EVALUATING AND MANAGING WATERFOWL HABITAT

A general reference on the biological requirements and management of ducks and geese common to Colorado

STATE OF COLORADO
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A General Reference on the Biological Requirements and Management of Ducks and Geese Common to Colorado

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1. INTRODUCTION

1.1 ORGANIZATION AND SCOPE OF THIS REPORT

The diversity and number of waterfowl in North America are unmatched anywhere else on earth. However, a decade of population declines in many duck species has raised the consciousness of waterfowl hunters and public agencies. Many duck clubs now strive for the admirable goal of raising as many birds as they shoot. Increasing numbers of urban and suburban residents are enjoying waterfowl for their aesthetic values. These circumstances have prompted a resurgence of interest in waterfowl habitat management. Because our rich waterfowl heritage has been the focus of international management for over a century, an extensive body of literature exists on waterfowl management techniques. The wide array and sheer volume of information on waterfowl management often overwhelms the wildlife area or gun club manager that wishes to undertake habitat improvement for ducks and geese. This need not be the case. Improving waterfowl habitat is usually simple and straightforward if one chooses the "right tool for the job." The goal of this publication is to help the reader identify the job that needs to be done, and select the correct tools to accomplish the work.

The focus of this report is to describe management techniques for ducks and geese that breed in or migrate through Colorado, although much of the information is applicable to waterfowl management elsewhere in North America. There is a danger in a generalized publication such as this; the differences in habitat requirements just among duck species can be great. Mergansers, lesser scaup, mallard, and gadwall are representative of species that differ from strict carnivores to omnivores to herbivores. Habitat selection, diet, and behavior vary as a result of these differences in natural history. If this inherent species variability is superimposed upon the natural environmental diversity of habitats in Colorado, the task of prescribing specific management actions becomes riskier still.

A partial solution to this problem is education. Readers who are familiar with the general food, habitat, and social requirements of waterfowl at different times of the year are better equipped to deal with anomalies caused by unique species or habitat diversity. The next chapter provides an overview of these requirements. Suggested references listed in the last chapter present greater detail than those provided by the text. These readings are categorized by subject for easier reference.

This report contains no formal literature cited, even though information is based on popular, semi-technical, and technical publications. Instead, chapter and sub-heading numbers are used to cross-reference topics, thereby linking discussions of limiting factors and seasonal habitat requirements with management prescriptions.

Most importantly, the reader is urged *not* to skip ahead to management prescriptions without first reading and considering the chapters on seasonal habitat requirements, premanagement information, and limiting factors. The history of waterfowl management is littered with examples of monetary waste resulting from inappropriate management actions. Given the large number of management options available, uninformed actions are likely to result in wasted resources. The relatively small investment in time necessary to learn about habitat requirements, collect premanagement data, and identify limiting factors is a small price to pay for the capability of selecting a correct management strategy.

Successful waterfowl habitat management is dependent upon a logical progression of knowledge and actions:

Obtain premanagement information,
Identify the limiting factor,
Plan and implement management,
Evaluate management effectiveness.

These topics are discussed in detail in the following chapters.

Several individuals made important contributions to this report. A. Anderson, D. Benson, R. Hoffman, R. Hopper, R. Kirby, R. Kufeld, L. Roberts, and M. Szymczak provided helpful comments on early drafts of the manuscript. J. Boss, R. Falice, E. Lessner, and M. Willms spent many hours identifying, obtaining, and filing literature and figures. G. McNeill wrote much of the chapter on Colorado water law. The contributions of these individuals greatly increased the readability, accuracy, and completeness of this report.

1.2 A MANAGEMENT PHILOSOPHY

Waterfowl are adept at exploiting many environments. However, their morphological adaptations, physiology, and behavior are best suited to those natural environments in which they evolved. Natural ecosystems shaped waterfowl evolution for eons before human activities altered whole landscapes in a geological blink of an eye. In the long term, large blocks of intact, natural ecosystems are the best waterfowl habitats. A few Colorado landscapes, such as some higher elevation montane habitats, are relatively intact ecosystems. Although management can temporarily "improve" these natural landscapes, they do so only at high cost, intensive labor, and to the detriment of the overall ecosystem. The waterfowl response to management in such areas will be relatively slight when compared to the same effort applied to dysfunctional ecosystems. Thus, before initiating any management, consider whether human disturbances have sufficiently altered the ecosystem to warrant management intervention. Do not use the following management "tools" as "weapons" against a healthy landscape.

Although the final chapter has yet to be written, an evaluation of successes and failures in waterfowl management suggests that our most successful management actions are those that "work with" the natural system. Systematic drawdowns, moist-soil management, and development of diverse wetland communities are examples of practices that simulate natural processes and landscapes. Other techniques that initially looked very promising, such as electrified nesting enclosures and the introduction of exotic, cool-season grasses for dense nesting cover, have proven to be disappointing when closely evaluated. Perhaps new technologies and greater effort will overcome the deficiencies in such techniques, but they will invariably do so at ever-increasing costs in energy and labor. In stating this, I do not mean to imply that these and other "unnatural" methods are not useful and should never be applied. Rather, I seek to underscore the merits of management actions that simulate natural processes or landscapes, and, when the option is available, are generally preferable to more artificial methods.

2. SEASONAL HABITAT REQUIREMENTS OF DUCKS

Although seasonal events are linked in the life cycles of birds, the migratory nature of waterfowl and the sedentary nature of habitat management areas causes most managers to consider habitat requirements on a seasonal basis. This practice tends to "compartmentalize" management options, yet it is so firmly ingrained in the waterfowl literature that it cannot be ignored. The following discussion therefore treats habitat requirements in this seasonal framework while at the same time recognizing that seasonal events and habitat requirements are neither discrete nor independent of one another. Because their life history strategies differ, the seasonal requirements of ducks and geese are discussed separately.

2.1 BREEDING

Breeding chronology in Colorado varies among species and habitats. Early nesting species such as mallard and pintail begin breeding about a month before late nesting species such as teal, gadwall, and wigeon. On the eastern plains and west-slope, early nesters begin establishing territories about mid-March. In the mountain parks, these same species set up territories in early April (Fig. 1), whereas in higher elevation breeding habitats this activity may be further delayed until early May (Fig. 2). Territories that are defended against breeding birds of the same species include wetlands of varying size, water permanency, and vegetative composition. The need for dietary protein during the pre-nesting and egg-laying periods causes ducks to seek aquatic invertebrate foods such as shrimp, clams, and similar animals. These animal foods typically compose 75-100% of the hen's diet.

Many ducks maximize food intake during this period by capitalizing on the seasonal peaks in aquatic food abundance that differ among wetland types. For example, shallow, temporary wetlands may exist only a few weeks, but they warm early in spring and develop invertebrate populations long before more permanent wetlands. By moving among wetlands and selecting those with the richest invertebrate fauna, ducks are able to quickly acquire the necessary protein for egg production. A diverse wetland community is critical to this feeding strategy. Thus, small, shallow, wetlands contribute as much to ducks during this period as do large, permanent cattail marshes.

Fig. 1. Good breeding habitat in the San Luis Valley consists of shallow water interspersed with hummocks of baltic rush or greasewood which are used as nesting sites. Water applied to impoundments during late March and early April attracts spring migrants and promotes the development of aquatic invertebrate communities.

Ducks exhibit territoriality during the breeding season when they sight other birds of the same species. This visual spacing limits the number of pairs that an area can accommodate. Habitats with numerous small ponds on which ducks may isolate themselves, or wetlands with heavy vegetation, bays, or inlets where pairs are visually separated, reduce territorial encounters and increase pair densities. Wetlands most attractive to dabbling ducks (mallard, pintail, gadwall, wigeon, teal, and other species that feed at or just below the water surface) contain a 50:50 ratio of open water to emergent vegetation. Patches of emergent plants, sparse enough to allow a duck to swim through, are more attractive than large blocks of thick, unbroken vegetation.

Fig. 2. High elevation wetland complexes support relatively high breeding densities of mallards, green-winged teal, and ring-necked ducks.

Nest sites range from overwater vegetation (cattail, bulrush) used by most diving duck species (scaup, redhead, canvasback, and other species that feed by diving under the water) to dabbling duck nests in grassland and shrub habitat located a mile or more from water. Tall, dense grasses or shrubs with low growth forms are usually preferred by dabbling ducks. Islands are also attractive to many species, if adequate vegetative cover is present. Hens explore many potential sites, but select only one as a permanent nest site. Most ducks lay a single egg a day until a clutch of 9-11 eggs is complete. Incubation periods range from 23 to 30 days for most species, with shorter periods typical of species that lay smaller eggs.

Duck nests are often destroyed by predators such as red fox, coyote, mink, skunk, raccoon, ground squirrels, magpies, and crows. In areas where predators are abundant and duck nests are concentrated because nesting cover is limited, the percentage of nests that hatch at least 1 egg (nest success) may be less than 15%. In habitats where nests are dispersed and predators uncommon, much higher (40-70%) success rates are typical. Most ducks will renest if their first clutch is destroyed during laying or early in incubation and a sufficient number and diversity of wetlands remain available. Hens that successfully hatch a clutch often return to the vicinity of the successful nest site in subsequent years. During incubation, hens leave the nest for recess 3-5 times per day. They continue to meet their mates during these recesses until the male leaves his territory and joins groups of other drakes in preparation for molt. This usually occurs about 1-2 weeks into incubation.

Newly hatched ducklings leave the nest 12-24 hours after hatching, and may walk over land or follow streams to brood-rearing wetlands up to a mile away. Even after reaching a wetland, broods may frequently move to other wetlands. Ducklings tend to feed almost entirely upon aquatic invertebrates until about 40 days old, at which time young dabbling ducks begin to consume seeds and other vegetation. Because ducklings cannot thermoregulate until they are about 2 weeks old, they are periodically brooded by the hen. Predation, exposure, and starvation can cause high mortality among ducklings. About 20% of all duck broods are entirely destroyed, and typically only about half of the ducklings in the remaining broods survive. Habitat use by broods differs among species, but is generally related to the need for areas secure from predators and severe weather. Diving duck broods seek security in open water, where they dive to escape predators. Dabbling duck broods usually prefer dense, emergent vegetation.

About the time the ducklings become fully feathered, the hen abandons her brood to congregate with other hens and drakes in preparation for a complete molt of body and flight feathers. Little is known about the characteristics of duck molting habitat. During the molt, ducks lose their ability to fly for 20-30 days. Security from predators and human disturbance is probably important at this time. Because feathers are comprised of keratin, a proteinaceous substance, availability of aquatic invertebrate foods is probably also important. Some species undergo long distance migrations to traditional molting wetlands, suggesting that such areas have characteristics uniquely suited for molting birds. Following molt, ducks concentrate in large groups on "staging areas" in preparation for fall migration.

2.2 FALL MIGRATION

Staging areas are often large wetlands with abundant vegetative foods such as seeds, nutlets, and tubers, which compose the bulk of a duck's diet during this period. Many dabbling duck species will also begin consuming waste grain after agricultural harvests begin. Fall migration chronology (Fig. 3) and habitat use differ among species. Blue-winged and cinnamon teal, both early migrant species, use shallow areas of reservoirs

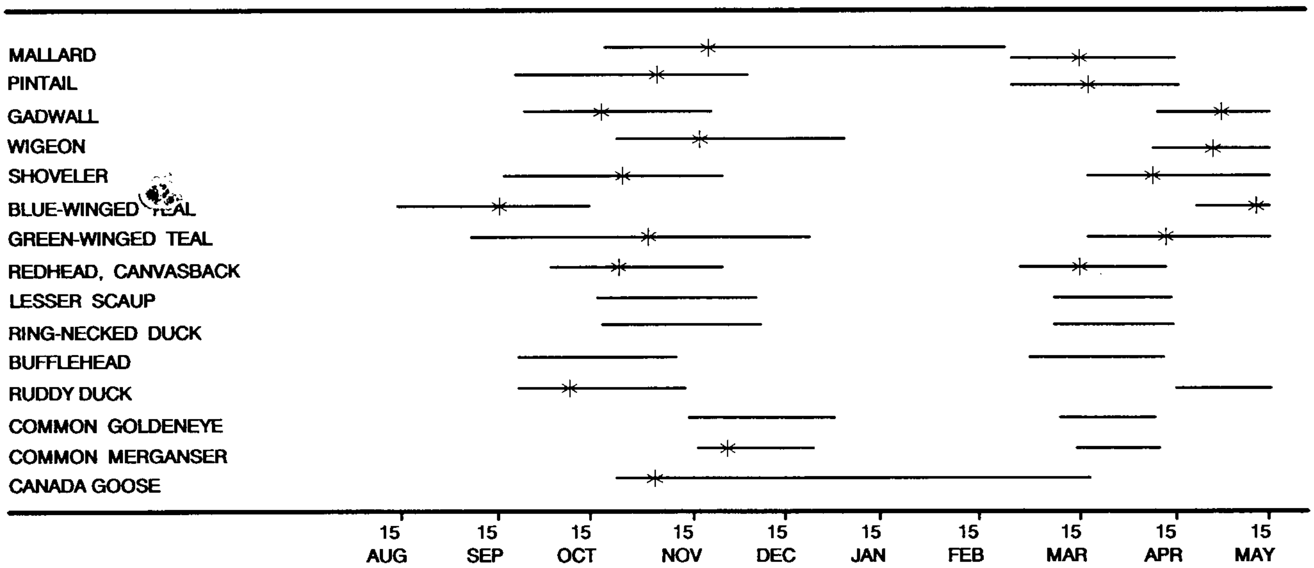

Fig. 3. The migration chronology of waterfowl through eastern Colorado. Horizontal bars indicate the period when a species is present; asterisks denote approximate peak of migration.

and small wetlands during August through early October. Mid-season migrants, including gadwall, northern shoveler, lesser scaup, and redhead, migrate in September through December, but numbers usually peak in October. Those species that migrate late, peaking in late November and early December, include the common merganser and common goldeneye. Some species are present throughout the fall, including mallard, American wigeon, green-winged teal, and pintail. Most wetland types are used by migrants until they freeze, after which larger wetlands and rivers receive heavy use.

2.3 WINTER

In winter, mallards make up over 90% of Colorado's duck population, with green-winged teal, pintail, and lesser scaup present in far fewer numbers. Ducks congregate on rivers, reservoirs, warmwater sloughs, and other wetlands where open water is present. Grains, particularly corn and barley, provide a high energy food that dominates the winter diet of mallards and other dabbling ducks. However, because most cereal grains are nutritionally imbalanced, ducks must supplement their diets with small amounts of high protein, aquatic invertebrate foods. Cereal grains are obtained during twice-a-day field-feeding flights originating from the roosting area. Most grain is acquired within a 5-mile radius of the roost, but it is not unusual for ducks to fly over 20 miles in search of cornfields.

Courtship and pairing occurs in mallards during mid- and late-winter, with reservoirs and other large wetlands serving as "courtship arenas" where ducks search for and select a mate (Fig. 4). After obtaining a mate, pairs tend to isolate themselves from courtship arenas by seeking secluded wetlands. Females of many species also undergo a complete molt of the body feathers during winter, once again creating the need for high protein foods in the form of aquatic invertebrates.

Fig. 4. Ice holes in large, eastern plains reservoirs attract large numbers of mallards and Canada geese during winter. These concentration areas provide secure roosting sites as well as "courtship arenas" where unpaired ducks can find mates for the upcoming breeding season.

Ducks traditionally return to specific wintering areas. When daylength begins to increase in late December, the attraction to a traditional wintering area may outweigh the instinct to migrate farther south in the face of severe weather or food shortage. Suboptimal body condition and even starvation may result in such instances. In Colorado's relatively severe winter climate, ducks must maintain body condition (fat reserves) to enhance their survival in the event of persistent snow cover and resultant food shortage. Fat reserves later provide the nutrients used during spring migration, egg production, and breeding.

3. SEASONAL HABITAT REQUIREMENTS OF CANADA GEESE

Forty years ago, goose management would have deserved little mention in a publication on Colorado waterfowl. Only a small population of Canada geese nested along rivers in the northwestern part of the state. Some geese wintered in southeastern Colorado and on reservoirs east of the Front Range. Then a Canada goose restoration project by the Colorado Division of Wildlife greatly increased the numbers of breeding and wintering geese. By the late 1960s and early 1970s, breeding populations were established from Fort Collins south to Denver, in 3 of the 4 mountain parks, and along many west-slope river drainages (Fig. 5). Resident breeding geese remained year-round, attracting tens of thousands of migrating Canada geese and causing winter goose populations to enlarge. This case history is a dramatic example of the potential waterfowl response to appropriate management actions.

3.1 BREEDING

Canada geese begin the breeding period in family units. After arrival, yearling geese, which do not breed, leave their parents and congregate in flocks away from breeding adults. Mature geese, which pair for life, establish territories often near the same nest site used in previous years. Canada geese occupy a wider diversity of nest sites than ducks, using muskrat dens, beaver lodges, islands, and artificial structures. Good visibility is a characteristic of most nest sites, and territories are aggressively defended in response to visual sightings of other geese. As with ducks, visual obstructions effectively reduce territory sizes and increase breeding pair densities. Canada geese are the earliest nesting waterfowl in Colorado, initiating nests in mid-March along the Front Range, about early April in the mountain parks, and by late-March in west-slope riverbottom habitats.

Geese are herbivores, and therefore differ from ducks in the ways in which they acquire nutrients necessary for egg production. Their larger body size enables them to store relatively large fat and protein reserves, which are acquired during late winter and early spring prior to migration. Canada geese consume large quantities of green forage. They often enhance the overall general quality of their diet by selectively feeding on new shoots or the tips of old shoots, both of which have a higher protein content than the other plant tissues. Their strategy of digesting large quantities of low quality foods requires them to feed for a much larger portion of the day than ducks. Canada geese lay an average of 5 eggs over a 7-9 day period, with a subsequent incubation period of 25-30 days. Renesting is uncommon, but may occur if a clutch is destroyed during laying. Because of their large size and aggressive nature, nest predation rates are less than for ducks. Coyotes, raccoons, and ravens are the principal agents of egg predation. Nest failure also results from nest desertion caused by territorial aggression among geese. Severe cold accompanying spring snowstorms may chill eggs, causing death of the embryos and subsequent nest desertion. Males remain in the vicinity of the nest while the female incu-

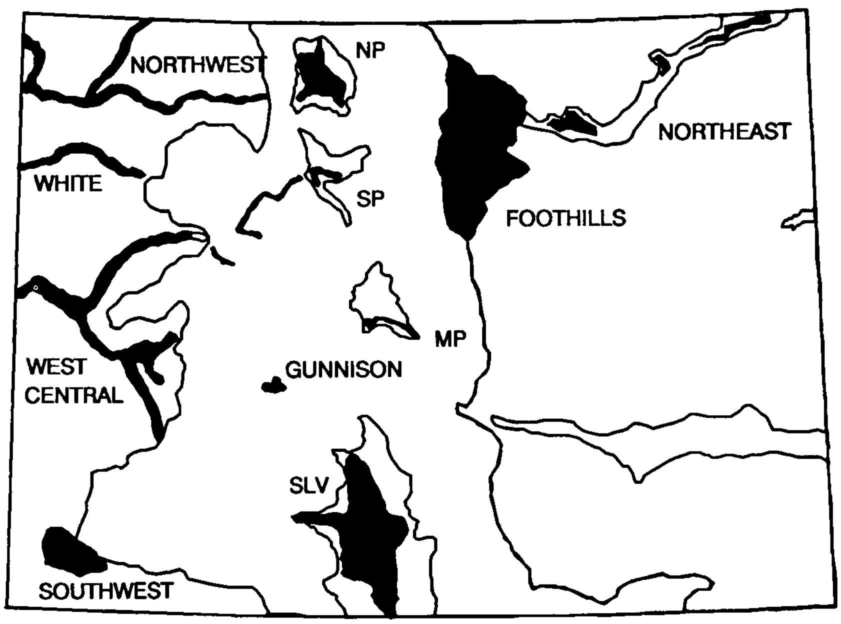

Fig. 5. Distribution of Canada goose breeding populations in Colorado.

bates. Females typically take 2-3 incubation breaks per day.

Newly hatched goslings leave the nest within 24 hours, accompanied by their parents. They are quickly led to brood rearing areas over land or via watercourses, where they feed on green forage almost continuously. Alfalfa fields, meadows, bluegrass, or herbaceous vegetation along the margins of wetlands commonly serve as brood rearing sites. About 80% of the goslings, or an average of 4 goslings per brood, survive to fledging.

Canada geese have a single complete molt per year. The first molters are yearlings, non-nesting adults, and adults whose nests were destroyed. These individuals congregate on large reservoirs beginning about mid-June. Geese may initiate long migrations to traditional molting areas, where they remain until late summer. In contrast, adults with broods molt late in the brood-rearing period and both adults and young attain flight capabilities about the same time. Nutrients to regrow feathers are obtained from nearby forage as well as body tissues, which often causes extreme weight losses among molting Canada geese.

3.2 FALL MIGRATION

In early fall, Colorado-reared geese begin wandering among wetlands in family groups and small flocks. Those that breed in mountain parks may undertake short-distance migrations within state or long-distance migrations to southern wintering areas. Geese from the Hi-Line breeding population, which nest in eastern Wyoming, eastern Montana, southeastern Alberta, and southwestern Saskatchewan, begin migrating into north-central Colorado in late October. The smaller subspecies that compose the short-grass prairie population nest primarily across the western Canadian arctic. They generally do not arrive in eastern Colorado until mid-November, accompanied by smaller numbers of snow geese from the west-central population. Canada geese of the Rocky Mountain population, which winter in westcentral Colorado, begin moving through northwest Colorado river drainages from central Wyoming nesting areas in late November. Geese move southward in response to freezing weather and snowfall, using large wetlands along the way. Cereal grains become an increasingly important component in their diet during fall. Hi-Line geese are attracted to areas along the Front Range, decoyed by resident geese and encouraged to linger by abundant grain fields, green forage, and refuge areas. Shortgrass prairie geese, although present in increasing numbers in northeastern Colorado, are still primarily found in their traditional wintering areas of southeastern Colorado.

3.3 WINTER

Many wetlands used as fall migration areas are also used as winter roosts. Geese are less dependent than ducks on open water during the winter. Nevertheless, they tend to congregate on the same ice-free wetlands as ducks (Fig. 6). Grain, particularly corn, becomes an important part of their winter diet. When fields are free of snow, sprouts of winter wheat are favored as green forage; but brome, Kentucky bluegrass, barley, wheat, and alfalfa are also eaten. Because they do not undertake courtship activities and their large body size makes their thermoregulatory costs low, geese have relatively lower energy demands than ducks. Wintering geese are therefore less subject to weather-related stresses than are ducks. This trait, along with their capacity to adapt to refuge environments, results in a high overwinter survival rate.

Fig. 6. Their relatively large body size, adaptability, and propensity to consume high energy cereal grains enable mallards and Canada geese to survive in Colorado's severe winter climate.

4. COLLECTING PREMANAGEMENT DATA

Waterfowl habitat management is an investment in time and money. A typical investor in the stock market carefully reviews a stock's prospectus, notes the value of shares at the time of purchase, then monitors the progress of the stock to evaluate whether his money was well spent. Yet waterfowl habitat is often developed with little forethought, no premanagement information, and little follow-up evaluation. Such actions result partially from the urge to produce immediate on-the-ground results, and partly from the misconception that waterfowl management is simple and that any action will prove beneficial. Immediate, unplanned action frequently wastes time and money. The approach I present here will help minimize the likelihood of wasted resources. This chapter is intended to serve as a guide on how to collect relevant information needed to make a decision on management actions. When used in conjunction with the following chapter on limiting factors, these data will serve as a guide to management actions discussed in Chapters 5 and 6.

4.1 BREEDING WATERFOWL

Information on the number of spring migrants and resident breeding pairs can be obtained through a series of ground counts beginning with the first influx of spring migrants and continuing through the early incubation period. Ideally, surveys should be conducted 2 or 3 times per week, but in no case less than once a week. Because females typically take incubation recesses early and late in the day, nesting chronology and indices to nest success are most readily interpretable if observers restrict their counts to the period between 1 hour after sunrise to 1 hour before sunset. Observers should quietly walk near wetlands but avoid flushing ducks. If birds flush to nearby areas, observers should avoid duplicate counts on these individuals. During the time when spring migrants are moving through the region, simply tally the numbers of individuals by species and sex. When the number of ducks and the species composition stabilizes, one may assume that many birds now in the area are beginning to establish home ranges in preparation for breeding. At this time, begin counting male-female pairs and single males, tallying the latter category as "indicated pairs". These single or "lone" males are usually mates of females who are searching for nest sites, laying eggs, or incubating. For each species, consider the highest number of observed pairs plus indicated pairs for any one census as the total estimated pairs resident in the wetland community.

The quantity of available nesting habitat is often easy to judge in relation to species requirements. Most diving ducks construct nests over water in robust emergent plants. Map the distribution and vegetative composition of these emergent beds, and note if such areas remain inundated during the incubation period. Cavity-nesting duck species use holes excavated by woodpeckers or created by internal rot in old trees. Note the number and distribution of potential nest trees or actual nest sites and their distances from the wetland. Dabbling ducks and some diving ducks nest in grasses or shrubs adjacent to wetlands. Map the area and distribution of these habitats.

The quality of nesting habitat is difficult to judge for overwater- and cavity-nesting species. However, the height and density of upland sites can be measured using a Robel pole (Robel et al. 1970, see 4.0 references) or a similar device. Readings obtained at a standardized viewing height and distance can then be compared with minimum standards required by different species. Whenever possible, managers should determine the quality of potential nesting habitat.

Duck nesting success is a more indirect index of nesting habitat conditions because it is not only dependent on the quality and quantity of habitat, but also the density and composition of the local predator community. In grassland habitats, large numbers of nests can often be located using cable-chain drags (Higgins et al. 1977, see 4.0 references). In shrubland or wooded areas, hand drags, dogs, or observations of hens returning to nest sites may be necessary to locate nests. When nests are found, note the size of the completed clutch, candle the eggs (Weller 1956, see 4.0 references) to determine the stage of incubation, then flag the site by placing a marker at some set distance and direction away from the nest. Excessive disturbance to the nest site must be avoided. Later, revisit the site to determine the fate of the nest. Nests that were abandoned or destroyed by predators will contain whole eggs and/or pieces of eggshell with membranes firmly attached to the shells (Fig. 7). Note the condition of the eggs and look for tracks, fecal droppings, or other evidence that may suggest the cause of nest failure. Successful nests are typified by shell membranes that are easily separated from shell fragments.

Begin duck brood surveys when broods of early-nesting species first appear. Surveys should be conducted in early morning (30 minutes before to 1 hour after sunrise) and in late evening (2 hours before until 30 minutes after sunset). Counts conducted at times other than early and late in the day will census only a fraction of the broods present and will be biased towards geese and diving duck species that use open water areas during brood-rearing. Viewers should quietly observe broods, from elevated vantage points if

Fig. 7. Membranes that separate easily from eggshells are indicative of successful nests, whereas those that adhere firmly to shells usually indicate an egg that did not hatch.

necessary, and note the species, size of the brood (number of ducklings), and age (Fig. 8) of the ducklings. Be aware that duck broods may move among wetlands, and try to avoid duplicate counts. If inter-wetland movements are uncommon and the number of broods per wetland is low, it is often possible to distinguish individual broods based on a combination of species, size and age. In such cases, note the number of ducklings in a brood on subsequent observations. If a brood is not observed on subsequent surveys and the likelihood of secondary movements to another rearing wetland are remote, record the possibility that the entire brood perished. To obtain good data on duckling attrition, individual broods should be reobserved every 3 to 5 days, particularly when ducklings are young and mortality rates are highest. The most important index to obtain during the brood-rearing period is the number of young remaining in old (pre-fledging or class III) broods.

In most regions of Colorado, Canada goose broods aggregate as they grow older, resulting in an increase in average brood size over time. Direct estimates of gosling mortality are therefore largely ineffective, and indirect measures must be used. The most accurate method of measuring gosling mortality is to compare the number of young reaching flight stage with the number of nesting pairs.

4.2 MIGRATING WATERFOWL

When evaluating migratory habitat, it is not necessary to measure recruitment and survival parameters as is done during breeding. Instead, note the number of birds using each wetland. Conduct periodic counts during mid-day when roosting birds have returned from field-feeding. Also note the species composition of ducks during each census. Finally, combine both length of stay and numbers into a measure of waterfowl use-days for ducks and geese.

If the area is hunted, keep records of harvest, hunter-days, and disturbances such as vehicle and pedestrian traffic near waterfowl concentrations. Associated non-hunting disturbance such as passing motorists and photographers should also be recorded.

4.3 WINTERING WATERFOWL

The same type of data gathered on migrating waterfowl should be collected for wintering birds. In addition, managers should carefully monitor the amount of open water available during periods of sub-freezing temperatures, because the amount of open water limits the wetland habitat available for use by waterfowl. Note also the approximate distance flown by field-feeding waterfowl, and the foods consumed during field-feeding bouts. Are birds using unusual habitats such as cattle feedlots or urban areas? If possible, examine the amount of waste grain remaining in fields recently abandoned by field-feeding birds. Lastly, time the duration of field-feeding flights under average weather conditions.

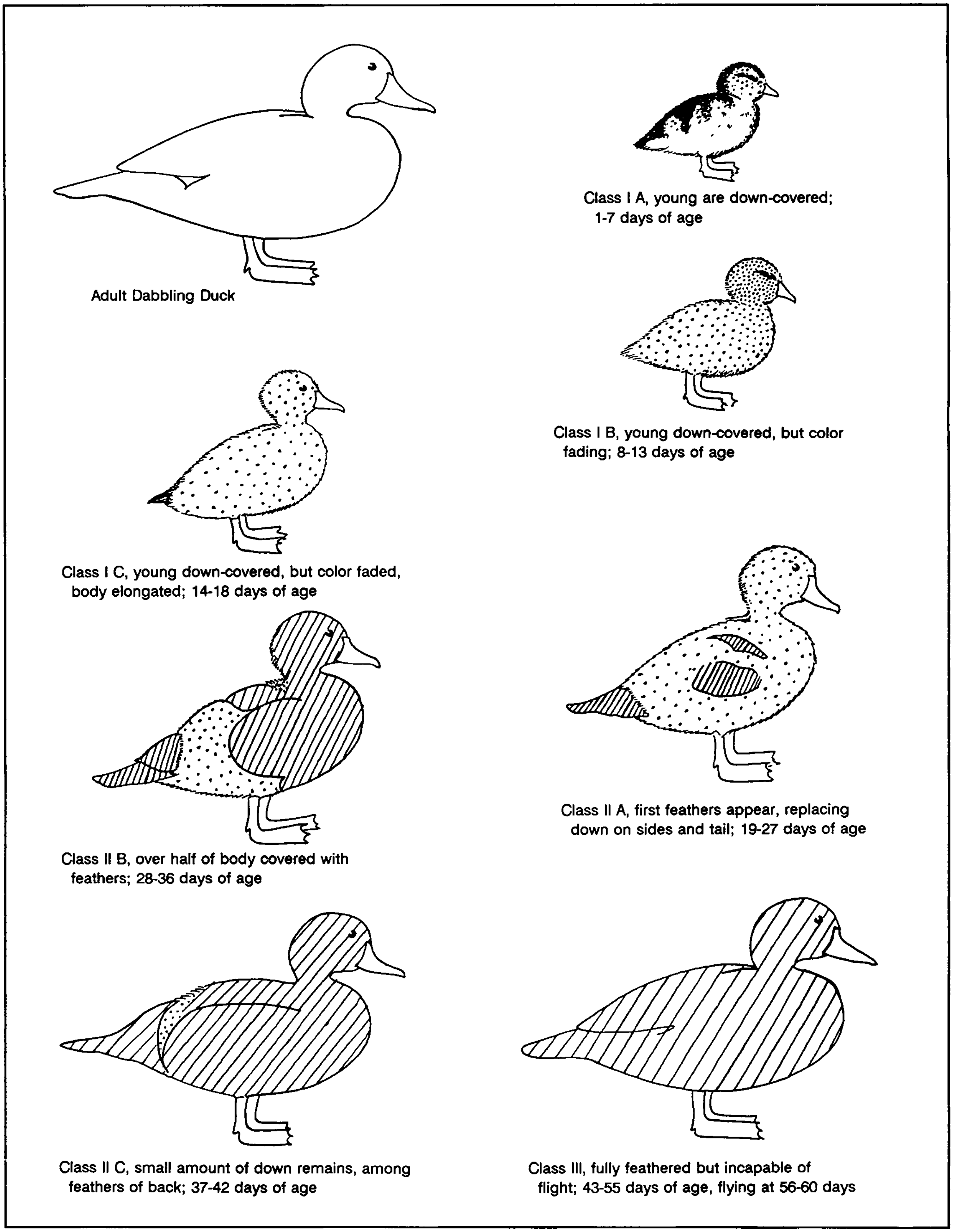

Fig. 8. Plumage development and age classification of ducklings. (Reprinted with permission of Wildlife Management Institute)

5. IDENTIFYING THE LIMITING FACTOR

Predation, resource limitations, and environmental conditions are all factors that may suppress waterfowl populations below their biological potential. However, only one factor is *most* limiting to populations at a given point in time. Aldo Leopold described the limiting factor as "the one that has to be removed first, and usually the one to which the application of a given amount of effort will pay the highest returns, under conditions as they stand." The effort required to remedy a limiting factor may vary, but until it is removed, activities directed at other, non-limiting factors will not improve populations.

Many ecologists correctly view the limiting factor concept as an oversimplification of complex interrelationships. Nonetheless it is a useful concept for waterfowl managers with limited time and resources, but a commitment to improve waterfowl habitat (Fig. 9). This approach, however, should be tempered with a recognition of its limitations. Sometimes, a factor that limits a waterfowl population can result from deficiencies external to the habitat in question. For example, feeding conditions on wintering areas may not allow adequate development of fat reserves necessary for successful breeding. In such cases, managers may be incapable of rectifying the deficiency. The dynamic nature of many waterfowl habitats may also cause the limiting factor to differ among years. Thus, management to correct long-term habitat deficiencies should be based on average habitat conditions. These average conditions are best determined by evaluating premanagement information collected during more than one breeding season.

Because wetland communities are the basic unit in which waterfowl live and acquire resources during breeding, premanagement information should be gathered independently for each discrete community, not "averaged" across several isolated wetland complexes. Waterfowl researchers are just beginning to understand the implications of habitat fragmentation for breeding waterfowl. It is well established that the utility of small tracts of habitat is often lost due to the effects of habitat degradation on adjacent lands. The protocol described here may still be useful for identifying factors limiting waterfowl recruitment, but management to overcome these deficiencies on small tracts of land may be futile in the face of overwhelming, external forces.

This chapter discusses how to identify the limiting factor using the premanagement data described above. Management prescriptions for correcting these limitations are described in Chapters 6 and 7, cross-referenced by chapter and section number.

5.1 BREEDING DUCKS

The first step in the evaluation process is to determine if a habitat attracts and holds breeding pairs of ducks "up to its potential." The key to assessing this potential is knowing how many pairs are attracted to good, fair, and poor habitats similar to the area in question. Examining good, nearby breeding pair habitat provides the best yardstick for comparison. Lacking these data, Table 1 presents average duck breeding pair densities for good, fair, and poor areas in several habitat regions of Colorado (Fig. 10). This table, although broad in scope, provides some basis for comparison within the same habitat region.

Table 1. Representative duck breeding pair densities in major habitats of Colorado.

	Relative density (pairs/mi^2 of wetland)		
Habitat region[a]	Low	Average	High
High plains prairie	< 5	5-13	> 13
High plains riverine	< 8	8-18	> 18
Mountains and foothills	< 2	2- 8	> 8
Mountain parks			
North Park	< 13	13-39	> 39
South Park	< 5	5-10	> 10
San Luis Valley	< 5	5-13	> 13
Plateau riverine	< 5	5-13	> 13
Plateau	< 2	2- 4	> 4

[a] See Fig. 10.

If an area ranks poor in pair density, or if it ranks fair while other factors rank good, management action should be initiated to attract and hold breeding pairs. A primary consideration in such action is the quality and quantity of available water, and an objective assessment of how water can be managed at a site (6.1). With adequate water, it is possible to create new wetlands or a more diverse wetland community (6.2). Alternatively, managers may modify existing aquatic vegetation to increase "edge" (6.3) or promote growth of desirable aquatic plant species (6.4).

Ducks may be attracted to wetlands, but never attempt to nest if cover is inadequate or lacking. Suitable nesting cover should be dense at heights of 8-12 inches above ground and occur in large, unbroken blocks near the wetland complex. It should be secure from grazing and agricultural manipulations until after the incubation period. Several options exist for creating and managing upland nesting cover (6.6). For overwater nesting duck species, overwater nesting vegetation such

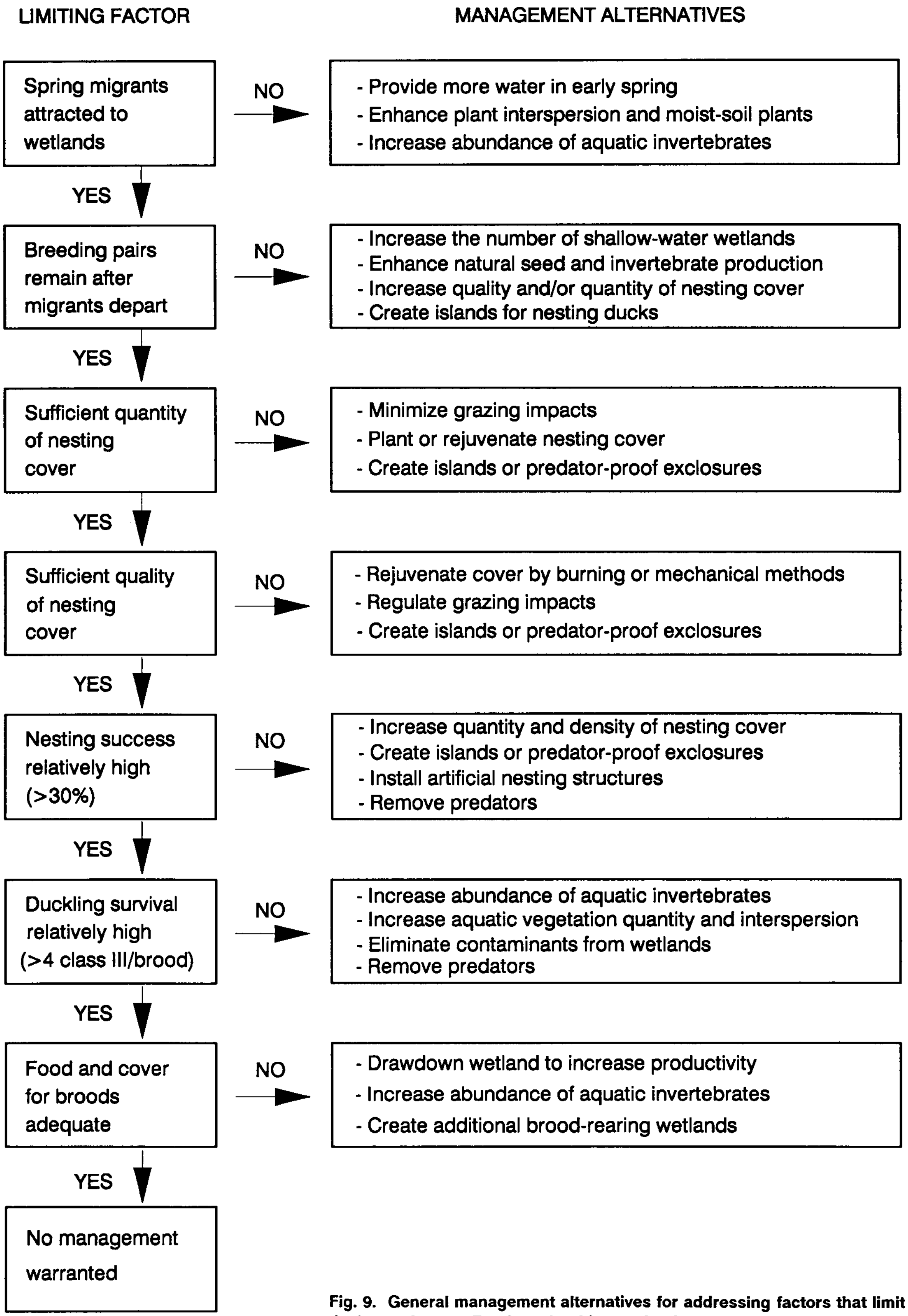

Fig. 9. General management alternatives for addressing factors that limit duck recruitment. Readers should consult other sections of this report and selected readings listed in section 10 for details needed to implement alternatives.

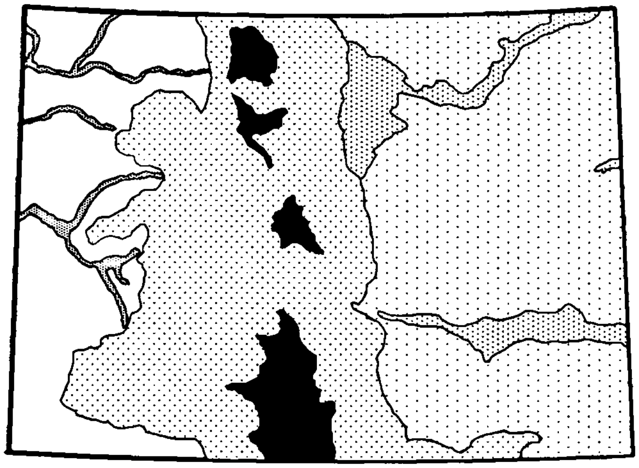

Fig. 10. Waterfowl habitat regions of Colorado.

as cattail or bulrush should be upright and dense in springtime, and in patches or bands at least 12 feet wide. If such areas do not exist, vegetative improvement methods (6.3, 6.4) should be applied. Most cavity-nesting species select nest sites within 100 yards of a wetland. If suitable cavities are few or absent within this area, artificial nesting structures can help correct the deficiency.

Alternatively, ducks may attempt to nest but nests may be destroyed by predators, flooding, or other factors. If nest success is less than 40% and predators appear to be the source of nest loss, examine the quantity, quality, and dispersion of nesting cover. Beware of isolated patches or narrow bands of cover that may attract predators or serve as travel lanes. Consider predator management strategies for such areas (6.7), or alternatively, evaluate the potential to create secure nesting islands in wetlands (6.5) or increase the amount of upland cover (6.6). Nest success rates greater than 60% are considered good, requiring no management action.

Data on the fate of marked nests should be corrected for exposure (Johnson 1979, see 4.0 references), then average nest success rates calculated for the management area. Generally, nest success rates greater than 40% are considered good in most habitats, whereas rates less than 15% are usually insufficient to maintain a stable duck population. Lacking direct measures of nest success, managers may obtain qualitative indices of nest loss through "social indices" that rely on the tendencies of many duck species to renest if their initial nests are destroyed. The simplest of these indices is an analysis of the weekly ratios of indicated pairs (lone males) to actual (male-female) pairs during the egg-laying and incubation period for each species. Local populations experiencing low rates of nest loss will exhibit ratios that increase sharply in the first few weeks, then gradually decline from a high level (e.g., 0.2:1, 1.3:1, 3.4:1, 3.0:1, and 2.8:1). Populations experiencing high nest loss often exhibit an increase, followed by a sharp decrease, then a subsequent increase in these ratios (e.g., 0.2:1, 1.3:1, 3.4:1, 1.8:1, and 2.7:1), indicative of unsuccessful hens rejoining their mates in preparation for a second nesting attempt. In cases similar to the latter example, nesting habitat management (6.5, 6.6), predator barriers (6.7), or artificial nesting structures (6.8) may be needed.

Additional evidence of nest destruction is derived from examining the hatching chronology of duck broods. This is accomplished by back-dating the hatching date of broods using data on duckling age and information provided in Table 2. A frequency distribution of number of broods hatched by 5-day intervals typically depicts a peak of hatch followed by a much smaller, well-defined second peak from renesting attempts (Fig. 11). Hatching curves that exhibit pronounced renesting peaks or are flat and extended (Fig. 11) suggest excessive nest loss that may warrant the management actions described above.

Table 2. Approximate midpoint age (in days) of ducklings for each plumage age class, by species. Refer to Fig. 8 for field characteristics of each age class.

	Age class						
Species	Ia	Ib	Ic	IIa	IIb	IIc	III
Blue-winged teal	3	8	12	18	26	34	39
Gadwall	4	11	17	23	33	42	48
Mallard	4	10	16	22	31	41	51
Pintail	3	9	16	21	29	39	48
Redhead	4	13	22	29	39	50	58
Ring-necked duck	3	8	14	21	28	35	44
Scaup	3	10	17	25	31	38	47
Shoveller	4	10	16	23	32	40	48
American wigeon	4	10	16	23	31	39	46

Excessive duckling mortality may be indicated by either loss of complete broods or brood attrition, wherein the number of ducklings in a brood is reduced over time. Mortality caused by exposure, starvation, or death from pesticides or other contaminants typically occurs during the first week after hatch, and is often reflected in the loss of entire broods. Death from exposure may be caused by lack of dense, emergent cover that offers protection for ducklings, and may be reversed through vegetation management (6.3, 6.4). Starvation, a relatively rare problem, may result from a lack of aquatic invertebrates or terrestrial insects in shallow water, on

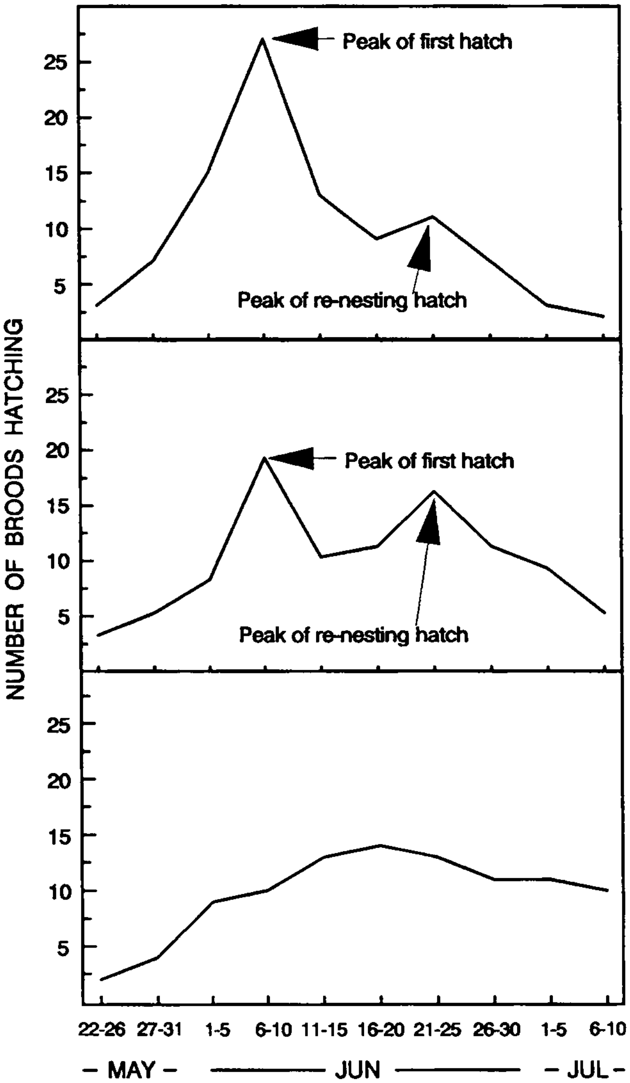

Fig. 11. Hypothetical hatching curves for populations experiencing normal nest loss (top) versus high nest loss (middle and bottom).

the water surface, or on emergent vegetation. Actions to enhance invertebrate populations may be warranted in these situations (6.9). Pesticides or other contaminants may also act indirectly by eliminating invertebrate foods, or through direct toxicity. If contaminants are suspected, experts should be consulted to confirm the presence of toxicants and to recommend management actions.

A gradual loss of ducklings, although possibly caused by the above factors, is more often an indication of predation. Mink, raccoon, raptors, snapping turtle, and carnivorous fish are common duckling predators. If the average brood size at fledging (Class III, Table 2) is less than 5, managers should consider enhancing wetland complexes (6.2) or vegetation (6.3, 6.4) to increase the number of wetlands with permanent summer water and extensive, robust stands of vegetation.

5.2 MIGRATING DUCKS

If migrating ducks are not attracted to an area during fall, first examine wetland characteristics. Migrating ducks are drawn to disturbance-free wetlands with significant stands (10% and 50% coverage) of emergent vegetation (6.4). A "hemi-marsh" pattern of vegetation dispersion (Fig. 12), in which plants are not so dense as to impede duck movement, is desirable (6.3). If ducks are attracted to wetlands but do not remain for over 2 days, a lack of food or excessive disturbance may be the cause. Ideally, the water depth in at least half of a wetland should be 18 inch or less so bottom foods are available to dabbling ducks. Submergent vegetation in deeper water areas is also desirable. Seeds and tubers of aquatic plants are highly sought after at this time of year. Although most ducks will continue their southward migration even if food resources are plentiful, wetlands with abundant food resources will support a larger number of ducks over time. Wetlands lacking natural plant communities rich in these foods can be managed by reversing wetland succession, moist-soil management, or introduction of new plant species (6.4).

Migrating ducks also consume agricultural foods such as corn and small grains. If these foods do not exist in the immediate vicinity of a wetland, ducks may loose their attachment for a site in favor of a wetland located nearer their food source. Planting grains in or near the wetland basin or enhancing their availability in upland sites (6.10) can effectively increase duck use.

Disturbance, particularly from hunters, can quickly "burn-out" a wetland resulting in little or no use by migrating ducks. Unfortunately, the amount of disturbance that leads to "burn-out" is not easily quantified,

Fig. 12. This "hemi-marsh" pattern of vegetation interspersion is typical of marshes at mid-successional stages. The vegetative pattern is promoted through periodic drawdowns that allow aerobic decay, germination of aquatic plants, and compaction of bottom substrate to provide a better rooting medium.

because the reaction of ducks is dependent upon the number and distribution of hunters and weather conditions. If ducks do not return the day following intensive hunting, this may indicate excessive disturbance. Several options are available for providing secure resting areas (6.11) or otherwise managing hunting for the betterment of both hunters and ducks (6.12).

5.3 WINTERING DUCKS

The amount and distribution of open water, along with the availability of waste grain, are factors that determine duck use during winter. Seep ditches, warmwater sloughs, rivers that run free of ice, and ice holes in large reservoirs are commonly used winter habitats (Fig. 13). These wetlands are most attractive to ducks if they possess submergent or emergent aquatic vegetation (5.2), but wetlands will be used even if no plants are present. Because of the heavy duck use received by such areas, it is usually not practical to establish aquatic plants where none have previously existed. Instead, consider techniques to provide new areas of open water, or

Fig. 13. Rivers provide valuable winter habitat until they freeze or flow with slush ice (top), which causes waterfowl to increase their use of critical warmwater slough habitat (bottom).

enlarge existing water areas (6.14). Warmwater wetlands appear to be the key to maintaining good populations of wintering ducks in Colorado. However, these sensitive areas are often subject to intensive hunting pressure during December and early January. If duck use-days decline significantly during the hunting period, restricting hunting activity may be an appropriate strategy (6.12).

The behavior of field-feeding ducks will often provide clues to the adequacy of food resources. Under normal winter weather conditions, most ducks will undertake 2 field-feeding flights per day. These flights, which normally last 1-2 hours, occur at dusk and dawn. When snowfall is heavy or temperatures are extremely cold, ducks will either feed throughout the day or, if their energy reserves become low or weather is extreme, forego field-feeding altogether until the weather moderates. These behaviors are normal. However, if ducks field-feed for over 4 hours per day in normal weather, fly over 10 miles to obtain food on a regular basis, or feed in unusual areas such as cattle feedlots for long periods of time, food may be limiting. Fields that continue to be used by ducks even when grain has been entirely depleted may also be indicative of food shortage. In these cases, managers should consider actions that either increase the amount of grain (6.10) or enhance the availability of existing grain (6.10).

Because cereal grains are nutritionally incomplete, seeds of wild plants, green vegetation, and aquatic invertebrates are all-important supplemental foods in the winter diet. Warmwater habitats usually provide these foods without special management. In many cases, reservoirs or riverine areas with sandy, unstable bottoms may be lacking sufficient supplemental foods. If adequate open water areas and grain foods have been ruled out as limiting resources, development of areas containing supplemental foods may help boost winter duck populations (6.13).

5.4 BREEDING GEESE

Unlike ducks, geese do not quickly expand into new breeding areas. Although most regions of Colorado now have breeding populations of Canada geese, managers should make certain that breeding geese are present in their locality prior to initiating other habitat management strategies. If breeding populations are not present, techniques have been refined to enable such populations to be established (7.1).

In most cases, breeding Canada geese select wetland and upland nesting habitats with much less cover than that preferred by ducks. Their use of open habitats increases the territorial encounters among pairs. Consequently, if large wetlands contain only 1-2 pairs, or medium-sized ponds have no pairs at all, efforts should be directed at modifications that will create more nest sites (7.1) and reduce territorial encounters (7.2).

Although Canada geese are more flexible than ducks in their selection of nesting habitat, they still require secure nest sites near brood-rearing areas. Nest success rates average 70% for Canada geese, and values less than 50% should trigger management action. Goose nests are usually easy to locate and monitor, and the causes of nest loss are often obvious. In areas with large numbers of nesting geese, nests that appear to be deserted with no sign of predation may be indicative of territorial encounters that led to nest abandonment. One solution is to initiate measures to improve the dispersion of vegetation around nesting sites (7.2). Deserted nests in areas with low nesting densities are usually attributable to harassment from predators. If nests are being destroyed by mammals, consider constructing secure nesting islands (6.5) or erecting predator barriers as described for ducks (6.7). Alternatively, construction of predator-proof artificial nesting structures (7.3) may alleviate both territorial strife leading to nest abandonment and loss of eggs to mammalian predators. Because males remain with females throughout the nesting period, and renesting is not as common among geese as in ducks, the indirect measures of evaluating nest success described for ducks are not applicable to geese.

Survival of goslings is typically high, with average brood size decreasing from 5 young at hatch to 4 young by flight stage. Thus, an average of 2.8 goslings per breeding pair is indicative of normal gosling mortality rates. To increase the sensitivity of this index, managers are advised to calculate their own expected number of goslings per nesting pair by multiplying the nest success rate in their area times the average clutch size. If the number of goslings per pair is less than 30% of the expected value (2 goslings per pair given average nest success and clutch size) and pair density and nest success are acceptable, gosling survival should be considered limiting to population growth.

Gosling mortality is most commonly caused by predation, exposure to the elements, or starvation. Adult geese are the greatest safeguard against the first and second factors, and short of directly removing predators, managers have few options to counter such mortality. Inadequate food resources, however, can be improved by managing green forage (7.5). In urban areas, with abundant Kentucky bluegrass forage available in residential yards and parks, geese may consume prized ornamental plants or create a nuisance because of their droppings. Simple management techniques (7.4) will often alleviate these problems.

5.5 MIGRATING GEESE

Migrating Canada geese are attracted to large, open water areas with open roost sites. The number of geese using a wetland in fall is determined by migration chronology, historical use patterns, weather, human disturbance, nearby food sources, and characteristics of the wetland itself. If a suitable wetland is consistently avoided or underused, it may be because of its remote location relative to migratory pathways or local breeding populations. Often, geese from a resident breeding population that remain on a wetland through fall attract or "decoy" nonresident, migrating geese, thereby increasing goose use-days. Adequate food resources near the roosting wetland will also help attract and hold geese. In early fall, newly-harvested grain fields are sought by geese, and these can be effectively managed to enhance the availability of waste grain (6.10). After winter wheat has sprouted, Canada geese will also use these fields, as well as brome and Kentucky bluegrass forage in urban areas. Fields of harvested grain and green forage should be juxtaposed with large wetland areas to create an ideal fall migration area.

Even though they have a high tolerance for human activity, proper fall management of Canada geese must consider the degree and distribution of hunting pressure. Temporal and spatial distribution of hunter pressure in combination with appropriately located resting areas are important considerations in maximizing local goose abundance (7.7).

5.6 WINTERING GEESE

Considerations for managing wintering Canada geese are identical to those described for wintering ducks. The availability of open water is paramount to all other factors in regulating the abundance and distribution of waterfowl. Therefore, wetland areas that are unattractive to geese because of the lack of open water would benefit first from increasing the amount and distribution of water (6.14) prior to being considered in the management sequence outlined for migrating geese (5.5).

Recent management attention directed towards wintering Canada geese has focused on problems created by these birds in urban areas. Although not strictly applicable to the topic of evaluating factors that limit waterfowl, management options are presented because the problem has become an important management issue (7.7). A related topic concerns a widespread interest in managing wetlands for ducks while at the same time making them unattractive to Canada geese (7.8).

6. MANAGEMENT PRESCRIPTIONS FOR DUCKS

Once a limiting factor has been identified, an appropriate management prescription can be applied. The following management prescriptions are not intended to provide extensive technical details; rather, they are synopses of state-of-the-art management procedures derived from published sources. Greater detail is provided by the references in the Selected References chapter, which is organized by chapter and section number. Citations presented in the text will also be found under the appropriate chapter and section heading in the Suggested References chapter.

6.1 MANAGING WATER QUALITY, QUANTITY, AND APPLICATION

The quality of water available for wetlands management and development is an important initial consideration. "Wastewater" from agriculture, which is available at low cost, can be used for waterfowl developments as long as care is taken to assure it is uncontaminated. Such water may carry with it dissolved pollutants such as pesticides or heavy metals, which may lead to deformities in embryos, destruction of aquatic invertebrates and plants, or can be lethal to birds. A water quality test, conducted prior to initiating wetland projects, is good insurance against such problems. Water quality tests will not only detect harmful contaminants, but will also provide basic water chemistry information such as pH, alkalinity, and specific conductivity. This chemical information is important when planning vegetation management and plant introductions, because conditions conducive to plant growth differ among species.

Water percolation tests should be performed prior to constructing new wetlands. If underlying soils do not hold water, ponds may need to be sealed with plastic liners or bentonite. Alternatively, supplemental water must be used to flood and maintain wetland basins. The need for water in early spring usually precedes the period when river or ditch water is available, forcing the use of more expensive sources such as well water. Regardless of the source, proper timing of water application and flooding depth are important for managing wetland succession, regulating plant and invertebrate communities (6.3, 6.4, 6.9), and making these resources available to waterfowl. Creating wetlands that are temporarily flooded during fall migration is a common technique to enhance hunting opportunities. The addition of water during winter, particularly if the water is from a warmwater source, will attract mallards and Canada geese resident during this period. To benefit the largest number of waterfowl species, wetlands should be flooded to an average depth of 18 inches or, in deeper areas, possess submergent vegetation near the water surface. Brood-rearing wetlands must have a large water area during the entire summer.

One frequently overlooked aspect of water management is periodic drawdowns (de-watering) of wetland basins, which mimic the natural wet-dry cycle of natural systems. Wetlands managed for waterfowl should be completely dewatered for 1 year every 5-7 years to allow aerobic decay of organic matter, compaction of soils to promote rooting by aquatic plants, and to retard wetland succession. In man-made wetlands, this usually requires outlet structures that allow a wetland to be completely drained. This capability is an important consideration in the design of impoundments, as is the ability to flood a wetland at least 12 inches deeper than its normal water level to control nuisance aquatic plant species (6.4).

6.2 ENHANCING THE EXISTING WETLAND COMPLEX

A diverse wetland community, ranging from ephemeral wet meadows to semi-permanent cattail ponds, is essential to waterfowl breeding success and desirable for migrating and wintering birds (Fig. 14). During breeding, habitat requirements of waterfowl differ not only among species, but by sex and reproductive stage. Diversity in the wetland complex promotes a wide range of "microhabitats," thereby helping to assure that the needed resources are present. Since interspecific territoriality is rare among ducks and geese, diverse wetland will result in a higher density and diversity of waterfowl than that found in monotypic communities.

Wetland complexes occur naturally where they have not been destroyed through drainage or cultivation.

Fig. 14. Suitable duck breeding habitat offers a diverse wetland community with ponds of differing water permanencies, depths, and sizes. (Photo by M. W. Tome)

Restoring the natural wetland community is often a simple matter of filling ditches, drain tiles and pipes, or eliminating cultivation, thereby allowing natural depressions to collect water. In regions of Colorado that lack shallow water, depressions should be flooded to restore the ephemeral and temporary wetlands most often lost from human activity.

In flat terrain, contour levees with water control structures are the best means to create new wetlands with a maximum flexibility to control water levels and vegetation. Maps with 1-foot contour elevations are helpful when designing such impoundments. Explosives have been used to create new wetlands for breeding pairs in mountain park and eastern plains habitats, but such wetlands are generally not as attractive to waterfowl as natural ponds. Potholes created by using explosives are generally small, steep-sided and deep in the center. Such wetlands afford pair isolation, but development of emergent vegetation and aquatic invertebrate communities is poor. Wetlands created by draglines, bulldozers, or excavators are preferred over those blasted with explosives, because the manager can create the edge design, bank steepness, and depth that is optimum for attracting ducks and geese (Fig. 15).

Fig. 15. Levee plows (top) or bulldozers (bottom) can be used to construct low contour dikes that provide shallow-water habitat without the deep "borrow-ditch" that often results from other construction methods.

In forested and riverbottom habitats, beaver create wetland communities that are very attractive to breeding ducks. Newly flooded beaver ponds are very fertile due to abundant organic nutrients. Aquatic invertebrate populations peak 2-3 years after inundation, but the structural cover created by flooded willow or alder persists for many years, offering the overhead and lateral cover needed by duck broods. Controlling beaver populations and distribution through trapping, transplanting, and food manipulations can be the most cost-effective means to enhance wetlands in these habitats.

Wetland complexes are also important to migrating and wintering ducks, because they provide a range of foraging habitats and isolation for paired birds away from concentrations of unpaired individuals. Such complexes also tend to have more numerous "microhabitats," which help increase the likelihood of meeting the habitat needs of many species.

6.3 IMPROVING DISPERSION OF WETLAND VEGETATION

High quality wetland habitat for dabbling duck species contains islands, peninsulas, and irregular shorelines of emergent aquatic vegetation (Fig. 16). Waterfowl use and invertebrate biomass peaks when this interspersion occurs in a 50:50 ratio of vegetation to open water (Fig. 17). Several techniques are available to change large, monotypic stands of emergents into desired patterns. Most of the persistent, emergent species such as cattail and bulrush cannot grow in water over 30 inches deep. Thus, one method of breaking up a monotypic stand is to dredge or otherwise remove bottom substrate to this depth. An alternative technique is to cut or cultivate vegetation and reflood treated areas to a depth of at least 3 inches above remaining stems, thereby eliminating the oxygen supply to rhizomes. Winter cutting, followed by flooding during the spring and summer, is most effective. Cut portions of plants should be removed or burned if possible, to prevent an overload of detritus that will deplete oxygen in the water and result in algal blooms. Wetlands should be quickly flooded after treatment, or cattail seedlings may germinate on moist mud flats. De-watering a wetland for 2 consecutive growing seasons will also kill cattail, but the soil must be completely deprived of moisture for this treatment to be effective.

Some herbicides, particularly the glyphosate herbicide Rodeo , have shown much promise for eliminating emergents such as cattail while leaving aquatic invertebrates unharmed. As with most herbicide treatments, the timing and method of application are important considerations. Like other perennials, cattail stores energy in the form of carbohydrates, which are used during the early period of spring growth when energy demands outstrip photosynthetic production. The key to effective

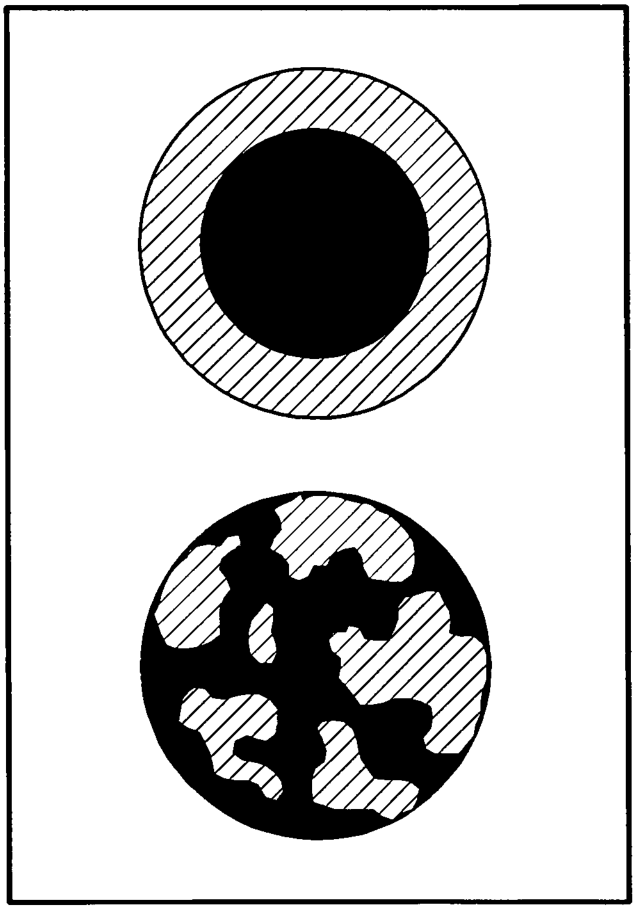

Fig. 16. A 50:50 ratio of open water (solid) to vegetative cover (hatched) can be achieved in several ways, some more desirable than others. The upper configuration, typical of a wetland basin surrounded by cattail or other emergents, will have a far lower carrying capacity for breeding pairs than the bottom configuration, which provides bays and islands of vegetation that allow territorial pairs to isolate themselves from conspecifics.

cattail control is to apply sprays or other control treatments at a time when carbohydrate reserves are at their lowest level and photosynthetic energy production has not yet peaked. Although this normally occurs in mid-June on the eastern plains, the low point in carbohydrate reserves occurs abruptly, and managers should use phenological indicators to determine the exact time to spray. This critical point can best be determined from examining the floral heads; apply spray when the pistillate (lower portion) of the spike is lime green in color *and* the staminate (upper portion) spike is dark green and has a pebbled appearance. Crisscross spray patterns attract higher densities of breeding ducks than single-strip patterns. The number of years cattail are controlled after being sprayed depends upon the amount of water in a wetland. If the wetland dries 1-2 years after being sprayed, cattail seeds germinate on mudflats and quickly reinvade. However, in wetlands that are continuously flooded, control for 3 years or longer can be expected. Cost of herbicide plus aerial application ranges from $75 to $100 per acre.

Grazing can be an effective method to create greater interspersion of aquatic vegetation, but cattle must be carefully monitored so that destruction is contained. Shoreline erosion and water quality degradation, along with reduced water quality, are negative effects of grazing. Bird nests in and near wetlands may also be destroyed.

6.4 CHANGING AQUATIC VEGETATION SPECIES COMPOSITION

Natural wetlands undergo a predictable pattern of plant succession. Without disturbance to the system, wetlands become dominated by a few emergent and submergent species, nutrients become chemically bound, and productivity declines. Drawdowns give the seeds of valuable wetland food plants a chance to reestablish themselves, since most require exposed mudflats to germinate. In general, drawdowns promote the growth of seed producing annual plants in and around shallow regions of a wetland. Care must be taken that undesirable species such as cattail do not germinate during the period when mudflats are exposed. Drawdowns during May and early June, followed by reflooding the next spring, are the most common practice.

Fig. 17. This excellent interspersion of aquatic vegetation provides optimum conditions for duck breeding pairs.

Another consideration in changing plant species composition is the nature of the seed bank in wetland soils. Many aquatic plant seeds remain viable for years or decades, so introduction of new seed into wetland basins is rarely necessary. Ducks and geese may also introduce aquatic plants by transporting seeds and vegetation on their feet or in plumage. Some seeds with hard coatings, such as pondweeds and burreed, may remain viable after passing through the digestive tract of waterfowl. In general, it is more beneficial to work with resident plant species and the natural wetland system than to attempt to establish non-native plants. However, wetlands developed from upland sites may be deficient in aquatic plant seeds, and introductions may be necessary for timely development of vegetation. Depending upon soil and water chemistry, seeds or tubers provided from commercial sources may be used to establish or introduce desirable species. Selection of appropriate plant species should be guided by several considerations, including waterfowl food and cover requirements and limitations imposed by water chemistry, soils, or growing season (Table 3). Managers are cautioned to consider these variables prior to contemplating plant introductions.

Moist-soil management, which relies on the timing and duration of drawdown during the growing season to promote the germination of selected plant species, is another technique finding increasing favor among wetland managers. This technique is discussed in 6.13.

6.5 CONSTRUCTING NESTING ISLANDS

Ducks often home to nesting areas used successfully in previous years. Because of the predator protection afforded by islands, it is not surprising that extremely high nesting densities have been recorded on natural islands in the Great Plains. Managers have attempted to duplicate this phenomenon by constructing nesting islands. Although the costs of construction are high, and man-made islands are often much smaller than natural islands, nesting densities and success on man-made islands are often higher than on surrounding, upland sites.

Islands can be created in two ways: by cutting a peninsula off from the mainland (Fig. 18), or by mounting soil in a site normally underwater (but see 9.0). Cutting a channel to isolate a peninsula from the mainland is advantageous because it (1) may eliminate the need to establish nesting cover, since grasses and shrubs are usually present on the peninsula, (2) often creates a larger island than that formed by new construction, and (3) is less expensive because earthmoving costs are comparatively low. Disadvantages are that (1) the island may not be situated in an area that is assured of water during the nesting season, (2) it is often not possible to space islands at desired intervals, and (3) the cut channel may not prevent predators from swimming to the island.

The best time to create islands is when new wetlands are being constructed. If the wetland site has undulating terrain, design the dam or levee so that the highest topography in the wetland site will remain above the high water line. Alternatively, consider raising the height of an existing dam so that peninsulas become islands. As a last alternative, fill can be added to existing wetlands to create nesting islands, but the necessary permits must be obtained before starting such work (see 8.2). New islands created by fill have complimentary advantages and disadvantages to those listed for cutoff peninsulas.

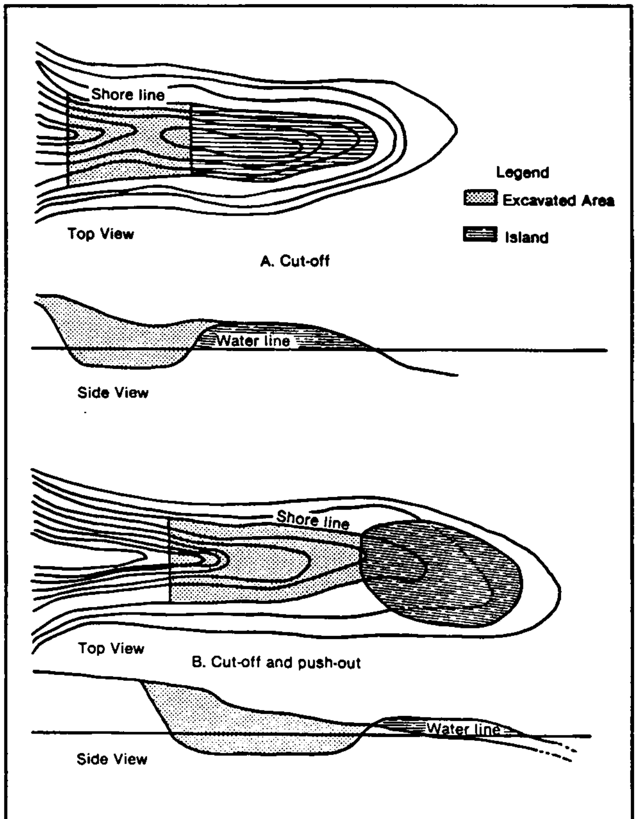

Fig. 18. Islands can be created from peninsulas by simply removing soil to isolate the region of the peninsula with high elevation (top), or by cutting off the peninsula and using some of the excavated material to add elevation to the portion of the island lacking adequate relief (bottom). (Reprinted with permission of Terry Messmer, North Dakota State University Extension Service)

Whenever possible, construct islands according to the following guidelines. Build islands about 0.1 acre in size in a rectangular shape measuring about 30 feet wide and 75 feet long. Side slopes should be 5:1, with a berm width of 15 feet. Construct islands in wetlands at least 25 acres in size, with a maximum density of 1 island per acre. Place islands at least 300 feet from the mainland and 200 feet apart. Although islands are best situated in wetlands 1-3 feet deep, they should be surrounded by a moat of water that remains over 3 feet deep during the nesting season. Seed newly constructed islands with suitable nesting cover (6.6), and if possible locate islands in areas surrounded by moderately dense vegetation to minimize wind erosion. If islands are constructed in winter, make sure that fill material is free of ice, and that ice on or over the foundation has been removed.

Table 3. Desirable aquatic plants for waterfowl in Colorado.

Species	Application	Special Considerations
SUBMERGENTS		
Sago pondweed	Seeds, tubers, invertebrate cover	Clear, fresh-slightly alkaline water, 1.5-8 ft deep
Fineleaf pondweed	Seeds, tubers, invertebrate cover	Mountain Parks -- see above for water conditions
Duckweed spp.	Food plant	Floating -- grows under most water conditions and depths
Common elodea	Seeds, food plant	Clear, fresh-slightly acidic water, 1-10 ft deep. Prefers mud/ sandy loam substrate
American wild celery	Food plant, tubers, seeds, invertebrate cover	Fresh-slightly brackish water, 1.5-10 ft deep. Some current preferred.
Spiked watermilfoil	Nutlets, invertebrate cover	Fresh-slightly alkaline water, 3-12 ft deep.
Coontail	Food plant, invertebrate cover	Floating -- Grows under most water conditions, 2-5 ft deep
Common widgeongrass	Seeds, invertebrate cover	Fresh-alkaline water, 1-8 ft. deep
Common arrowhead	Tubers	Freshwater up to 1.5 ft deep
EMERGENTS		
Hardstem bulrush	Protective cover	Fresh, acidic, or slightly brackish water, 0.5-3 ft deep
Burreed spp.	Protective cover, seeds	Freshwater up to 1.5 ft deep
Watercress	Food plant, invertebrate cover	Spring fed streams, warm-water sloughs
MOIST SOIL		
Smartweed spp.	Seeds, protective cover	Mudflats and fresh-slightly alkaline water, < 0.5 ft deep
Japanese millet	Seeds	Moist soil, mudflats. Tolerates moderately alkaline soil

6.6 MANAGING UPLAND NESTING COVER

Large blocks of nesting cover are needed by dabbling ducks during spring and early summer. The area of nesting cover should be 3 times the surface area of wetlands, and preferably in unbroken blocks of 20 acres or more. Nesting cover should be located adjacent to water or within a 1 mile radius of a wetland complex (6.2), and must contain vegetation that will stand up to winter snows and therefore retains enough structure to hide nesting ducks in early spring. During mid-April, potential nesting cover should be tall and dense enough that it is 100% effective at screening to a height of at least 8 inches when viewed from a distance of 13 feet and a sighting height of 3.2 feet.

In most cases, the nesting cover used by ducks will be residual plant material from the previous growing season, not new vegetative growth. Thus, it is important to have vegetation that stands up well against wind and snow. To provide habitat on eastern plains or west-slope sites lacking adequate nesting cover, grasses or legumes are well-suited for planting because they create multi-layered, dense nesting vegetation. Proper attention must be given to site selection, site preparation, and seeding technique (see Duebbert et al. 1981, Cunningham 1991). Species such as orchardgrass, western wheatgrass, alfalfa, and sweetclover possess the most desirable structural characteristics. Tall wheatgrass is a coarse bunchgrass that is recommended for areas with annual precipitation as low as 8 inches. It is especially adapted to poorly drained soils. Western wheatgrass is a vigorous rhizomatus species that is adaptable to many sites and soils where annual precipitation averages 8-20 inches. Varieties of alfalfa that have desirable vegetative qualities include Ranger, Ladak, and Grimm.

In mountain park habitats, most duck nesting occurs in wet meadow vegetation dominated by baltic rush, with scattered cattail and other emergents. Upland nests are often situated under black greasewood or sagebrush. Growing season and/or precipitation often limit introductions of the cool season species described above, and management options are reduced to altering existing plant communities to produce vigorous stands suitable for nesting ducks.

Regardless of the location, nesting cover will need to be periodically rejuvenated to maintain optimum vigor. Burning eliminates duff, releases nutrients, and improves vegetation density (Fig. 19). Preceding burning with short-duration grazing may enhance these benefits. Cool season grasses are best rejuvenated with mechanical treatments in either early spring or late summer. The soil and plant roots should be disturbed to a depth of 4-6 inches by spiking, chiseling, or shallow plowing followed by light discing or harrowing. Frequency of rejuvenation depends upon the site, soil fertility, moisture, plant species, and other factors, but should generally occur every 5-10 years.

Fig. 19. Controlled burning can be used to improve the interspersion of aquatic plants and upland nesting cover. A cool burn interspersed with patches of unburned areas is preferable to a hot burn that eliminates all vegetation.

6.7 PREDATOR MANAGEMENT

Excessive predation rates are usually a symptom of imbalances in the ecosystem, therefore the ultimate solution to predator problems often lies in modifying land use practices. Unfortunately, waterfowl management areas are seldom large enough to overcome imbalances in surrounding, often agricultural, habitats. This often forces managers to initiate intensive management activities on their relatively small "islands" of suitable waterfowl -- and predator -- habitat.

Common mammalian predators on duck nests are red fox, raccoon, striped skunk, coyote, mink, badger, and ground squirrels. Avian predators are raven, crow, magpie, and gulls. Techniques to reduce predation on duck nests fall into two broad categories: altering the density or behavior of predators, or reducing the vulnerability of ducks. Actions directed at the first category have the potential to benefit other avian species as well as ducks, but are difficult to accomplish and are fraught with ethical concerns and controversy. Extensive predator control is not practical on a landscape scale. Selective predator control on management areas is logistically feasible with the use of sport trapping, but has been found to be largely ineffective because fur harvest occurs in fall and winter, long before the duck nesting period. Destroying young coyotes and foxes at their den may have some short-term effects on local populations, but has serious ethical implications, particularly in areas managed for multiple use of wildlife species. Moreover, any effort to reduce predator populations by eliminating adults or young must be viewed as a long-term, ongoing operation. Dispersing predators from surrounding areas will quickly recolonize vacant habitat.

Prey vulnerability can be reduced by creating more nesting habitat or increasing vegetation density so that predators have a difficult time traveling through cover and detecting nesting ducks (6.6). Restoring native grassland vegetation may, in time, stabilize the grassland community and decrease waterfowl predation rates by increasing the abundance of alternate prey species (mice, voles, and other small mammals). Islands (6.5) and artificial nesting structures (6.8) are also effective means to separate ducks from predators.

Upland nesting sites secured by electric fences decrease nest losses in areas with scarce upland habitat and high mammalian predator densities. Contemporary designs call for placing poisoned eggs inside electrified enclosures in early spring to eliminate any predators that entered when the fence was inactivated. A 7-strand fence with poultry netting near the base is energized with solar cells that charge a wet cell battery. Such fences are relatively inexpensive; an 80-acre enclosure costs between $3,000 and $4,000 to construct. In addition to immediately enhancing nesting success, electrified enclosures may continue to attract successful hens and their offspring in the same manner as islands. Thus, nesting densities may increase markedly over time. However, recent findings indicate that many hens with broods will not pass through the fence after departing the nest. Managers are cautioned to consult the recent literature for fence designs that may reduce or eliminate this problem.

6.8 ARTIFICIAL NESTING STRUCTURES

A few duck species, particularly mallards and wood ducks, will use artificial nesting structures. Such structures not only provide nesting habitat in areas lacking adequate upland sites or natural tree cavities, but also afford security from predators. Rafts and other floating structures have been used by mallards in artificial impoundments that lack vegetation or have fluctuating water levels. However, in Colorado, such structures are quickly occupied by Canada geese, require extensive maintenance due to damage from ice, and do not provide sufficient protection from certain predators such as mink. Elevated structures are mostly immune to these problems, and are therefore preferred over floating designs. Several types of elevated structures have been developed for mallards, including round hay bales, upright concrete culverts filled with dirt, and baskets, cones, and cylinders mounted on metal poles. Each design should provide the overhead and lateral cover preferred by ducks (Figs. 20 and 21).

Hay bales and culverts are installed during winter when ice cover is thick enough to allow the use of heavy equipment. Because of the logistics of installation and the relatively short life, hay bales are generally not recommended. Concrete culverts are very attractive to nesting mallards, and usually result in much higher

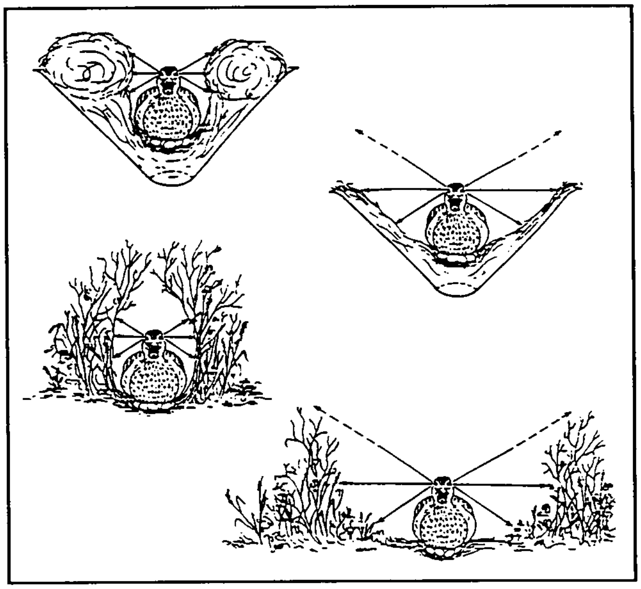

Fig. 20. Nesting baskets for ducks should provide lateral and overhead concealment (top left) that simulates cover found at desirable upland nesting sites (bottom left). If nesting material is improperly installed or allowed to settle (top right), the effect is similar to low concealment at undesirable upland sites (bottom right). (Reprinted with permission of Terry Messmer, North Dakota State University Extension Service)

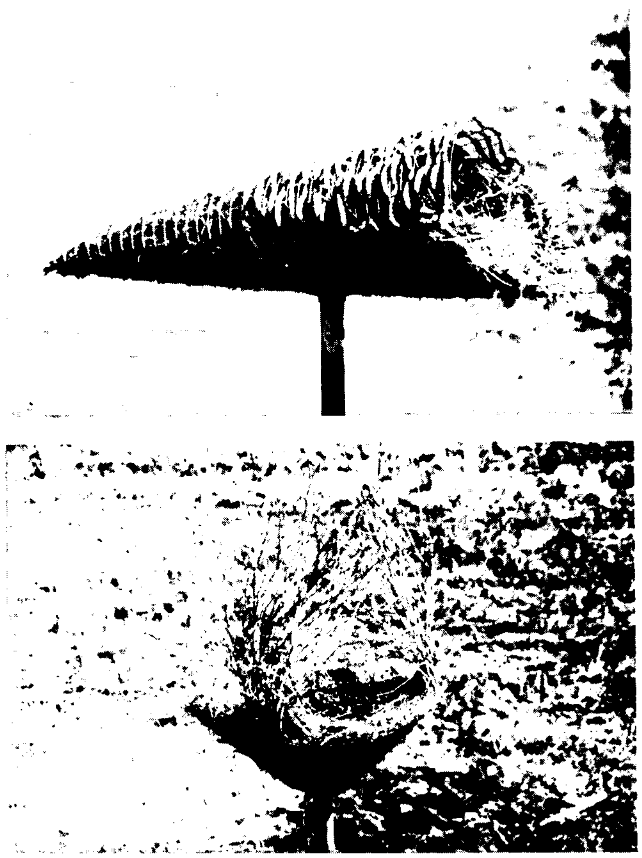

Fig. 21. Latest designs in elevated structures incorporate overhead cover by weaving rope into the top of nesting cones (top) or twigs into wire mesh of nesting baskets (bottom).

occupancy rates and nest success than either baskets or cones. Recommended culverts are 5 feet high and 36 inches in diameter. Culverts should be set upright then filled with dirt (not gravel) to within a few inches of the top. Additional dirt will probably need to be added again before the second nesting season to compensate for settling that occurs during the winter. Heavy equipment is required for transporting, setting, and filling culverts. If such equipment is unavailable, nesting baskets, cones, or cylinders are suitable alternative structures. Baskets cost less than $10.00 to construct and remain intact with minimal maintenance for about 20 years. Cone designs are preferred in areas where crows, ravens, or magpies are common.

Regardless of the design of elevated structures, they all should be placed in marshes 2-4 feet deep that will retain water during summer. Locate structures in small openings near emergents, but not in dense stands of vegetation. The top of the structure should be 3.5-5 feet above the water surface, and not less than 10 feet from shore. Structures should be stuffed with nesting material before 1 April, checked for ice damage, and repaired if necessary.

Wood ducks are common nesters in eastern Colorado, and readily accept artificial nesting structures (Fig. 22). Nesting "boxes" should be placed where wood ducks have been seen near streams and ponds that contain flooded timber or large trees near the water's edge, a mixture of herbaceous plants and open water, and abundant aquatic invertebrates. Select a pond where water remains through mid-summer. Secure boxes to trees or on poles with the opening facing the pond. Once a year during late winter boxes should be cleaned, repaired, and stuffed with 3-5 inches of nesting material such as wood shavings. Other cavity-nesting species will also use nesting boxes (Fig. 23).

6.9 MANAGING AQUATIC INVERTEBRATES

Aquatic invertebrates are vitally important food items in the diets of breeding adults and ducklings (Fig. 24). They also provide protein and supplemental vitamins and minerals to migrating and wintering ducks. Although invertebrates are present in most wetlands, it is possible to manage wetlands to change the composition or increase the biomass of invertebrate fauna for the benefit of ducks.

Like wildlife populations in terrestrial ecosystems, invertebrate communities change with wetland succession. In newly flooded wetlands or after a lengthy drawdown, the first invertebrates to become accessible to ducks are terrestrial organisms such as earthworms, which are driven out by the advancing water. In wetlands which have been drawn down, dormant stages of species such as daphnia, copepods, and mosquitos are

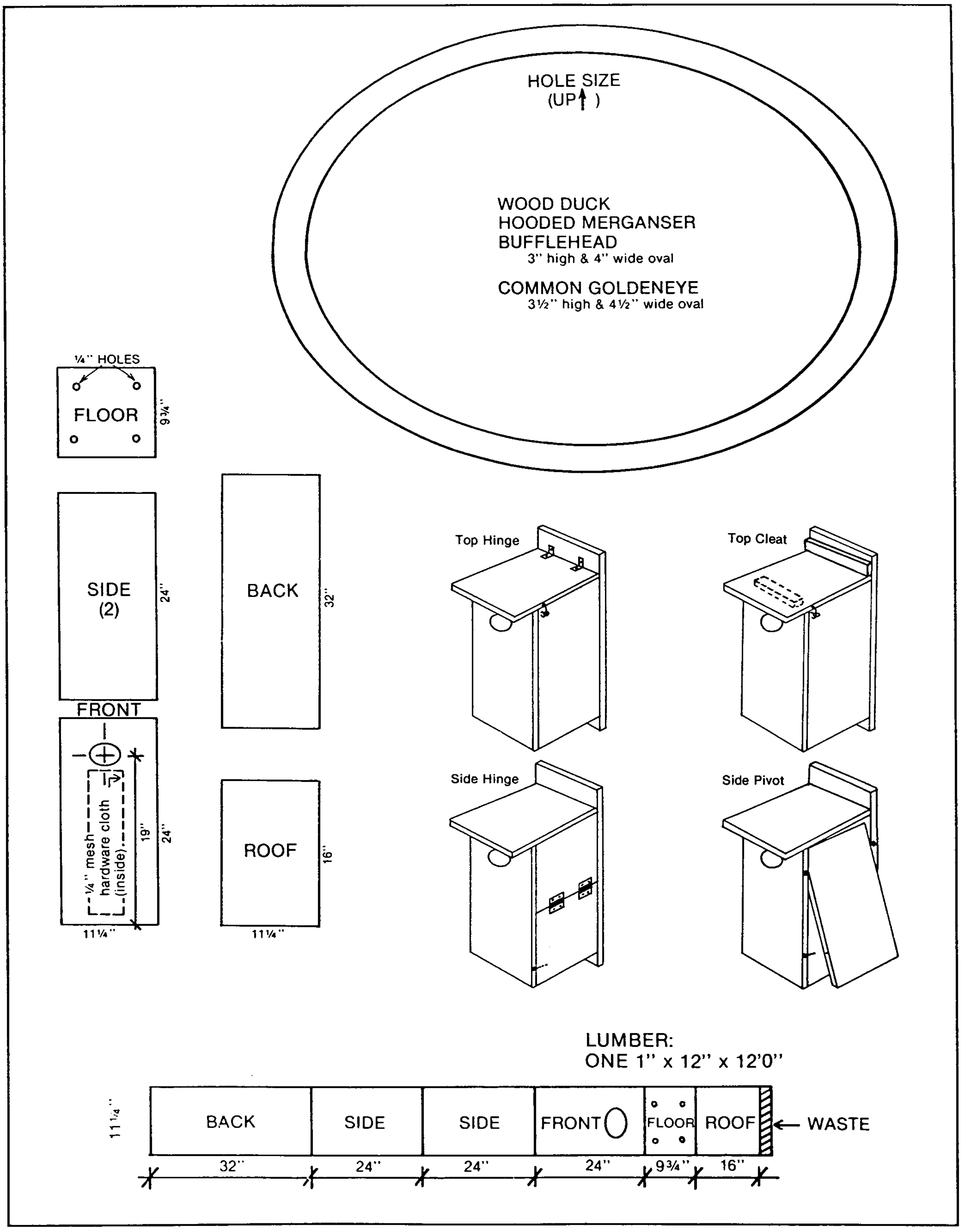

Fig. 22. Wood ducks readily accept artificial nesting structures placed in suitable breeding habitat. This common design is easily constructed, but must be maintained and stuffed with fresh nesting material annually. (Reprinted with permission of Terry Messmer, North Dakota State University Extension Service)

Fig. 23. Wood ducks are not the only cavity-nesting duck that can benefit from nesting boxes. Boxes for buffleheads (photo), goldeneyes, and mergansers can be adpated from designs developed for wood ducks. (Photo by M. A. Willms)

usually present in the sediments and will hatch on reflooding. In newly created water bodies, pioneer species such as midges and water boatmen will colonize ponds. These early successional stages are characterized by a low diversity but high biomass of invertebrates that are very desirable for breeding ducks. As the wetland progresses towards mid-succession and developing vegetation provides numerous microhabitats, invertebrate diversity increases but biomass declines. Carnivorous species become abundant, and further reduce the numbers of herbivorous invertebrates. Later stages of succession continue the progressive decline in invertebrate abundance. Late stages are often associated with a decline in wetland fertility and the presence of fishes, which consume and may completely eliminate the larger, more conspicuous invertebrate prey. Bottom-dwelling fauna become dominated by small organisms or large species of snails that are more immune to predation from other invertebrates.

Fig. 24. Aquatic invertebrates such as this amphipod provide the protein needed by ducks for egg formation and feather synthesis.

Herbivorous invertebrates feed on periphyton attached to the underwater portion of plants. Periphyton, and therefore invertebrates, are most numerous in wetlands that have abundant underwater substrates, such as plants with finely divided leaves. Management to enhance the amount and structural complexity of underwater plants will directly benefit invertebrates and the ducks that feed on them. Carp or other fish that muddy the water, reduce submergent plant growth, and feed on aquatic plants should be eliminated. Submergent plant species such as watermilfoil, coontail, or pondweed, which have complex underwater structure, should be encouraged (6.4). Lastly, periodic drawdowns (6.1) are important for releasing nutrients that provide the basis for the periphyton-invertebrate-duck food chain. Care must be taken, however, to ensure that only a few wetlands in a community are drawn down at any one time, thereby allowing birds the opportunity to exploit foods in the wetlands that remain flooded.

Some wetlands such as gravel pits, reclamation ponds, or new ponds with poor soil may benefit from invertebrate transplants to accelerate development of the wetland community. This can be accomplished by introducing aquatic plants, with invertebrates attached, gathered from nearby wetlands. If organic material is not present in a wetland, as often occurs in new ponds with sand or gravel bottoms, straw can be distributed in pockets throughout a wetland to provide a substrate for periphyton, bacteria, and invertebrates. Bales should be broken and loose "wedges" of straw thrown into water 6-18 inches deep. The straw may need to be confined with netting or wire until it sinks.

6.10 CEREAL GRAIN QUALITY AND QUANTITY

During fall and winter, dabbling ducks such as mallard, pintail, and green-winged teal depend greatly on agricultural grains for high energy food. Mallards consume about 100 grams of waste grain per day during this period, and average-sized geese need twice this amount. Most grains are consumed after crops are harvested, when waste corn and small grains become available. However, increasing harvester efficiency and a decline in irrigated agriculture in many regions of Colorado has resulted in less available waste grain. This has created a need in some areas for grain crops to be planted specifically for waterfowl. Grain food plots, together with natural seeds and invertebrates, are an important part of fall and winter duck management.

Corn, wheat, barley, rye, oats, grain sorghum, millet, soybeans, field peas, and buckwheat are used as waterfowl food crops. Growing season, precipitation, irrigation systems, soil conditions, and availability of farm implements for planting all influence the choice of crop and planting technique. Cost is also a consideration when planting food crops. Crops that can be grown without irrigation will normally be less expensive than water-demanding varieties. Some crops, such as millets, are closely related to wild plant species used by waterfowl. Millets are advantageous because they can be either drilled or broadcast, are inexpensive, grow quickly, and are less susceptible to wildlife depredations than other crops. Japanese millet tolerates shallow flooding and saturated soils, and produces high yields of seed. Other species, such as white proso millet, achieve a desirable, low growth form with little loss in seed production if grown under low moisture conditions. Carefully planned crop rotations may eliminate the need for inorganic nitrogen or insecticide applications, thereby reducing costs. One common rotation used in midwestern states is a mixture of sweet clover and oats the first year followed by corn in the second year and soybeans or other legumes in the third year. Winter wheat is planted in the autumn of the third year, with clover and oats repeated in the summer of the fourth year. Similar rotations may be adapted for use in Colorado.

The best indication of the nutritional quality of foods is given by an analysis of their chemical composition. The amount of gross energy, crude protein, fat, ash, fiber, and digestible carbohydrates (NFE) are indices to food value. However, since waterfowl use grains primarily as a high-energy food and supplement their diet with natural foods to compensate for nutritional deficiencies, the energy content of grains is the most commonly used basis for comparison. Unfortunately, energy content varies among varieties of the same grain, as well as by soil and environmental conditions. Moreover, waterfowl cannot digest all kinds of grains with the same efficiencies. In recognition of this variation in digestibility, metabolizable energy, which is indicative of the energy actually derived from a food, is a better comparative measure than gross energy content.

Agricultural foods (with the exception of soybeans) provide high levels of metabolizable energy (Table 4). Energy values, while indicative of fresh seeds, are not representative of grains under water or weathered outdoors for an extended period. Under these conditions, energy value may decline rapidly. For example, rice will lose only 19% of its energy value after 90 days of flooding, but milo and corn will lose 42 and 50%, respectively, and soybeans will lose 86% of their energy content. Such losses underscore the need for well-timed harvests and manipulations to maintain food quality. Harvesting fields at intervals will help ensure a constant supply of fresh feed. When fields are flooded, water should be released gradually so that a "flooding front" is created that progressively inundates new grain. Legumes such as soybeans should be avoided because they often contain digestive inhibitors that reduce the availability of protein and other nutrients.

Table 4. Metabolizable energy content and chemical composition of common agriculture foods planted for waterfowl.

	Metabol. energy[a]		Percent (dry weight)				
Common name	Mallard	Canada goose	Protein	Fiber	NFE	Fat	Ash
Barley	2.98[b]	3.32	14	5	–	2	2
Milo	–	3.85	12	3	80	3	2
Rice	3.34	–	9	1	–	2	1
Rye	3.14	2.74	14	4	68	2	2
Soybeans	2.65	3.20	42	6	28	19	5
Wheat	3.32[b]	3.35	26	19	34	4	17
Yellow corn	3.60	4.01	10	5	80	5	2

[a] Apparent metabolizable energy in kcal/g.

[b] Estimated as 6% less than the true metabolizable energy value.

Before grain crops are selected, managers should consider the physical characteristics of the seed head. Large seeds, such as corn, are more quickly located and consumed than smaller seeds. Seed head structure is also important; even though barley has a lower metabolizable energy, ducks select it over hard spring wheat because they are able to remove seeds more quickly from the heads. Thus, grains with large, abundant seeds that are easily removed are preferred for food plots.

Abundant grain crops are of little value if they are not available in a manner that the birds can utilize. The amount of residual food remaining after harvest is affected by harvester efficiency and operation, slope of the field, insects, disease, cultivar, and moisture content of the grain. Surface grain density is reduced by all postharvest cultivation treatments (Table 5). In some instances, postharvest treatments may be beneficial, even if grain residues are decreased, because reduction of asdkfa

Table 5. Estimated waste corn abundance resulting from autumn tillage systems. Estimates do not account for differences related to cultivar, growing conditions, harvest efficiency, grain moisture at harvest, soil type, depth of soil penetration, mowing or chopping of stalks, or the speed at which implements were driven.

	Grain abundance (lbs/acre)	
Tillage system	Middle range	Lower range
Untilled	320	76
Disk (tandem)	233	56
Chisel (straight shank)	148	35
Chisel (twisted shank)	27	5
Chisel (straight shank - disk (tandem)	22	4
Chisel (straight shank) - disk (offset)	8	1
Chisel (twisted shank) - disk (tandem)	5	<1
Chisel (twisted shank) - disk (offset)	3	0
Moldboard plow	2	0

ground litter increases the foraging efficiency of waterfowl. However, such benefits are difficult to quantify and may constitute illegal baiting (8.3); therefore the best strategy is to present unharvested or freshly harvested crops in ways that have proven attractive to waterfowl and consistent with normal agricultural practices. Such practices regulate secondary availability, or the accessibility of grain residues after harvest.

Waterfowl will use agricultural fields until available grain has been greatly reduced. Waste corn, at typical postharvest densities of 45-710 pounds per acre, has to be reduced to a density of 90 pounds per acre before any appreciable decrease in mallard feeding rate occurs. Generally, waterfowl will feed on dry fields until grain is reduced to 13 pounds per acre before switching to alternate food sites. Waterfowl using foods under water may abandon fields after densities decline to 45 pounds per acre.

Secondary availability is the availability of crop residues, largely as a function of weather and animal husbandry practices. Snowfall and cattle grazing are the most important components of secondary availability in Colorado. Mallards use standing, unharvested corn during periods of heavy snowfall. Cattle grazing in corn stubble generally enhance availability by breaking ears, scattering kernels, and exposing the soil by walking and foraging. The growth form of plants may also influence its use by waterfowl. Geese prefer to feed in short vegetation, and are reluctant to land in standing plants over 6 inches high. Generally, geese will not land in unharvested cornfields, but will walk into fields or reach for ears from atop snowdrifts. Mallards, however, will land among standing cornstalks and are not reluctant to land in and feed upon unharvested grains such as barley.

The physical layout of fields is also important. It may be advantageous to plant crops in blocks of rows running perpendicular to one another. This helps assure that the tops of some rows will be exposed by the prevailing winds during heavy snow. Managers who manipulate crops on waterfowl harvest areas should familiarize themselves with regulations pertaining to illegal baiting of waterfowl (8.3) before conducting post-harvest treatments.

6.11 SECURE RESTING AREAS

Resting areas free from predators and excessive human disturbance are a necessity for waterfowl, particularly during fall and winter. During this period, secure resting areas are equivalent to refuges, wherein waterfowl are afforded either temporal or spatial protection from disturbance. Urban habitat or areas posted as hunting closures are examples of spatial refuges that afford security from hunting. A spatial refuge is also created by the vast ice surface that surrounds ice holes in large reservoirs, since the open visibility in such a situation enables birds to detect and avoid predators, including hunters.

Sunset marks the closure of hunting and a decrease in human disturbance at wetlands. Waterfowl respond to this temporal refuge by occupying sites they normally would not use during the day. In Colorado, warm-water sloughs and toe-drains below reservoir dams are used in this manner. Many hunting clubs further regulate temporal use of wetlands through club rules that restrict shooting to particular days or hours within days. The hunting closures between season splits in eastern Colorado provide waterfowl the opportunity to use wetlands that they previously avoided because of hunting disturbance.

Fishermen, fishing primarily from boats, are in ever-increasing conflict with waterfowl on large reservoirs. Establishing a temporal refuge by restricting fishing to established seasons, or creating a spatial refuge by demarking closed fishing areas with buoys or ropes, may be necessary to provide adequate secure resting sites. Hunting management (6.12), which is closely tied to the establishment of secure resting areas, is critically important to the well-being of local waterfowl populations and the success of hunters.

6.12 HUNTING MANAGEMENT

A conflict often exists between the biological needs of migrating and wintering waterfowl and the practices of the hunting public. Sportsmen select wetlands to hunt based primarily on their use by waterfowl. These same wetlands, typically small marshes and warm-water sloughs, often provide ducks with aquatic invertebrates and natural seeds necessary for a balanced diet, sheltered or warmwater areas that reduce energy use during cold periods, and habitats where pairs can isolate themselves from unpaired birds. The effects of excluding ducks from such wetlands are unknown, because we do not yet know the amount of time they require in such areas to maintain body condition and vigor. Thus, a conservative approach of providing a secure resting area (6.11) and managing existing wetlands to enhance their attractiveness to ducks is recommended.

Shallow wetlands less than 18 inches deep provide the proper depth for foraging ducks and allow duck hunters to easily retrieve downed ducks and set up decoys. Blind placement is largely a matter of personal preference, but for safety reasons adjacent blinds should not be spaced nearer than 200 yards. Birds are most easily identified on the wing under low light conditions if blinds are placed so that the sun shines from behind. Hemi-marsh vegetation (5.2) is most attractive to ducks, as is a 50:50 ratio of open water to emergent vegetation (6.3). Submergent plant species that provide seeds or tubers should be encouraged (6.4). Cattail or other high emergents provide concealment for hunters and can be managed in areas designated for blinds (6.4). Techniques to provide natural foods (6.13) or open water areas during freezing weather (6.14) will attract ducks and extend the time during which birds are available for harvest.

Although nontoxic steel shot will be required for all waterfowl hunting beginning in 1991, spent lead shot may remain in wetland or upland soils for decades. In heavily hunted areas, managers should be alert for waterfowl suspected of becoming ill or dying from lead poisoning. It may be necessary to take remedial action such as cultivating or otherwise disturbing the bottom substrate or soil in a manner that makes shot unavailable to foraging birds.

6.13 NATURAL FOOD PRODUCTION

Invertebrates, seeds, and green vegetation from natural plants are generally lower in energy than grains (Table 6), but offer a better nutritional balance than agricultural foods. Plant foods are an important part of a duck's diet during late summer, fall, and winter. Although many valuable species are found in the wild, proper wetland management can greatly increase their abundance and availability.

Table 6. Metabolizable energy of some common waterfowl foods.

Taxon	Test animal	Metabol. energy (kcal/g)
Water flea	Blue-winged teal	0.82
Amphipod (*Gammarus* spp.)	Blue-winged teal	2.32
Pond snail	Blue-winged teal	0.59
Japanese millet	Duck (male)	2.63
Japanese millet	Duck (female)	2.99
Rice cutgrass	Duck (male)	3.00
Duckweed	Blue-winged teal	1.07
Smartweed	Dabbling duck (male)	1.12
Smartweed	Dabbling duck (female)	1.10

Optimum water level regimes are those that promote the growth of important food plants in wetlands and retain sufficient water to meet the habitat requirements of waterfowl. In Colorado, an ideal water regime to promote natural food production is high water levels through April, followed by an abrupt lowering of water in May and early June to promote the germination of moist-soil plants, then gradual reflooding from late summer until freeze-up. Unfortunately, the fluctuating water regimes of most eastern plains reservoirs often run counter to this optimum scenario; managers begin filling reservoirs in September-November and continue to store water until freeze-up. During winter, pool levels are held constant. With little additional inflow during March-May, pool levels remain fairly constant until the call for irrigation water in June-August, when water levels sharply decline. Even when water regimes are timed correctly, the magnitude of changes often leaves newly germinated seedlings desiccated, or high water in autumn drowns out valuable emergent vegetation. Additionally, reservoirs often suffer from high water turbidity and bank erosion, which further reduce natural foods.

Shallow subimpoundments, separate from the main lake, have proven useful for developing and maintaining natural waterfowl foods by minimizing the effects of water level fluctuations. Fencing shorelines, seeding disturbed areas with grasses, and planting windbreaks are actions that help reduce turbidity problems in reservoirs. However, the potential for managing natural foods associated with reservoirs will always be low, because waterfowl management will invariably be a secondary consideration on reservoirs constructed and managed for domestic or irrigation water. Much greater potential exists when artificial impoundments are constructed for the purpose of growing natural waterfowl foods.

One of the most efficient ways to produce natural foods is the collection of practices known as moist-soil management--the propagation of annual plants that grow on exposed mud flats (Fig. 25). Production of moist-soil plants is related to the timing of water removal in the spring, with different plant communities resulting from different drawdown dates. Although prescriptions and plant responses unique to Colorado have yet to be developed, May and June drawdowns are usually most beneficial. Moist-soil techniques allow management schemes targeted at important duck species by manipulating food availability to coincide with migration and breeding phenology, and by providing preferred vegetative foods. Initial development of moist-soil impoundments is expensive, because heavy equipment is required for dike construction and water control structures are needed. However, once constructed, moist-soil impoundments are often less expensive to manage than traditional agricultural crops. A reliable source of water, flat topography, precise control of water levels, and the ability to completely drawdown and reflood an impoundment are all vital characteristics of moist-soil wetlands.

Fig. 25. Mudflats maintained in a wet condition during the growing season promote the germination and growth of moist-soil plants (top), which provide seeds for migrating and wintering waterfowl when flooded to a depth of less than 18 inches (bottom).

6.14 MAINTAINING OPEN WATER DURING WINTER

Waterfowl respond to a hierarchy of habitat needs, the most important of which is water. Creating areas of open water in wetlands that normally freeze completely, or increasing the size of open water areas, can dramatically increase waterfowl use (Fig. 26). Aerators have been used to maintain open water in Colorado reservoirs. Two or more submerged hoses, with air holes spaced at intervals along their length, have maintained open water even under subzero conditions. Wind-driven water circulators that move relatively warm water to the surface are also effective in deep wetlands. During extreme cold, obstructions that slow the flow of water in warmwater sloughs may cause portions of these wetlands to freeze. It may therefore be necessary to periodically remove fallen trees and other debris blocking the waterway. Beaver dams are a common problem, and control of beaver is an important practice on these areas. A good procedure is to trap beaver and remove their dams beginning at the spring source and continuing downstream until all beavers are eliminated or until the point is reached where even unobstructed flow would cool to the point of freezing. Cattail control (6.4) may also be necessary to keep water flowing adequately.

Fig. 26. Open water areas, such as this artesian well site in the San Luis Valley, provide essential winter habitat for waterfowl.

7. MANAGEMENT PRESCRIPTIONS FOR GEESE

7.1 ESTABLISHING BREEDING POPULATIONS

Unlike 35 years ago, when the only breeding populations of Canada geese were along the river systems of northwestern Colorado, most suitable breeding habitats are now occupied by geese. This widespread distribution is the result of programs to establish breeding goose populations. Such successes have helped fine-tune procedures for new introductions.

Because Canada geese are widespread throughout Colorado, establishing a local breeding population is often a matter of providing suitable nesting and brood-rearing habitat. Suitable vegetation structure (7.2) and wetland communities (6.2) are important for initially attracting geese. Once on an area, birds will search for secure nesting sites. If natural sites are lacking, development of islands (6.5) or artificial structures (7.3) may help overcome this shortcoming. Suitable brood-rearing areas, with ample green forage (7.5), open water (6.3), and security from predators, are essential.

In the event that geese do not colonize a potential breeding area, or if managers want to establish a breeding population quickly, techniques have been developed to establish free-flying flocks. With the large populations of Canada geese throughout the state, the first requirement of establishing a free-flying flock--a source of new birds--is easily met by transporting goslings from areas with a surplus of geese. Although either 2-year-old or yearling birds can be used, goslings are the most economical age class to release if hunting mortality is controlled. The transplant method of establishing geese, wherein flightless adults and goslings are captured and transported to a release site, is the most effective at establishing populations. The ratio of adults to young should be 1:4 or 1:5. After release, adults will migrate to traditional fall staging areas with the young, thus establishing the migratory tradition. In the spring, adults return to the area of capture to nest again, but yearling birds will return to their transplant site, where they initially learned to fly. Since the transplanted young will not breed until they are at least 2 years old, the transplant program should be continued for 2 or 3 successive years until the new flock is well established. Hunting should be prohibited or tightly controlled during and after transplant operations, usually for a period of 5 years or more.

Potential transplant sites should be carefully evaluated. Sites with nearby small grain crops or alfalfa will be attractive to geese, but crops are likely to suffer damage from foraging birds. Transplant areas should also be located away from roads, or flightless geese are likely to wander into the path of vehicles. Wetlands fed by runoff from feedlots or sewage lagoons create the potential for disease, and should be avoided. However, saline ponds are suitable habitat for geese, perhaps because the high salinities reduce or eliminate emergent vegetation, creating the open vistas preferred by geese. Water levels should be stable enough that spring floods are uncommon, yet ample brood-rearing water remains during summer. Lastly, because Canada geese have become a nuisance species in some parts of Colorado, transplant efforts should be carefully considered and approved by the Colorado Division of Wildlife prior to moving geese.

7.2 IMPROVING VEGETATION DISPERSION

Although the techniques for manipulating wetland vegetation for geese are the same as for ducks (6.3, 6.4), the goals of vegetation manipulations for geese are very different. Unlike ducks, geese prefer wetlands with large expanses of open water and good visibility surrounding nest sites and brood-rearing areas. These preferences are largely responsible for the success of Canada geese on the large irrigation reservoirs of the eastern plains. Islands isolated from predators and human disturbance are preferred nesting sites. However, the same open visibility that attracts geese and helps them defend against predators also leads to territorial strife when local populations expand. Topographic relief such as hills and depressions, or tall emergent or shrub vegetation, can effectively increase carrying capacities of breeding geese by visually isolating pairs. These barriers should be located away from nest sites so that the feeling of openness adjacent to nests is preserved.

7.3 ARTIFICIAL NESTING STRUCTURES AND ISLANDS

Artificial nesting structures (Fig. 27) are the hallmark of Canada goose restoration projects in Colorado, and for good reason. Geese readily adapt to structures, with resulting increases in nesting densities and success. Structure designs have changed over time, but primary considerations have been attractiveness to geese, cost of installation and construction, and maintenance needs. The four-post structures used in early restoration efforts have given way to elevated structures set on posts. A single-pole structure with a snow fence box is now the standard design. The spacing of the snow fence lath allows goslings to escape the structure after hatching. Other, preformed fiberglass baskets can now be purchased from commercial sources. These types of structures require stuffing on an annual basis. Wood shavings are preferred, but flax straw or prairie

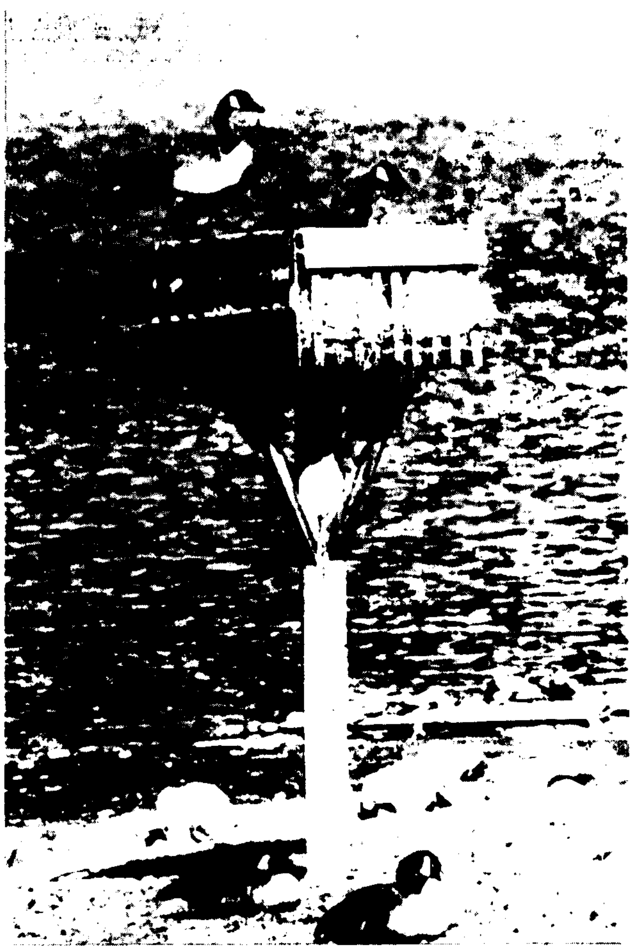

Fig. 27. Canada geese use several types of elevated nesting structures. This design, which uses snow fence to contain the nest and nesting material, provides better ventilation than tubs or other designs with solid sides.

hay is satisfactory. Alternatively, large, round bales made of flax straw, native grasses, or slough hay may be placed on the ice of frozen wetlands; these will later break through the ice during spring thaw. At least half of the bale should extend above the water after immersion. In areas with soft bottoms or deep water, bales are prone to tipping over, and may have to be set in place through holes in the ice.

Regardless of the design, elevated structures must be properly positioned. If possible, erect structures directly over or within a few yards of ground nests, but several hundred yards away from each other. As the breeding population builds, additional structures can be added, but should never be located closer than 120 yards apart. Because single-pole structures are susceptible to damage from ice action, they should be erected near the shore of wetlands but set back from the winter high-water line.

Floating structures are an alternative to elevated designs, but require greater maintenance, removal in the fall, and reinstallation in spring to prevent damage from ice and water. They must be stuffed with the same materials described for elevated structures, and weighted with at least a 100-pound anchor with an equalizer to prevent drifting in the wind.

Lastly, geese respond well to artificial nesting islands. Although many of the island construction techniques and placement considerations are the same as those described for ducks (6.5), the criteria for an attractive nesting island for geese differ from those described for ducks. Geese do not require heavy vegetative cover on islands, but instead prefer islands with sparse vegetation that afford open visibility. Small islands, down to the size of muskrat hummocks, are most suitable for geese. Geese can often be induced to nest by placing logs or similar structures on newly constructed islands devoid of vegetation.

7.4 PREVENTING DAMAGE FROM BREEDING GEESE

Goslings and flightless adults can become a nuisance during the breeding season, particularly in urban areas, where they defecate on lawns and walkways and feed on ornamental plants. Reducing their impacts is often a matter of simple landscape modifications. Large lawns extending to the waters edge are an enticement for geese. A barrier between the water and geese will often discourage geese at this time of year. Natural barriers such as shrubs not only produce an aesthetic barrier, but also can be used to break up the large expanses of bluegrass lawn that geese find attractive. Artificial barriers, such as low fences, large rocks, or steep banks will also discourage geese. In areas with recurring problems, nesting structures should be eliminated to reduce breeding densities. People should be discouraged from feeding geese. As a last resort, eggs can be rendered infertile or adults and goslings can be removed by trapping. These latter actions require appropriate state and federal permits, and are only a stopgap measure, since they do nothing to prevent similar problems in subsequent years.

7.5 MANAGING GREEN FORAGE

Use of green forage varies seasonally, but in general relates to the availability of green vegetation near breeding or roosting wetlands. More important than the type of forage consumed is the quality of the plant selected. Canada geese selectively feed on the new shoots or tips of old leaves, which have higher protein and digestible cell content than the rest of the plant (Fig. 28). Fertilized grasses, such as bluegrass lawns, also have higher concentrations of these materials.

In early spring, green shoots of grasses such as smooth brome appear in sunny exposures, and are fed

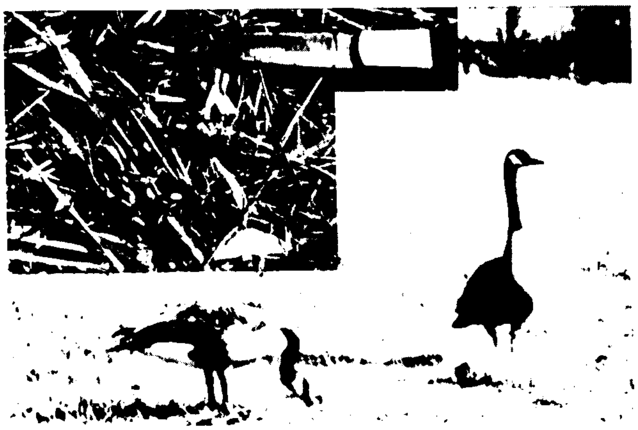

Fig. 28. Canada goose pairs begin feeding on green shoots as soon as they become available in early spring. Most birds selectively feed on new shoots and tips of older leaves (inset), which have a higher protein content than older plant parts.

upon by geese. Generally, such feeding sites are abundant, and no management to provide additional areas is indicated. Limitations in green forage may occur during the brood-rearing period, which coincides with the flightless period for adults. During this time, geese are entirely dependent upon forage available within walking distance of their wetland. Many reservoirs with fluctuating water levels are drawn-down at this time of year, causing the loss of peripheral, shoreline vegetation which would otherwise be green and available to geese. In such instances, food plots of green, drought-resistant forage may be needed to maximize survival of goslings, who are out-competed by adults when food is limiting. In extremely dry areas, forage plots may need to be irrigated to maintain vigor and withstand heavy grazing. Alfalfa is a highly desirable green forage for molting geese and goslings, and should be considered the most desirable forage plot species if growing conditions are acceptable. In fall and winter, green forage will consist of wild grasses, alfalfa, Kentucky bluegrass, and winter wheat. These forages are normally abundant at these times, and special management is usually not indicated.

7.6 HUNTING MANAGEMENT

Although geese are traditionally hunted in grain fields and other upland sites, management of their roosting wetlands plays an important role in hunting management. Canada geese require a secure place to rest, but will tolerate more human disturbance than other waterfowl species. Areas closed to hunting should be a minimum of 640 acres in size and encompass a roost site and adjacent agricultural lands. Such closures effectively hold goose populations in a region, and enable managers to entice geese away from urban areas where they become unavailable for harvest and most often cause problems. A disadvantage is that closures create a "firing line", where hunters may congregate to "pass shoot" at flying birds. Such hunting tends to promote long distance shots that wound and cripple birds. Using roads as closure boundaries helps reduce the firing line effect, since hunting regulations prevent discharging a firearm next to a road. In heavily-hunted areas, managers should also be sensitive to the possibility that geese may be ingesting spent lead shot, and take appropriate action (6.12) if indicated.

Blinds placed at intervals in agricultural fields near area closures are a popular and effective way to harvest geese. Considerations for cereal grain management and manipulations of grain availability (6.10) described for ducks apply to geese as well, as do regulations pertaining to baiting (8.3). Spatial and temporal refuge areas (6.11) are important for geese. Generally, hunters realize an increased harvest of geese if such refuges are provided for geese as part of an overall land management scheme.

7.7 MANAGING NUISANCE GEESE DURING FALL AND WINTER

Colorado's location in the migratory path of at least three distinct Canada goose populations, coupled with resident flocks and abundant food and water that attract and hold geese, have created nuisance and damage problems in many areas of the state. In urban areas, geese damage turf, cause over-fertilization of ponds, and drop feces in parks, beaches, playing fields and residential yards (Fig. 29). Several control measures have been applied, but all have met with little or qualified success. Proper hunting management (7.6), which encourages geese to remain outside of urban areas, is among the most effective techniques. Once inside urban areas, geese can be discouraged by reducing the number of secure feeding areas and eliminating open water for roosting. During subfreezing temperatures, hazing geese off of roosting wetlands prior to nightfall may cause ice holes to freeze over, thereby reducing goose use of the wetland. Dogs, pyrotechnics, and human disturbance have proven somewhat successful in hazing geese from small areas. However, hazed geese simply move a short distance, where they become someone else's problem. Minimizing or eliminating large, attractive foraging sites such as bluegrass lawns is effective, but not feasible on a large scale. As in summer, people should be discouraged from feeding geese.

One effective control method is the chemical methiocarb, sold under the trade name Mesurol, which can be used to condition geese not to feed in a particular locality. Methiocarb makes geese ill, but is not highly toxic and is not stored in their tissues, thus assur-

Fig. 29. Bank erosion and fecal droppings are problems common to city parks and other urban sites where Canada geese concentrate.

assuring that they remain safe for human consumption. After becoming ill, they develop an aversive conditioning which causes them to avoid a particular foraging area. A single application in small areas has been found effective at repelling geese for 2 weeks, even if turf is mowed and watered. When entire feeding areas are sprayed, control is effective for up to 8 weeks. At an application rate of 2.7 pounds per acre, methiocarb costs about $350.00 to treat 1 acre of turf. Unfortunately, methiocarb has not yet been cleared by the EPA for use on grass as a goose repellant at the time of this writing. Managers desiring more information on this repellent should consult the EPA.

7.8 WETLANDS THAT DISCOURAGE GEESE BUT ENCOURAGE DUCKS

Geese are probably the most important watchable wildlife species in Colorado, but despite their popularity, many municipalities along the Front Range are trying to stabilize or reduce the number of geese in their jurisdictions. Concurrently, interest in watchable wildlife programs is building, with much emphasis on wetlands wildlife, particularly ducks. Because the habitat preferences of ducks and geese differ, it is possible to develop wetlands that discourage use by geese but are attractive to many duck species.

Several actions will discourage nesting geese. Managers should modify secure nest sites that are surrounded by water, such as islands or other high locations. Unlike ducks, geese prefer unrestricted visibility from their nest site. Because geese are highly territorial, the size of their territory may enlarge with increasing visibility distances, thereby decreasing breeding densities. Therefore, creating level terrain around the water area will discourage some nesters (Fig. 30).

Reducing or destroying grazing areas near wetlands, particularly bluegrass lawns, limits the amount of brood-rearing habitat. Allow native vegetation to remain and restore vegetation around the pond margin. Artificial barriers such as rocks or fences will discourage geese from walking onto land to graze. Similarly, emergent vegetation such as cattail or bulrush should be encouraged along the margin of ponds. Constructed wetlands should be kept small, with several small ponds considered preferable to a single, large one. Lastly, swans are known to defend their breeding territories from geese, and may be introduced to wetlands with chronic goose problems.

Fig. 30. This small island located in a water trap at a golf course provides ideal breeding habitat for Canada geese because of its open exposure and lack of vegetation. Unfortunately, such desirable breeding habitats in urban areas often lead to local nuisance goose problems.

Ducks such as mallards are attracted to small wetlands less than 18 inches deep. They also prefer a good interspersion of emergent vegetation (6.3) and submergent plants, which harbor aquatic invertebrates (6.9). Dense upland vegetation, both grasses and shrubs, will provide nesting habitats used by dabbling ducks (6.6). If suitable land areas are unavailable, artificial nesting structures for ducks (6.8), which are too small for geese, may be attractive to mallards. Such structures have the advantage of providing nest sites secure from the many duck nest predators found in cities.

8. LEGAL CONSIDERATIONS

8.1 COLORADO WATER LAWS

Water rights often create problems when developing waterfowl habitat in Colorado. However, the problems are not insurmountable if managers understand the practical application of Colorado water laws. With this understanding, the waterfowl manager can begin assessing water-right issues early in the project development phase and thereby avoid delays in the implementation of habitat development plans. This section is intended to provide a general overview of Colorado water laws, particularly as they pertain to waterfowl habitat development. It is not intended to be all-inclusive, serve as legal advice, or substitute in lieu of consultation with water law experts.

Colorado water law operates under the doctrine of prior appropriation, which is often referred to as the "first in time is first in right" system for allocating water. Simply put, the first person to appropriate water from a source and apply it to a beneficial use has the first right to use water from that source thereafter. Subsequent appropriators may take their share of water from that source only after water rights senior to them have been satisfied.

A water right is a property right that can be bought and sold. Water rights entitle the owner to use the amount of water needed to efficiently accomplish the specified beneficial use. However, it does not entitle him to the ownership of the molecules of water. Once the water has been diverted and used, the unconsumed portion must be allowed to return to the stream for use by other appropriators.

Water rights are confirmed and decreed by special district courts known as water courts. Whenever an owner or claimant of a water right wants to decree the right, he must apply to the water court. After hearing evidence, the water court establishes the relative priority of water rights, location of diversion, source of water from which the water right takes its supply, the type of beneficial use for which the water may be used, and the amount of water the right is entitled. There are 7 water courts (aligned by major river basins) in Colorado. Once decreed, absolute water rights can be lost by abandonment (nonuse and intent to relinquish the right, usually over a period of at least 10 years), or adverse possession (see references). Water right decrees are administered (enforced) by 7 Water Division Engineers and numerous Water Commissioners, who ensure that upstream junior water right owners cease use during times when water flows are insufficient to satisfy senior, downstream water rights. This is referred to as administering a "call" for water from the downstream senior user.

The appropriation of water contains two basic elements. First, the water must be diverted (except water appropriated by the Colorado Water Conservation Board for Instream Flows). Second, the water must be applied to a beneficial use, which may include use by wildlife. However, there are two limitations on the ability to appropriate water: the appropriation must be from a natural stream, and unappropriated water must be available. Natural streams include surface water and tributary groundwater.

The limitation that unappropriated water be available is where the waterfowl manager will encounter the most challenging problems, because virtually all streams in Colorado are overappropriated for at least some portion of most years. To overcome this limitation, the manager has essentially three choices. First, he can make an original appropriation of water (as described above) if it is determined that unappropriated water is available at the times and in the amounts needed (e.g., during spring runoff) for his project. Under this scenario water may not be available every year due to the unpredictability of annual runoff. Second, the manager can seek to acquire existing water rights and change the use to wildlife purposes. Third, a plan of augmentation can be developed to cover the out-of-priority consumption of water caused by the use of water for habitat development.

A change of water right is simply a change in one or more of the components of the right. It may include some or all of the following: change in type of use, location of use, point of diversion, time of diversion, or change from direct flow to storage. However, a change of water right will not be allowed or will be limited in scope if it results in injury to other water right owners. In such cases, augmentation plans may be required. Applications for changes of water rights have to be filed with the water court similar to filing for a water right. The applicant has the burden of proving the change will not injure other water right owners.

Plans of augmentation describe means to mitigate injury to water rights that may result from changes in other water rights. Typically, plans of augmentation are developed when a water right owner (usually a junior water right owner) does not want to have the use of his water right "called out" by downstream senior water rights. To avoid being called out, the junior water right owner develops a plan of augmentation to replace to the stream the amount of water which is consumed. In many instances, a plan of augmentation will be required before a decree for a new water right will be granted. It is important to recognize that the amount of water consumed is less than the total water right. The total water right equals the sum of deep percolation, return flow (to the river, etc.) evaporative loss, and transpiration loss. Only the latter two losses are considered consumptive use, which is the measure used to determine injury. Because of the complexities in measuring these components of a water right, an out-of-priority depletion is typically determined through an engineering analysis using hydrologic, climatologic, and other site-specific data.

Waterfowl managers most often encounter problems with water laws when removing aquatic vegetation to create open water, digging soil to expose ground water for a pond, or building a new impoundment that requires constructing a dam. When waterfowl managers remove cattail or other emergent vegetation from wetland basins to create open water areas, they increase evaporation because surface water is exposed. This causes an increase in consumptive water use. Countering this increase, however, is a decrease in transpiration loss because of vegetation removal. In some parts of Colorado, this transpiration loss may be significant, and may be used in an augmentation plan to "credit" against evaporative losses in such a manner that the net increase in consumptive water use is slight or even insignificant. Note, however, that eradication of plants that use water through a deep root system (phreatophytes such as cottonwoods, alfalfa, salt cedar) is specifically declared not to be a source of augmentation in Colorado. The burden of proving the amount of natural consumption rests with the person or entity claiming the credit for it.

Under Colorado water law, any excavation that exposes groundwater to the atmosphere or improves the flow of water from a natural spring is considered a well. These activities require a well permit from the State Engineer's Office. In most instances, the State Engineer will require the development of a plan of augmentation to replace surface evaporation from the exposed groundwater.

Impoundments often constitute a change in water right because, for example, of a change from direct water application to storage, a change in storage location, or using the water for a purpose other than that for which it was originally decreed. Permits may also be required for constructing a pond. In general, if the planned impoundment will have (1) a dam less than 10 feet in height, (2) a surface area less than 20 acres, and (3) a volume under 100 acre-feet, the manager must file a "Notice of Intent to Construct a Non-jurisdictional Water Impoundment Structure" with the local Water Division Engineer. Normally, projects of this size are routinely approved. Projects exceeding these limits require state office approval.

8.2 404 PERMITS

Section 404 of the Clean Water Act was enacted to achieve the laudable goal of regulating (not necessarily prohibiting) the discharge of solid materials into wetlands. In some cases, however, this law may apply to waterfowl habitat developments. This situation most commonly arises when managers wish to construct nesting islands in existing wetlands, or want to remove vegetation or soil from a wetland to increase the amount of open water. Managers that are contemplating these or other actions that deposit material in wetlands must be aware of section 404 requirements.

Two important initial considerations are the definitions of the terms "wetland" and "solid material." Wetlands are "areas that have a predominance of hydric soils and that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions." The "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" describes how to identify hydric soils, wetland hydrology, and hydrophytic vegetation. Alternatively, contact the Regional Engineer of the Army Corps of Engineers (Corps) Regulatory Branch for a site inspection. "Solid materials" include dredge material (material that is excavated or dredged from wetlands) and fill material (any material used for the primary purpose of replacing an aquatic area with dry land or of changing the bottom elevation of a waterbody. Thus, artificial islands, rip-rap, dams, dikes, and organic matter mixed with plant debris all qualify as solid material.

Carpenter (1990) provides a good layman's perspective on the process of obtaining a 404 permit for waterfowl habitat improvements. If a wetland will be affected by the proposed development, the applicant will need to produce a detailed map of the site, including a summary of wetland sizes and classifications. The map is verified in the field by Corps personnel, then practical alternatives to depositing fill are explored and plans modified accordingly. A Department of the Army Permit Application is then completed and submitted, and is reviewed by both the Corps and the Colorado Department of Health (for water quality certification). A public notice is then prepared, followed by a comment period and, if necessary, a public hearing. The permit application is then evaluated by the Corps, and an environmental assessment is made. Shortly thereafter, the permit is either issued or denied.

Many persons will find this procedure arduous and uncomfortable, but technical assistance to ease the process is available from the Army Corps of Engineers and other sources. Naturally, the easiest approach is to avoid the entire process by designing waterfowl habitat improvements that do not require a 404 permit. However, if you are firm in your belief that the most beneficial management action is one that needs a 404 permit, try not to become deterred by the red tape. Persistence and a cooperative attitude with the personnel employed by the regulatory agencies will eventually pay off.

8.3 BAITING

The federal baiting laws, found in 16 U.S. Code 703 and 50 CFR 20.21(i), state in part that no person shall take migratory game birds:

> "(i) By the aid of baiting, or on or over any baited area. As used in this paragraph, 'baiting' shall mean the placing, exposing, depositing, distributing, or scattering of shelled, shucked, or unshucked corn, wheat or other grain, salt, or other feed so as to constitute for such birds a lure, attraction or enticement to, on, or over any areas where hunters are attempting to take them; and 'baited area' means any area where shelled, shucked, or unshucked corn, wheat or other grain salt, or other feed whatsoever capable of luring, attracting, or enticing such birds is directly or indirectly placed, exposed, deposited, distributed, or scattered; and such area shall remain a baited area for 10 days following complete removal of all such corn, wheat or other grain, salt, or other feed. However, nothing in this paragraph shall prohibit:
>
> "(1) The taking of all migratory game birds, including waterfowl, on or over standing crops, flooded standing crops (including aquatics), flooded harvested croplands, grain fields properly shocked on the field where grown, or grains scattered solely as the result of normal agricultural planting or harvesting..."

The genesis of baiting laws was the market hunting period, an era when incredible numbers of waterfowl were taken by every available means. Illegal baiting continues to be a problem today, therefore federal and state law enforcement personnel aggressively investigate and prosecute baiting cases. Penalties can be harsh, with convictions punishable by a fine up to $500, 6 months in prison, or both. Because intentional baiting robs us all of our valuable waterfowl resources, such penalties are appropriate and well deserved. Colorado hunters who learn of illegal baiting situations are urged to report the violation to the Colorado Division of Wildlife at 1-800-332-4155.

However, one disadvantage to modern baiting laws is that well-meaning hunters can become "innocent" violators. Uninformed managers can become unwitting accomplices to these unintentional violations. Two provisions in the baiting laws are largely responsible for these circumstances. One is the provision that a waterfowler can be convicted of hunting over bait even if they had no knowledge of bait being placed in the vicinity and even when no bait remains on the site. Thus, a person hunting at a site baited by someone else, even when all bait had been consumed 9 days prior to the hunt, could still be convicted of illegal baiting. Ignorance is no excuse! Obviously, prudent hunters should make an effort to familiarize themselves with the recent history of their hunting grounds.

A second problem is that enforcement of baiting statutes is somewhat site-specific, in part because of the definition of "area" used in the baiting laws. One needs to consider area as the region within which bait is able to influence waterfowl behavior. Thus, baiting violations have been written for hunting on lands adjacent to but several hundred yards away from a baited field, as well as for pass shooting at birds flying to a baited field a mile or more away. Of course, it is not illegal to feed waterfowl if such feeding occurs when the hunting season is closed (provided you meet the 10 day provision) and/or the feeding does not increase the likelihood of hunters taking birds.

Managers who work on hunting areas must take care that manipulations of crops or plants do not constitute baiting. The easiest way to assure compliance is to employ methods that conform to the definition of a "normal agricultural practice." Some actions that one would intuitively consider baiting are legally acceptable. For example, growing a crop of millet in a wetland basin, then flooding the crop as a food for waterfowl, is a legal and common practice. However, other seemingly innocent situations can arise that pose potential problems. For example, a wildlife management area recently had to be temporarily closed because a manager cut down weeds in a wetland basin, then flooded the wetland to attract waterfowl. Although the manager's intent was to clear out vegetation to provide a proper interspersion of open water to vegetation, federal agents considered the action baiting because the acts of mowing and flooding increased the availability of natural seeds, which were considered bait. In another case, disturbing snow on the surface of a cornfield during the process of setting decoys was considered baiting because the action exposed waste grain, even though the cornfield was harvested in a normal manner and no grain was added as an enticement to waterfowl. These examples may represent extreme interpretations of the baiting statutes, but nonetheless exemplify the care which should be taken by managers and waterfowlers when hunting in managed habitats.

9. EVALUATION AND FOLLOW-UP

The management prescriptions presented here are a result of many decades of research. Although much of the information has been gathered through formal research studies, an increasing amount of data is obtained through so-called "management experiments." Management experiments are simply a byproduct of well conceived management actions, with appropriate pre-management surveys (4.0) and follow-up evaluations on the effectiveness of the management actions. Wildlife managers frequently "re-invent the wheel" out of ignorance of a similar, previous action that went unreported. With ever-tightening budgets and dwindling waterfowl resources, it is imperative that managers not only plan and execute their programs in an efficient manner, but also make the results of their management actions known. Several local, regional, or national publications provide outlets for such information, and managers are urged to convey the results of their works in these forums. Alternatively, summarize your findings to the author or other Colorado Division of Wildlife employees, and urge them to pass the information along. Only in this way can we learn to avoid future mistakes and profit from our victories.

10. SELECTED REFERENCES

These references provide detailed information to supplement the general discussions presented in this guide. Copies of most articles are on file at the Research Library, Colorado Division of Wildlife, 317 W. Prospect Road, Fort Collins, CO 80526; (303) 484-2836.

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APPENDIX A. Common and scientific names of plants and animals named in text.

Common name	Scientific name
Plants	
Tall wheatgrass	*Agropyron elongatum*
Intermediate wheatgrass	*Agropyron intermedium*
Common elodea	*Anacharis canadensis*
Sagebrush	*Artemisia* spp.
Smooth brome	*Bromus inermis*
Coontail	*Ceratophyllum demersum*
Japanese millet	*Echinochloa crusgalli*
Baltic rush	*Juncus balticus*
Rice cutgrass	*Leersia oryzoides*
Duckweed	*Lemna* spp.
Spiked watermilfoil	*Myriophyllum spicatum*
Water cress	*Nasturtium officinale*
Kentucky bluegrass	*Poa pratensis*
Smartweed	*Polygonum* spp.
Fineleaf pondweed	*Potamogeton filiformis*
Sago pondweed	*Potamogeton pectinatus*
Docks	*Rumex* spp.
Common widgeongrass	*Ruppia maritima*
Common arrowhead	*Sagittaria latifolia*
Black greasewood	*Sarcobatus vermiculatus*
Hardstem bulrush	*Scirpus acutus*
Johnson grass	*Sorghum halepense*
Burreed	*Sparganium* spp.
Cattail	*Typha* spp.
American wild celery	*Vallisneria americana*
Mammals	
Coyote	*Canis latrans*
Beaver	*Castor canadensis*
Striped skunk	*Mephitis mephitis*
Mink	*Mustela vison*
Raccoon	*Procyon lotor*
Franklin's ground squirrel	*Spermophilus franklinii*
Badger	*Taxidea tax*
Red Fox	*Vulpes fulva*

Common name	Scientific name
Birds	
Pintail	*Anas acuta*
American wigeon	*Anas americana*
Northern shoveler	*Anas clypeata*
Green-winged teal	*Anas crecca*
Blue-winged teal	*Anas discors*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Lesser scaup	*Aythya affinis*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Canvasback	*Aythya valisineria*
Canada goose	*Branta canadensis*
Bufflehead	*Bucephala albeola*
Common goldeneye	*Bucephala clangula*
Crow	*Corvus brachyrhynchos*
Raven	*Corvus corax*
Gulls	*Larus* spp.
Common merganser	*Mergus merganser*
Ruddy duck	*Oxyura jamaicensis*
Magpie	*Pica pica*
Reptiles	
Snapping turtle	*Chelydra serpentina*
Fish	
Carp	*Cyprinus carpio*
Invertebrates	
Midges	Chironomidae
Copepods	Copepoda
Water boatman	Corixidae
Mosquitos	Culicidae
Water fleas	Daphnidae
Amphipods	*Gammarus* spp.
Pond snails	Lymnaeidae
Earthworms	Oligochaeta

APPENDIX B. Conversion table for metric and U.S. customary measures.

METRIC TO U.S. CUSTOMARY

Multiply	By	To obtain
Hectares (ha)	2.471	Acres
Square kilometers (km^2)	0.3861	Square miles
Centimeters (cm)	0.3937	Inches
Meters (m)	3.281	Feet
Kilometers (km)	0.6214	Miles
Grams (gm)	31.103	Ounces
Kilograms (kg)	2.2046	Pounds

U.S. CUSTOMARY TO METRIC

Multiply	By	To obtain
Acres (acre)	0.4047	Hectares
Square miles (mi^2)	2.5901	Square kilometers
Inches (in.)	2.5400	Centimeters
Feet (ft)	0.3048	Meters
Miles (mi)	1.6093	Kilometers
Ounces (oz)	0.0321	Grams
Pounds (lb)	0.4530	Kilograms