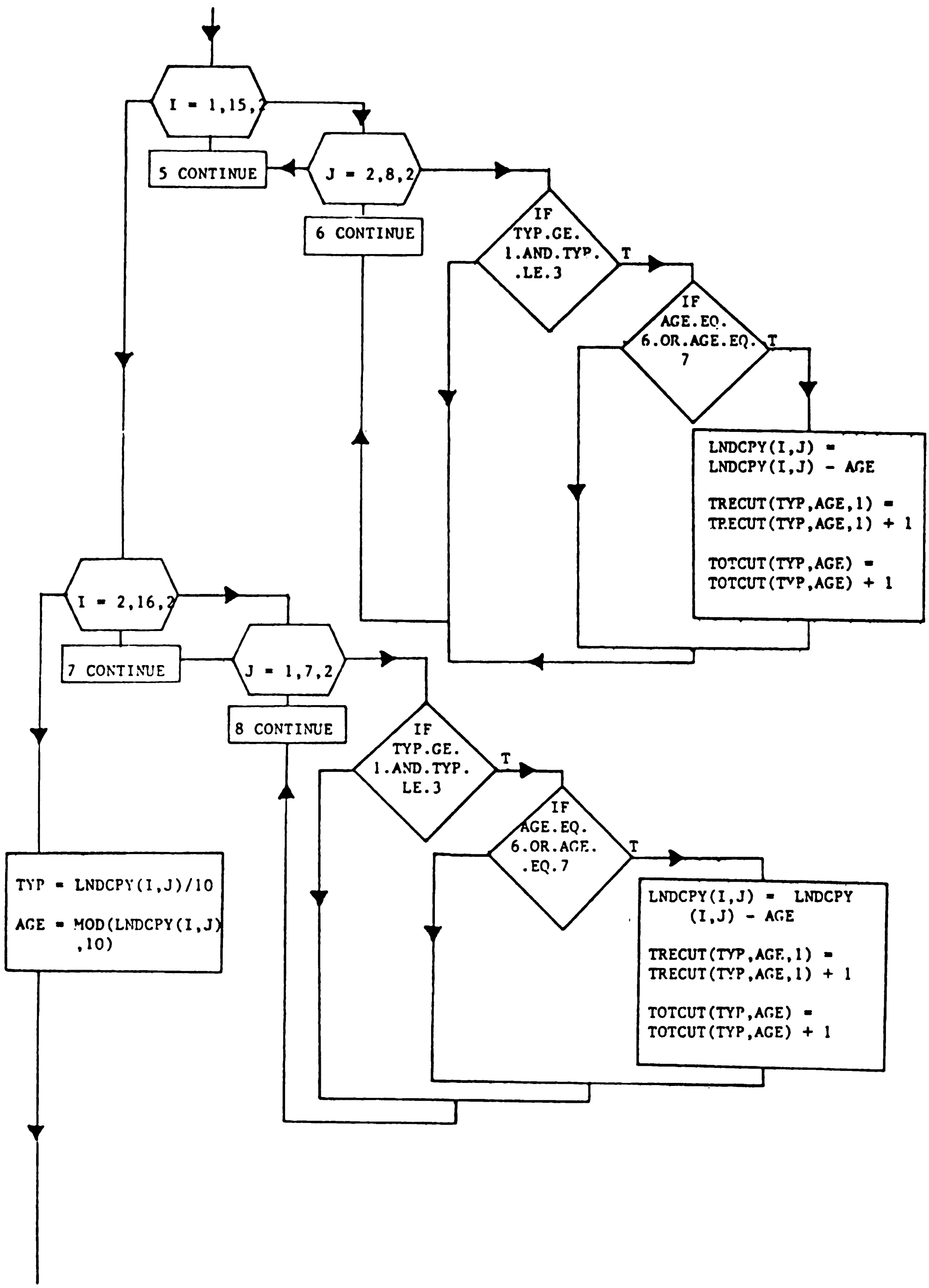


Table 3c. Subroutine MGMT (cont'd)

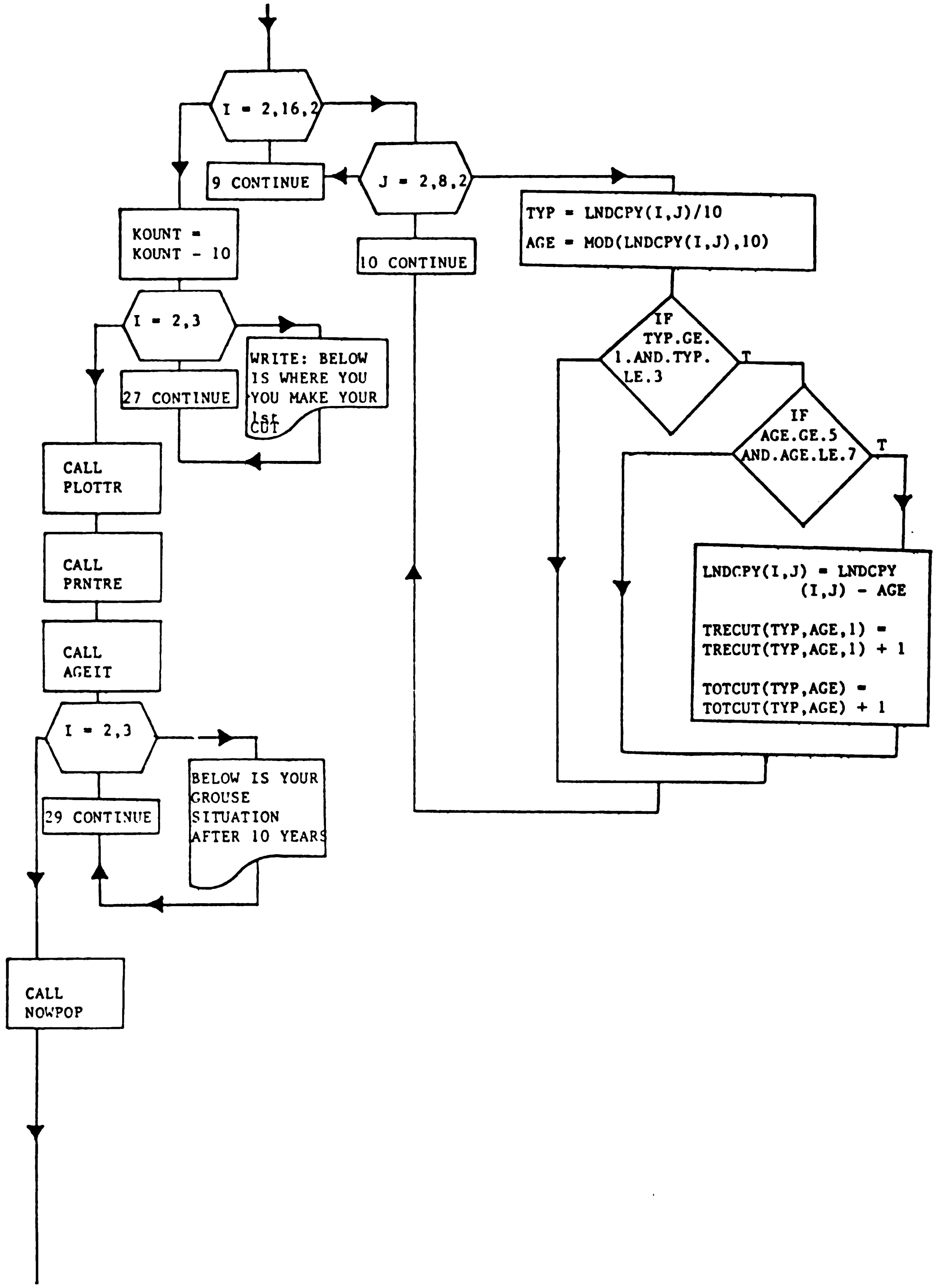


Table 3d. Subroutine MGMT (cont'd)

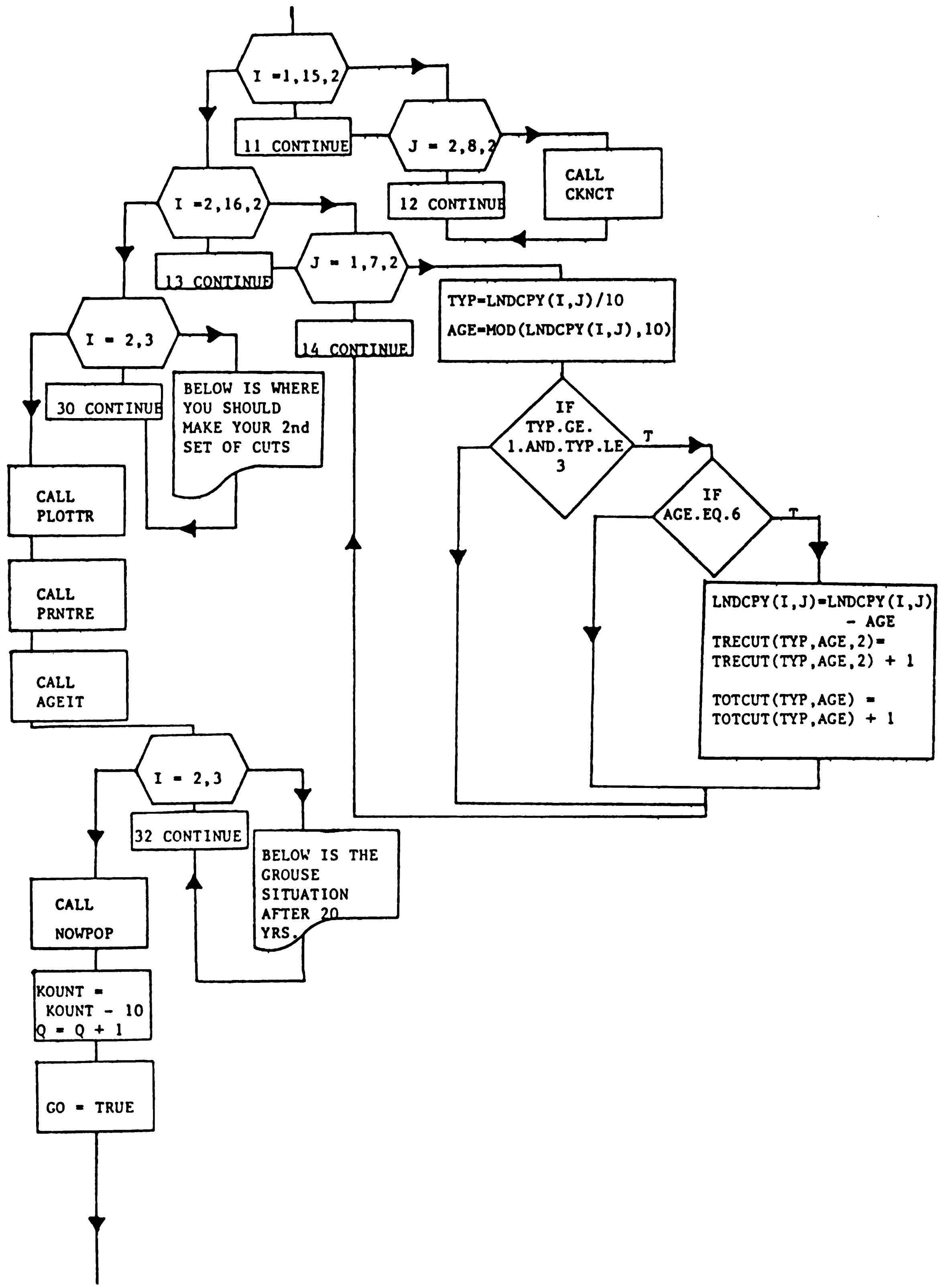


Table 3e. Subroutine MGMT (cont'd)

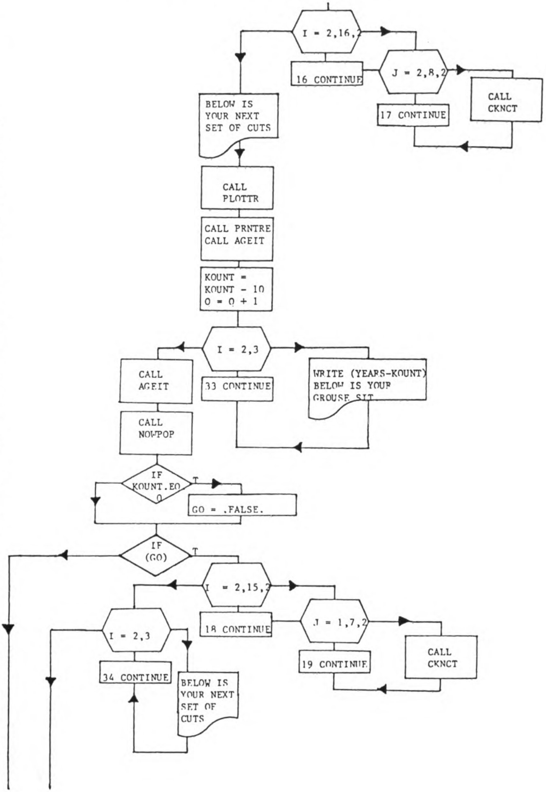


Table 3f. Subroutine MGMT (cont'd)

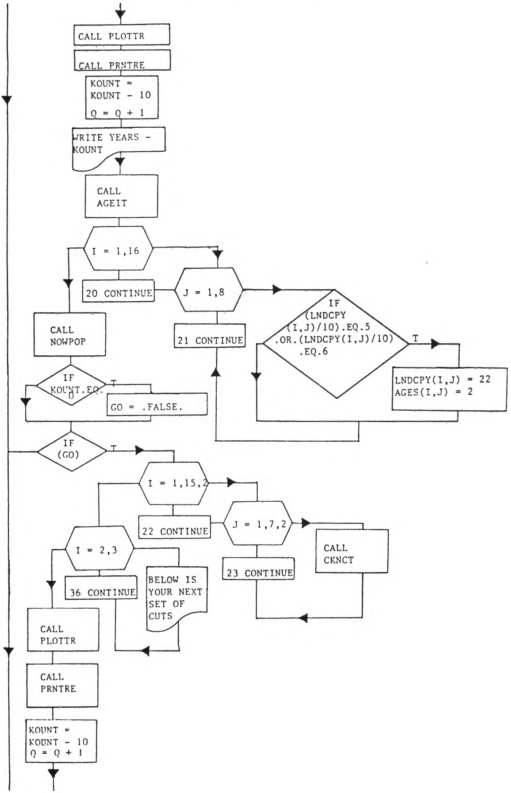
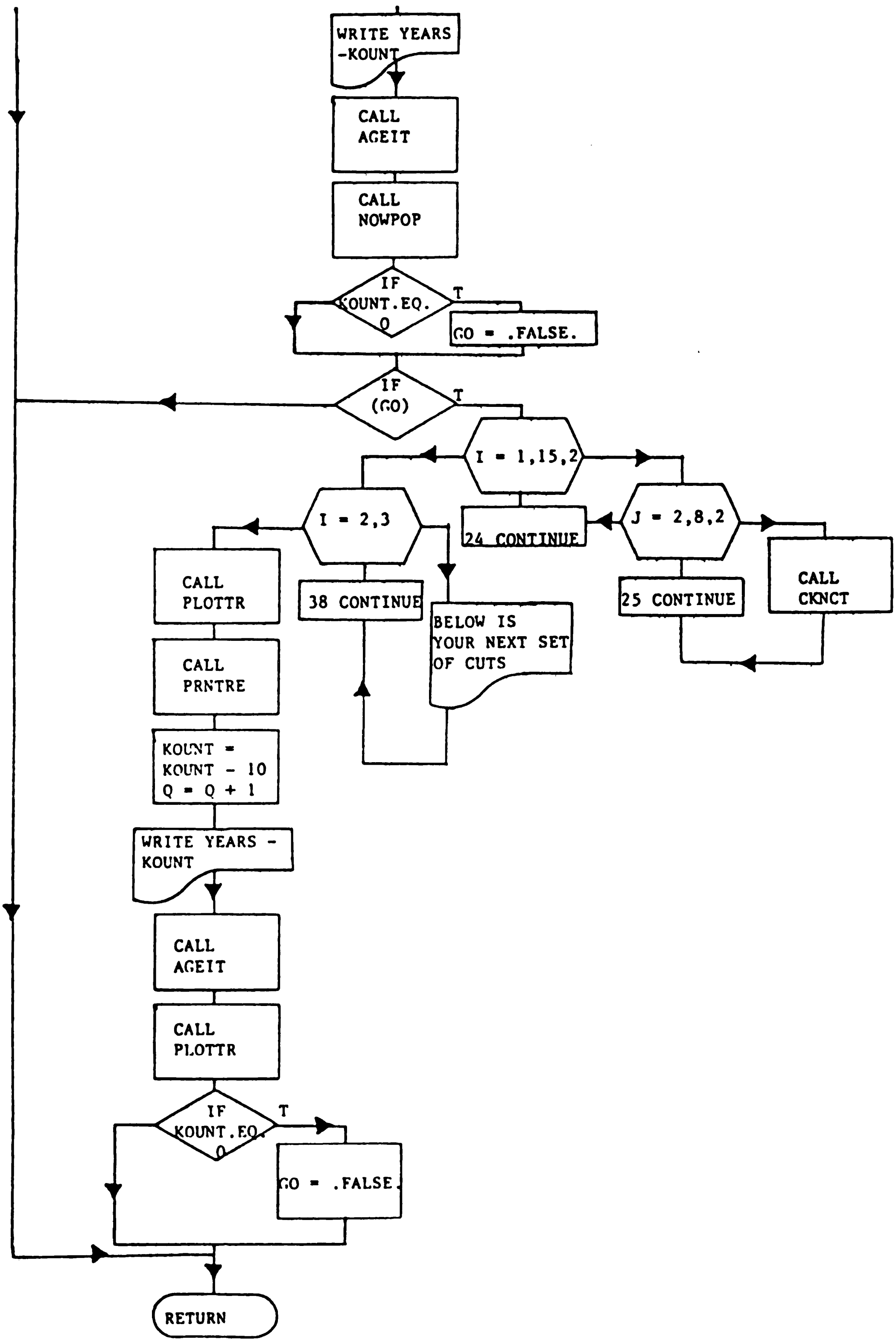


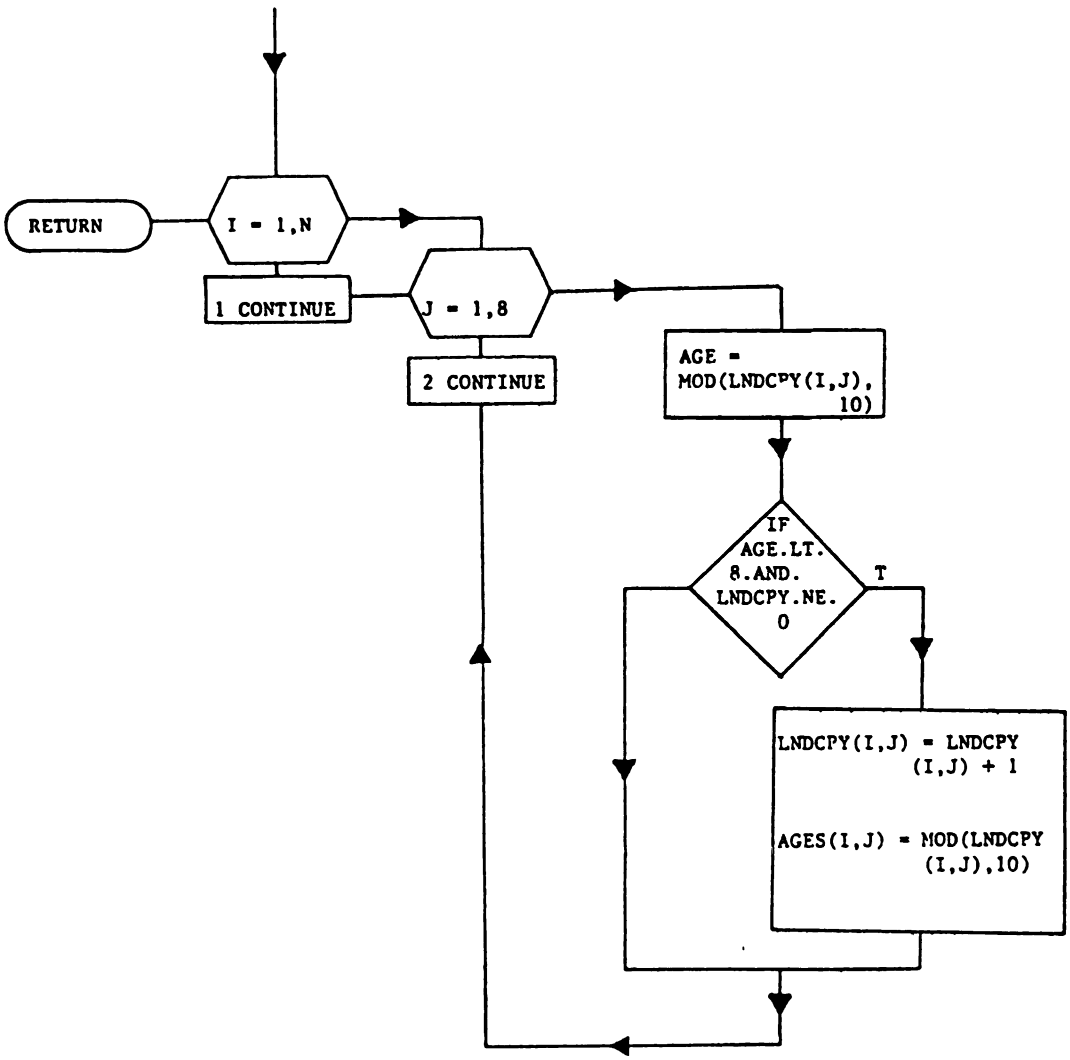
Table 3g. Subroutine MGMT (cont'd)



Subroutine AGEIT

The purpose of this subroutine is to age the vegetation on the land. Integers are implicit from A to Z, and LAND, CENTRS, LNDCPY, and AGES are defined and dimensioned as in previous subroutines. Of the items in the common block /LANDS/ only LNDCPY, AGES and N are used. The vegetation is aged for eight columns and for N number of rows, where N is the number of rows that contain land entered in the main program. AGE equals the remainder of LNDCPY divided by ten. If AGE is less than eight and LNDCPY does not equal zero, the vegetation is aged by adding one to LNDCPY. Once the vegetation reaches AGE equals eight, there is no longer any need to age it because age class eight is 71-80 plus years of age. LNDCPY equals zero for any land that is not to be considered in the analysis. After the land is aged, AGES is set equal to the remainder of LNDCPY divided by ten (Table 4).

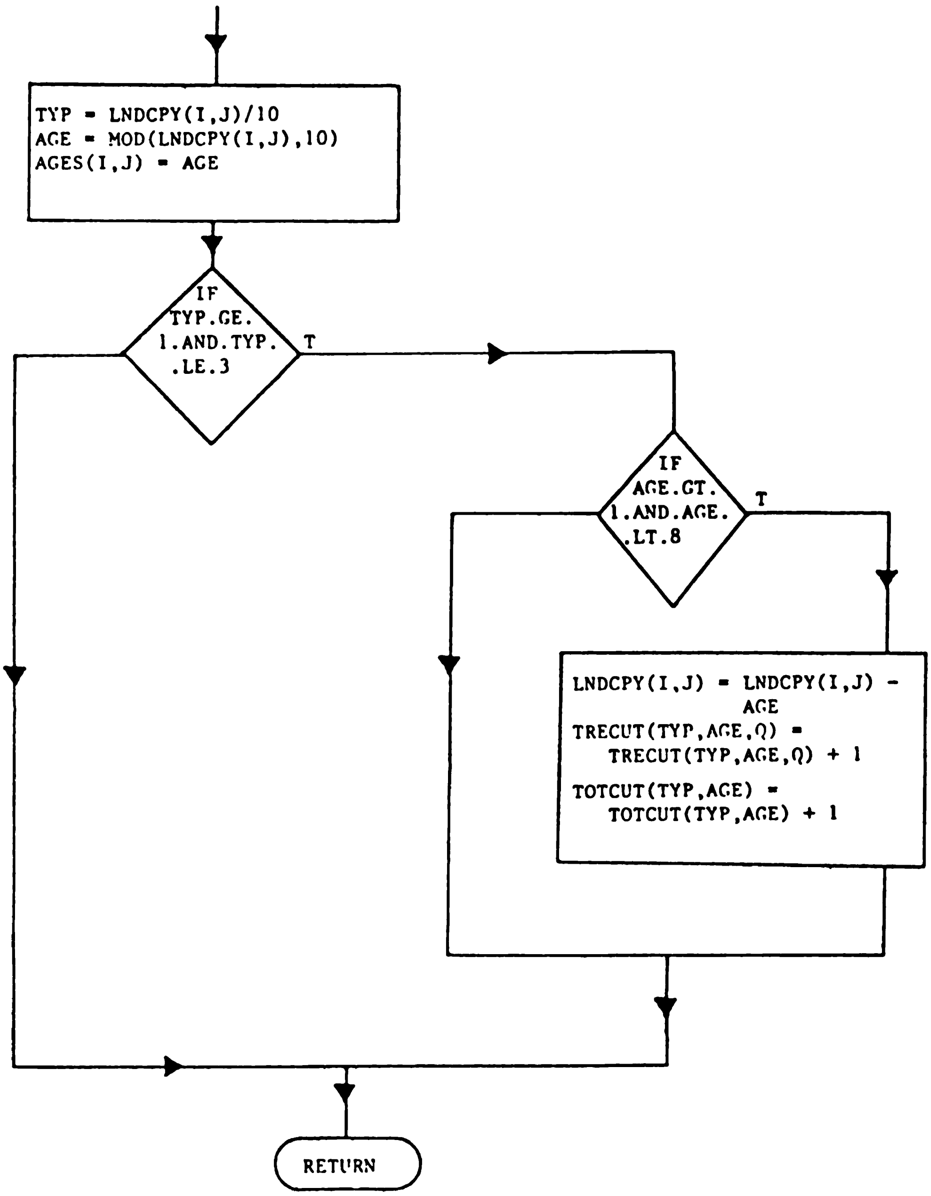
Table 4. Subroutine AGEIT



Subroutine CKNCT

This subroutine cuts the vegetation on a block if it is of the correct type and age. The variables I,J, and Q are carried by this subroutine. Integers are implicit from A to Z. LAND, CENTRS, LNDCPY, AGES, TRECUT, and TOTCUT are all defined and dimensioned as in previous subroutines. Of the items in the /LANDS/ common block, only LNDCPY, AGES, TRECUT, and TOTCUT are used. TYP equals LNDCPY divided by ten. AGE is a whole number. AGES is then set equal to AGE. If the vegetation on the block is aspen, lowland hardwoods or upland hardwoods and it is between 11-80 years of age, then it is cut and the value is stored in the TRECUT and TOTCUT arrays. A block of vegetation is cut by subtracting AGE from LNDCPY (Table 5).

Table 5. Subroutine CKNCT



Subroutine NOWPOP

This subroutine estimates the grouse population that is to be expected on the land entered. Any name, unless otherwise stated, beginning with the characters A-Z is assumed to be an integer. LAND, LNDCPY, CENTRS, and AGES are all defined and dimensioned here as they were in previous subroutines. COND1, COND2, and COND3 are logical statements concerning the types of vegetation thay must be present for an activity center to exist. PSBLAC represents possible activity centers. OPNING, a real value, represents the openings for grouse due to fields, marsh and/or water. Of the items in the common block /LANDS/, only LAND, LNDCPY, CENTRS, AGES, and YEARS are used in this subroutine. All items in the common block /PARAMS/ are utilized. RIVNRD is the number of feet of streams, rivers and/or roads on the user's land, a value entered in the main program. MAXGRS, the maximum number of grouse possible on the land, is calculated in the main program.

First this subroutine clears the CENTRS matrix and sets VEGAC, the number of activity centers due to the juxtaposition of vegetative types, equal to zero. Then the three conditions that are to be met are defined as: COND1, vegetation provides winter resources and nesting cover; COND2, vegetation provides winter, nesting and breeding cover; and COND3, vegetation provides brood cover (Table 6a, lines 10-17). Next, the computer checks for other activity centers near the block. If the block is too close to another activity center it is not a PSBLAC (a possible activity center). Then the four squares around the block in question are checked to see if there are activity centers present (Table 6a, lines 18-64). If these surrounding squares do not contain activity centers, then the vegetation type and the age of the block itself is checked to see if it meets any of the three conditions. Figure 2 is a list of the three conditions and the vegetation types and ages that will meet them. If within the block itself, or the square above it, to the right of it, or on the diagonal above and to the right of it, these three conditions are met, then an activity center will exist (Table 6b, lines 20-65). This is an activity center due to the vegetation types, VEGAC.

CONDITION 1	CONDITION 2	CONDITION 3
ASPEN 21-70 yrs.	UPLAND HARDWOODS 21-60 yrs.	BRUSH (any age)
	ASPEN 11-20 yrs.	ASPEN 0-10 yrs.
	LOWLAND HARDWOODS 11-50 yrs.	LOWLAND HARDWOODS 0-10 yrs.
		UPLAND HARDWOODS 0-20 yrs.

Figure 2. Three conditions necessary for the model to predict an an activity center.

Now NUMOPS, which represents the number of blocks containing fields, marsh and/or water, is set to zero. If a block contains fields, marsh and/or water of any age NUMOPS will equal one. The total NUMOPS are counted and multiplied by 2.5 to arrive at OPNING, the total acres of openings on the land. The activity centers due the vegetation associated with these openings, OPNAC, is calculated by dividing by 40 and rounding it off to the nearest integer. If more than ten but less than forty acres of openings exists, the computer counts one OPNAC (Table 6c, lines 39-46). For every quarter mile of rivers, roads and/or streams, one activity center is counted, BORDAC. To arrive at TOTAC, the total number of activity centers, BORDAC, OPNAC and VEGAC are added together. If TOTAC is greater than MAXGRS (from the main program), then TOTAC is set equal to MAXGRS (Table 6c, lines 54-61).

If TOTAC and VEGAC are equal, the number of grouse pairs on the land is the TOTAC, and all of these activity centers will be printed out on the map. In the case where TOTAC and VEGAC are zero, the number of grouse pairs on the land is 0-1 and no activity centers appear on the map (Table 6d, lines 11-51). The reason behind printing out 0-1 pairs, instead of zero pairs, is that a pair of grouse may exist in marginal habitat if all other conditions are favorable.

If TOTAC is greater than VEGAC (VEGAC>0), the computer prints out that there will be between VEGAC and TOTAC numbers of breeding grouse pairs. Only those pairs due to VEGAC will appear on the maps. The computer tells how many pairs on the land are due to the vegetation associated with openings and/or rivers, streams and/or roads (Table 6d, lines 18-51). If TOTAC is greater than VEGAC but VEGAC is zero, the computer prints out that there should be from zero to TOTAC number of breeding pairs of grouse. In this case, no activity centers are plotted on the maps but the computer lists the number of breeding pairs that may be present due to the vegetation associated with openings and/or rivers, streams and/or roads (Table 6d, lines 18-51). If TOTAC is less than VEGAC, TOTAC number of breeding pairs are present on the land (Table 6d, lines 57-60). The only time this happens is if TOTAC is greater than MAXGRS, and thus it would be set back to MAXGRS due to grouse territoriality.

Next, the range in actual numbers of birds is calculated and printed out. If TOTAC (TOTAC>0) equals VEGAC, or TOTAC is less than VEGAC, the range is from TOTAC times five, to TOTAC times six number of birds (Table 6e, lines 6-36). When both TOTAC and VEGAC equal zero the range lies between zero and six birds. If TOTAC is greater than VEGAC (VEGAC>0), then the range is between VEGAC times five and TOTAC times six number of birds (Table 6e, lines 6-26). In the case of TOTAC greater than zero with VEGAC equal to zero, the number of birds is between zero and TOTAC times six. Finally, the subroutine PLOTTR is called to print out the activity centers (only VEGAC).

Table 6a. Subroutine NOWPOP

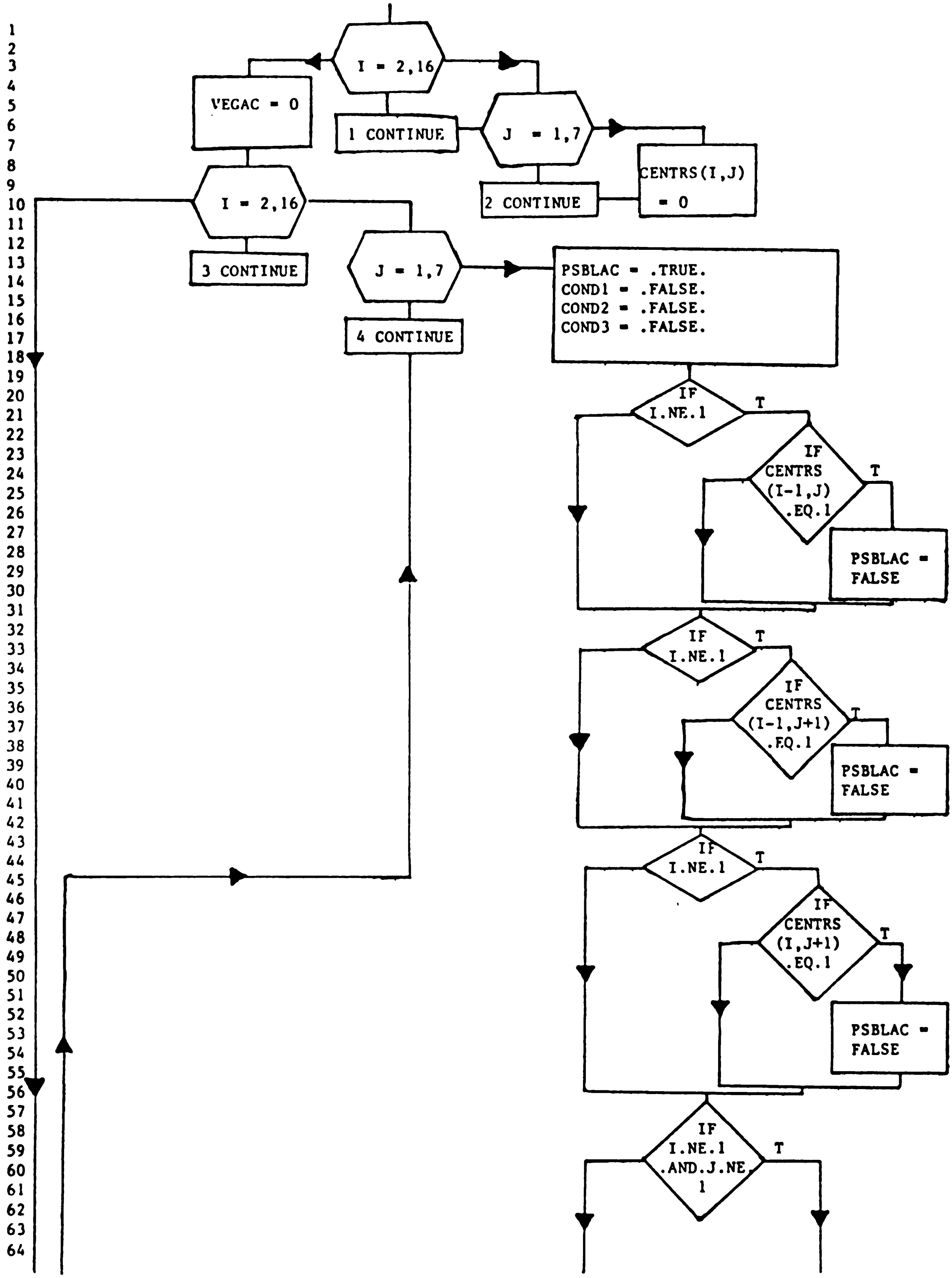


Table 6b. Subroutine NOWPOP (cont'd)

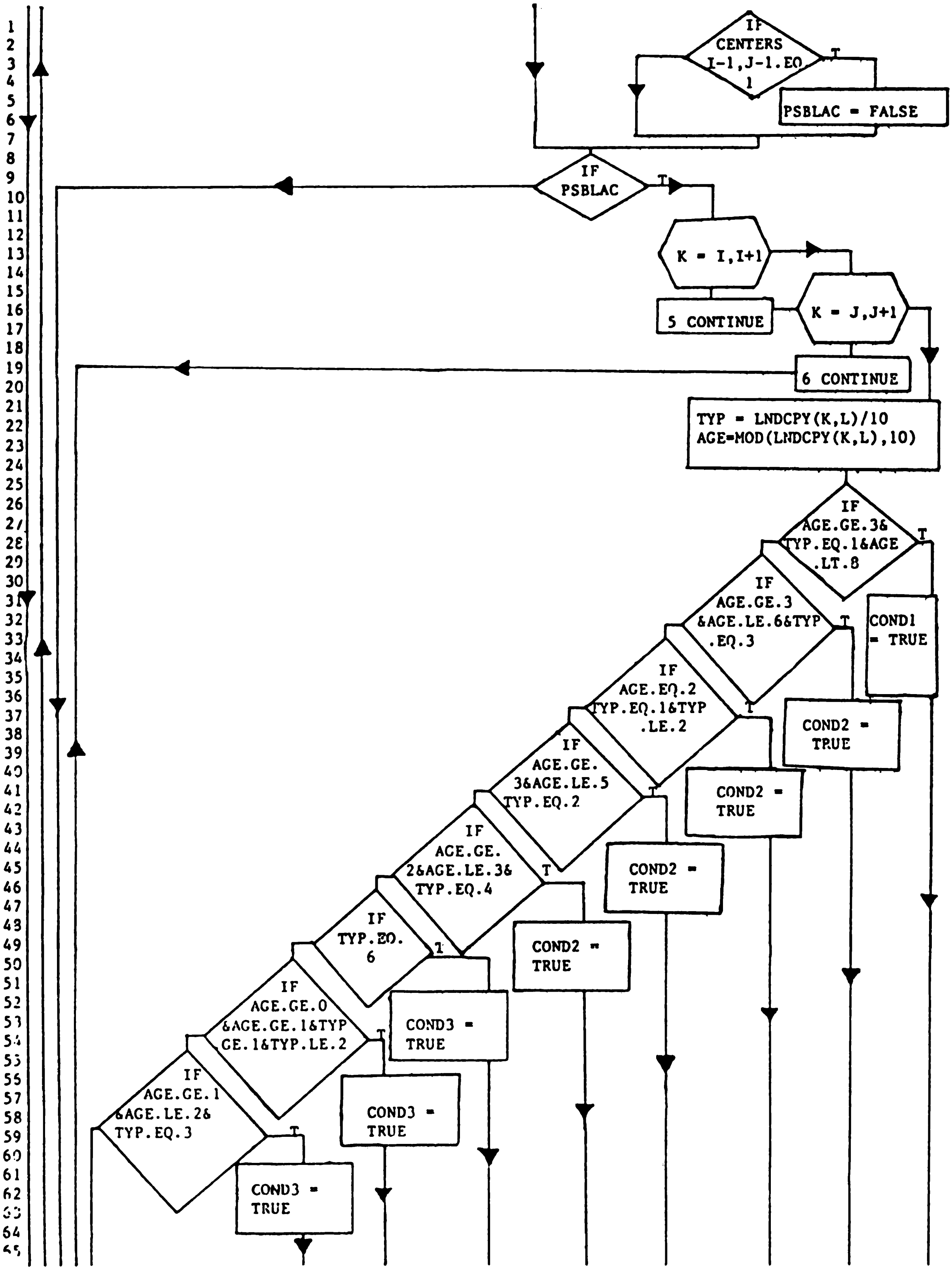


Table 6c. Subroutine NOWPOP (cont'd)

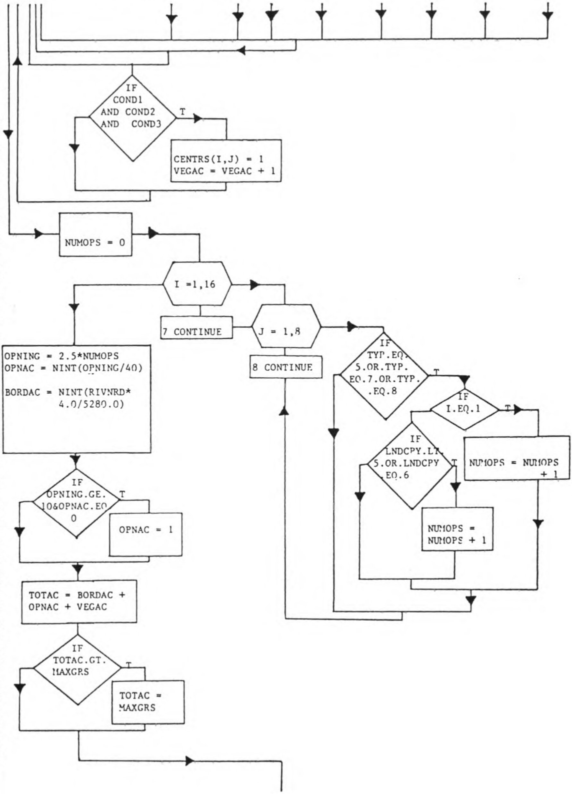


Table 6d. Subroutine NOWPOP (cont'd)

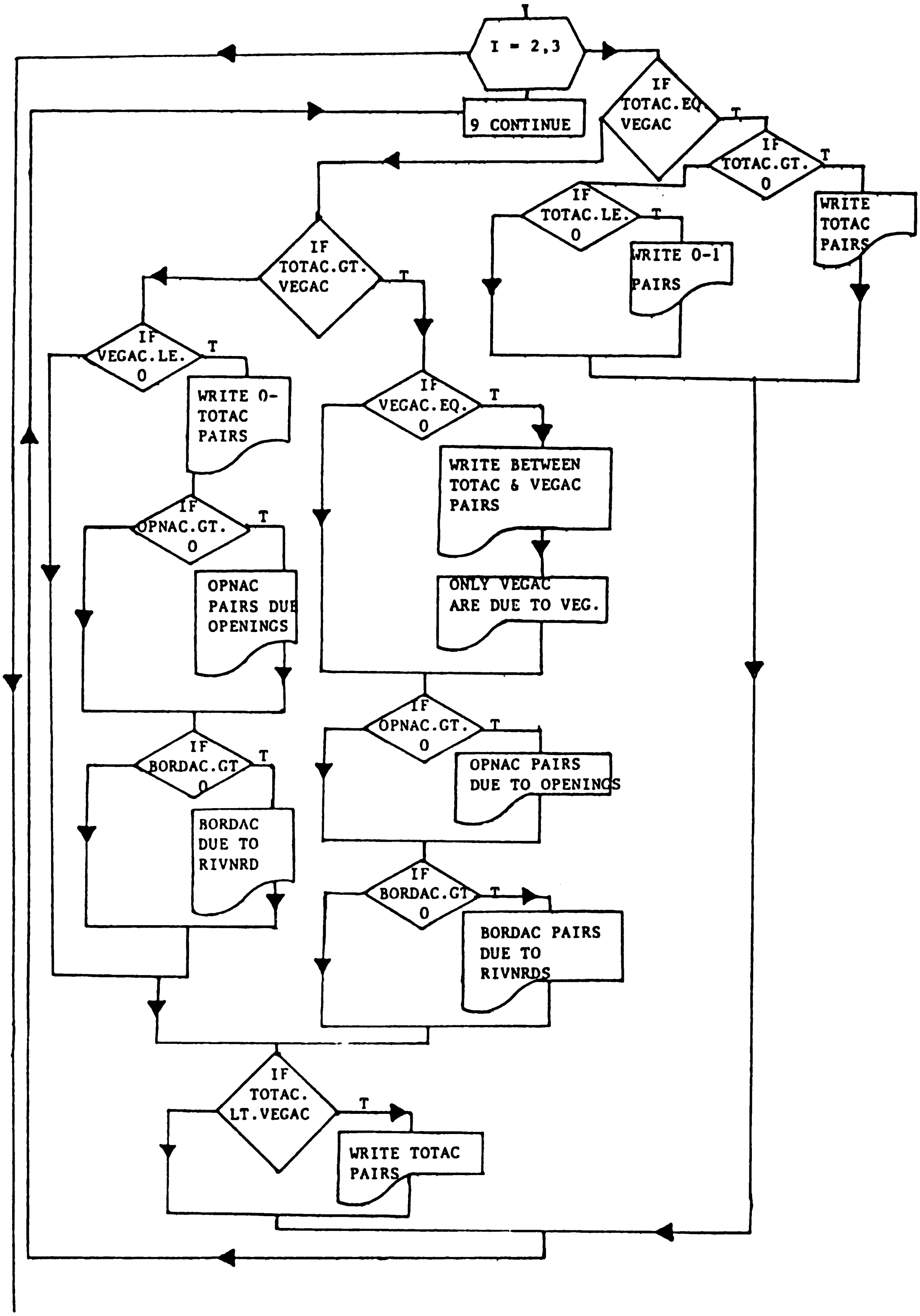
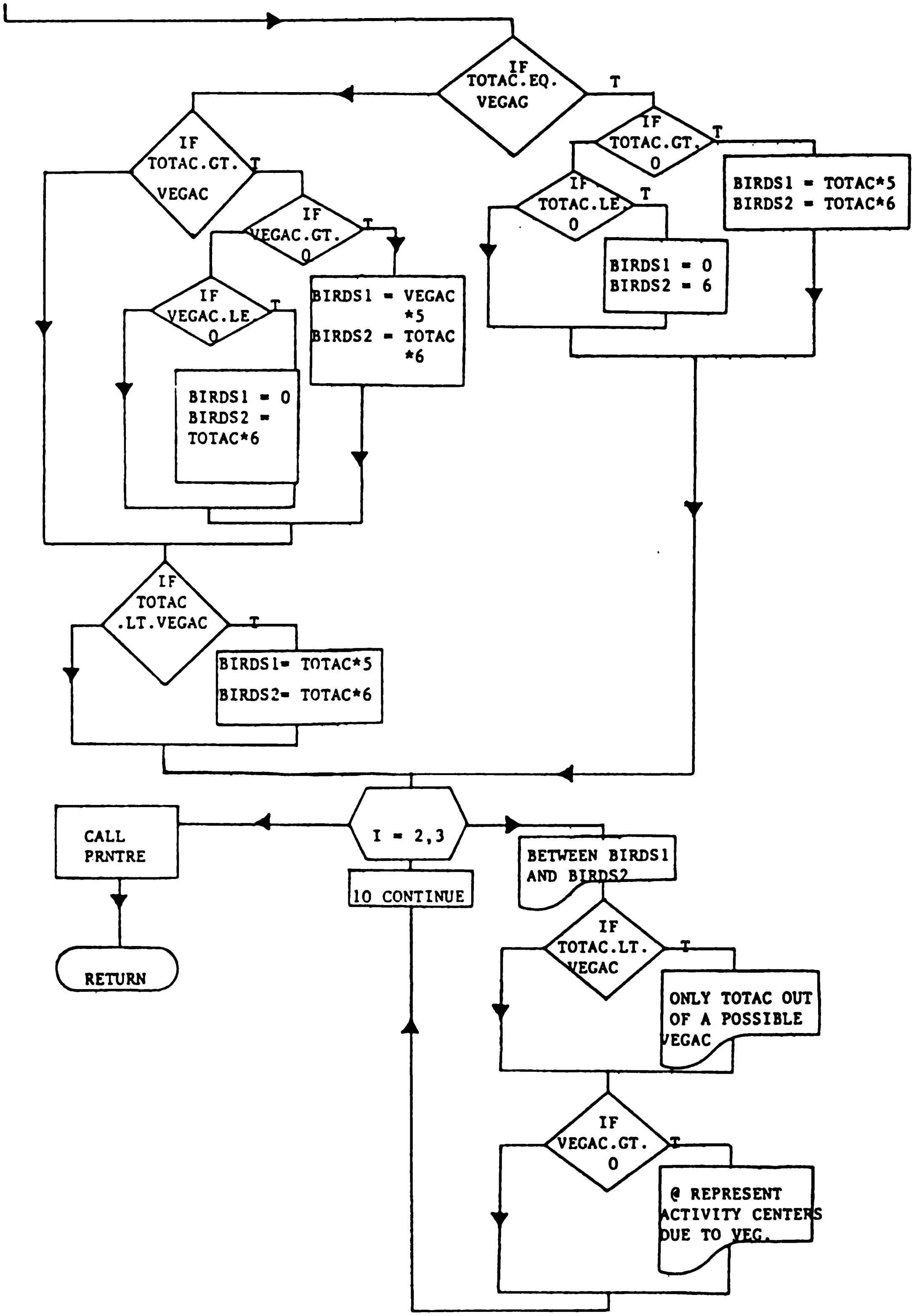


Table 6e. Subroutine NOWPOP (cont'd)



Subroutine PLOTTR

This subroutine plots a map of the land. Any name beginning with the characters A-Z is assumed to be an integer. LAND, LNDCPY, AGES, and CENTRS are all defined and dimensioned as they were in previous subroutines. The values of both DECODE and CUTLIN are three characters long, while ACSITE is only one character in length. This subroutine uses LNDCPY and AGES from the common block /LANDS/. The computer prints out a key to the vegetation types and age classes first. The subroutine DECODR is called to change the number codes entered in the main program to the character information displayed on the map (Table 7a, lines 11-15). Next, the computer calls the subroutine CUTS to print out whether the users are to cut the block of land or not. It then calls the subroutine SITES to plot the activity centers on the map (Table 7a, lines 19-27). SITES is not called for blocks in the first row because there are no activity centers in the first row due to the manner in which surrounding vegetation is checked in subroutine MGMT.

Now the computer plots the actual map. First a dashed line is printed across the top of the row. Then, depending upon the age of the block, the symbols in the key denoting age are printed for each block in the row. On the next line, the characters from DECODR, DECODE is printed (Table 7b, lines 31-36). DECODE is the alphanumeric symbol for the vegetation on the block of land, for example ten year old aspen would be A10. On a seperate line, the computer prints out the information from CUTS as to whether or not each block in the row is to be cut or not (Table 7b, lines 34-38). Below this it prints whether the block will have an activity center using ACSITE, unless the block is in the top row (Table 7b, lines 37-47). In that case there will be no activity centers due to the lack of surrounding vegetation. Then the symbols that denote age will be printed again for each block of the row, and another dashed line across the bottom of the row will follow (Table 7c, lines 2-5). The above steps are repeated for each row of land, starting with the dashed line across the top of the blocks in row.

Table 7a. Subroutine PLOTTR

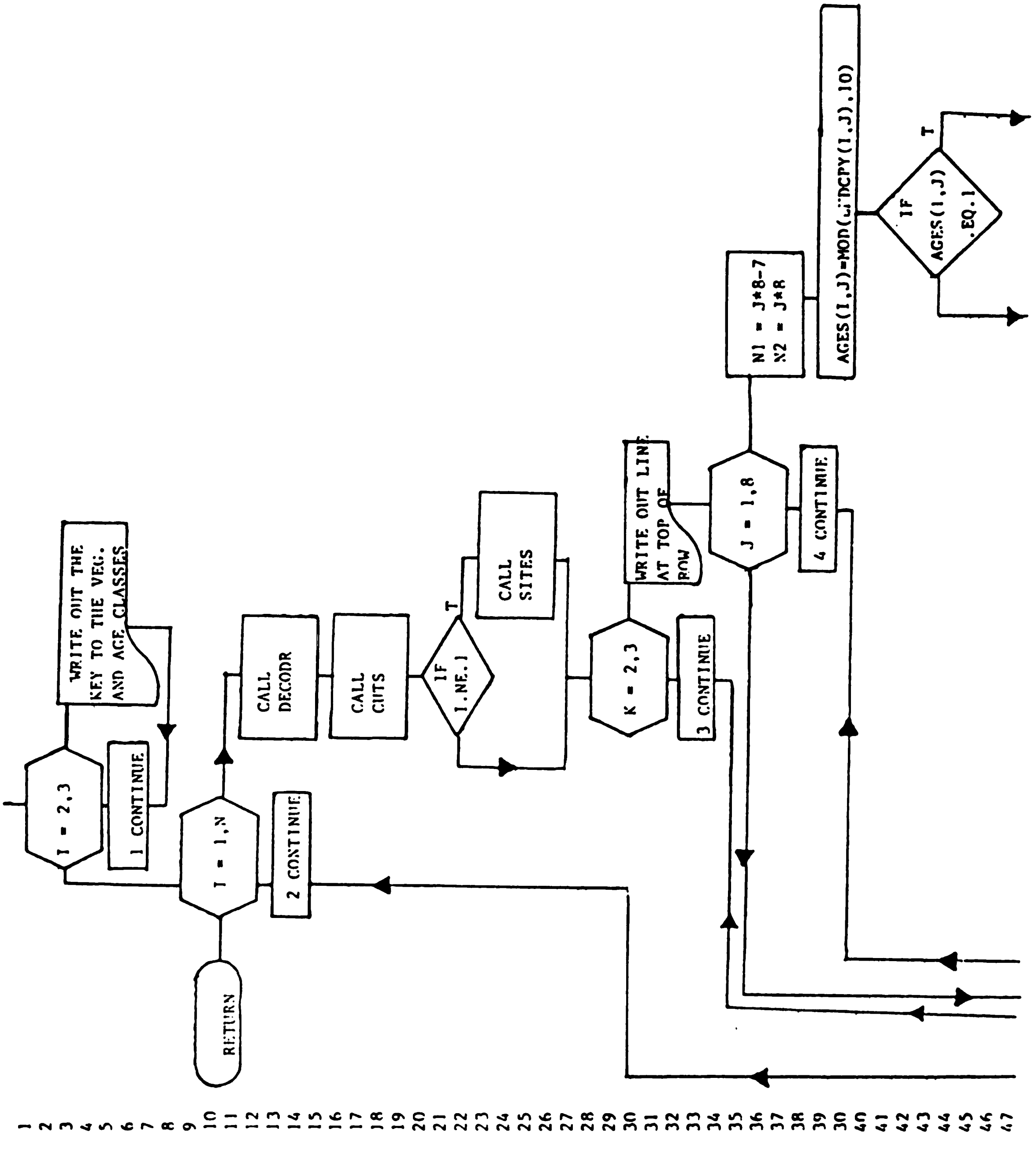


Table 7b. Subroutine PLOTTR (cont'd)

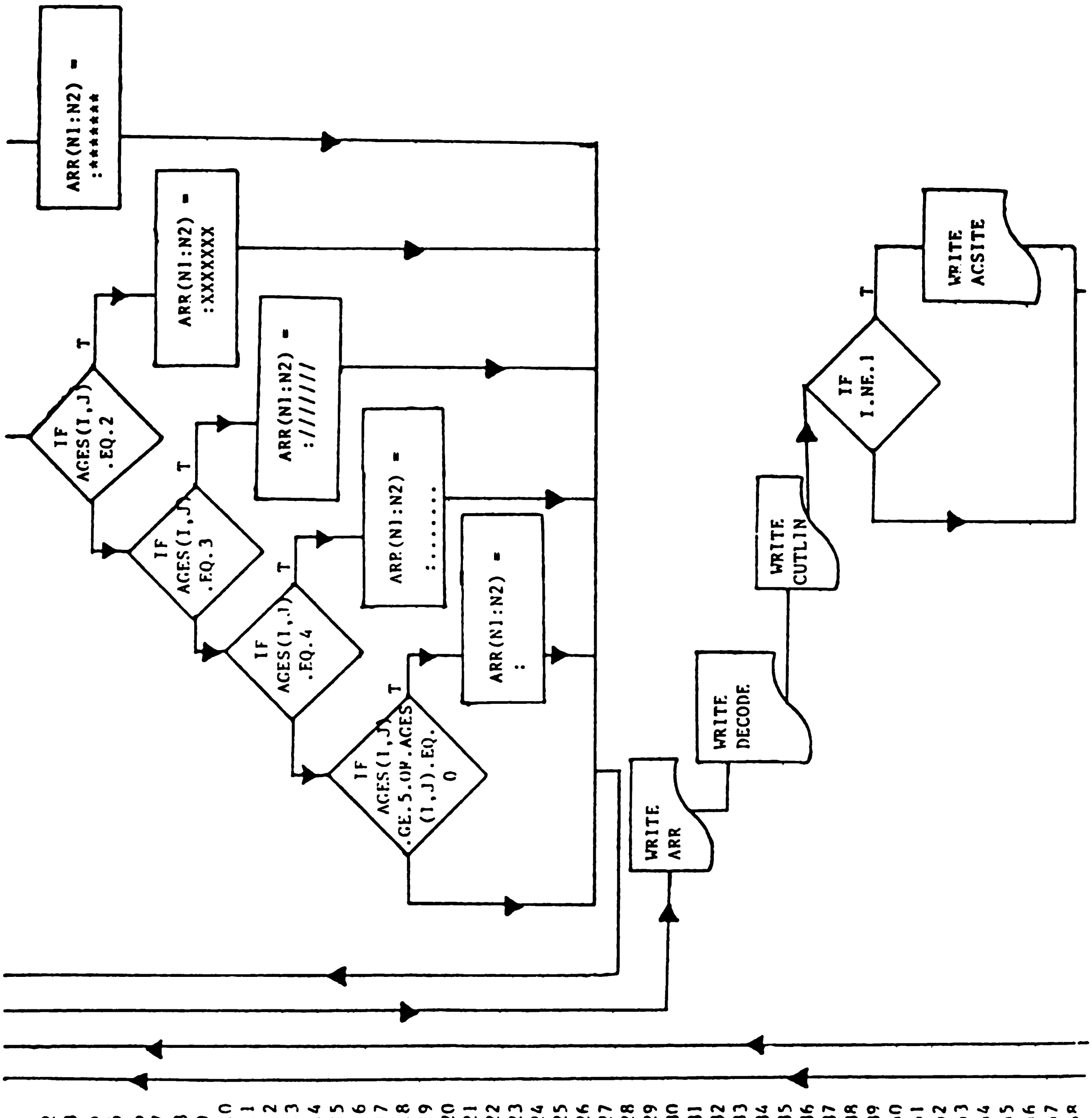
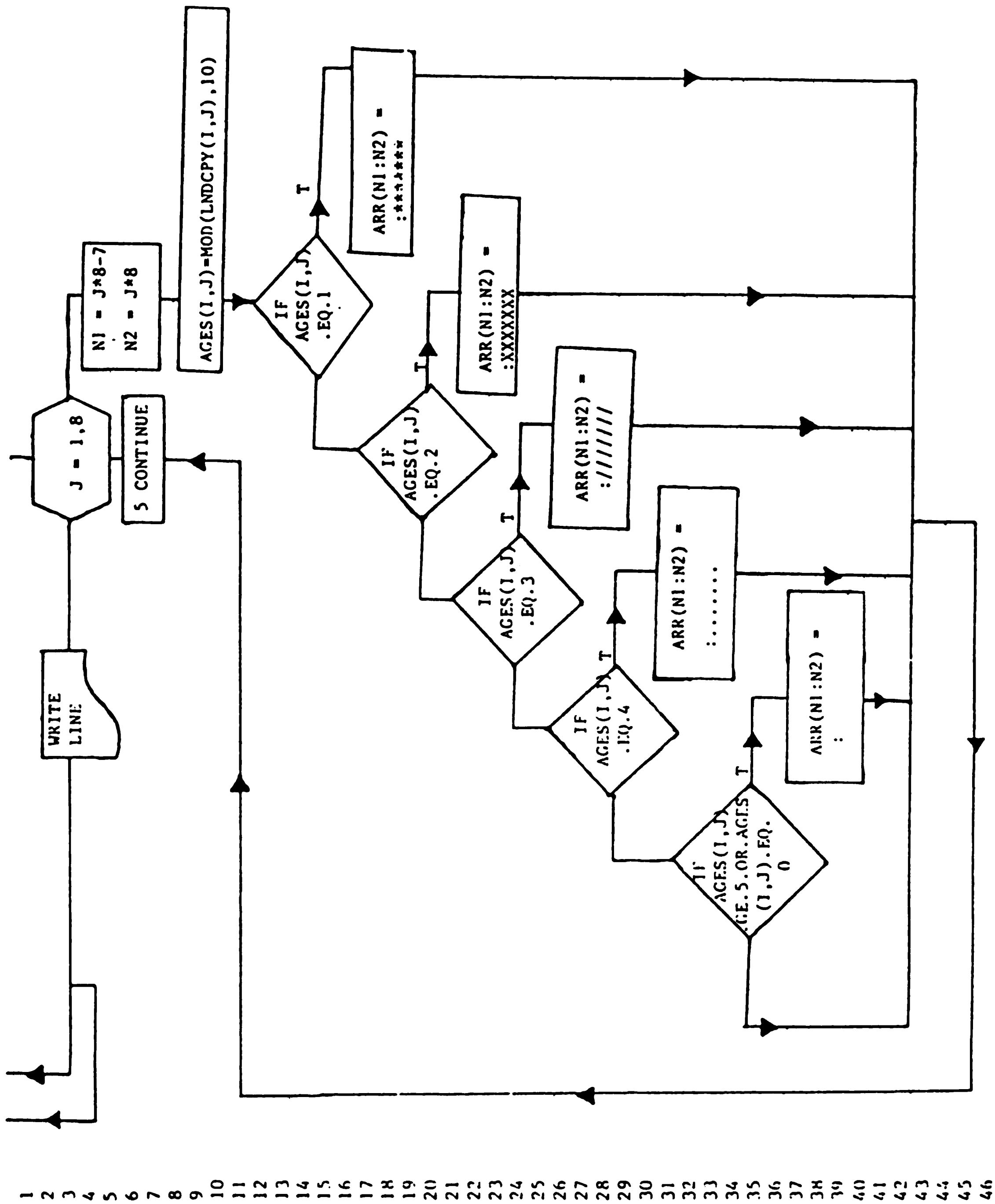


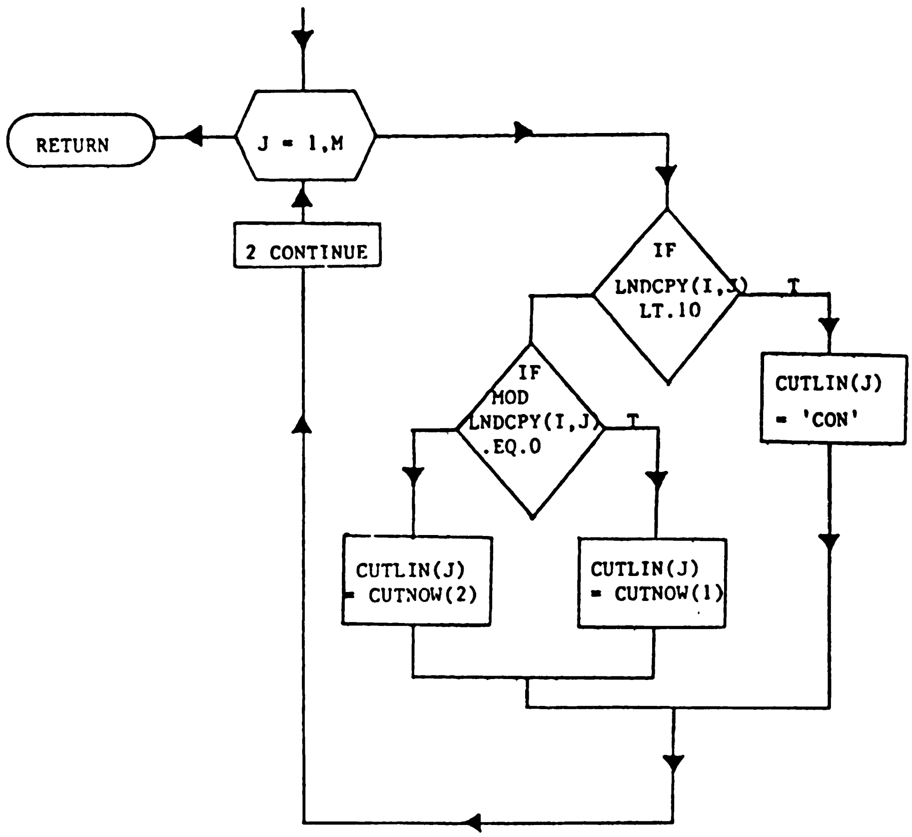
Table 7c. Subroutine PLOTTR (cont'd)



Subroutine CUTS

This subroutine converts the age of the vegetation to characters that indicate whether or not a particular block is to be cut. The values: LNDCPY, I, M, and CUTLIN are carried by this subroutine. Integers are implicit from A-Z and LNDCPY is defined and dimensioned as in previous subroutines. Both CUTNOW and CUTLIN are three characters in length. The DATA statement CUTNOW, gives the corresponding character values for blocks that are to be cut, and those that are not. If LNDCPY, entered in the main program is less than ten, the computer prints out CON. This is for land not be considered in the analysis. If AGE equals zero, this means that the block was cut, and the corresponding value of CUTNOW will be stored in the CUTLIN array. If AGE does not equal zero, then this block was not cut and and the appropriate value of CUTNOW will be stored in the CUTLIN array (Table 8).

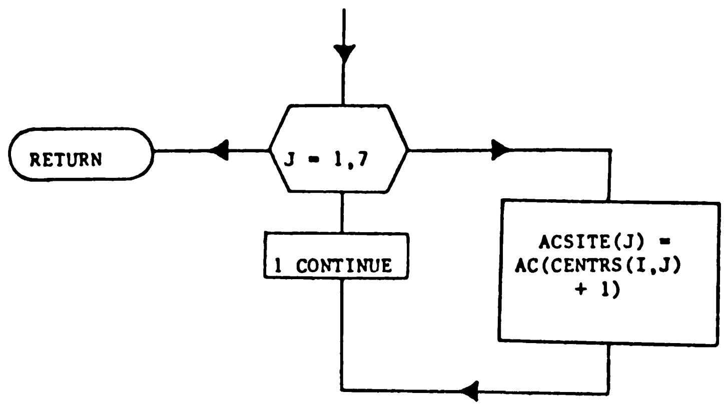
Table 8. Subroutine CUTS



Subroutine SITES

This subroutine converts the numbers indicating whether an activity center is present or absent to a character code for printing on the map. The values: CENTRS, I, M, and ACSITE are carried by this subroutine. Once again, there are implicit integers from A-Z, and CENTRS is defined and dimensioned as in earlier subroutines. Both AC and ACSITE are one character in length. The DATA statement for AC gives the character codes to be printed for blocks with and without activity centers. For each block in a row, if there is (or is not) an activity center present, the appropriate symbol for AC will be stored in the ACSITE array for printing. There are no activity centers in the last column due to the lack of surrounding vegetation (Table 9). This subroutine is not called for blocks in the first row for the same reason.

Table 9. Subroutine SITES

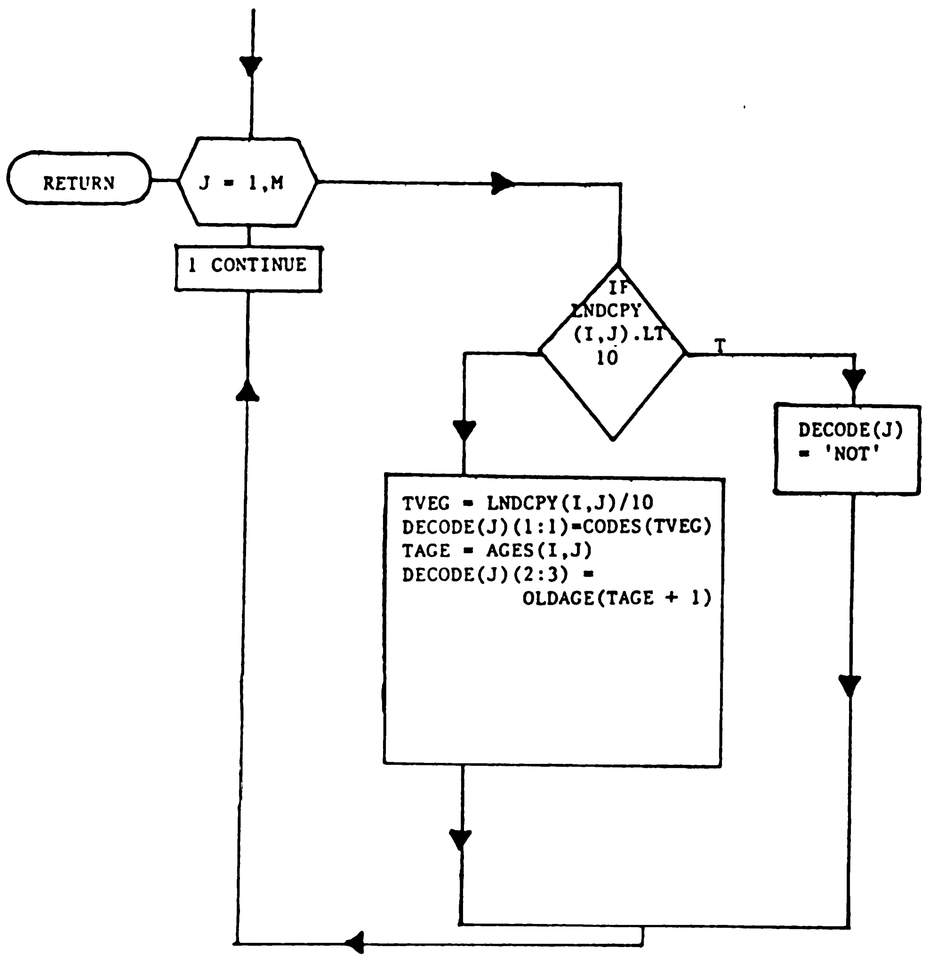


Subroutine DECODR

This subroutine seperates the two-digit vegetation-age code entered in the main program and converts it to the alpha-numeric symbol printed on the map. The vegetation type is changed from its number code into its character equivalent. Then the single number code for age is converted into a two-digit number for printing on the map along with the vegetation character. The values LNDCPY, I, M, DEOCDE, and AGES are carried by this subroutine. Integers are implicit for names from A to Z. LNDCPY and AGES are defined and dimensioned as they were in earlier subroutines. DECODE is the three-character value printed out on the map to represent both the age and vegetation of the block of land. OLDAGE is the two-digit part of DECODE that represents the age of the vegetation. CODES is the single value part of DECODE that stands for the vegetation type. The DATA statements for OLDAGE and CODES, gives the letters and numbers for the corresponding vegetation types and ages given in the key.

If any two-digit code entered in the main program is less than ten, DECODE equals NOT. This is for blocks of land that are not to be considered in the analysis. The vegetation type is first seperated out by dividing LNDCPY by ten to arrive at TVEG. This value is set to its character equivalent through CODES and saved in the DECODE array. Then AGE, the remainder after dividing LNDCPY by ten, is saved in the DECODE array (Table 10).

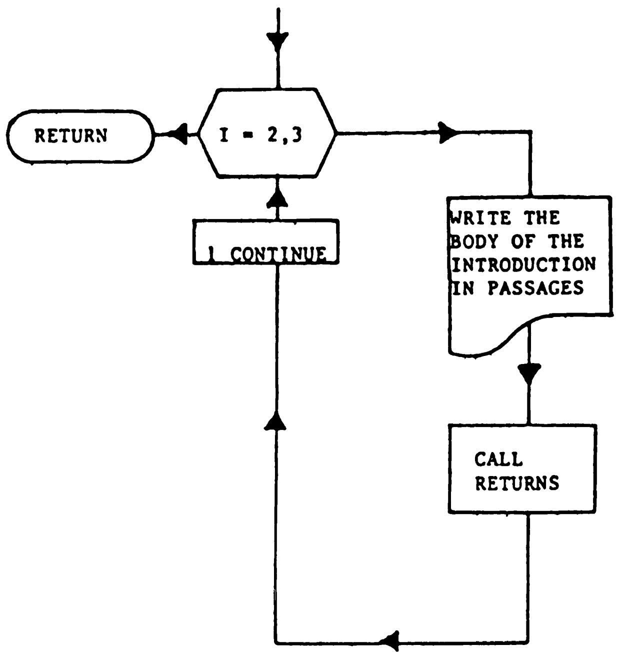
Table 10. Subroutine DECODR



Subroutine INTRO

This subroutine provides users with instructions on how to use the model and what the model does. After each passage of the introduction, the subroutine RETURNS is called to allow users time to read the passage (Table 11).

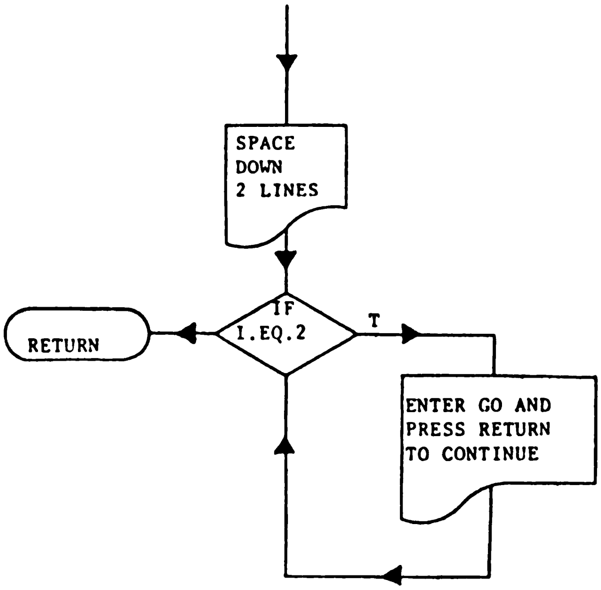
Table 11. Subroutine INTRO



Subroutine RETURNS

This subroutine provides spacing between passages of the introductiom, allowing the users time to read the passage. I is an integer value. First, the computer spaces down two lines, then it prints out "(ENTER "GO" AND PRESS RETURN TO CONTINUE)". When users enter GO, I equals two, then the next passage of the introduction will be printed (Table 12).

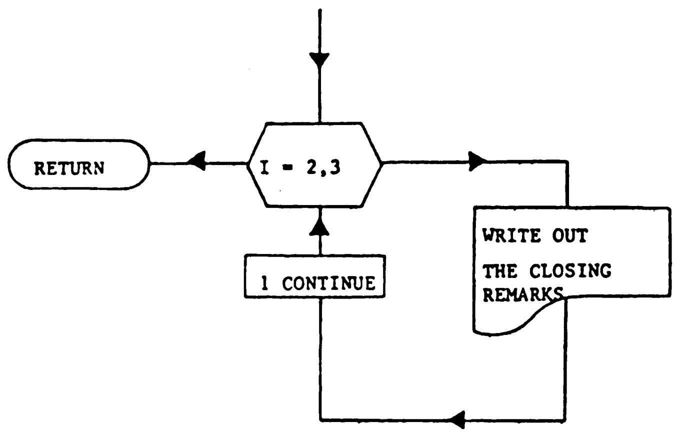
Table 12. Subroutine RETURNS



Subroutine ENDING

This subroutine prints out the closing paragraph of the program which tells users how to obtain additional information (Table 13).

Table 13. Subroutine ENDING



Subroutine OWNCUT

This subroutine allows users to try their own cutting plan for the land originally entered. Potential activity centers, acres cut and revenues generated from the users cutting plan are shown. Integers are implicit from A-Z, and LAND, CENTRS, LNDCPY, and AGES are defined and dimensioned as earlier in the program. OCTCUT, dimensioned 4 (the four vegetation types: aspen, lowland hardwoods, upland hardwoods, and swamp conifers/pines) by 8 (the eight age classes of the vegetation) by 8 (the quarters of time in the management plan), is the total number of blocks cut of each type, age and quarter. Swamp conifers/pines are included for the calculations within this subroutine because users may decide to cut them for economic or other reasons. OCPCUT is the number of blocks cut of each vegetative type and age. ANSWER represents a value three characters in length. OCBLOCK, NUMBLKS, IX, and OCYEARS are all integer values. The common block /SECTOR/ brings LOCALE in from the main program. Of the items in the common block /LANDS/ only LAND, LNDCPY, CENTRS, AGES, and PRICE are used in this subroutine. All of the variables listed after REAL, have real number values. The DATA statement RATE gives the interest rate used in present value calculations.

Users may enter more than one cutting strategy within this subroutine and each strategy may be up to eighty years (8 quarters) in duration. The following steps are for a single cutting plan and, if necessary would be repeated for any additional cutting plans starting again at this point. First, the computer copies LAND into the LNDCPY matrix, and AGES is set equal to the remainder of LAND divided by ten. Then it initializes the CENTRS and OCTCUT matrices to zero (Table 14a, lines 13-26).

The computer prompts users to enter how many years they would like to manage their land between ten and eighty years (in multiples of ten). The computer reads this number as OCYEARS (Table 14a, lines 13-26).

First Q is set equal to K plus 9 divided by 10, where K is a counter that starts at 1 and is increased in increments of 10. For example in the first quarter, Q would equal 1 plus 9 divided by 10, or 1. The OCPCUT array is now intialized to zero (Table 14a, lines 41-45). IX, the year the cutting is done, equals K minus 1.

The computer then prompts users to enter the number of blocks of land they want to cut in the particular year of their management plan. The computer reads this number as NUMBLKS. If the users do not want to cut any land in a particular year they enter a 999, and the computer goes back to where they are asked how many blocks they want to cut (Table 14b, lines 2-7).

The computer asks users which blocks of land they want to cut for the years in question. The numbers they enter represent the locations of the blocks of land on the grid map, for example the first row contains blocks 1-8. The computer reads the number entered as OCBLOCK (Table 14b, lines 21-24). These steps are followed for each block entered from one to NUMBLKS. First, LOCALE, from the main program, is set equal to OCBLOCK for each block. TYP equals LNDCPY divided by ten, and AGE is the remainder. The blocks are cut by subtracting AGE from LNDCPY. The computer then increases both OCTCUT and OCPCUT by one for every block cut (Table 14b, lines 25-38). If IX equals thirty (year 30), any fields and/or brush are converted to lowland hardwoods 11-20 years of age. The computer calls AGEIT to age all of the land. NOWPOP is called to give the grouse population.

OCPA, dimensioned 4 (the four vegetation types: aspen, lowland hardwoods, upland hardwoods, and swamp conifers/pines) by 8 (the eight age classes of the vegetation), represents the acres of each vegetation type and age cut each quarter. OCGPA, the acres of each vegetation type cut regardless of its age, is calculated for every quarter along with OCPA and OCPCUT. Before the computer determines OCPA, OCGPA is set to zero. OCPA equals OCPCUT, the number of blocks of each vegetative type and age, multiplied by 2.5 (2.5 acres per block). OCGPA is now calculated for each vegetative type, regardless of its age, for each quarter (Table 14c, lines 14-24).

OCPA1, dimensioned 4 (the four vegetative types) by 8 (the eight age classes), represents the revenues from each vegetation type and age class cut. OCGPA1, the revenues from each type, irrespective of age, is calculated each quarter along with OCPA1. Before the computer determines OCPA1, OCGPA1 is set to zero. OCPA1 equals OCPA multiplied by PRICE (the price for each vegetative type and age class). OCGPA1 is now calculated for each vegetation type, regardless of its age, for each quarter (Table 14c, lines 20-30).

OCTA, dimensioned 4 (the four vegetation types) by 8 (the eight age classes) by 8 (the eight quarters), is the total acres cut for each type, age and quarter. OCGTA, the total acres of each type cut irrespective of the vegetations age or the quarter it was cut in, is first set to zero. OCTA equals OCTCUT, the total number of blocks cut of each type, age and quarter, multiplied by 2.5 (2.5 acres per block). OCGTA is then calculated for each vegetation type regardless of its age or the quarter it was cut (Table 14c, lines 29-43).

Finally OCTA1, the present value of the revenues for each type, age and quarter, is determined. OCGTA1, the total present value of the revenues for each of the four vegetation types cut, is set to zero. OCTA1 and OCGTA1 are calculated in a loop where R varies from one to Q. OCTA1 equals OCTA multiplied by PRICE and then divided by 1.0 plus RATE, to the (R minus 1 multiplied by 10) power. For example in the first quarter R minus 1 would equal zero, therefore the present value is the same as the revenues from the acres cut for the first quarter (the acres cut in year zero). OCGTA1, the net present value for each of the four vegetation types, is then calculated (Table 14c, lines 39-52).

The users are asked if they would like to enter another plan. If ANSWER equals yes, then the computer starts at the very beginning of this subroutine again. If ANSWER equals no, the computer returns to the main program (Table 14d, lines 17-21).

Table 14a. Subroutine OWNCUT

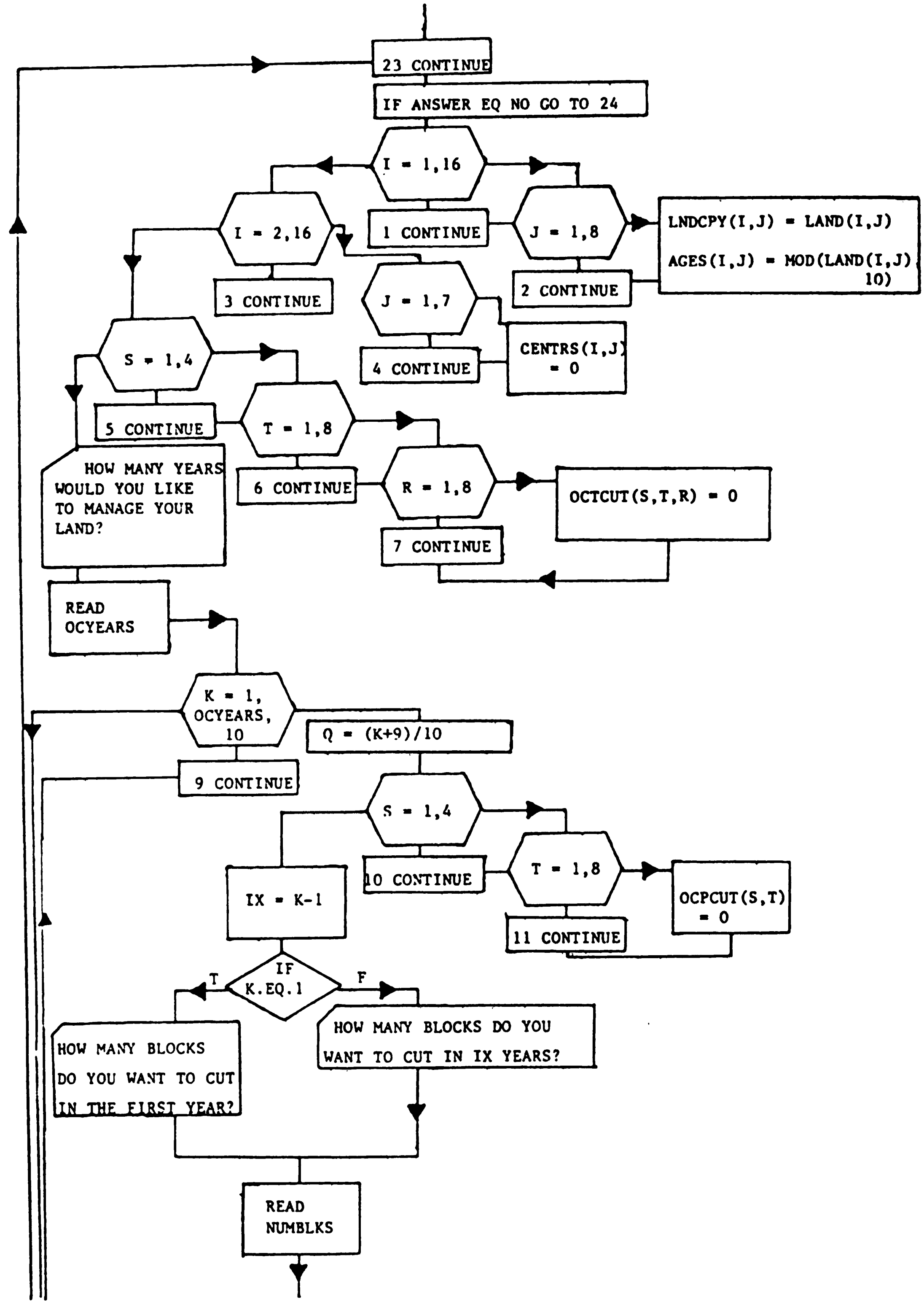


Table 14b. Subroutine OWNCUT (cont'd)

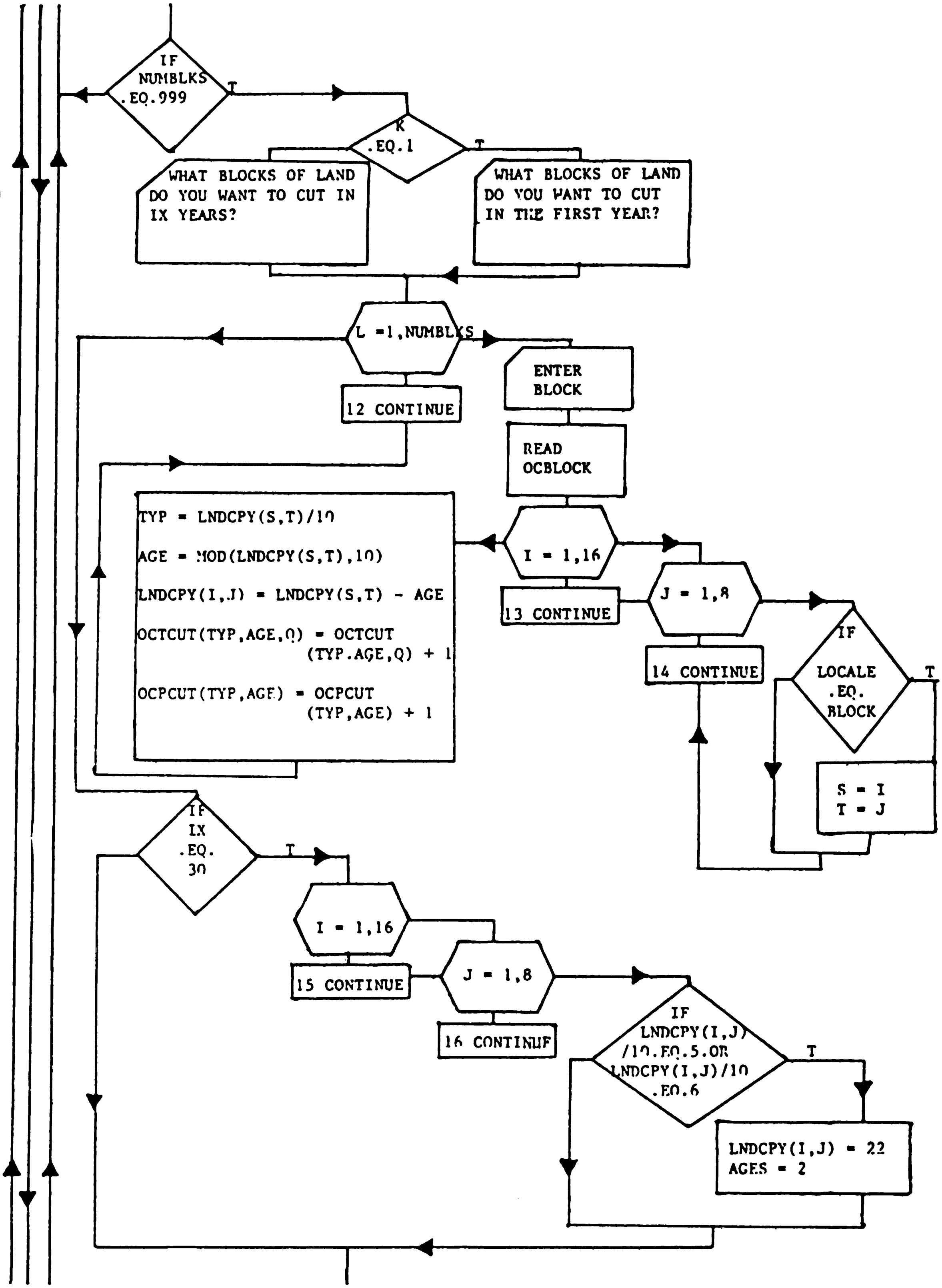


Table 14c. Subroutine OWNCUT (cont'd)

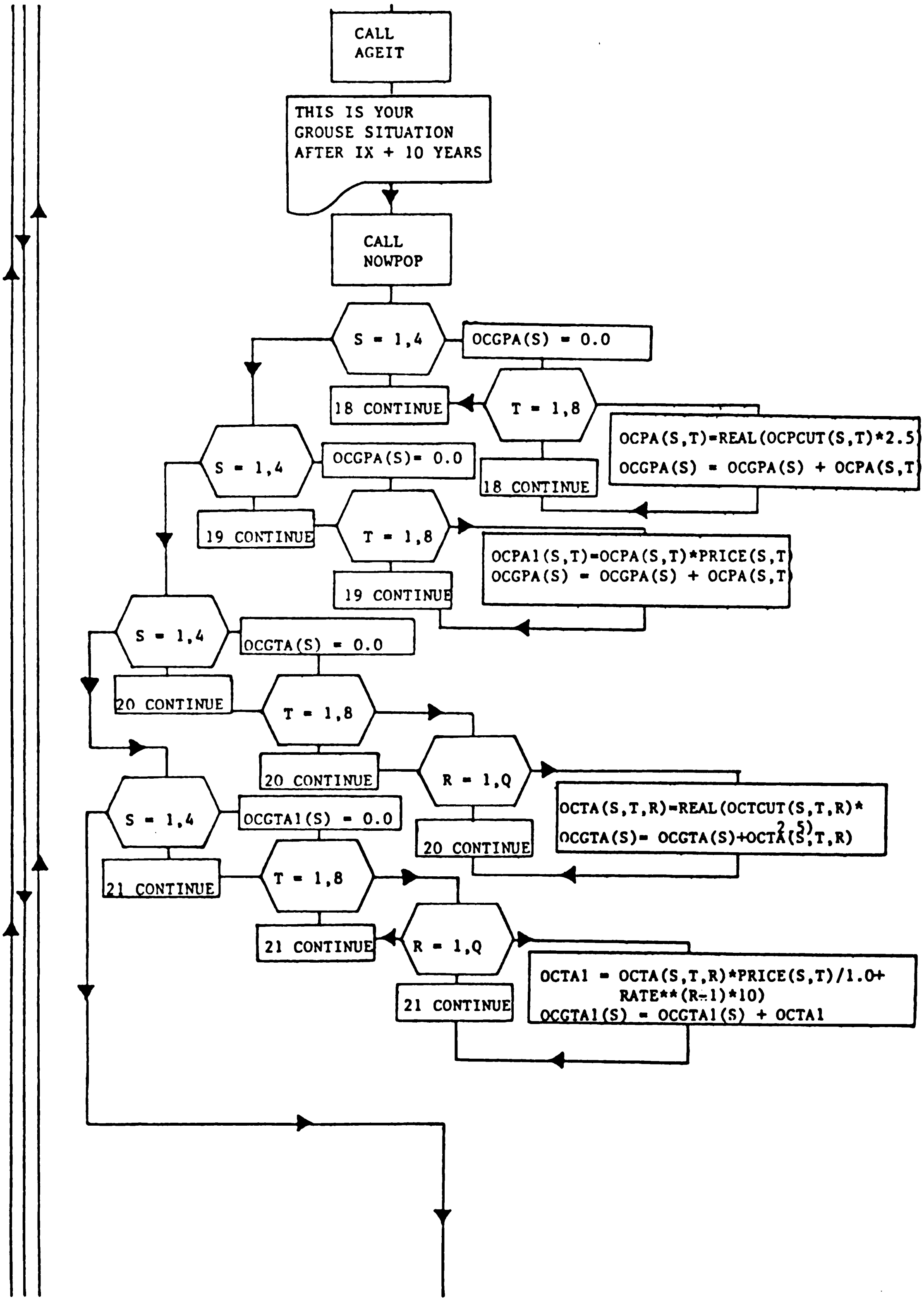
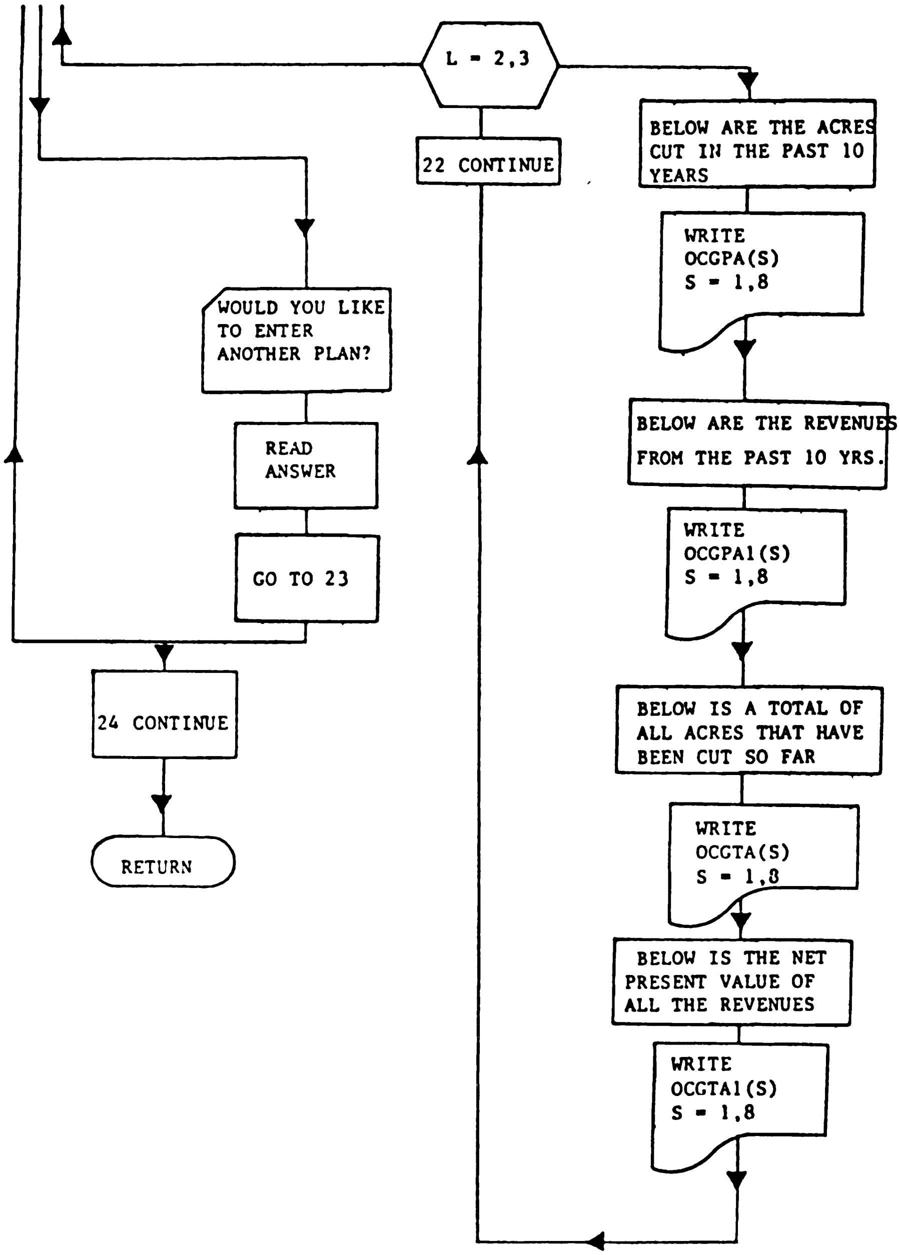


Table 14d. Subroutine OWNCUT (cont'd)



Subroutine PRNTRE

This subroutine calculates and then prints a list of the acres cut of each vegetative type within the past ten years, the revenues from these acres, the total acres of each type cut so far and the net present value of all revenues. This subroutine is called only during the computer generated management plan. Integers are implicit from A-Z. LAND, CENTRS, LNDCPY, AGES, TRECUT and TOTCUT are defined and dimensioned as in previous subroutines. Of the items in the common block /LANDS/ only TRECUT, TOTCUT and PRICE are used. PA, TA, GTA, GPA, GTA1, GPA1, TA1, PA1, PRICE, and RATE are all real number values. The DATA statement RATE gives the value of the interest rate that is being used in the present value calculations.

PA is dimensioned 3 (the three vegetation types cut in the subroutine MGMT: aspen, lowland hardwoods and upland hardwoods) by 8 (the eight age classes of vegetation) by 8 (the quarters or ten-year time periods in the management plan). GPA is the number of acres cut in the past ten years only for aspen, lowland hardwoods and upland hardwoods, irrespective of the vegetation's age. TRECUT, the number of blocks cut of each type, age and quarter, is calculated in the MGMT subroutine. To arrive at PA, the number of acres of each type, age and quarter, TRECUT is multiplied by 2.5 (there are 2.5 acres per block). Before PA is calculated each time period, GPA is set to zero so that only the acres of each type (irrespective of age) for the time period in question, the past ten years are counted (Table 15a, lines 2-16).

Next GPA1, the revenues from acres cut in the past ten years for each vegetation type (aspen, lowland hardwoods and upland hardwoods) is determined. PA1 is dimensioned 3 (the three vegetation types) by 8 (the eight age classes) by 8 (the quarters or time periods in the management plan). Before calculating PA1 each quarter, GPA1 is set to zero. PA1 equals the acres of each type and age for each quarter, multiplied by PRICE. PRICE is set in the main program for each vegetation type and age. Then GPA1, the revenues for each vegetation type irrespective of age is calculated (Table 15a, lines 8-22).

TA is dimensioned 3 (the three vegetation types) by 8 (the eight age classes of the vegetation) by 8 (the quarters of the management plan). GTA is the total number of acres cut for each type so far, irrespective of the age of the vegetation. TOTCUT, the total number of blocks cut of each type and age, is calculated in the MGMT subroutine. Before TA is determined, GTA is set to zero. To arrive at TA, the total number of acres of each type and age, TOTCUT is multiplied by 2.5 (there are 2.5 acres per block) (Table 15a, lines 14-28).

Finally, GTA1, the present value of all revenues generated up to this point for each of the three vegetative types, is calculated. GTA1 is first set to zero. Then inside a loop where K varies from 1 to Q (the number of quarters), TA1 is determined. TA1 is the present value of the revenues generated for each vegetation type and age for all quarters so far. TA1 equals PA, defined earlier in this subroutine multiplied by PRICE. This number is in turn divided by 1.0 plus RATE, to the (K minus 1 multiplied by 10) power (Table 15a, lines 21-35). For example, in the first quarter of the management plan the cutting is done in year zero, so K minus 1 would equal zero and GTA1, the present value of the revenues would equal GPA1 for that quarter. Another example, in the second quarter of the management plan the cutting is done in year ten, so K minus 1 would equal 1, and TA1 would be multiplied by PRICE and then divided by (1.0 plus RATE) to the tenth power. GTA1 is calculated for each vegetation type irrespective of it's age. Then GPA, GPA1, GTA, and GTA1 are all printed out in a list for the users (Table 15b).

Table 15a. Subroutine PRNTRE

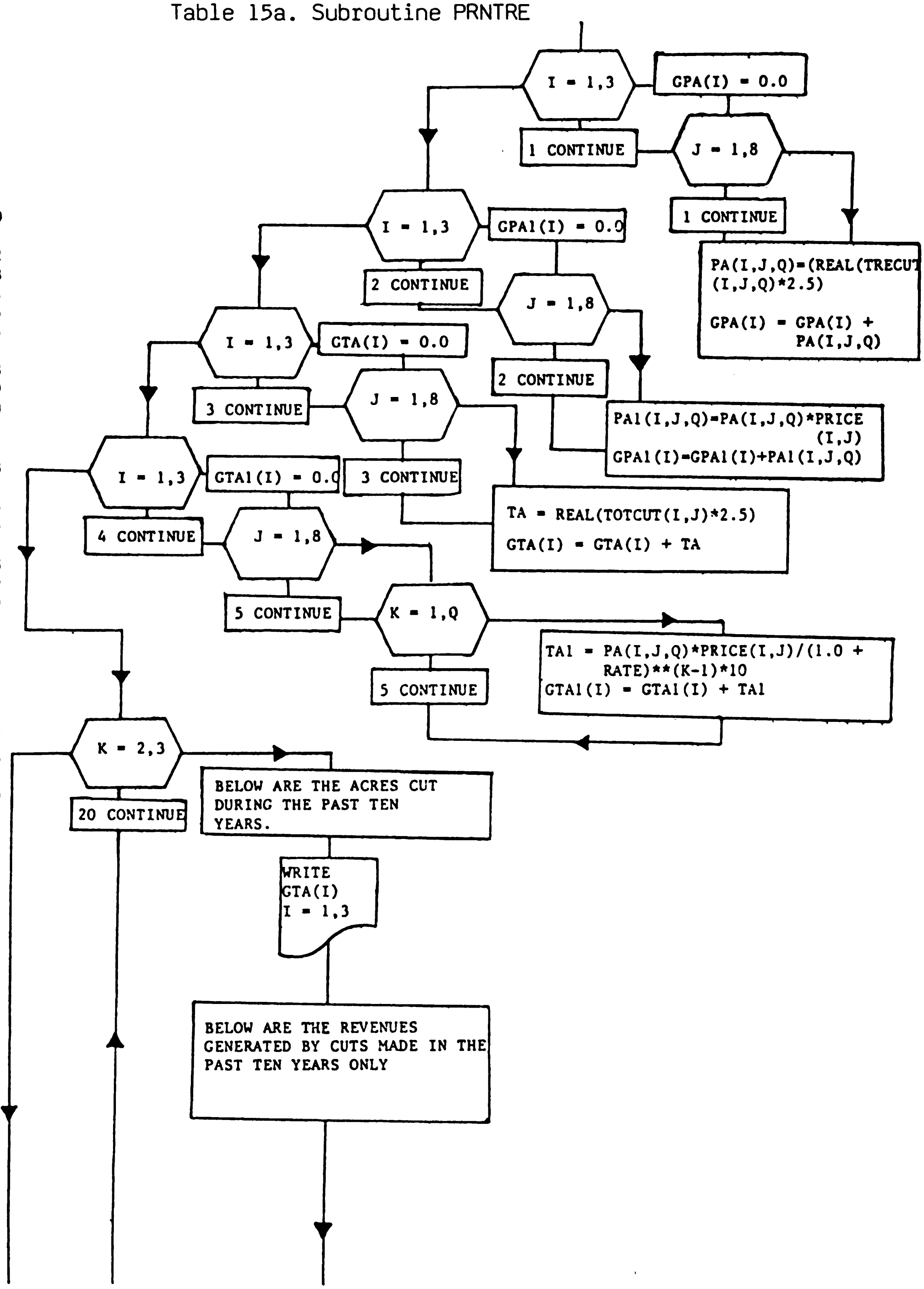
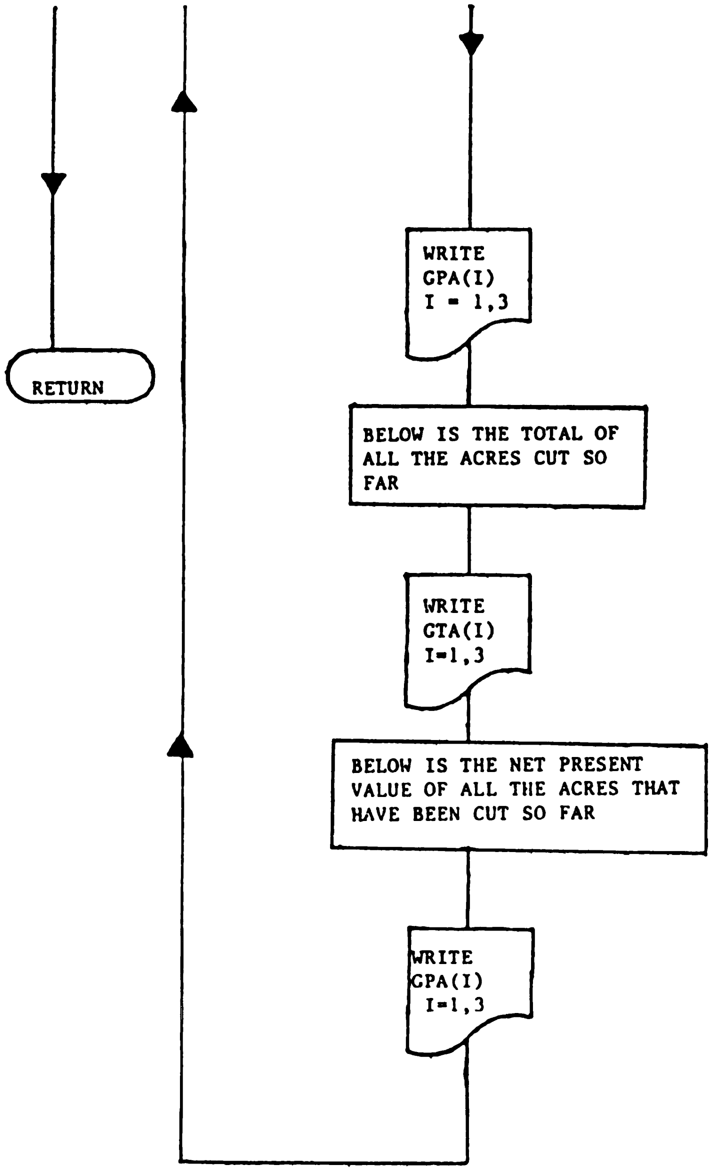


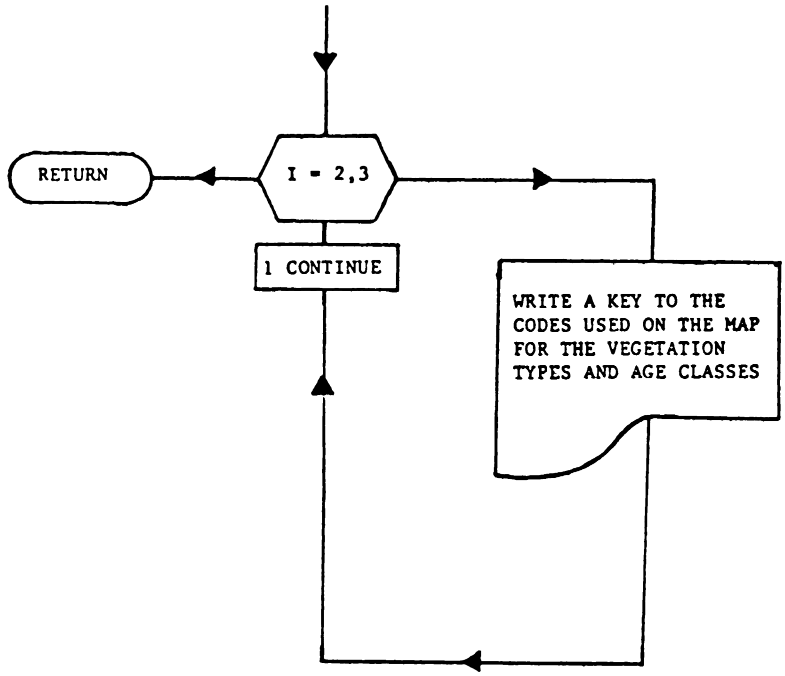
Table 15b. Subroutine PRNTRE (cont'd)



Subroutine MAPKEY

This subroutine provides users with a key to the vegetation types and related age classes. It is called after the introduction has been printed out as a reminder for the users. Also it is called when users do not want a printed copy of the instructions (Table 16).

Table 16. Subroutine MAPKEY



RESULTS

The model was tested with field data from Gladwin County, Michigan to see how well it performed. Two sections of land were entered into the computer model. Both sections are located in the Gladwin Field Trial area (T20N-R20W). This particular area is predominately covered by aspen and upland hardwoods, in particular oak. Both sections of land are one square mile in area. The numbers of drumming male ruffed grouse on these sections of land were counted in the spring of 1984 by the Michigan Department of Natural Resources (DNR).

The largest piece of land that the model will accept is ½ mile by 1 mile in area. Therefore, the two sections of land tested each were divided into two parts. Each section was first divided horizontally and entered into the computer, and then divided vertically and entered. Thus for each section of land there will be two predictions of the grouse population given, one for the section of land divided into two parts horizontally, and one for it divided vertically. By dividing each section of land both horizontally and vertically, it will show the effect of the manner in which the land is entered into the computer on the prediction of the grouse population.

On the first section tested the DNR observed five pairs of grouse, whereas the model predicted 0-7 and 0-4 pairs. Four pairs from the upper limit of both predictions were due to the vegetation associated with rivers, roads and/or streams. When the section of land was divided into two parts horizontally and entered, three additional pairs due to the juxtaposition of vegetation types were also predicted. When the section of land was divided vertically, zero pairs were predicted due to the interspersion of vegetative types.

On the second section of land tested the DNR observed nine pairs of grouse. Due to the irregular size of the area that the DNR used, a small portion of this area, forty acres, was not entered into the computer model. The forty acres not entered is relatively small compared to the 660 acres of land that were entered for this section of land. On this section of land the model predicted 1-7 pairs and 1-9 pairs. Six pairs from the upper limit of both predictions were due to the vegetation associated with rivers, roads and/or streams. From one to three pairs from the upper limit of both predictions were due to the juxtaposition of the vegetative types. The reasons that the model's predictions are somewhat lower than the numbers observed by the DNR may include the forty acre section of land that was not entered into the model and the influence of the surrounding land not entered into the model on the prediction of the grouse population. The above results show that the model predicted a range of grouse numbers that include numbers of grouse estimated by field surveys.

CONCLUSIONS AND RECOMMENDATIONS

This model was designed for use by private forest landowners. The predictions of both grouse numbers and timber revenues will be useful to them. Tests using field data showed that the model predicted reasonably well, although not statistically.

There are two problems with the model. It does not take into ocnsideration the effect of land outside the area entered into the computer and the size limit of ½ mile by 1 mile in area may be too small or too large for landowner use. It would be useful to test the model with field data from a section of land smaller than the area tested. The model needs to be tested with land that does not contain aspen to see how well it performs.

This model has not yet been used by actual landowners, which will test how easy the computer model is to use. Actual landowner use will show if the users will be more inclined to manage their woodlands for grouse or some other objective. In addition, a follow-up study of landowners who started managing their land according to the computer's plan, will show if they actually continued the prescribed cutting in the future. Actual landowner use will also demonstrate the practicality of the model's recommendations.

APPENDIX A

APPENDIX A

Table 17. Computer program for model

```
C
      PROGRAM MAIN
C  THIS PROGRAM WILL ACCEPT A PIECE OF LAND AS INPUT,PREDICT THE
C  NUMBER OF GROUSE ON THE LAND AT PRESENT, GIVE A STANDARD CUT-
C  TING PLAN, AND PREDICT THE NUMBER OF GROUSE AND REVENUES DUE TO THE
C  CUTTING PLAN.  THE USER WILL BE ALLOWED TO ENTER A CUTTING
C  PLAN OF THEIR OWN WHICH WILL THEN BE EVALUATED FOR THE CHANGE
C  IN THE GROUSE POPULATION AND REVENUES GENERATED.
      IMPLICIT INTEGER (A-Z)
      DIMENSION LAND(16,8),CENTRS(16,7),LNDCPY(16,8)
      DIMENSION AGES(16,8),TRECUT(3,8,8),TOTCUT(3,8)
      REAL YRTEMP,ACRES,PRICE(4,8)
      CHARACTER*3 RESPND
      CHARACTER*3 ANSWER
      COMMON/LANDS/LAND,LNDCPY,CENTRS,AGES,N,M,YEARS,TRECUT,
     +TOTCUT,PRICE
      COMMON/PARAMS/RIVNRD,MAXGRS
      COMMON/SECTOR/LOCALE(16,8)
C
      OPEN(2,FILE='OUTPUT')
      OPEN(3,FILE='USRCPY')
C
C  INITIALIZE THE LAND MATRIX TO ZERO AND THE LOCALE MATRIX FROM 1-128
      K=0
      DO 1 I=1,16
        DO 2 J=1,8
          K=K+1
          LOCALE(I,J)=K
          LAND(I,J)=0
          AGES(I,J)=0
2       CONTINUE
1     CONTINUE
C  INITIALIZE CENTERS MARTIX TO ZERO
      DO 3 I=2,16
        DO 4 J=1,7
          CENTRS(I,J)=0
4       CONTINUE
3     CONTINUE
C  CALL THE INTRO SUBROUTINE AND/OR MAPKEY SUBROUTINE
      PRINT*,' WOULD YOU LIKE TO HAVE THE INSTRUCTIONS
      PRINT*,' PRINTED OUT? ENTER YES OR NO'
      READ 100,RESPND
100   FORMAT(A3)
      IF(RESPND.EQ.'YES')THEN
      CALL INTRO
      ENDIF
C
      CALL MAPKEY
C
      LCOUNT=0
      DO 6 I=1,16
       DO 7 J=1,8
C  PROMPT USER TO ENTER SQUARES OF LAND
        PRINT 101, LOCALE(I,J)
101     FORMAT(' ENTER BLOCK ',I3,'(THE TWO DIGIT CODE): ')
        READ *, BLOCK
        IF(((BLOCK.GT.00).AND.(BLOCK.LT.10)).OR.((BLOCK.LT.00).AND.
     +(BLOCK.NE.-1)).OR.(BLOCK.GT.89))THEN
        PRINT 102, LOCALE(I,J)
102     FORMAT(' THE TWO DIGIT CODE YOU ENTERED FOR BLOCK ',I3,' WAS')
        PRINT*,' INVALID, PLEASE ENTER THE TWO DIGIT CODE FOR THIS'
        PRINT*,' BLOCK AGAIN:'
        READ*, BLOCK
        ENDIF
            IF (BLOCK .EQ.-1) GOTO 20
             LAND(I,J) = BLOCK
             AGES(I,J)=MOD(LAND(I,J),10)
             TYP=LAND(I,J)/10
             IF((TYP .LT. 7) .AND. (TYP .GT. 0) .AND.
     +          (TYP .NE. 5))THEN
                LCOUNT=LCOUNT+1
             ENDIF
C  COUNTING NUMBER OF LAND NOT MARSH, WATER OR FIELDS.
7       CONTINUE
6     CONTINUE
C
20    N=I-1
      M=8
C
      PRINT*,' ENTER THE NUMBER OF FEET OF STREAMS, RIVERS, AND/OR'
      PRINT*,' ROADS ON YOUR PROPERTY. ENTER A WHOLE NUMBER. IF THERE'
```

APPENDIX A

Table 17. Computer program for model (cont'd)

```
      PRINT*,' ARE NONE ON YOUR PROPERTY, ENTER A ZERO.**'
      READ *,RIVNRD
C
      ACRES = 2.5*LCOUNT
C  MAXGRS ARE THE MAXIMUM NUMBER OF MALE GROUSE (OR ACTIVITY CENTERS)
C  TO BE EXPECTED ON THIS PIECE OF LAND.
      MAXGRS=ACRES/10
C
      PRINT *,' FOR HOW MANY YEARS WOULD YOU LIKE TO MANAGE? '
      PRINT *,' ENTER A MULTIPLE OF 10 BETWEEN 30 AND 80.** '
      READ *, YEARS
      YRTEMP = YEARS/10.0
C  ROUND TO NEAREST MULTIPLE OF 10
      YEARS = NINT(YRTEMP)*10
C
C  PREDICTS GROUSE BREEDING PAIRS IF THERE IA NO MANAGEMENT
      CALL NOMGMT
C
      PRICE(1,1)=0.00
      PRICE(1,2)=0.00
      PRICE(1,3)=77.50
      PRICE(1,4)=177.76
      PRICE(1,5)=212.90
      PRICE(1,6)=259.87
      PRICE(1,7)=377.46
      PRICE(1,8)=377.46
      PRICE(2,1)=0.00
      PRICE(2,2)=0.00
      PRICE(2,3)=0.00
      PRICE(2,4)=58.52
      PRICE(2,5)=177.52
      PRICE(2,6)=367.36
      PRICE(2,7)=477.12
      PRICE(2,8)=619.36
      PRICE(3,1)=0.00
      PRICE(3,2)=0.00
      PRICE(3,3)=0.00
      PRICE(3,4)=66.00
      PRICE(3,5)=322.50
      PRICE(3,6)=774.00
      PRICE(3,7)=1080.00
      PRICE(3,8)=1230.00
      PRICE(4,1)=0.00
      PRICE(4,2)=0.00
      PRICE(4,3)=227.11
      PRICE(4,4)=290.45
      PRICE(4,5)=341.43
      PRICE(4,6)=380.06
      PRICE(4,7)=414.04
      PRICE(4,8)=414.04
C
      PRINT 110,PRICE(1,8)
110   FORMAT('0',' FOR MATURE ASPEN WE ARE USING A PRICE OF ',F9.2)
      PRINT*,' DOLLARS PER ACRE. DO YOU WANT TO CHANGE THIS '
      PRINT*,' PRICE? ENTER YES OR NO'
      READ 100,RESPND
      IF(RESPND.EQ.'YES')THEN
       PRINT*,' ENTER THE PRICE THAT YOU WOULD LIKE TO USE FOR '
       PRINT*,' MATURE ASPEN IN DOLLARS AND CENTS.'
       READ 120,PRICE(1,8)
120    FORMAT(F9.2)
      ENDIF
C
      PRINT*,' FOR MATURE LOWLAND HARDWOODS WE ARE USING '
      PRINT 130,PRICE(2,8)
130   FORMAT(' A PRICE OF ',F9.2,' DOLLARS PER ACRE. ')
      PRINT*,' DO YOU WANT TO CHANGE THIS PRICE? ENTER YES OR NO'
      READ 100,RESPND
      IF(RESPND.EQ.'YES')THEN
       PRINT*,' ENTER THE PRICE THAT YOU WOULD LIKE TO USE FOR '
       PRINT*,' MATURE LOWLAND HARDWOODS IN DOLLARS AND CENTS.'
       READ 140,PRICE(2,8)
140    FORMAT(F9.2)
      ENDIF
C
      PRINT*,' FOR MATURE UPLAND HARDWOODS WE ARE USING '
      PRINT 150,PRICE(3,8)
150   FORMAT(' A PRICE OF ',F9.2,' DOLLARS PER ACRE. ')
      PRINT*,' DO YOU WANT TO CHANGE THIS PRICE? ENTER YES OR NO'
      READ 100,RESPND
      IF(RESPND.EQ.'YES')THEN
```

APPENDIX A

Table 17. Computer program for model (cont'd)

```
         PRINT*,' ENTER THE PRICE THAT YOU WOULD LIKE TO USE FOR '
         PRINT*,' MATURE UPLAND HARDWOODS IN DOLLARS AND CENTS.'
         READ 160,PRICE(3,8)
160      FORMAT(F9.2)
        ENDIF
C
        CALL MGMT
C
        PRINT *,' DO YOU HAVE A CUTTING PLAN FOR YOUR PROPERTY THAT'
        PRINT *,' YOU WOULD LIKE TRY? ENTER YES OR NO'
        READ 105, ANSWER
105     FORMAT(A3)
C   IF THE USER HAS A CUTTING PLAN OF THEIR OWN ALLOW IT TO BE ENTERED
        IF(ANSWER.EQ.'YES')THEN
        PRINT*,' IN ADDITION TO THE PRICES PREVIOUSLY GIVEN FOR MATURE '
        PRINT*,' ASPEN, LOWLAND HARDWOODS AND UPLAND HARDWOODS, WE WILL '
        PRINT 170,PRICE(4,8)
170     FORMAT(' BE USING A PRICE OF ',F9.2,' DOLLARS PER ACRE FOR ')
        PRINT*,' MATURE SWAMP CONIFERS/PINES. DO YOU WANT TO CHANGE '
        PRINT*,' THIS PRICE? ENTER YES OR NO'
        READ 100,RESPND
        IF(RESPND.EQ.'YES')THEN
         PRINT*,' ENTER THE PRICE THAT YOU WOULD LIKE TO USE FOR '
         PRINT*,' MATURE SWAMP CONIFERS/PINES IN DOLLARS AND CENTS.'
         READ 180,PRICE(4,8)
180      FORMAT(F9.2)
         ENDIF
          CALL OWNCUT(ANSWER)
          GOTO 8
        ENDIF
8       CONTINUE
C   SUBROUTINE TO PRINT CLOSING REMARKS
        CALL ENDING
C
        END
        SUBROUTINE NOMGMT
        IMPLICIT INTEGER (A-Z)
        REAL ACRES
        DIMENSION LAND(16,8),CENTRS(16,7),LNDCPY(16,8),AGES(16,8)
        COMMON/LANDS/LAND,LNDCPY,CENTRS,AGES,N,M,YEARS,TRECUT,
       +TOTCUT,PRICE(4,8)
C   MAKE A COPY OF THE LAND MATRIX FOR MANIPULATING FOR IN NOMGMT.
C   START WITH ORIGINAL AGE MATRIX.
        DO 1, I=1,16
          DO 2, J=1,8
            LNDCPY(I,J) = LAND(I,J)
            AGES(I,J)=MOD(LAND(I,J),10)
2         CONTINUE
1       CONTINUE
C
        WRITE(2,*)' BELOW IS YOUR GROUSE SITUATION AT PRESENT:  '
        WRITE(3,*)' BELOW IS YOUR GROUSE SITUATION AT PRESENT:  '
C
        CALL NOWPOP
C
        DO 3,K=10,YEARS,10
C   AGE THE LAND
          DO 4,I=1,16
            DO 5, J = 1,8
C   AGE IS THE AGE OF THE STAND
              AGE = MOD (LNDCPY(I,J),10)
C   TYP IS THE VEGETATIVE TYPE OF THE STAND
              TYP=LNDCPY(I,J)/10
C   AFTER 40 YEARS, BRUSH AND FIELDS BECOME LOWLAND HARDWOODS
C   11-20 YEARS OLD
              IF(((TYP.EQ.5).OR.(TYP.EQ.6)).AND.(K.EQ.40)) THEN
                LNDCPY(I,J) = 22
                AGES(I,J)=2
C   INCREASE AGE UNLESS AGE IS 80 OR THERE IS NO VEGETATION THERE
              ELSE IF((AGE .NE. 8) .AND.(LNDCPY(I,J).NE.0))THEN
                LNDCPY(I,J) = LNDCPY(I,J) +1
                AGES(I,J)=MOD(LNDCPY(I,J),10)
              ENDIF
C
5           CONTINUE
4         CONTINUE
C
          DO 6 I=2,3
            WRITE(I,100)
100         FORMAT('0')
            WRITE(I,101)K
```

Table 17. Computer program for model (cont'd)

```
101       FORMAT (' BELOW IS YOUR GROUSE SITUATION AFTER ',I2,' YEARS ')
          WRITE(1,*) ' WITHOUT MANAGEMENT '
6       CONTINUE
C
        CALL NOWPOP
C
3     CONTINUE
C
      RETURN
      END
      SUBROUTINE MGMT
C  THIS SUROUTINE CALCULATES THE INITIAL NUMBER OF ACTIVITY CENTERS ON
C  THE LAND, PRESECRIBES A CUTTING PATTERN AND CALCULATES THE CHANGE IN
C  THE NUMBER OF ACTIVITY CENTERS DUE TO THE CUTTING PLAN.  TIMBER
C  REVENUES WILL BE PRINTED ALONG WITH A MAP CONTAINING THE AREA OF
C  VEGETATION BEING CUT AND THE CHANGE IN THE NUMBER OF ACTIVITY CENTERS
      IMPLICIT INTEGER (A-Z)
      LOGICAL GO
      DIMENSION LAND(16,8),CENTRS(16,7),LNDCPY(16,8),AGES(16,8),
     +  TRECUT(3,8,8),TOTCUT(3,8)
      COMMON/LANDS/LAND,LNDCPY,CENTRS,AGES,N,M,YEARS,TRECUT,
     +TOTCUT,PRICE(4,8)
C
C  ZERO OUT THE TREE CUT AND TOTAL CUT ARRAYS
        DO 99,  I=1,3
          DO 99,  J=1,8
            DO 99,  K=1,8
           TRECUT(I,J,K)=0
99         CONTINUE
        DO 98, I=1,3
          DO 98, J=1,8
            TOTCUT(I,J)=0
98         CONTINUE
C  MAKE A COPY OF THE LAND MATRIX FOR MANIPULATING AGE STRUCTURE
C  START WITH ORIGINAL AGES
      DO 1, I=1,16
        DO 2, J=1,8
          LNDCPY(I,J) = LAND(I,J)
          AGES(I,J)=MOD(LAND(I,J),10)
2       CONTINUE
1     CONTINUE
C
      KOUNT=YEARS
      Q=2
C  CUT THE (ODD,ODD) SQUARES OF LNDCPY
      DO 3,I=1,15,2
        DO 4, J=1,7,2
          CALL CKNCT(I,J,1)
4       CONTINUE
3     CONTINUE
C  CUT TREES OF ASPEN,LOWLAND HARDWOOD OR UPLAND HARDWOOD IF 51 TO 70
      DO 5, I=1,15,2
        DO 6, J=2,8,2
          TYP= LNDCPY(I,J)/10
          AGE=MOD(LNDCPY(I,J),10)
          IF ((TYP .GE. 1) .AND. (TYP .LE. 3)) THEN
            IF ((AGE .EQ. 6) .OR. (AGE .EQ. 7)) THEN
              TRECUT(TYP,AGE,1)=TRECUT(TYP,AGE,1) + 1
              LNDCPY(I,J) = LNDCPY(I,J)-AGE
              TOTCUT(TYP,AGE)=TOTCUT(TYP,AGE) + 1
            ENDIF
          ENDIF
6       CONTINUE
5     CONTINUE
C
      DO 7, I=2,16,2
        DO 8, J =1,7,2
          TYP = LNDCPY(I,J)/10
          AGE = MOD(LNDCPY(I,J),10)
          IF ((TYP .GE. 1) .AND. (TYP .LE. 3)) THEN
            IF((AGE .EQ. 6) .OR. (AGE .EQ. 7)) THEN
              TRECUT(TYP,AGE,1)=TRECUT(TYP,AGE,1) + 1
              LNDCPY(I,J) = LNDCPY(I,J)-AGE
              TOTCUT(TYP,AGE)=TOTCUT(TYP,AGE) + 1
            ENDIF
          ENDIF
8       CONTINUE
7     CONTINUE
C
      DO 9,I=2,16,2
        DO 10, J=2,8,2
```

Table 17. Computer program for model (cont'd)

```
          TYP = LNDCPY(I,J)/10
          AGE = MOD(LNDCPY(I,J),10)
          IF ((TYP .GE. 1) .AND. (TYP .LE. 3)) THEN
            IF ((AGE .GE. 5) .AND. ( AGE .LE. 7)) THEN
              TRECUT(TYP,AGE,1)=TRECUT(TYP,AGE,1) + 1
              LNDCPY(I,J) = LNDCPY(I,J)-AGE
              TOTCUT(TYP,AGE)=TOTCUT(TYP,AGE) + 1
            ENDIF
          ENDIF
10      CONTINUE
9     CONTINUE
C  FIRST ROUND OF CUTTING NOW COMPLETE
      KOUNT=KOUNT-10
      DO 27 I=2,3
        WRITE(I,100)
100     FORMAT('0')
        WRITE(I,*)' BELOW IS WHERE YOU SHOULD MAKE THE FIRST SET ',
     +'OF CUTS.'
27    CONTINUE
C  PLOT THE MATRIX TO SHOW USER WHERE TO CUT TREES
      CALL PLOTTR
      CALL PRNTRE(KOUNT,1)
      CALL AGEIT
C
      DO 29 I=2,3
        WRITE(I,100)
        WRITE(I,*)' BELOW IS YOUR GROUSE SITUATION AFTER 10 YEARS: '
29    CONTINUE
C
      CALL NOWPOP
C  CUT (ODD,EVEN) SQUARES OF LNDCPY
      DO 11, I=1,15,2
        DO 12, J=2,8,2
          CALL CKNCT(I,J,2)
12      CONTINUE
11    CONTINUE
C
      DO 13, I = 2,16,2
        DO 14, J=1,7,2
          TYP = LNDCPY(I,J)/10
          AGE = MOD(LNDCPY(I,J),10)
          IF ((TYP .GE. 1) .AND. (TYP .LE. 3)) THEN
            IF (AGE .EQ. 6) THEN
C  THESE ARE THE 50 YEAR OLDS THAT WEREN'T CUT LAST TIME
              TRECUT(TYP,AGE,2)=TRECUT(TYP,AGE,2) + 1
              LNDCPY(I,J) = LNDCPY(I,J)-AGE
              TOTCUT(TYP,AGE)= TOTCUT(TYP,AGE) + 1
            ENDIF
          ENDIF
14      CONTINUE
13    CONTINUE
C  SECOND ROUND OF CUTS DONE
      DO 30 I=2,3
        WRITE(I,100)
          WRITE(I,*)' BELOW IS WHERE YOU SHOULD MAKE YOUR SECOND ',
     +'SET OF CUTS. '
30    CONTINUE
C
      CALL PLOTTR
      CALL PRNTRE(KOUNT,2)
      CALL AGEIT
C
      DO 32 I=2,3
        WRITE(I,100)
          WRITE(I,*)' BELOW IS THE GROUSE SITUATION AFTER 20 YEARS ',
     +'OF MANAGEMENT.  '
32    CONTINUE
C
      CALL NOWPOP
C
      KOUNT=KOUNT-10
      Q=Q+1
      WRITE(2,100)
      WRITE(3,100)
C  LOGICAL GO TO INDICATE IF THERE ARE YEARS LEFT TO MANAGE
      GO=.TRUE.
C
26    CONTINUE
       IF (.NOT. GO) GOTO 15
C  CUT (EVEN,EVEN) SQUARES OF LNDCPY
        DO 16, I=2,16,2
```

Table 17. Computer program for the model (cont'd)

```
          DO 17, J=2,8,2
            CALL CKNCT(I,J,Q)
17        CONTINUE
16      CONTINUE
C
      DO 33 I =2,3
        WRITE(I,100)
        WRITE(I,*)' BELOW IS YOUR NEXT SET OF CUTS:'
33    CONTINUE
C
        CALL PLOTTR
        CALL PRNTRE(KOUNT,Q)
C
        KOUNT = KOUNT-10
        Q=Q+1
        DO 34 I=2,3
          WRITE(I,100)
          WRITE(I,101) YEARS-KOUNT
101       FORMAT('-','BELOW IS YOUR GROUSE SITUATION AFTER ',I2,
     +' YEARS:     ')
34      CONTINUE
        CALL AGEIT
        CALL NOWPOP
C
        IF(KOUNT .EQ. 0) THEN
          GO = .FALSE.
        ENDIF
C
        IF (GO) THEN
C  CUT (EVEN,ODD) SQUARES OF LNDCPY
          DO 18, I=2,16,2
            DO 19, J=1,7,2
              CALL CKNCT(I,J,Q)
19          CONTINUE
18        CONTINUE
C
          DO 35 I=2,3
            WRITE(I,100)
            WRITE(I,*)' BELOW IS YOUR NEXT SET OF CUTS: '
35        CONTINUE
C
          CALL PLOTTR
          CALL PRNTRE(KOUNT,Q)
          KOUNT=KOUNT-10
         Q=Q+1
          WRITE(2,101) YEARS-KOUNT
          WRITE(3,101) YEARS-KOUNT
C
          CALL AGEIT
C  AGE BRUSH AND FIELD TO LOWLAND HARDWOODS
          DO 20, I = 1,16
            DO 21, J=1,8
              IF ((LNDCPY(I,J)/10 .EQ. 5) .OR. (LNDCPY(I,J)/10 .EQ.6))
     +        THEN
                LNDCPY(I,J)=22
              AGES(I,J)=2
              ENDIF
21          CONTINUE
20        CONTINUE
C
          CALL NOWPOP
C
          IF (KOUNT .EQ. 0) THEN
            GO = .FALSE.
          ENDIF
        ENDIF
C
        IF (GO) THEN
C  CUT (ODD,ODD) SQUARES OF LNDCPY
          DO 22, I=1,15,2
            DO 23, J=1,7,2
              CALL CKNCT(I,J,Q)
23          CONTINUE
22        CONTINUE
C
          DO 36 I=2,3
            WRITE(I,100)
            WRITE(I,*)' BELOW IS YOUR NEXT SET OF CUTS: '
36        CONTINUE
C
          CALL PLOTTR
```

```
          CALL PRNTRE(KOUNT,Q)
C
          KOUNT=KOUNT-10
         Q=Q+1
          WRITE(2,101) YEARS-KOUNT
          WRITE(3,101) YEARS-KOUNT
C
          CALL AGEIT
          CALL NOWPOP
C
          IF (KOUNT .EQ. 0) THEN
            GO = .FALSE.
          ENDIF
        ENDIF
        IF (GO) THEN
C  CUT (ODD,EVEN) SQUARES OF LNDCPY
          DO 24, I=1,15,2
            DO 25, J=2,8,2
              CALL CKNCT(I,J,Q)
25          CONTINUE
24        CONTINUE
C
          DO 38 I=2,3
            WRITE(I,100)
            WRITE(I,*)' BELOW IS YOUR NEXT SET OF CUTS: '
38        CONTINUE
C
          CALL PLOTTR
          CALL PRNTRE(KOUNT,Q)
C
          KOUNT=KOUNT-10
         Q=Q+1
          WRITE(2,101) YEARS-KOUNT
          WRITE(3,101) YEARS-KOUNT
C
          CALL AGEIT
          CALL NOWPOP
C
          IF (KOUNT .EQ. 0) THEN
            GO = .FALSE.
          ENDIF
        ENDIF
C
      GOTO 26
15    CONTINUE
C
      RETURN
      END
      SUBROUTINE NOWPOP
C  THIS SUBROUTINE COMPUTES THE GROUSE POPULATION THAT IS EXPECTED
C  TO BE FOUND ON THE LAND ENTERED.  NOWPOP PRINTS A MAP OF
C  THE LOCATION OF THE CENTERS, THE AGE OF THE VEGETATION, AND THE
C  VEGETATIVE TYPE. THE TOTAL NUMBER OF ACTIVITY CENTERS AND THE
C  POTENTIAL NUMBER OF GROUSE ON THE LAND.
      IMPLICIT INTEGER (A-Z)
      DIMENSION LNDCPY(16,8),CENTRS(16,7),LAND(16,8),AGES(16,8)
      LOGICAL COND1,COND2,COND3,PSBLAC
      REAL OPNING
      COMMON/LANDS/LAND,LNDCPY,CENTRS,AGES,N,M,YEARS,TRECUT,
     +TOTCUT,PRICE(4,8)
      COMMON/PARAMS/RIVNRD,MAXGRS
C  CLEAR THE CENTERS MATRIX
      DO 1, I=2,16
        DO 2, J=1,7
          CENTRS(I,J)=0
2       CONTINUE
1     CONTINUE
C
      VEGAC=0
      DO 3, I=2,16
        DO 4, J=1,7
          PSBLAC= .TRUE.
          COND1 = .FALSE.
C  COND1:VEGETATION PROVIDES WINTER FOOD RESOURCES AND NESTING COVER
          COND2= .FALSE.
C  COND2:VEGETATION PROVIDES WINTER, NESTING, AND BREEDING COVER
          COND3 = .FALSE.
C  COND3:VEGETATION PROVIDES BROOD COVER
            IF ( I .NE. 1) THEN
C  BEGIN ON THE TOP ROW
              IF (CENTRS(I-1,J) .EQ. 1) THEN
```

```
               PSBLAC = .FALSE.
C  IT'S TOO CLOSE TO ANOTHER CENTER, THEREFORE IT CAN'T BE A CENTER
              ENDIF
              IF (J .NE. 7) THEN
                IF (CENTRS(I-1,J+1) .EQ. 1) THEN
                  PSBLAC = .FALSE.
                ENDIF
              ENDIF
            ENDIF
            IF (J .NE. 1) THEN
C  BEGIN IN THE LEFT-MOST COLUMN
              IF (CENTRS(I,J-1) .EQ. 1) THEN
                PSBLAC = .FALSE.
              ENDIF
            ENDIF
            IF ((I .NE. 1) .AND. (J .NE. 1)) THEN
              IF (CENTRS(I-1,J-1) .EQ. 1) THEN
                PSBLAC = .FALSE.
              ENDIF
           ENDIF
C  IF IT IS A POSSIBLE ACTIVITY CENTER CHECK THE FOUR SQUARES AROUND
C  IT FOR OTHER ACTIVITY CENTERS
          IF (PSBLAC) THEN
            DO 5, K = I,I+1
              DO 6, L=J,J+1
                TYP = LNDCPY(K,L)/10
                AGE = MOD(LNDCPY(K,L),10)
                IF ((AGE .GE. 3) .AND. (TYP .EQ. 1) .AND.
     +      (AGE .LT. 8)) THEN
C  ASPEN >=30 YEARS BUT <80 YEARS
                  COND1=.TRUE.
                ELSE IF ((AGE .GE. 3) .AND. (AGE .LE. 6) .AND.
     +         (TYP .EQ. 3)) THEN
C  30-60 YEAR OLD UPLAND HARDWOODS
                  COND2 = .TRUE.
                ELSE IF ((AGE .EQ. 2) .AND. (TYP .GE. 1) .AND.
     +        (TYP .LE. 2)) THEN
C  20 YEAR OLD ASPEN OR LOWLAND HARDWOODS
                   COND2 = .TRUE.
                ELSEIF((AGE.GE.3).AND.(AGE.LE.5).AND.
     +       (TYP.EQ.2))THEN
C  30-50 YEAR OLD LOWLAND HARDWOODS
                  COND2=.TRUE.
                ELSE IF ((AGE .GE.2) .AND. (AGE .LE. 3) .AND.
     +       (TYP .EQ. 4)) THEN
C  20-30 YEAR OLD CONIFERS
                  COND2 = .TRUE.
                ELSE IF (TYP .EQ. 6) THEN
C  BRUSH IS PRESENT FOR BROODING
                  COND3 = .TRUE.
                ELSE IF ((AGE .GE. 0) .AND. (AGE .LE. 1) .AND.
     +      (TYP .GE. 1) .AND. (TYP .LE. 2)) THEN
C  ASPEN OR LOWLANDS < 10 YEARS OLD
                  COND3 = .TRUE.
                ELSE IF ((AGE .GE. 1) .AND. (AGE .LE. 2) .AND.
     +         (TYP .EQ. 3)) THEN
C  10-20 YEAR OLD UPLANDS
                  COND3 = .TRUE.
                ENDIF
6             CONTINUE
5           CONTINUE
C  IF ALL CONDITIONS ARE MET FOR AN ACTIVITY CENTER, PLOT AND COUNT IT
           IF ((COND1) .AND. (COND2) .AND. (COND3)) THEN
              CENTRS(I,J) = 1
              VEGAC=VEGAC+1
            ENDIF
          ENDIF
C  END OF CHECK FOR POSSIBLE ACTIVITY CENTERS
4       CONTINUE
3     CONTINUE
C  FINISHED COMPUTING ALL CENTERS DUE TO THE JUXTAPOSITION OF THE 3
C  VEGATATIVE TYPES. NOW COUNT UP THE NUMBER OF OPENINGS THERE ARE
C  DUE TO FIELDS, MARSH, AND/OR WATER
      NUMOPS = 0
      DO 7, I=1,16
        DO 8, J=1,8
          TYP = LNDCPY(I,J)/10
          IF ((TYP .EQ. 5) .OR. (TYP .EQ. 7) .OR. (TYP .EQ. 8))THEN
            IF (I .EQ. 1) THEN
              NUMOPS = NUMOPS + 1
            ELSE IF ((LNDCPY(I,J) .LT. 5) .OR.
```

Table 17. Computer program for model (cont'd)

```
     +          (LNDCPY(I,J) .EQ. 6)) THEN
                NUMOPS = NUMOPS + 1
              ENDIF
            ENDIF
8         CONTINUE
7       CONTINUE
C  CALCULATE ONE ACTIVITY CENTER FOR EVERY QUARTER MILE OF RIVERS,
C  ROADS, OR STREAMS
        OPNING = 2.5*NUMOPS
        OPNAC = NINT(OPNING/40)
        BORDAC = NINT(RIVNRD*4.0/5280.0)
        IF((OPNING.GE.10).AND.(OPNAC.EQ.0))THEN
          OPNAC=1
        ENDIF
C  CALCULATE THE TOTAL NUMBER OF ACTIVITY CENTERS ON THE LAND
        TOTAC = BORDAC+OPNAC+VEGAC
        IF (TOTAC .GT. MAXGRS) THEN
          TOTAC = MAXGRS
        ENDIF
C
        DO 9 I=2,3
        IF(TOTAC.EQ.VEGAC) THEN
          IF(TOTAC.GT.0) THEN
           WRITE(I,101) TOTAC
101        FORMAT('  FOR THIS CONFIGURATION, YOU SHOULD HAVE ',I3)
           WRITE(I,*)' BREEDING PAIR(S) OF GROUSE ON YOUR LAND. '
          ELSE IF(TOTAC.LE.0) THEN
           WRITE(I,*)' FOR THIS CONFIGURATION, YOU SHOULD HAVE 0-1 '
           WRITE(I,*)' BREEDING PAIRS OF GROUSE ON YOUR LAND. '
          ENDIF
        ELSE IF(TOTAC.GT.VEGAC) THEN
          IF(VEGAC.GT.0) THEN
           WRITE(I,*)' FOR THIS CONFIGURATION, YOU SHOULD HAVE BETWEEN '
           WRITE(I,102) VEGAC,TOTAC
102        FORMAT(' ',I3,' AND ',I3,' BREEDING PAIRS')
           WRITE(I,*)' OF GROUSE ON YOUR LAND. OF THESE PAIRS, ONLY '
           WRITE(I,103) VEGAC
103        FORMAT(' ',I3,' ARE DUE TO THE VEGETATION TYPES. ')
           IF(OPNAC.GT.0) THEN
            WRITE(I,104) OPNAC
104         FORMAT('  ALSO, THERE ARE ',I3,' PAIR(S) DUE TO OPENINGS.')
           ENDIF
           IF(BORDAC.GT.0) THEN
            WRITE(I,105) BORDAC
105         FORMAT('  WHILE, ',I3,' PAIR(S) OF GROUSE ON YOUR LAND ARE ')
            WRITE(I,*)' DUE TO RIVERS AND/OR ROADS. '
           ENDIF
          ELSE IF(VEGAC.LE.0)THEN
           WRITE(I,106) TOTAC
106        FORMAT('  FOR THIS CONFIGURATION, YOU SHOULD HAVE 0 TO ',I3)
           WRITE(I,*)' BREEDING PAIRS OF GROUSE ON YOUR LAND. NONE OF '
           WRITE(I,*)' THESE GROUSE ARE DUE TO VEGETATION TYPES. '
           IF(OPNAC.GT.0) THEN
           WRITE(I,107) OPNAC
107        FORMAT(' ',I3,' PAIR(S) OF GROUSE ARE DUE TO OPENINGS ')
           WRITE(I,*)' ON YOUR LAND. '
           ENDIF
           IF(BORDAC.GT.0) THEN
           WRITE(I,108) BORDAC
108        FORMAT('  THERE ARE ',I3,' PAIR(S) DUE TO RIVERS AND/OR ROADS.
     +')
           ENDIF
          ENDIF
        ELSE IF(TOTAC.LT.VEGAC) THEN
          WRITE(I,109) TOTAC
109       FORMAT('  FOR THIS CONFIGURATION, YOU SHOULD HAVE ',I3)
          WRITE(I,*)' BREEDING PAIRS OF GROUSE ON YOUR LAND.'
        ENDIF
9       CONTINUE
C  CALCULATE THE NUMBER OF GROUSE ON THE LAND
          IF (TOTAC.EQ.VEGAC) THEN
           IF (TOTAC.GT.0) THEN
            BIRDS1 = TOTAC*5
            BIRDS2 = TOTAC*6
           ELSEIF(TOTAC.LE.0) THEN
            BIRDS1 = 0
            BIRDS2 = 6
           ENDIF
          ELSEIF(TOTAC.GT.VEGAC) THEN
           IF(VEGAC.GT.0) THEN
            BIRDS1 = VEGAC*5
```

```
          BIRDS2 = TOTAC*6
         ELSEIF(VEGAC.LE.0) THEN
          BIRDS1 = 0
          BIRDS2 = TOTAC*6
         ENDIF
        ELSEIF(TOTAC.LT.VEGAC) THEN
         BIRDS1 = TOTAC*5
         BIRDS2 = TOTAC*6
        ENDIF
C
      DO 10 I=2,3
        WRITE(I,*)' IN AN AVERAGE YEAR, THIS IS APPROXIMATELY ',
     +  'EQUIVALENT TO A FALL '
        WRITE(I,110) BIRDS1,BIRDS2
110     FORMAT ('  POPULATION OF BETWEEN ',I3,' AND ',I3,' GROUSE.')
        IF (VEGAC.GT.0) THEN
         WRITE(I,*)' THE @''S IN THE FOLLOWING GRAPH REPRESENT'
         WRITE(I,*)' ACTIVITY CENTERS DUE TO VEGETATIVE TYPES.'
        ENDIF
C  PRINT MESSAGE IF THERE ARE MORE CENTERS VIA VEGETATION THAN POSSIBLE
        IF (TOTAC .LT. VEGAC) THEN
          WRITE(I,111) TOTAC
111       FORMAT(' BECAUSE OF GROUSE TERRITORIALITY, ONLY ',I3,' OF A')
          WRITE(I,112) VEGAC
112       FORMAT(' POSSIBLE ',I3,' ACTIVITY CENTERS WILL BE OCCUPIED.')
        ENDIF
10    CONTINUE
C  PLOT THE LAND INDICATING VEG. ACTIVITY CENTERS
      CALL PLOTTR
      RETURN
      END
      SUBROUTINE CKNCT(I,J,Q)
      IMPLICIT INTEGER (A-Z)
      DIMENSION LAND(16,8),CENTRS(16,7),LNDCPY(16,8),AGES(16,8),
     +TRECUT(3,8,8),TOTCUT(3,8),OCTCUT(4,8)
      COMMON/LANDS/LAND,LNDCPY,CENTRS,AGES,N,M,YEARS,TRECUT,
     +TOTCUT,PRICE(4,8)
C
      TYP=LNDCPY(I,J)/10
      AGE = MOD(LNDCPY(I,J),10)
      AGES(I,J)=AGE
C  CUT THE VEGETATION IF OF RIGHT TYPE AND AGE
      IF ((TYP .GE. 1) .AND. (TYP .LE. 3) ) THEN
        IF ((AGE .GT. 1) .AND. (AGE .LE. 8)) THEN
          TRECUT(TYP,AGE,Q)=TRECUT(TYP,AGE,Q) + 1
          LNDCPY(I,J) = LNDCPY(I,J)-AGE
          TOTCUT(TYP,AGE)=TOTCUT(TYP,AGE) + 1
        ENDIF
      ENDIF
      RETURN
      END
      SUBROUTINE AGEIT
      IMPLICIT INTEGER (A-Z)
      DIMENSION LAND(16,8),CENTRS(16,7),LNDCPY(16,8),AGES(16,8)
      COMMON/LANDS/LAND,LNDCPY,CENTRS,AGES,N,M,YEARS,TRECUT,
     +TOTCUT,PRICE(4,8)
C
C  AGE VEGETATION IF <80 YRS & OF TREE TYPE
      DO 1, I=1,N
        DO 2, J=1,8
          AGE = MOD(LNDCPY(I,J),10)
          IF ((AGE .LT. 8) .AND. (LNDCPY(I,J) .NE. 0)) THEN
            LNDCPY(I,J) = LNDCPY(I,J)+1
            AGES(I,J)=MOD(LNDCPY(I,J),10)
          ENDIF
2       CONTINUE
1     CONTINUE
      RETURN
      END
      SUBROUTINE PLOTTR
C  THIS SUBROUTINE IS USED TO PRINT A PLOT OF THE ORIGINAL LAND AND THE
C  LAND AS IT IS CHANGED BY THE PRESCRIBED CUTTING
      IMPLICIT INTEGER (A-Z)
      DIMENSION LAND(16,8),LNDCPY(16,8),CENTRS(16,7),AGES(16,8)
      CHARACTER*3 DECODE(9),CUTLIN(9)
      CHARACTER*1 ACSITE(9)
      CHARACTER ARR*64
      COMMON/LANDS/LAND,LNDCPY,CENTRS,AGES,N,M,YEARS,TRECUT,
     +TOTCUT,PRICE(4,8)
      DO 1 I=2,3
      WRITE(I,*)' '
```

Table 17. Computer program for model (cont'd)

```
        WRITE(I,*)' KEY:'
        WRITE(I,*)'   VEGETATION TYPES: '
        WRITE(I,*)'     ASPEN(A)        LOWLAND HARDWOODS(L)'
        WRITE(I,*)'     FIELDS(F)       UPLAND HARDWOODS(U)'
        WRITE(I,*)'     BRUSH(B)        SWAMP CONIFERS/PINES(C)'
        WRITE(I,*)'     MARSH(M)        WATER(PONDS & LAKES) (W)'
        WRITE(I,*)'        NOT TO BE CONSIDERED(NOT CON) '
        WRITE(I,*)' '
        WRITE(I,*)'   AGE CLASSES:(IN YEARS) '
        WRITE(I,*)'     0-10(10)       ***  '
        WRITE(I,*)'     10-20(20)      XXX  '
        WRITE(I,*)'     20-30(30)      ///  '
        WRITE(I,*)'     30-40(40)      ...  '
        WRITE(I,*)'     40+  '
1     CONTINUE
C
      DO 2 I=1,N
C   CHANGE NUMBER CODE INTO CHARACHTER INFORMATION
        CALL DECODR(LNDCPY,I,M,DECODE,AGES)
C   GET THE CHARACTERS TO TELL THE USER IF THEY ARE TO CUT BLOCK OF LAND
        CALL CUTS(LNDCPY,I,M,CUTLIN)
C   PUT ACTIVITY CENTERS INTO A CHARACHTER ARRAY EXCEPT IN THE FIRST ROW
      IF(I.NE.1)THEN
        CALL SITES(CENTRS,I,M,ACSITE)
      ENDIF
C   PLOT THE VEGETATIVE CODE AND THE POTENTIAL ACTIVITY CENTERS
        DO 3 K=2,3
          WRITE(K,104)
104       FORMAT(' ',13('_____'))
          DO 4 J=1,8
      N1=J*8-7
      N2=J*8
          AGES(I,J)=MOD(LNDCPY(I,J),10)
           IF(AGES(I,J).EQ.1) THEN
           ARR(N1:N2)=':*******'
            ELSE IF(AGES(I,J).EQ.2) THEN
           ARR(N1:N2)=':XXXXXXX'
            ELSE IF(AGES(I,J).EQ.3) THEN
           ARR(N1:N2)=':///////'
            ELSE IF(AGES(I,J).EQ.4) THEN
           ARR(N1:N2)=':.......'
      ELSEIF((AGES(I,J).GE.5).OR.(AGES(I,J).EQ.0))THEN
           ARR(N1:N2)=':       '
            ENDIF
4         CONTINUE
C
      WRITE(K,105)ARR
105   FORMAT(' ',A64)
C
          WRITE(K,110)(DECODE(J),J=1,8)
110       FORMAT(' ',8(':',2X,A3,2X),':')
C
          WRITE(K,120)(CUTLIN(J),J=1,8)
120       FORMAT(' ',8(':',2X,A3,2X),':')
C
          IF(I.NE.1) THEN
            WRITE(K,130)(ACSITE(J),J=1,7)
130         FORMAT(' ',8(':',3X,A1,3X),'::')
          ELSE
            WRITE(K,140)
140         FORMAT(1X,':',8(7X,':'))
          ENDIF
C
      DO 5 J=1,8
      N1=J*8-7
      N2=J*8
      AGES(I,J)=MOD(LNDCPY(I,J),10)
        IF (AGES(I,J).EQ.1) THEN
         ARR(N1:N2)=':*******'
          ELSE IF(AGES(I,J).EQ.2) THEN
           ARR(N1:N2)=':XXXXXXX'
          ELSE IF(AGES(I,J).EQ.3) THEN
           ARR(N1:N2)=':///////'
          ELSE IF(AGES(I,J).EQ.4) THEN
           ARR(N1:N2)=':.......'
      ELSEIF((AGES(I,J).GE.5).OR.(AGES(I,J).EQ.0))THEN
           ARR(N1:N2)=':       '
       ENDIF
5     CONTINUE
C
      WRITE(K,145)ARR
```

Table 17. Computer program for model (cont'd)

```
145    FORMAT(' ',A64)
C
       WRITE(K,104)
C
3         CONTINUE
C   CONTINUE PLOTTING
2      CONTINUE
       RETURN
       END
       SUBROUTINE DECODR(LNDCPY,I,M,DECODE,AGES)
C   THIS SUBROUTINE TAKES THE 2 DIGIT VEGETATION-AGE CODE, SEPARATES THE
C   VEGETATION TYPE AND SETS THE NUMBER CODE TO ITS CHARACTER EQUIVALENT.
C   THE EQUIVALENT IS SAVED FOR PRINTING IN THE CHARACTER ARRAY DECODE.
       IMPLICIT INTEGER (A-Z)
       DIMENSION LNDCPY(16,8),AGES(16,8)
       CHARACTER*3 DECODE(9)
       CHARACTER*2 OLDAGE(9)
       CHARACTER*1 CODES(8)
       DATA CODES/'A','L','U','C','F','B','M','W'/
       DATA OLDAGE/' 0','10','20','30','40','50','60','70','80'/
       DO 1 J=1,M
C   CHECK FOR EMPTY SPACE
          IF(LNDCPY(I,J).LT.10)THEN
             DECODE(J)='NOT'
          ELSE
C   SEPARATE THE VEGETATION TYPE
             TVEG=LNDCPY(I,J)/10
C   SAVE THE CHARACTER VALUE OF THE VEGATATION TYPE IN THE ARRAY
             DECODE(J)(1:1)=CODES(TVEG)
C   GET THE AGE BEFORE CUTTING
             TAGE=AGES(I,J)
C   SAVE THE CHARACTER VALUE OF THE AGE BEFOR PUTTING IN THE ARRAY
             DECODE(J)(2:3)=OLDAGE(TAGE+1)
          ENDIF
1      CONTINUE
       RETURN
       END
       SUBROUTINE SITES(CENTRS,I,M,ACSITE)
C   TAKES THE NUMBERS THAT INDICATE AN ACTIVITY CENTER BEING PRESENT
C   OR ABSENT AND CONVERTS THEM TO CHARACTER CODE FOR PRINTING.
       IMPLICIT INTEGER(A-Z)
       DIMENSION CENTRS(16,7)
       CHARACTER*1 AC(2),ACSITE(9)
       DATA AC/' ','@'/
C
       DO 1 J=1,7
             ACSITE(J)=AC(CENTRS(I,J)+1)
1      CONTINUE
C
       RETURN
       END
       SUBROUTINE CUTS(LNDCPY,I,M,CUTLIN)
C   TAKES THE AGES OF VEGETATION AND CONVERTS THEM TO CHARACTERS TO BE
C   PRINTED TO TELL THE USER IF HE IS TO CUT THAT AREA THIS YEAR OR NOT.
       IMPLICIT INTEGER(A-Z)
       DIMENSION LNDCPY(16,8)
       CHARACTER*3 CUTNOW(2),CUTLIN(9)
       DATA CUTNOW/'CUT','   '/
C
       DO 2 J=1,M
          IF (LNDCPY(I,J).LT.10)THEN
             CUTLIN(J)='CON'
          ELSE
             IF (MOD(LNDCPY(I,J),10).EQ.0) THEN
                CUTLIN(J)=CUTNOW(1)
             ELSE
                CUTLIN(J)=CUTNOW(2)
             ENDIF
          ENDIF
2      CONTINUE
C
       RETURN
       END
       SUBROUTINE  INTRO
C   PRINTS OUT INSTRUCTIONS TO THE USER DESCRIBING HOW TO USE THE MODEL,
C   AND WHAT THE MODEL DOES.
C
C   WRITE INTRO TO THE TERMINAL AND THEN TO THE USERCOPY FILE
       DO 1 I=2,3
          WRITE(I,100)
100       FORMAT('0')
```

APPENDIX A

Table 17. Computer program for model (cont'd)

```
      WRITE(I,*)'     GROUSE MANAGEMENT:'
      WRITE(I,*)'   THE OBJECTIVES OF RUFFED GROUSE MANAGEMENT ARE TO'
      WRITE(I,*)' PROVIDE FOOD AND COVER FOR GROUSE AT ALL STAGES OF'
      WRITE(I,*)' THEIR LIFE CYCLE AND DURING ALL SEASONS OF THE '
      WRITE(I,*)' YEAR.  IN MICHIGAN, THE BEST GROUSE HABITAT '
      WRITE(I,*)' MANAGEMENT SHOULD INVOLVE, IF POSSIBLE, ASPEN AND'
      WRITE(I,*)' OTHER HARDWOOD TREE MANAGEMENT.  FOR THIS MODEL'
      WRITE(I,*)' THERE ARE THREE CONDITIONS THAT MUST BE MET '
      WRITE(I,*)' FOR RUFFED GROUSE TO BE PRESENT ON YOUR LAND. '
      WRITE(I,*)' FIRST, ASPEN GREATER THAN 21 YEARS OLD ARE REQUIRED'
      WRITE(I,*)' FOR WINTER FOOD.  SECOND, EITHER UPLAND HARDWOODS '
      WRITE(I,*)' 21-60 YEARS OLD, LOWLAND HARDWOODS 11-59 YEARS OLD,'
      WRITE(I,*)' CONIFERS 21-30 YEARS OLD, OR 11-20 YEAR OLD ASPEN'
      WRITE(I,*)' ARE NEEDED TO PROVIDE WINTER, NESTING, AND BREEDING'
      WRITE(I,*)' COVER.  THIRD, EITHER ASPEN OR LOWLAND HARDWOODS '
      WRITE(I,*)' UP TO 10 YEARS OLD, UPLANDS HARDWOODS UP TO 20 '
      WRITE(I,*)' YEARS OLD, OR BRUSH OF ANY AGE MUST BE PRESENT FOR '
      WRITE(I,*)' BROOD COVER.  IN GENERAL CLEAR CUTTING SMALL PLOTS '
      WRITE(I,*)' OF ASPEN AND OTHER HARDWOOD TREES IN TEN YEAR '
      WRITE(I,*)' INTERVALS BETWEEN THE DIFFERENT CUT IS THE MOST    '
      WRITE(I,*)' EFFECTIVE STRATEGY FOR ESTABLISHING AND MAINTAINING'
      WRITE(I,*)' THE ABOVE COMBINATIONS OF AGE CLASSES. '
C
      CALL RETURNS(I)
C
      WRITE(I,*)'    WHAT THE MODEL WILL DO:'
      WRITE(I,*)'   BASED ON THE DATA YOU PROVIDE REGARDING THE '
      WRITE(I,*)' PRESENT CONDITION OF YOUR PROPERTY IN TERMS OF '
      WRITE(I,*)' VEGETATION TYPES AND AGES, AND THE EXISTING FOOTAGE'
      WRITE(I,*)' OF RIVERS, STREAMS, AND ROADS THE MODEL IDENTIFIES'
      WRITE(I,*)' EXISTING ACTIVITY CENTERS.  THE COMPUTER THEN '
      WRITE(I,*)' RECOMMENDS BLOCKS OF YOUR LAND THAT SHOULD BE CUT'
      WRITE(I,*)' IN ORDER TO MAXIMIZE YOUR GROUSE POPULATION.  THE'
      WRITE(I,*)' COMPUTER PREDICTS THE NUMBER OF GROUSE THAT WILL'
      WRITE(I,*)' REPRODUCE ON YOUR LAND IF YOU FOLLOW ITS CUTTING '
      WRITE(I,*)' PLAN.  IT ALSO TELLS YOU THE REVENUES YOU WILL  '
      WRITE(I,*)' RECIEVE FROM CUTTING THE TIMBER ON YOUR LAND.  ALSO'
      WRITE(I,*)' YOU MAY ENTER YOUR OWN CUTTING STRATEGIES AND SEE '
      WRITE(I,*)' HOW THOSE PLANS WILL EFFECT THE GROUSE POPULATION '
      WRITE(I,*)' COMPARED WITH THE COMPUTER GENERATED CUTTING PLAN. '
C
      CALL RETURNS(I)
C
      WRITE(I,*)'   THE STATUS OF YOUR RUFFED GROUSE POPULATION WILL'
      WRITE(I,*)' BE GIVEN IN TERMS OF THE AVAILABILITY OF SITES FOR'
      WRITE(I,*)' MALES TO SET UP TERRITORIES.  THESE SITES, REFERRED'
      WRITE(I,*)' TO AS ACTIVITY SITES, WILL BE PRESENT ON YOUR LAND'
      WRITE(I,*)' WHEN ALL 3 OF THE CONDITIONS PREVIOUSLY MENTIONED'
      WRITE(I,*)' ARE MET.  TO ACHEIVE THE DESIRED AGE COMBINATIONS  '
      WRITE(I,*)' A 30 YEAR MANAGEMENT PERIOD IS RECOMMENED. THIS  '
      WRITE(I,*)' MODEL PROVIDES A TOOL FOR ANYONE CONSIDERING '
      WRITE(I,*)' MANAGING THEIR LAND FOR GROUSE. '
C
      CALL RETURNS(I)
C
      WRITE(I,*)'     REPRESENTATION OF LAND:'
      WRITE(I,*)'   THE LAND IS TO BE REPRESENTED AS A MAP OF  '
      WRITE(I,*)' PREDETERMINED VEGETATION TYPES FOR TREES AND THE'
      WRITE(I,*)' LOCATION OF BODIES OF WATER.  THE MAP CONSISTS OF '
      WRITE(I,*)' AN 8 ROW BY 16 COLUMN MATRIX, OR 128 BLOCKS, WITH '
      WRITE(I,*)' EACH BLOCK REPRESENTING A 2.5 ACRE SECTION OF YOUR '
      WRITE(I,*)' LAND.  EACH BLOCK IS 330 FEET WIDE (OR 1/16 MILE) '
      WRITE(I,*)' BY 330 FEET LONG (OR 1/16 MILE).  THIS ALLOWS FOR'
      WRITE(I,*)' AREAS OF UP TO 320 ACRES, OR ONE HALF MILE BY ONE'
      WRITE(I,*)' IN AREA.  FOR EACH 2.5 ACRE BLOCK OF YOUR LAND YOU'
      WRITE(I,*)' MUST DETERMINE THE TYPE AND AGE OF THE VEGETATION.'
      WRITE(I,*)'   THE VEGETATION TYPES AND RELATED AGE CLASSES '
      WRITE(I,*)' ARE AS FOLLOWS (THE LETTERS OR NUMBERS IN THE '
      WRITE(I,*)' PARENTHESIS ARE THE ABBREVIATIONS PRINTED ON THE '
      WRITE(I,*)' COMPUTER GENERATED MAPS): '
      WRITE(I,*)' '
     WRITE(I,*)' VEGETATION TYPES           CODE     AGE CLASSES      CODE'
     WRITE(I,*)'  ASPEN(A)                   1        0-10 YRS.(10)      1'
     WRITE(I,*)'  LOWLAND HARDWOODS(L)       2        11-21 YRS.(20)     2'
     WRITE(I,*)'  UPLAND HARDWOODS(U)        3        21-30 YRS.(30)     3'
     WRITE(I,*)'  SWAMP CONIFERS/PINES(C)    4        31-40 YRS.(40)     4'
     WRITE(I,*)'  FIELDS(F)                  5        41-50 YRS.(50)     5'
     WRITE(I,*)'  BRUSH(B)                   6        51-60 YRS.(60)     6'
     WRITE(I,*)'  MARSH(M)                   7        61-70 YRS.(70)     7'
     WRITE(I,*)'  WATER (PONDS &LAKES) (W)   8        71-80+ YRS.(80)    8'
     WRITE(I,*)'  NOT CONSIDERED(NOT CON)    00 '
```

Table 17. Computer program for model (cont'd)

```
C
        CALL RETURNS(I)
C
        WRITE(I,*)'   REMEMBER - THE VEGETATION TYPE AND AGE MUST BE  '
        WRITE(I,*)' ENTERED AS A TWO DIGIT CODE.  THE FIRST DIGIT '
        WRITE(I,*)' REPRESENTS THE VEGETATION TYPE, FOR EXAMPLE THE '
        WRITE(I,*)' CODE FOR UPLAND HARDWOODS IS 3.  THE SECOND DIGIT'
        WRITE(I,*)' REPRESENTS THE AGE CLASS, FOR EXAMPLE THE CODE FOR'
        WRITE(I,*)' 61-70 YEAR OLD VEGETATION IS 7.  THEREFORE, A'
        WRITE(I,*)' BLOCK OF ASPEN 31-40 YEARS OLD WILL BE ENTERED AS '
        WRITE(I,*)' THE NUMBER 14 FROM THE ABOVE LIST.  THE FIRST '
        WRITE(I,*)' INFORMATION THAT THE COMPUTER WILL PROMPT YOU TO '
        WRITE(I,*)' ENTER ARE THE TWO DIGIT CODES REPRESENTING THE   '
        WRITE(I,*)' VEGETATAIVE TYPE AND AGE OF YOUR BLOCKS OF LAND.  '
        WRITE(I,*)' THE BLOCKS ARE NUMBERED FROM LEFT TO RIGHT ACROSS '
        WRITE(I,*)' THE ROWS, THE FIRST ROW CONTAINS BLOCKS 1-8 AND '
        WRITE(I,*)' THE SECOND ROW BEGINS WITH BLOCK 9 AND SO ON. '
        WRITE(I,*)' EACH ROW THAT YOUR LAND FALLS ON MUST BE COMPLETELY'
        WRITE(I,*)' FILLED IN. IF PART OF THE ROW, FOR ANY REASON, IS '
        WRITE(I,*)' LAND THAT YOU DO NOT WANT CONSIDERED IN YOUR '
        WRITE(I,*)' ANALYSIS JUST ENTER A 00.  ENTER A -1 IN THE AFTER'
        WRITE(I,*)' THE ROW CONTAINING YOUR FINAL BLOCK OF LAND. '
        WRITE(I,*)' REMEMBER TO COMPLETELY FILL ALL ROWS THAT CONTAIN '
        WRITE(I,*)' ANY LAND THAT YOU WANT TO BE EXAMINED.  IF A -1 IS '
        WRITE(I,*)' ENTERED ANY PLACE IN A ROW THAT ENTIRE ROW AND ALL'
        WRITE(I,*)' SUBSEQUENT ROWS WILL NOT BE CONSIDERED.  A REMINDER'
        WRITE(I,*)' OF THE CODES THAT YOU WILL NEED TO ENTER INTO THE'
        WRITE(I,*)' THE COMPUTER IS GIVEN BELOW.'
1     CONTINUE
C
      CALL RETURNS(I)
C
      RETURN
      END
      SUBROUTINE ENDING
      DO 1 I=2,3
        WRITE(I,*)' '
        WRITE(I,*)' '
        WRITE(I,*)' REMINDER : THIS MODEL IS MEANT TO BE A TOOL TO HELP'
        WRITE(I,*)' YOU TO UNDERSTAND THE GENERAL PRINCIPLES OF RUFFED '
        WRITE(I,*)' GROUSE MANAGEMENT AND TO SHOW THE ADVANTAGES OF    '
        WRITE(I,*)' MANAGING YOUR LAND FOR RUFFED GROUSE.  IT'
        WRITE(I,*)' DOES NOT TAKE INTO ACCOUNT THE FLUCTUATING '
        WRITE(I,*)' BIOLOGY OF THE RUFFED GROUSE.  FOR A MORE' '
        WRITE(I,*)' INDIVIDUALIZED SET OF MANAGEMENT RECOMMENDATIONS,'
        WRITE(I,*)' CONSULT YOUR LOCAL WILDLIFE BIOLOGIST, COMMERCIAL  '
        WRITE(I,*)' FORESTER, OR RUFFED GROUSE SOCIETY REPRESENTATIVE.'
        WRITE(I,*)' '
        WRITE(I,*)' I HOPE THAT THE INFORMATION THIS MODEL PROVIDES'
        WRITE(I,*)' WILL BE USEFUL TO YOU AND THAT YOU HAVE ENJOYED'
        WRITE(I,*)' WORKING WITH THE MODEL.'
1     CONTINUE
C
      RETURN
      END
      SUBROUTINE OWNCUT(ANSWER)
C  THIS SUBROUTINE ALLOWS THE USER TO ENTER THEIR OWN CUTTING PLAN FOR
C  THE TREE STANDS ENTERED ORIGINALLY. THE USER MUST ENTER THE BLOCK
C  TO BE CUT EACH YEAR BY BLOCK NUMBER. PLOTS OF THE LAND ARE PRODUCED
C  BUT THE AREAS CUT ARE NOT DEPICTED. POTENTIAL CENTERS ARE SHOWN.
      IMPLICIT INTEGER (A-Z)
      DIMENSION LAND(16,8),CENTRS(16,7),LNDCPY(16,8),AGES(16,8),
     +OCTCUT(4,8,8),OCPCUT(4,8)
      CHARACTER*3 ANSWER
      INTEGER OCBLOCK,NUMBLKS,IX,OCYEARS
      COMMON/LANDS/LAND,LNDCPY,CENTRS,AGES,N,M,YEARS,TRECUT,
     +TOTCUT,PRICE
      COMMON/SECTOR/LOCALE(16,8)
      REAL OCTA(4,8,8),OCGTA(4),OCTA1,OCGTA1(4),PRICE(4,8),OCGPA(4),
     +OCPA(4,8),OCGPA1(4),OCPA1(4,8),RATE,OCYTMP
      DATA RATE /0.10/
C
23    CONTINUE
      IF (ANSWER .EQ. 'NO ') GOTO 24
C  SET LNDCPY AND AGES MATRICES BACK TO ORIGINAL LAND AND AGES ENTERED
        DO 1 I = 1,16
          DO 2 J = 1,8
            LNDCPY(I,J) = LAND (I,J)
            AGES(I,J)=MOD(LAND(I,J),10)
2         CONTINUE
1       CONTINUE
```

Table 17. Computer program for model (cont'd)

```
C  SET CENTRS BACK TO NONE
         DO 3 I = 2,16
           DO 4 J = 1,7
             CENTRS(I,J) = 0
4          CONTINUE
3      CONTINUE
C
         DO 5 S = 1,4
          DO 6 T = 1,8
           DO 6 R = 1,8
           OCTCUT(S,T,R)= 0
6         CONTINUE
5        CONTINUE
C
         PRINT*,'FOR HOW MANY YEARS WOULD YOU LIKE TO MANAGE YOUR LAND? '
         PRINT*,'ENTER A MULTIPLE OF 10, BETWEEN 10 AND 80.'
         READ*,OCYEARS
         OCYTMP = OCYEARS/10.0
         OCYEARS = NINT(OCYTMP)*10
C
         DO 9 K = 1,OCYEARS,10
         Q = (K+9)/10
C
         DO 10 S = 1,4
           DO 11 T = 1,8
            OCPCUT(S,T)= 0
11         CONTINUE
10       CONTINUE
C
           PRINT*,' '
           PRINT*,' '
       IX=K-1
       IF (K .EQ. 1) THEN
        PRINT *,'HOW MANY BLOCKS OF LAND DO YOU WANT TO CUT IN THE '
        PRINT*,'FIRST YEAR OF YOUR MANAGEMENT PLAN? (IF YOU DO NOT '
        PRINT*,'WANT TO CUT THIS YEAR, TYPE THE NUMBER 999 RATHER  '
        PRINT*,'THAN THE NUMBER OF BLOCKS TO BE CUT.)'
       ELSE
        PRINT 100, IX
100     FORMAT(' HOW MANY BLOCKS DO YOU WANT TO CUT IN ',
     +          I2,' YEARS(999 = NONE)?')
C
           READ *, NUMBLKS
       ENDIF
C
           IF(NUMBLKS.EQ.999) GOTO 9
C
           IF (K .EQ. 1) THEN
             PRINT *,' WHAT BLOCKS OF LAND DO YOU WANT TO CUT IN '
             PRINT*,' THE FIRST YEAR OF YOUR MANAGEMENT PLAN?   '
           ELSE
             PRINT 110, IX
110          FORMAT (' WHAT BLOCKS DO YOU WANT TO CUT IN ',
     +                 I2,' YEARS?')
           ENDIF
C
         PRINT *,' ENTER THE CODES FROM YOUR OVERLAY ON SEPERATE LINES.'
         PRINT *,' FOR EXAMPLE, ENTER A 9 IF YOU WANT TO CUT THE '
         PRINT *,' FIRST BLOCK IN THE SECOND ROW.'
C  READ, FIND, AND CUT THE BLOCKS OF VEGETATION ENTERED BY THE USER
           DO 12 L=1,NUMBLKS
           PRINT *,' ENTER BLOCK:'
           READ *,OCBLOCK
C  FIND AND SAVE THE LOCATION OF THE BLOCK TO BE CUT
             DO 13 I=1,16
               DO 14 J=1,8
                 IF (LOCALE(I,J) .EQ. OCBLOCK) THEN
                   S=I
                   T=J
                 ENDIF
14             CONTINUE
13           CONTINUE
C  CUT THE TREES IN THAT INDICATED BLOCK
             TYP = LNDCPY(S,T)/10
             AGE = MOD(LNDCPY(S,T),10)
             LNDCPY(S,T) = LNDCPY(S,T) - AGE
             OCTCUT(TYP,AGE,Q) = OCTCUT(TYP,AGE,Q) + 1
             OCPCUT(TYP,AGE) = OCPCUT(TYP,AGE) + 1
12         CONTINUE
C
           IF (IX .EQ. 30) THEN
```

APPENDIX A

Table 17. Computer program for model (cont'd)

```
            DO 15 I=1,16
              DO 16 J=1,8
                IF ((LNDCPY(I,J)/10 .EQ. 5) .OR.
     +              (LNDCPY(I,J)/10 .EQ. 6)) THEN
                  LNDCPY(I,J)=22
                  AGES(I,J)=2
                ENDIF
16            CONTINUE
15          CONTINUE
          ENDIF
C
          CALL AGEIT
C
          DO 17 I=2,3
            WRITE(I,120) IX+10
120         FORMAT(' THIS IS YOUR GROUSE SITUATION AFTER ',I2,' YEARS',
     +             'OF MANAGEMENT: ')
17        CONTINUE
C
          CALL NOWPOP
C
C  THESE ARE THE ACRES CUT IN THE PAST TEN YEARS ONLY
        DO 18 S=1,4
         OCGPA(S)=0.0
         DO 18 T=1,8
          OCPA(S,T)=(REAL(OCPCUT(S,T)))*2.5
          OCGPA(S)=OCGPA(S) + OCPA(S,T)
18      CONTINUE
C  THIS IS THE REVENUE FROM THE ACRES CUT IN THE PAST TEN YEARS
        DO 19 S=1,4
         OCGPA1(S)=0.0
          DO 19 T=1,8
           OCPA1(S,T)=(OCPA(S,T)*PRICE(S,T))
           OCGPA1(S)=OCGPA1(S) + OCPA1(S,T)
19      CONTINUE
C  THIS IS THE TOTAL NUMBER OF ALL ACRES CUT SO FAR
        DO 20 S=1,4
         OCGTA(S)=0.0
          DO 20 T=1,8
           DO 20 R=1,0
            OCTA(S,T,R) = (REAL(OCTCUT(S,T,R)))*2.5
            OCGTA(S) = OCGTA(S) + OCTA(S,T,R)
20      CONTINUE
C  THIS IS THE NET PRESENT VALUE FROM ALL OF THE ACRES CUT SO FAR
        DO 21 S=1,4
         OCGTA1(S)=0.0
         DO 21 T=1,8
          DO 21 R=1,0
           OCTA1 = (OCTA(S,T,R) * PRICE(S,T))/((1.0 + RATE)**((R-1)*10))
           OCGTA1(S) = OCGTA1(S) + OCTA1
21      CONTINUE
C
        DO 22  L=2,3
        WRITE(L,125)
125     FORMAT('0','BELOW ARE THE ACRES CUT DURING THE PAST TEN YEARS.')
        WRITE(L,130) (OCGPA(S),S=1,4)
130     FORMAT('0','ASPEN',17X,F9.2,/,1X,'LOWLAND HARDWOODS',5X,F9.2,/,
     +1X,'UPLAND HARDWOODS',6X,F9.2,/,1X,'SWAMP CONIFERS/PINES',2X,F9.2)
        WRITE(L,135)
135     FORMAT('0','BELOW ARE THE REVENUES GENERATED BY THE CUTS MADE IN
     +THE PAST TEN YEARS.')
        WRITE(L,130) (OCGPA1(S),S=1,4)
        WRITE(L,140)
140     FORMAT('0','BELOW IS A TOTAL OF THE ACRES THAT HAVE BEEN CUT SO F
     +AR.')
        WRITE(L,130) (OCGTA(S),S=1,4)
        WRITE(L,145)
145     FORMAT('0','BELOW IS THE NET PRESENT VALUE OF ALL OF THE ACRES TH
     +AT HAVE BEEN CUT SO FAR.')
        WRITE(L,130) (OCGTA1(S),S=1,4)
22      CONTINUE
C
9        CONTINUE
C  ALLOW USER TO TRY ANOTHER CUTTING PLAN
         PRINT *,' WOULD YOU LIKE TO ENTER ANOTHER PLAN?'
         READ 105, ANSWER
105      FORMAT(A3)
C
      GOTO 23
24    CONTINUE
      RETURN
```

Table 17. Computer program for model (cont'd)

```
      END
      SUBROUTINE RETURNS(I)
C  THIS SUBROUTINE PROVIDES SPACING BETWEEN BLOCKS OF THE INTRODUCTION
C  AND ALLOWS THE USER TO GET A GOOD OPERTUNITY TO READ WHAT IS SAID
C  IN THE INTRODUCTION
      INTEGER I
C
      WRITE(I,100)
100   FORMAT('O')
C  ALLOW THE USER TO INDICATE THAT THEY ARE READY TO CONTINUE
      IF(I.EQ.2)THEN
C
        PRINT*,'                    (ENTER "GO" AND PRESS RETURN TO CONTINUE)'
        READ(*,*)
C
        WRITE(2,110)
110     FORMAT('-')
      ENDIF
      RETURN
      END
      SUBROUTINE PRNTRE(KOUNT,Q)
C  PRINT HOW MANY ACRES OF EACH TYPE WERE CUT
      IMPLICIT INTEGER(A-Z)
      DIMENSION LAND(16,8),CENTRS(16,7),LNDCPY(16,8),AGES(16,8),
     + TRECUT(3,8,8),TOTCUT(3,8)
      COMMON/LANDS/LAND,LNDCPY,CENTRS,AGES,N,M,YEARS,TRECUT,
     +TOTCUT,PRICE
      REAL PA(3,8,8),TA,GTA(3),GPA(3),GTA1(3),
     + GPA1(3),TA1,PA1(3,8,8),PRICE(4,8),RATE
      DATA RATE /0.10/
C
      DO 1, I=1,3
      GPA(I)=0.0
        DO 1, J=1,8
          PA(I,J,Q)=(REAL(TRECUT(I,J,Q)))*2.5
          GPA(I)=GPA(I)+PA(I,J,Q)
1     CONTINUE
C
      DO 3,I=1,3
        GTA(I)=0.0
        DO 3, J=1,8
          TA=(REAL(TOTCUT(I,J)))*2.5
          GTA(I)=GTA(I)+TA
3     CONTINUE
C
C        THIS IS THE TALLY OF REVENUES FROM ALL ACRES CUT SO FAR
      DO 4, I=1,3
        GTA1(I)=0.0
        DO 5, J=1,8
          DO 5, K=1,Q
            TA1 = (PA(I,J,K) * PRICE(I,J)) / ((1.0+RATE) ** ((K-1)*10))
            GTA1(I)=GTA1(I)+TA1
5       CONTINUE
4     CONTINUE
C
C        THIS IS THE REVENUE FROM THE ACRES CUT DURING THE
C        PAST TEN YEARS ONLY
      DO 6 I=1,3
       GPA1(I)=0.0
       DO 7, J=1,8
        PA1(I,J,Q)=(PA(I,J,Q)*PRICE(I,J))
        GPA1(I)=GPA1(I)+PA1(I,J,Q)
7      CONTINUE
6     CONTINUE
C
      DO 20, K=2,3
      WRITE(K,105)
105   FORMAT('O','BELOW ARE THE ACRES CUT DURING THE PAST TEN YEARS ')
      WRITE(K,110) (GPA(I),I=1,3)
110   FORMAT('O','ASPEN',16X,F9.2,/,1X,'LOWLAND HARDWOODS',
     + 4X,F9.2,/,1X,'UPLAND HARDWOODS',5X,F9.2)
      WRITE(K,115)
115   FORMAT('O','BELOW ARE THE REVENUES GENERATED BY THE CUTS MADE IN T
     +HE PAST TEN YEARS ONLY. ')
      WRITE(K,110) (GPA1(I),I=1,3)
      WRITE(K,120)
120   FORMAT('O','BELOW IS A TOTAL OF ALL ACRES THAT HAVE BEEN CUT SO FA
     +R. ')
      WRITE(K,110) (GTA(I),I=1,3)
      WRITE(K,125)
125   FORMAT('O','BELOW IS THE NET PRESENT VALUE OF ALL THE ACRES THAT H
```

Table 17. Computer program for model (cont'd)

```
     +AVE BEEN CUT SO FAR.')
      WRITE(K,110) (GTA1(I),I=1,3)
20    CONTINUE
      RETURN
      END
      SUBROUTINE MAPKEY
C  THIS SUBROUTINE PROVIDES THE USER WITH A KEY TO THE VEGETATION TYPES
C  AND RELATED AGE CLASSES
C
      DO 1, I=2,3
      WRITE(I,100)
100   FORMAT('0')
      WRITE(I,*)' THE VEGETATION TYPES AND RELATED AGE CLASSES '
      WRITE(I,*)' ARE AS FOLLOWS: '
      WRITE(I,*)' '
      WRITE(I,*)' VEGETATION TYPES          CODE     AGE CLASSES        CODE'
      WRITE(I,*)'  ASPEN(A)                 1         0-10  YRS.(10)     1   '
      WRITE(I,*)'  LOWLAND HARDWOODS(L)     2         11-20 YRS.(20)     2   '
      WRITE(I,*)'  UPLAND HARDWOODS(U)      3         21-30 YRS.(30)     3   '
      WRITE(I,*)'  SWAMP CONIFERS/PINES(C)  4         31-40 YRS.(40)     4   '
      WRITE(I,*)'  FIELDS(F)                5         41-50 YRS.(50)     5   '
      WRITE(I,*)'  BRUSH(B)                 6         51-60 YRS.(60)     6   '
      WRITE(I,*)'  MARSH(M)                 7         61-70 YRS.(70)     7   '
      WRITE(I,*)'  WATER (PONDS&LAKES) (W)  8         71-80+ YRS.(80)    8   '
      WRITE(I,*)'  NOT CONSIDERED(NOT CON)  00'
      WRITE(I,*)' '
1     CONTINUE
      RETURN
      END
```

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