CHAPTER 3. METHODS AND PROCEDURES FOR INVENTORYING FISH AND WILDLIFE POPULATIONS

3-1. General.

3-1.1. Definitions. Requisite to establishment of fish and wildlife management goals and objectives is a knowledge of the species, the sizes and trends of populations in the area, and the habitat potential for these species. It is necessary to know the habitat requirements of various species and, under existing or potential habitat conditions and with current or projected supply and demand, which species warrant special attention. This section deals with some of the principles and most practical approaches for inventorying fish and wildlife. Since many of the techniques in this chapter require technical expertise, experience and special equipment, it is suggested that assistance be obtained from state Fish and Game Agencies and the US Fish and Wildlife Service. Strictly speaking, a census of a wildlife species on an area is a count of the present number of individuals of certain species but may include other vital statistics such as sex and age. Two types of census are possible: the complete census and the sample census.

3-1.1.1. Complete Census. The complete census is a complete count or tally of animals over a specified point in time or a specified interval of time at a specified point in space (area). Except under very unusual circumstances (perhaps with a threatened or endangered species confined to a small area), complete counts are impractical. Furthermore, the costs involved cannot be justified and generally are unnecessary for management purposes.

3-1.1.2. Sample Census. The sample census is a count of animals in a specified area at a specified time.

3-1.2. Needs and Problems. Inventories of wildlife populations are used to evaluate management practices, indicate potentials, determine total harvest and mortality and for public information. Indices which show the trends in the wildlife populations of an area from year to year normally are sufficient for management purposes. An index is a count or ratio which is related in some sense to the total number of animals in a specified population. Even with indices, certain problems are obvious. Generally, the animals are secretive, mobile, and not randomly distributed because they favor a particular type of habitat. They vary in number from season to season, usually reaching their highest number at the end of the reproduction season. Many are active at night or spend much of their time in ground burrows or hollow trees. Many have a very short life span, and all are subject to mortality, whether from hunting, man-caused accidents, or natural causes. For management purposes, indices should be separated according to habitat type in order to determine which types are supporting desired species. Specific harvest data, e.g. age classes, sex ratios, parasite counts, ovulation rates as well as the degree of desperation foods utilized, are positive indicators of population trends and management needs.

3-1.3. Principles and Approaches. Because of the natality (birth rate), mortality, and movement of animals, it is desirable to conduct an inventory in a short period of time at a season when mortality, ingress, and egress are negligible. Otherwise, corrections must be made in the index. Also, it is generally assumed that all members of a population have an equal probability of being counted or included in the inventory. This is not always the case because behavioral traits may differ according to age or sex of the animals, season of the year, or weather conditions. Corrections in the index for such factors can be made only on the basis of knowledge of the species gained from intensive studies or published literature. However, if inventories are made as nearly as possible under the same conditions from year to year, trends in the size or make-up of a population will be indicated sufficiently well for a manager to judge the effectiveness of his program without having all of the intricate details of population dynamics. Good reviews of the principles and approaches to wildlife inventories appear in "Estimating the Number of Animals in Wildlife Populations" (app B, No. 82), "Estimating the Numbers of Game Populations" (app B, No. 25), "Wildlife Census Methods: A Resume" (app B, No. 61), and "Ecological Evaluation of Wildlife Populations and Habitats Affected by Highway Development: Phase I" (app B, No. 1). The Handbook of Computations for Biological Statistics of

Fish Populations (app B, No. 88) deals with methods for inventorying fish populations.

3-1.3.1. Sampling Schemes. Since it is usually impractical to count all individuals in a population in large areas, sampling becomes necessary. Inventories are conducted on part of the area or time dimension of the population. The portion sampled is assumed to be representative of the total population. Every effort should be made to develop a statistically sound sampling plan and to properly analyze the data collected. This can best be done with the help of a biometrician or statistician familiar with biological sampling. Several sampling schemes and many census or inventory techniques may be used, according to the particular species, time, place, area, and purpose for making the estimate. Basically, there are two steps in inventorying an animal population: obtaining the data and calculating the result or ratio of animals seen or heard per unit of time, area, trap, etc., to a known ratio of animals per unit. Inventories of wild animal populations usually are based upon counting animals directly, counting animal signs such as tracks or calls, or using index counts or ratios (i.e., counting some object which is related in some numerical way to the animal, such as estimating the number of whistling males.)

3-1.3.1.1. Harvest Check Stations. The game bag and creel census represents the best sample of wildlife on military installations. A complete sample can normally be checked because of the security and safety requirements on most installations. Operation of check stations to determine weight, number of points, general condition, etc., by nontechnical personnel is an expensive operation of no value to scientific management. Any game or creel check should be accomplished by technically qualified people. Physical, biological, and chemical data which can be collected includes weight corrected for extent of field dressing, sex, age, parasites, injuries, ovulation rates, sexual maturity, blood and tissue samples, specific physical measurements, and stomach/craw record.

3-1.3.1.2. Transect Method. One of the most versatile and useful methods for inventorying wildlife populations is the transect method of sampling. This method can be utilized after a cover map has been prepared (subpara 2-2.3.). The cover map can be used to select representative habitats for establishing transect count routes. The intensity of sampling of each habitat type depends upon available manpower (and other associated costs) and upon the inherent biological variability of the population to be sampled. The greater the variability, the greater the number of samples needed to obtain a given level of precision. In many cases, an estimate of the variability can be obtained by consulting with local biologists. If this is not possible, then the first year's data collection effort should yield such an estimate, and the sampling intensity for following years can be adjusted accordingly. The transect method is discussed in relation to various inventory techniques below. Further details regarding the line transect approach can be found in Guidelines for Line Transect Sampling of Biological Populations (App B, No. 3). However, transect lines are designed and located as follows:

3-1.3.1.2.1. A grid system should be overlaid on the cover-type map. The grid should consist of lines running North to South and East to West at 100-yard intervals. A cover-type description can then be assigned to any of the 100-yard segments. The transect line used for wildlife inventories should consist of a number of contiguous 100-yard segments. The manager must systematically and/or randomly select the starting point of each transect line. For example, he could randomly select the first point and systematically select the rest. It may be necessary to locate the beginning points of some transect lines close to a road to facilitate access. If an installation is too large for the grid technique, sample locations can be selected by the coordinate system or by an expansion of the grid technique, such as a grid based on 200-yard segments.

3-1.3.1.2.2. Upon determining the point at which the transect line will be initiated, two flips of a coin can be made to decide whether the transect line will run North, South, East, or West. Each transect line should consist of at least twenty 100-yard segments. These can be arranged in the most efficient configuration. Remember, each cover type should be sampled in a representative way. The basic sample plot will be 100 yards × 100 yards, bisected by a central transect line. The series of segments should be continuous, if possible, for maximum efficiency. Other alterations of this suggested scheme may be necessary, depending upon specific circumstances. However, some form of randomness must be built into the sampling scheme. This should be done even if a systematic sampling plan is used (by randomly selecting the first point, for example).

3-1.3.1.3. Size of Sample for Randomized Sampling Scheme. A manager needs some idea of the magnitude of error he can accept. Generally, wildlife biologists will accept an error of plus or minus 10 to 20 percent of the mean value (mean number of animals per plot, etc.). A manager must also decide what chance he can take that the error will exceed 10 to 20 percent. A five percent chance is accepted in many cases.

Then $n = \frac{t(o.o5)^2 S^2}{(0.2\bar{x})^2}$

where
n = required sample size
t(o.o5) = t value from t-distribution
s^2 = sample variance
0.2 = an acceptable error of 20 percent of the mean
$\bar{x}$ = sample mean.

3-1.3.2. Determining Trends by Using Indices. Upon completion of the field aspects of an inventory, all data should be edited according to rigorous standards, transcribed to punch cards, and subjected to a series of computer programs to verify, summarize, and analyze the current year's inventory data and to estimate probabilities associated with changes in the indices from previous years. In this computation, the test statistic should be:

$$z = \frac{\bar{D}}{\sqrt{\widehat{Var}\ (\bar{D})}}$$

where $\widehat{Var}\ (\bar{D}) = \frac{2}{N^2} \sum_{i=1}^{N} \widehat{Var}\ (X_{i,p})$,

where $\widehat{Var}\ (X_{i,p}) = \frac{\sum_{j=1}^{p} (X_{i,j} - \bar{X}_i)^2}{p-1}$,

and $\bar{X}_i = \frac{\sum_{j=1}^{p} X_{i,j}}{p}$,

where D denotes the mean change from year p-1 to year p in index value for all lines compared,
p denotes the present year,
N denotes the total number of lines run in both year p and year p-1,
i denotes line i,
j denotes year j, and
$X_{i,j}$ denotes the index value for line i in year j.

The above formula requires the assumptions that the lines are independent of each other, and that the variance for a given line is homogeneous from year to year. Data should be summarized in tabular form as follows:

Years compared	Number of comparable lines	Average index for comparable lines	Percent change	Probability

Comparable lines are those lines run in each of the two years being compared. Probability can be obtained from a z table of normal curve areas using z values calculated from the above formula. This table and a description of its use appear in Manual of Experimental Statistics (app B, No. 36).

3-2. Big Game.

3-2.1. Scope. Big game described herein include: deer (mule deer, white-tailed deer, elk, moose, caribou), sheep, mountain goat, pronghorn antelope, collared peccary, and bear (fig 3-1).

Figure 3-1. White-tailed deer.

3-2.2. Pellet-Group Counts. Systematic pellet-group counts, as described in "The Pellet-Group Count Technique for Big Game Trend, Census, and Distribution: A Review" (app B, No. 76) have been used for a variety of research and management objectives. The chief advantage is that'pellet groups can be sampled by standard field plot techniques. Most pellet-group plots are circles or long, narrow rectangles, distributed in some form of stratified-random design. This means that plots are grouped together on the basis of similarity of some characteristic such as habitat type. Each group or stratum is then sampled, and the group estimates are combined to give an index. Sampling intensity estimates can be made on the basis of mean and variance derived from preliminary sample counts. For determining sample size needed to produce a desired degree of sampling precision, a manager should refer to the formula described in sub paragraph 3-1.3.1.2. Pellet counts should be made within permanently marked, 0.02-acre, circular plots (diameter 33.3 feet) which are periodically cleared of old pellets. Two 0.02-acre units should be sampled within each 100x100-yard plot and located along the central transect line. Circular plots should be randomly located on the transect line in such a way that they do not overlap. Within each 0.02-acre unit, the observer should record the number of big-game pellet groups by species. Identification of pellets to species can be made by consulting A Field Guide to Animal Tracks (app B, No. 75). Observer bias may arise mainly from ferences in interpretation and from missed groups. Therefore, all observers should carefully adhere to standards for interpretation of pellet-group identity. Observer error can be avoided by continuously using the same observers. However, if observers change with time and area, observer correction factors should be developed. The "confidence limits" on such correction factors will necessarily be wide, and periodic rechecks will be needed. Optimal time for pellet-group sampling is in early spring (March 1 to April 1), prior to new vegetation growth. Relative pellet-group density on an installation over a period of years can be calculated as described in "Estimating the Numbers of Animals in Wildlife Populations" (app B, No. 82). An index to big-game use can be determined for each big-game species by counting the number of pellet groups in each plot.

Then, let $$t = \left(\frac{1}{n\acute{a}}\right) \Sigma y = \frac{1}{a} \Sigma y$$

Where Σy = the sum of groups counted over all n plots

$\acute{a}$ = The area of one plot

a = $n\acute{a}$

then t is expressed as pellet groups per unit area.

3-2.3. Track Counts. Big-game track and trails which cross the pellet group plots should be recorded during the pellet-group surveys, as described in "Estimating the Numbers of Animals in Wildlife Populations" (App B, No. 82). A Field Guide to Animals Tracks (app B, No. 75) is useful for these counts.

3-2.4. Drive Counts. Drive counts are often possible for such populations as deer. The technique is variable and is usually modified by the particular area. Two crews of observers are required: one crew to drive the area, the other stationed around the area to monitor animals entering or leaving. A suitable area is one that can be monitored on the boundaries. Well-defined and cleared boundaries are desirable since monitors must be able to clearly observe the boundary at least to the next observer. This technique is further described in "Estimating the Numbers of Animals in Wildlife Populations" (app B, No. 82). Drive counts may be desirable as a method to compare with the pellet-group count technique. A sufficient number of observers must be available to cover the area properly and to insure that no animals are uncounted. The total number of animals can be calculated as the sum of animals leaving the area ahead of the drive crew plus the sum of animals passing back through the drive line. The sum of animals passing forward through the drive line is then subtracted from the total count to yield the net count.

3-2.5. Aerial Surveys and Photographs. Aerial surveys can be used as a census approximating a total count on terrain of moderate relief in prairie areas, as described in "Aerial Census of Big Game in North Dakota" (app B, No. 96), and in coastal marshes, as described in The Everglades Deer Herd Life History and Management (App B, No. 65). Surveys should be done early in the morning and late evening. Aerial photographs can be valuable checks on aerial surveys. Large-scale photographs taken along the flight line of the survey aircraft and examined carefully can provide more accurate counts of big game which are partially hidden under trees. Photographs also form a permanent record of the condition and occupied areas of the range. Additional information about aerial surveys appears in "Aerial Photographs, Their Interpretation and Suggested Uses in Wildlife Management" (app B, No. 59).

3-2.6. Harvest Records. Daily bag checks of harvested game should be made during the hunting season in order to determine trends in game populations and to determine how many hunters should be permitted on an installation while maintaining a reasonable rate of hunter success. Other factors such as safety, installation size, terrain, and location also dictate how many hunters should be allowed. Data on age and sex composition of game can be obtained from harvest records. The techniques of aging and sexing of game animals are described in "Estimating the Numbers of Animals in Wildlife Populations" (app B, No. 82). It is also important to locate where animals examined were actually killed. This requires good maps, an interviewer familiar with the installation, and much patience. If it is not possible to interview each hunter in person, game-kill surveys can be made by contacting hunters by mail. Accurate records should be kept on the following: date, location, weather conditions during the hunt, man-hours hunted, kill or harvest per day or per man-hour hunted, and game observed. The restricted nature of most installations should permit virtually all hunters to be surveyed. Records of harvest should be kept for all game species, predators, and nuisance animals.

3-2.7. Browse Surveys: For all animals that browse and/or graze, a browse survey should be run to determine the relation of these animals to their food supply. This is far more important than the total number of animals and will provide information the manager can use.

One method for taking data on browse use which has found wide application was developed by

Aldous (1944). This is a plot system along transect lines by which use of food species as browse is compared with the amounts available. In addition to measuring degree of use, the method also indicates relative palatabilities among the species present. Aldous, S.E., 1944, A Deer Browse Survey Method, J. Mammal. 25: 130-136.

3-2.8. Petersen or Lincoln Index: This method is well suited to work with hunter bag check or creel census where all animals taken by hunters and fishermen are checked by base personnel. It involves first capture and marking a segment of the population. The assumption has to be made that the trapped, tagged and released animals are an unbiased sample of the total population. The second sample of captured, killed or bagged animals is also an unbiased sample. Refer to the book Wildlife Management Techniques by the Wildlife Society, 1971, for details.

3-2.9. Other Methods. Other methods range from direct counts of congregating deer and elk to rather complex techniques involving marked animals. While these may be of value in some cases, they can be unreliable, very expensive in terms of time and effort, or just not necessary for inventorying on military installations.

3-3. Terrestrial Furbearers and Mammalian Predators.

3-3.1. Scope. Terrestrial furbearers described herein include: opposum, porcupine, skunk, raccoon, ringtail, weasel, badger, fisher, pine marten, wolverine, mink, fox, coyote, wolf, bobcat, lynx, cougar, and bear.

3-3.2. Scent Stations and Track Counts. The presence of tracks at scent stations should be the principal method for sampling terrestrial furbearers. A flexible wire hoop, 39 inches in diameter, is an easily handled template. A thin layer (0.25-0.50 inches) of fine-textured soil over a hard surface produces tracks of the highest quality. Where proper soil conditions do not exist, it may be necessary to import soil. A two and one-half-gallon pail holds sufficient soil to prepare one station. A small mason trowel works well for smoothing the soil. A small watering can may be used to moisten soil under dry conditions. Scent stations should be located 100 yards apart on the centerline of the transect. The following are effective baits: a paste made from canned sardines, commercially prepared fox lure, and egg attractant which should be readily available from the Fish and Wildlife Service Animal Damage Control Office (app C, No. 6.c.(1)) or Denver Wildlife Research Center (app C, No. 6.c.(4)). Bait is placed in the center of a station. Then, all tracks present at the station are counted and identified as to species by consulting a field guide such as "A Field Guide to Animal Tracks" (app B, No. 75). After checking, the area should be cleared of tracks for the following night's operation. Stations should be operated for three consecutive nights. Scent station sampling should coincide with small mammal trapping. Good references on the scent station method include "Determining the Relative Abundance of Coyotes by Scent Station Lines" (app B, No. 64) and "Scent Station Index of Black Bear Abundance" (app B, No. 63).

3-3.3. Indices. Visitation indices can be obtained for each survey line by totaling the number of stations visited by each species for three nights. The total number of scent-station nights is derived by subtracting from the total number of station nights all nights that were inoperable because of weather, human interference, or animal interference (e.g., by cattle). In this context, an "inoperable" station is one for which predator tracks, if present, could not be distinguished. The index is calculated for each species of interest as follows:

$$\frac{\text{Total Number of Visits}}{\text{Total Number of Operable Station Nights}} \times 1{,}000 = \text{Index}$$

For example, a line with 20 coyote visits and 120 operable scent-station nights results in an index of 167 (i.e., $\frac{20}{120} \times 1{,}000 = 167$).

3-4. Aquatic Furbearers and Woodchucks.

3-4.1. Scope. Species described herein include muskrat, beaver, nutria, otter, and woodchuck.

3-4.2. House and Trail Counts and Indices. Indices should be obtained by counting active lodges, dens, houses, and trails which occur within 100 yard × 100-yard transect segments, linear segments of stream, or point counts in a defined radius. An active house is determined by signs of activity. The number of individuals per house will vary within and between species. An index to relative abundance for each species can be obtained by using the following formula:

$$\frac{\text{Total Number of Active Houses or Trails}}{\text{Total Number of Transect Segments}} = \text{Index}$$

These counts should be made annually during the summer. Methods for inventorying muskrat and beavers are described in "Estimating Muskrat Populations by House Counts" (app. B, No. 28) and "Beaver Census Methods in the Rocky Mountain Region" (app. B, No. 44).

3-5. Rabbits and Hares. Pellet counts for rabbits and hares should be a subsample of the circular, 0.02-acre plots used for big-game mammals. The subsample plot should be 0.01-acre. Records of pellets within these plots should be treated as in big-game pellet counts (subpara 3-2.2.).

3-6. Tree Squirrels and Chipmunks. Observations of diurnal mammals should be made while sampling birds and small mammals. See paragraphs 3-7. and 3-9. for details on transect counts of animals (by the strip transect method).

3-7. Small Mammals.

3-7.1. Scope. Small mammals described herein include: mouse, vole, rat, shrew, mole, chipmunk, tree and ground squirrel. Species and trend data can be obtained by transects and trapping. Numerous methods and techniques have been developed.

3-7.2. Snap Traps. Small mammals should be sampled with snap traps at stations located at five-yard intervals along the centerline of each 100 × 100-yard plot. There should be one snap-style mouse trap placed at each station and one snap-style rat trap placed at every fifth station. When the trap line is set, there should be 20 mouse traps and five rat traps within each 100-yard transect. Peanut butter, rolled oats paste, or a mixture of the two have been successful as bait. Trap lines should be run three consecutive days and nights. The ground should be scuffed up in order to set traps flush to the ground on bare soil; do not set traps on top of grass or leaf litter. If possible, a vegetation "overhang" should be left over the trap to break rain and thus avoid accidental tripping. When checking traps, remove animals and put all animals from each trap line into a plastic bag. Label as to line and date. Also note on the label the number of traps in each transect that have been tripped by rain or other animals. Record the presence of tails, legs, feet, etc., and attempt to identify as to species. Count "fragments" in totals if no animal is caught later with these parts missing. Replace broken or inoperative traps and reset traps for the next night's session. Trapping should be done in late winter to May. Data collected can be used to determine small mammal species composition and to obtain an index to small mammals present on an installation.

3-7.3. Indices. An index to small mammals can be obtained for each species by using the following formula:

$$\frac{\text{Total Number of Animals Trapped}}{\text{Total Number of Trap Nights}} \times 1{,}000 = \text{Index}$$

The total number of trap nights per transect segment is derived by subtracting from the maximum 75 trap nights (25 traps × 3 nights) all traps that were accidentally tripped.

3-8. Bats.

3-8.1. Visual Estimates. Visual estimates can be made as bats leave a cave entrance at dusk.

3-8.2. Systematic-Timed Photographs. Taking systematic-timed photographs of a column of bats as it leaves a cave and then counting individuals in the print is a more refined method of bat inventory. For roosting bats, the entire surface area of a roost can be determined; then portions of the surface can be photographed and individuals counted. The photographic method is suitable for bats that hang from a ceiling in a single layer. This method is further described in "Photographic Estimation of Population Size in the Mexican Free-Tailed Bat, *Tadarida brasiliensis*" (app B, No. 46).

3-8.3. Nets. Some species of bats hang in clusters composed of several layers. For these, it is necessary to take a sample of the surface area with a net and actually count the number of bats.

3-8.4. Other Methods. Counting bat pellets in trays, estimating numbers of roosting bats, using recapture ratios, and trapping bats are four other methods described in Activity Patterns of the Mexican Freetailed Bat (app B, No. 20). When working with mammals, care should be taken since rabies can be contracted through human-mammal contact.

3-9. Songbirds.

3-9.1. Scope and Approaches. Songbirds described herein include perching birds and birds with similar habits. Bird inventories should be carried out in both breeding and wintering periods when avian populations are relatively stable and most accurately reflect habitat conditions. Numerous techniques have been developed to measure the absolute and relative abundance of bird populations. These methods vary widely in both accuracy and efficiency. Methods generally considered to be among the most accurate include: mapping territories of singing males or the "spot-map" method; locating all nests; and marking and recapturing a fraction of a population to get a Lincoln index. The "spot-map" method is described in "The Composition and Dynamics of a Beech-Maple Climax Community" (app B, No. 114), "On the Determination of the Size and Composition of a Passerine Bird Population during the Breeding Season" (app B, No. 32), and

"Recommendations for an International Standard for a Mapping Method in Bird Census Work" (app B, No. 91). The time required to use these methods is extensive. Less time-consuming techniques are described below.

3-9.2. Strip Transect Method. This technique has been modified for use on military installations. In this method, the regular 100 yard × 100-yard transect segment is used as a defined area. The observer walks slowly down the centerline of the transect, covering the 100 yards in five minutes. Each bird noted within the transect segment is recorded by species on a data coding form. Whether the bird was noted by sight or sound should also be recorded. If a bird is heard first and subsequently seen, it should be recorded as seen. Only birds actually in the plot or judged by trajectory to be either taking off or landing within the plot during the survey interval should be counted. Birds flying over the plot should not be counted. No birds observed either behind or more than 50 yards in front of the observer should be counted. Data from these counts can be used to calculate an index to bird use for a defined area (100 X 100-yard segment) for each species or for total birds by using the following formula:

$$\frac{\text{Total Number of Birds}}{\text{Total Number of Segments}} = \text{Index}$$

This technique is effective for both breeding bird and winter counts. Breeding bird counts should be made in June (this period may vary somewhat according to geographic location; contact the state wildlife agency for exact dates) and should be made within the first five hours after sunrise. Winter bird counts should be made in January and can be run throughout the daylight hours. Observers must be able to identify common birds of the area by sight and sound. The few, unfamiliar songs can be learned in a few days of preliminary field work by an experienced birder. Surveys should be repeated at least five times for proper coverage. When using the technique, the observer should record all other animals (including mammals, reptiles, and amphibians). This data should be treated similarly to bird data and used to supplement other inventory techniques.

3-9.3. Roadside Breeding Bird Surveys. This method may be used on installations which cannot be inventoried by the Strip Transect Method, and which have an extensive road system traversing the installation in a representative way. The method provides an index of birds observed or heard at fifty, three-minute stops along a 24 and 1/2-mile route. Each survey begins one-half hour before local sunrise and continues along a predetermined route, stopping at one-half-mile intervals. This method can be used to survey nearly all bird groups (found along a road) and to cover a large area in a short period of time. However, crepuscular species may be missed, and specific habitat types may be omitted if the habitats are not crossed by roads. The technique has been described in detail by the Fish and Wildlife Service in connection with the Cooperative Breeding Bird Survey of North America. Details of field procedures and data analysis can be obtained by writing to the Service's Migratory Bird and Habitat Research Laboratory (app C, No.6.c.(5)).

3-10. Waterfowl, Wading Birds, and Shorebirds.

3-10.1 Ecologically Stratified Ground Surveys. It may be desirable to inventory these birds on small water areas by using an ecologically stratified ground survey. This term refers to selecting sample areas which include all significant habitat types for these birds and sampling some of the habitats more intensely than others. Observation points should have a good view of areas likely to be used by the birds. These sites can be chosen to allow complete coverage without overlap. The sites should be surveyed for a definite period of time (i.e., one-half hour). Counts should be made early in the morning (near sunrise) or late in the evening (near sunset). Counts at all sites should be repeated 10 to 15 different days during each breeding and wintering season to obtain an index to use of the area. An index to relative bird use for each species can be calculated using the following formula:

$$\frac{\text{Total Number of Birds}}{\text{Total Number of Observation Periods}} = \text{Index}$$

Experience has indicated that ground surveys are cheaper and more accurate than aerial surveys.

3-10.2. Roadside Transects. Roadside transects can be used to obtain indices of breeding waterfowl populations. Since the number of pairs fluctuate with time of day and from day to day, several counts of transects should be averaged to improve the reliability of the indices. Short transects of 7 miles may require as many as 25 counts between first light and 10:00 A.M. in order to obtain a meaningful index. Roadside transects are further described in "An Evaluation of the Roadside Technique for Censusing Breeding Waterfowl" (app B, No. 95). An index to bird use for each species can be obtained using the following formula:

$$\frac{\text{Total Number of Birds}}{\text{Total Number of Miles Driven}} = \text{Index}$$

The Fish and Wildlife Service (app C, No. 6.c.) should be contacted regarding waterfowl inventories since the Service conducts on an annual basis aerial waterfowl surveys which may be pertinent to some installations.

3-11. Upland Game Birds.

3-11.1. Auditory Indices. Upland game birds are often surveyed by state divisions of wildlife with the auditory index technique which has been developed for each species. One example of the index is the quail call index described in "Regression Coefficients Used to Adjust Bobwhite Quail Whistle Count Data" (app B, No. 92), "A Summer Whistling Cock Count of Bobwhite as an Index to Wintering Populations" (app B, No. 93), "Whistling Cock Indices and Bobwhite Populations in Autumn" (app B, No. 77), "Estimation of Fall Quail Populations in Iowa" (app B, No. 54), and Some Aspects of Missouri Quail and Quail Hunting, 1939-1948 (app B, No. 8). In this technique, stops are made every one-half mile along a route. Since many variables can affect the number of calls heard, correction formulae have been developed to improve the index. Another auditory index is the ring-necked pheasant crowing count described in "The Crowing Count Pheasant Census" (app B, No. 51). It is conducted along a 20-mile route, beginning about 40 minutes before sunrise. It yields an index based on the average number of calls heard during each two-minute stop. All of these techniques must consider variables such as time of day, time of year, weather, ability of the observer, etc. The index should be standardized as much as possible, or correction formulae must be developed for variables which are not standardized. Migratory game birds, excluding ducks and geese, include rails, coots, gallinules, shorebirds, pigeons, and doves. One shorebird, the American woodcock, is censused by an auditory count at the singing grounds, as described in "An Analysis of Woodcock Singing Ground Counts 1948-1952" (app B, No. 53). This bird is found only in the eastern United States. The mourning dove is found all across the United States. More of these birds are killed annually than all waterfowl combined. This bird is censused on a cooperative, nationwide basis by a randomized call-count census. The route consists of 20 stations at one-mile intervals, with counts beginning 30 minutes before sunrise. Calling doves are counted during each three-minute stop. This technique is discussed in "The Call Count as a Census Method for Breeding Mourning Doves in Georgia" (app B, No. 69), "Breeding Density and Productivity of Mourning Doves on a Countywide Basis in Georgia" (app B, No. 66), and Mourning Dove Status Report (app B, No. 113).

3-11.2. Strip Transect Method. This method is described in subparagraph 3-9.2.

3-12. Raptors.

3-12.1. Aerial Surveys. This method is suitable for nesting surveys in inaccessible areas. Advantages and Disadvantages of the Use of Rotor-winged Aircraft in Raptor Studies (app B, No. 112) provides information on using helicopters to locate nests of large raptors. It is suggested that searches be made between the hatching and fledging period when adult raptors are less likely to desert the young. Aerial surveys of golden eagles wintering in the Southwest are described in "Winter Golden Eagle Populations in the Southwest" (app B, No. 11).

3-12.2. Car Census. A car census is frequently used to survey wintering hawk populations. For this survey, the route should be limited as much as possible to dirt roads. Counts are made by two observers driving the road at 13 miles per hour. One observer drives, and the other records data on form sheets and maps. Buteos, marsh hawks, and American kestrels are recorded within a quarter-mile of each side of the road. Surveys should be conducted between 1:00 and 4:00 P.M., sun time. It has been determined that an accurate total of winter hawks can normally be found by making three or four closely-spaced car censuses and supplementing these with random observations on Cooper's hawks and American kestrels.

3-12.3. Hiking Survey. A foot-census of diurnal raptors (hawks) is described in Hawks, Owls and Wildlife (app B, No. 23). Individual surveys of species of crepuscular and nocturnal raptors (owls) have been attempted, but they require considerable time. Owls have also been surveyed by counting hoots as described in "Territory and Population in the Great Horned Owl" (app B, No. 6).

3-13. Amphibians and Reptiles.

3-13.1. Intensive Searches. Amphibians and reptiles are difficult to inventory. Temperature, precipitation, soil moisture, humidity, light intensity, wind, and season control their activity patterns. However, intensive, systematic searches of the 0.02-acre, circular plots described in subparagraph 3-2.2. should produce data adequate to determine population trends. Intensive searches involve careful examination of the ground surface, rocks, logs, tree trunks and stumps, and other objects within the plots. All rocks, logs, bark, and other objects lying on the ground should be moved in order to inspect the ground surface beneath them. Loose bark on logs and stumps must be removed. Rotten logs and stumps must be torn apart. Areas containing loose gravel or rock should be raked or dug to a four to six-inch depth. Streams or pools should also be examined carefully. Rocks, logs, etc., should be placed in their original position after inspection in order to minimize habitat degradation. An index to reptile and amphibian use can be determined for each species by counting the number of animals in each plot.

Then, let $t = \frac{1}{n\acute{a}} \Sigma y = \frac{1}{a} \Sigma y$

Where Σy = the sum of animals counted over all n plots

$\acute{a}$ = the area of one plot

$a = n\acute{a}$

then, t is expressed as animals per unit area.

3-13.2. Strip Transect Method. This method is described in subparagraph 3-9.2. Audio observations of frogs and toads should be recorded while sampling birds. Reptile and amphibian surveys should be conducted in April, May, and June.

3-14. Fish

3-14.1. Scope. The composition of a fish population in terms of numbers, sizes, and kinds at any instant is the result of the interaction of many factors, as discussed in Freshwater Fishery Biology (app B, No. 58). The factors are of two kinds: those stemming from the genetics and physiology of the fish and those stemming from the total environment of each species. The interaction of organism and environment determines the population composition by species and numbers and, within a species, the rate of growth and condition of the individuals. The first step in population analysis is to learn its makeup by species (a discussion of freshwater fish identification appears in "Identification of Freshwater Fishes" (app B, No. 67) and, within any species, the constituency by numbers (relative or absolute) and age groups. When the makeup and constituency are known, mortality and turn-over can be computed, and the future composition of a species-stock predicted. If a random sample of the total size range of a species-stock is obtained, if the age of each individual is assessed, and if the age-group composition of the stock is charted from youngest to oldest, the rate of mortality will be shown. If, in addition, the relative abundance at any moment can be learned, rational management becomes possible. Methods for fish inventories in inland lakes and streams are very similar. Procedures for enumeration of fish populations in inland waters are of two kinds: direct (actual counts) and indirect (estimations). These procedures are summarized in "The Measurement of Fish Population Size" (app B, No. 21). On installations, indirect methods should be used primarily.

3-14.2. Mark and Recapture Methods. There are several methods of indirect, numerical approximation, most involving mark and recapture means. These methods have been used extensively in inland water as described in "The Standing Crop of Fish in Lakes" (app B, No. 17). For example, a fish population in all streams and lakes on an installation can be sampled by mark and recapture means based upon the occurrence of previously marked fish in the catch. This is largely an outgrowth of the simple, direct-proportion estimation device proposed in The Yearly Immigration of Young Plaice into the Limfjord from the German Sea (app B, No. 83). Estimation of population by mark and recapture means involves: 1. the capture and release of a number of marked fish (m) into the population; 2. the subsequent recapture of marked fish (r) along with the capture of unmarked fish (u) from the population; and 3. the computation of the population using the equation $P = \frac{m(u + r)}{r}$. Workers must obtain any information needed to make required adjustments in the estimates.

3-14.2.1. Collecting or Capturing. Techniques for collecting fish include seining, trapping, electrofishing, poisoning, netting, and draining ponds or pools (fig. 3-2). Indirect methods of population survey (subpara 3-14.2.) have been used in streams with seining and with electrical shocking. They have also been employed for salmon populations where fish to be counted could be readily seen. Single, large sections or sample sections of streams can be used satisfactorily. The study portion can be either blocked off at both ends or left open. When a shocker is used, repeated passes are made through the sample section, marking and returning fish and recording the numbers of both those caught once and those caught repeatedly. An excellent discussion of electroshocking techniques appears in Fishing with Electricity—Its Application to Biology and Management (app B, No. 111). In standing waters, hoop, fyke, and trap nets, described in "Capture, Sampling, and Examination of Fishes" (app B, No. 57), can be used. In practice, the nets are run daily and the unmarked fish are marked and returned to the water, as are those which have been previously marked and recaptured. Days of such sampling are repeated, in practice, until estimates have become relatively constant as the basis of the formula in use. There are variations in the procedures for selecting the location for nets and the site for returning marked fish Because of the differences in response to netting among species and among different size groups within species, any given method of collecting may be more efficient for some kinds and sizes of fish than for others. Care must be taken to recognize such differences and adjust to them.

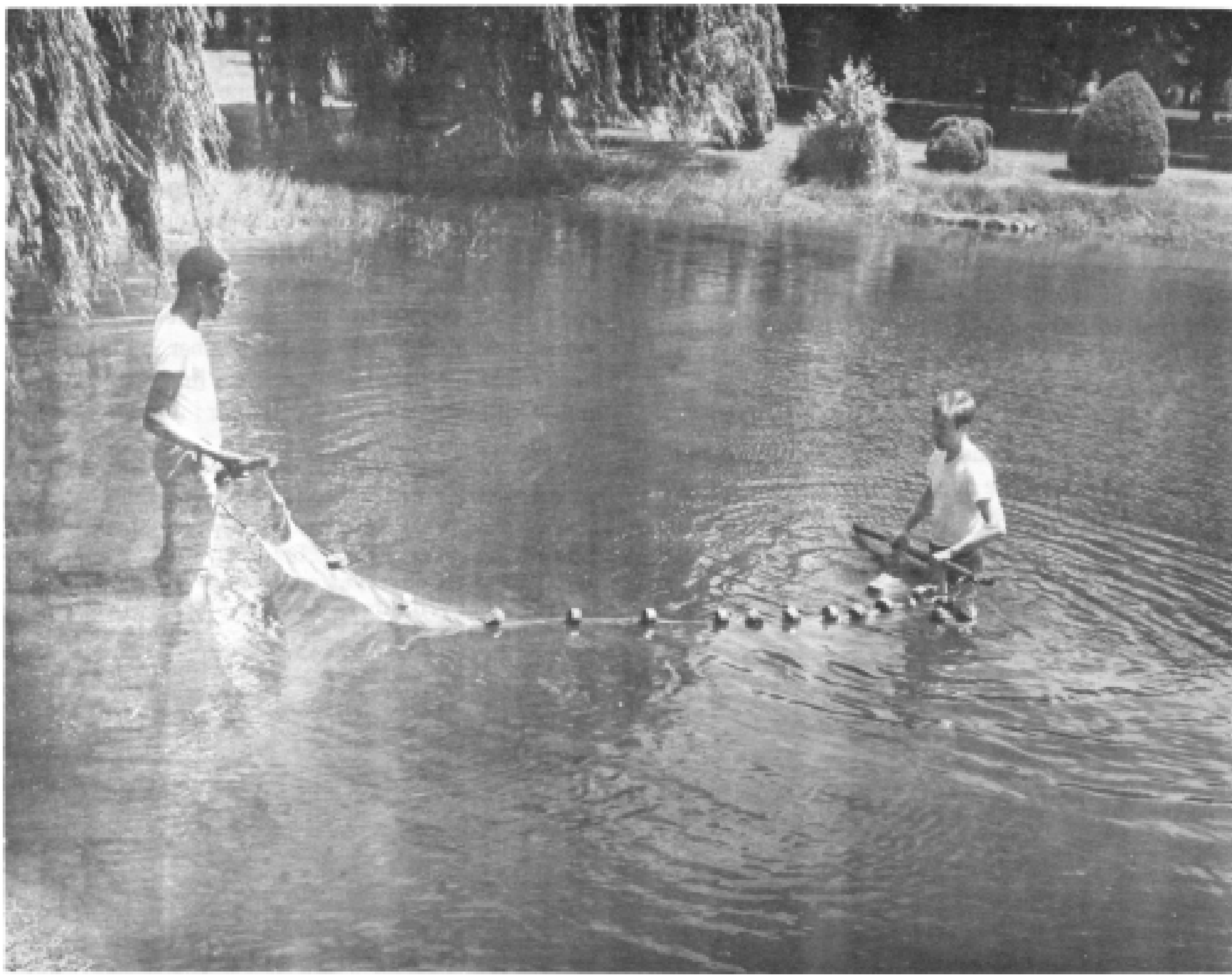

Figure 3-2. Seining.

3-14.2.2. Marking. Many different methods are described in "Marking and Tagging" (app B, No: 103) but basically, the means for marking fish are mutilating the fish or attaching a tag. Mutilation includes fin-clipping, which is the most common technique for short-term population studies. This method is fast and requires no special equipment. Often fish can be marked more readily, doing less harm to them or the handler, if they are anaesthetized. The use of anaesthetics on fish is discussed in "A Guide to the Properties, Characteristics and Uses of Some General Anaesthetics for Fish" (app B, No. 7). Care should be taken to follow the directions on the container when working with anaesthetics since humans can be harmed by repeated use.

3-14.3. Creel Census. Creel censuses can be valuable for obtaining broad information on trends in kinds of fishing, times of fishing, time spent, species and sizes caught, and the catch per unit of fishing effort (usually in terms of the numbers of legal fish per fisherman-hour). Complete censuses aim at highly individualized information on fishing type, time, effort, success, etc. They further seek complete information on the fishing pressure and yield for individual bodies of water or parts thereof. Although the creel census requires considerable time from competent persons, the resultant data may be of high quality and value. Where checking stations are maintained and manned by trained personnel, excellent results can be obtained. The restricted nature of installations may make a complete creel census attainable. Where a complete census is not feasible, a stratified random sample technique may yield desirable results. Such a scheme can be accomplished by distributing the sample among days according to the amount of fishing and the degree of variability of catch-effort data for each type of day. According to Sampling Problems in the Michigan Creel Census (app B, No. 105), greater efficiency may be achieved in this way than if an equal census effort is given by each day. The number of angler contacts made in a schedule including three half-days each week may be adequate for estimating the mean catch per hour in a season with considerable fishing effort. By comparing population estimates with creel censuses, a direct relationship may be shown to the size of fish populations and fishing success. US Fish and Wildlife Service (app C, No. 6 c) and state fish and game departments often can provide assistance in determining fish populations and stocking needs.

3-15. Threatened and Endangered Species. The Fish and Wildlife Service (app C, No. 6c) and state fish and game departments should be contacted for information on threatened and endangered species. These agencies can provide a list of sensitive animals by geographic distribution and habitat preference. Installation personnel should be aware of these species when making inventories. Particular attention should be paid to their habitat preferences. If similar habitat occurs on an installation, a more intensive inventory of that area may be warranted. Special techniques for inventorying some of these species have been compiled and described by the Bureau of Land Management (app C, No. 6a) and other Federal agencies. Table 3-1 lists techniques for inventorying fish and wildlife and sources for further information.

3-16. Technical Assistance. Additional information on inventories can be obtained from the National Marine Fisheries Service (app C, No. 5) and state wildlife agencies. Other helpful organizations are listed in the Conservation Directory published by the National Wildlife Federation (app C, No. 8).

Table 1. Procedures for Inventorying Fish and Wildlife Populations.

SPECIES	INVENTORY TECHNIQUE	SOURCE OF INFORMATION
CARIBOU DEER, MULE DEER, WHITE-TAILED ELK MOOSE PRONGHORN ANTELOPE BEAR COLLARED PECCARY MOUNTAIN GOAT SHEEP	DRIVE COUNTS	MORSE, 1943 OVERTON, 1969
	PELLET GROUP COUNTS	NEFF, 1968
	TRACK COUNTS	OVERTON, 1969
	AERIAL SURVEYS	SAUGSTAD, 1942 (Prairies) LOVELESS, 1959 (Coastal Marshes) BENSON, 1962 (Canada) GROON et al, 1969 (Infrared scanning devices)
	AERIAL PHOTOGRAPHS	LEEDY, 1949
	RECORDS OF HARVEST	OVERTON, 1969
BADGER BEAR BOBCAT COUGAR COYOTE FISHER FOX LYNX MINK OPOSSUM PINE MARTEN PORCUPINE RACCOON SKUNK WEASEL WOLF WOLVERINE	SCENT STATION AND TRACK COUNTS	LINDSEY et al, 1977 LINHART & KNOWLTON, 1975 ROUGHTON, 1976
HARE RABBIT	PELLET GROUP COUNTS	SEE LARGE MAMMAL PELLET GROUP COUNTS

Group	Species / Method	Technique	References
UPLAND GAME BIRDS	QUAIL	AUDITORY INDICES	ROBEL et al, 1969; ROSENE, 1957; NORTON et al, 1961; KOZICKY et al, 1956; BENNITT, 1951
	RING-NECKED PHEASANT	AUDITORY INDICES	KIMBALL, 1949
	GAMBEL QUAIL	AUDITORY INDICES	SMITH & GALLIZIOLI, 1956
	CHUCKAR PARTRIDGE	AUDITORY INDICES	WILLIAMS, 1961
	WILD TURKEY	AUDITORY INDICES	SCOTT & BOEKER, 1971
	RUFFED GROUSE	AUDITORY INDICES	PETRABORG et al, 1953; DORNEY et al, 1958
	AMERICAN WOODCOCK	AUDITORY INDICES	KOZICKY et al, 1954
	MOURNING DOVE	AUDITORY INDICES	MCGOWAN, 1953; LOWE, 1956; WIGHT & BAYSINGER, 1963; BLANKENSHIP et al, 1971
RAPTORS (HAWK, EAGLE, OWL)	AERIAL SURVEYS		BOEKER & BOLEN, 1972
	CAR CENSUSES		CRAIGHEAD & CRAIGHEAD, 1969
	HIKING SURVEYS		CRAIGHEAD & CRAIGHEAD, 1969; BAUMGARTNER, 1939
AMPHIBIANS REPTILES	INTENSIVE SEARCHES MODIFIED EMLEN DURING BIRD INVENTORIES		EMLEN, 1971

Species	Method	Reference
BEAVER, MUSKRAT, NUTRIA, OTTER, WOODCHUCK	HOUSE COUNTS AND TRAILS	HAY, 1958; DOZIER, 1948
CHIPMUNK, SQUIRREL, TREE	TRANSECT COUNTS DURING BIRD INVENTORIES	EMLEN, 1971
CHIPMUNK, MICE, MOLE, RAT, SHREW, SQUIRREL, GROUND, VOLE	SNAP TRAPS	
BAT	MIST NETS	O'FARRELL et al, 1967
	VISUAL ESTIMATES	
	SYSTEMATIC TIMED PHOTOGRAPHS	HUMPHREY, 1970
	NETS AT THE ROOST	
	OTHER METHODS	CONSTANTINE, 1967
SONGBIRD	"SPOT-MAP" METHOD	WILLIAMS, 1936; ENEMAR, 1959
	LOCATING ALL NESTS	ROBBINS, 1970
	MARK AND RECAPTURE	LINCOLN, 1930
	MODIFIED EMLEN TECHNIQUE	EMLEN 1971
	ROADSIDE BREEDING BIRD SURVEYS	ROBBINS & VAN VELZEN, 1967
WATERFOWL, WADING BIRD, SHOREBIRD	ECOLOGICALLY STRATIFIED GROUND SURVEYS	HOFFMAN, 1970; STOTT AND OLSON, 1972
	ROADSIDE TRANSECTS	SAUDER et al, 1971

FISH

- MARK AND RECAPTURE
  - RICKER, 1975
  - CARLANDER, 1955
  - LAGLER, 1956
  - STOTT, 1968
  - GULLAND, 1966
- CREEL CENSUSES
  - TAIT, 1953

ENDANGERED SPECIES

CONTACT: U.S. DEPARTMENT OF AGRICULTURE
U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF LAND MANAGEMENT
STATE FISH AND GAME DEPARTMENTS