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WHITE CLOVER (*Trifolium repens*)

Section 7.3.5, US ARMY CORPS OF ENGINEERS  
WILDLIFE RESOURCES MANAGEMENT MANUAL

by

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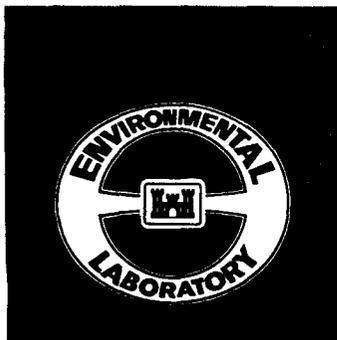
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<p>A plant materials report on white clover (<i>Trifolium repens</i>) is provided as Section 7.3.5 of the US Army Corps of Engineers Wildlife Resources Management Manual. The report was prepared as a guide to assist the Corps District or project biologist with the selection, cultivation, and management of suitable plant materials for development of wildlife habitat. Topics covered for white clover include description, distribution, habitat requirements, wildlife value, establishment, maintenance, and cautions and limitations.</p> <p>White clover is an introduced, herbaceous, perennial legume that has become naturalized throughout much of the United States. Plants are used as food and cover by numerous wild-life species. Diagnostic characteristics of white clover are described, and the species distribution and regions of greatest management use are shown. Habitat requirements are</p> <p style="text-align: right;">(Continued)</p>					
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described, and soil, moisture, and shade requirements are specified. Wildlife benefits are discussed, primarily for game mammals and upland game birds, and major species known to use white clover for food and cover are listed. Specifications are given for establishing and managing stands of white clover; topics covered include site selection, site preparation, propagule selection, and planting methods. Maintenance requirements and cautions and limitations are discussed.

## PREFACE

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NOTE TO READER

This report is designated as Section 7.3.5 in Chapter 7 -- PLANT MATERIALS, Part 7.3 -- LEGUMES, of the US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL. Each section of the manual is published as a separate Technical Report but is designed for use as a unit of the manual. For best retrieval, this report should be filed according to section number within Chapter 7.

# WHITE CLOVER (*Trifolium repens*)

Section 7.3.5, US ARMY CORPS OF ENGINEERS  
WILDLIFE RESOURCES MANAGEMENT MANUAL

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White clover is an introduced, herbaceous, perennial legume that has become naturalized throughout much of the United States. It is sown for pasture, hay, silage, and, to a limited extent, for soil conservation (Graham 1942); plants are also commonly used by bees for pollination and honey production. Many wildlife species are known to use clovers for food and cover, and white clover is often a preferred dietary item when available.

## DESCRIPTION

White clover grows either erect or as a short, spreading sod-former with stoloniferous branches that root at the nodes (Fig. 1). The species exists in several types or growth forms. The wild or common types are usually small, prostrate, and low-growing, whereas large forms such as the Ladino variety are upright and tall; there are also many intermediate types (Wasser 1982). The smooth, prostrate stems are 4 to 16 in. (1 to 4 dm) long and give rise to leaves and flowers on separate stalks (Radford et al. 1968, Niering and Olmstead 1979). Each plant initially has a taproot but later develops a finely branched root system that is contained mostly within the top 6 in. (15 cm) of soil (Wasser 1982).

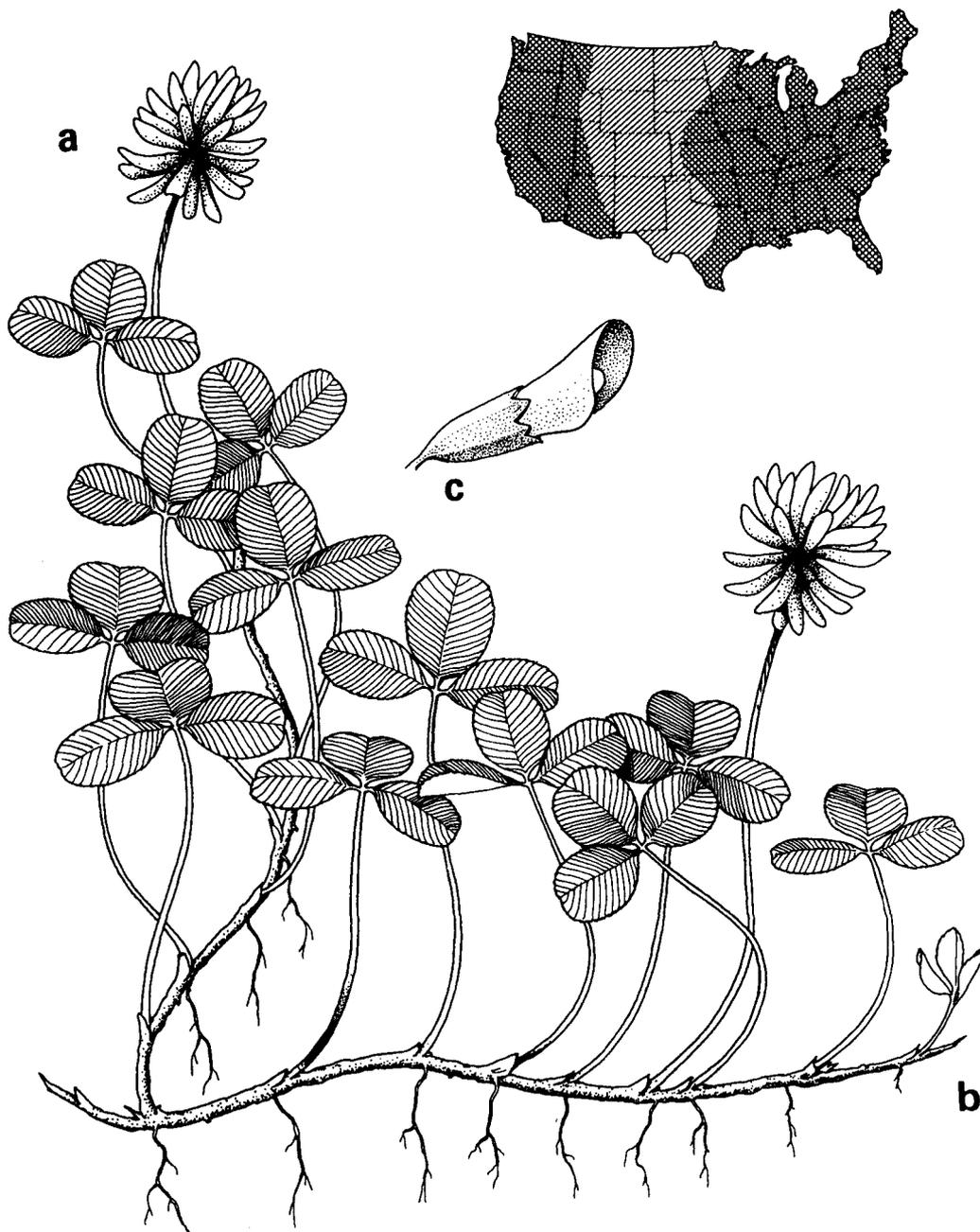


Figure 1. Distribution and distinguishing characteristics of white clover (*Trifolium repens*): (a) entire plant, (b) stoloniferous branch, and (c) flower. The map shows the overall species distribution (diagonal lines) and regions of greatest management use (crosshatching)

The palmately compound leaf consists of 3 smooth, elliptic to obovate leaflets with finely toothed margins; each leaflet is 0.4 to 1.2 in. (1 to 3 cm) long and may have white V-shaped markings at the base (Radford et al. 1968, Leffel and Gibson 1973). The stipules are fused to form a membranous sheath around the bases of the leaf and flower stalks; thus, the leaves and flowers may appear to be borne on a single stalk. The inflorescence is composed of 40 to 80 small, white to pinkish-white, pea-like flowers that form a nearly globose head 0.4 to 1.2 in. (1 to 3 cm) in diameter (Radford et al. 1968). The miniature, oblong to linear legume contains 3 to 5 seeds that require from 3 weeks to 1 month for maturation. White clover flowers from April through September in cool, moist regions but becomes semidormant under hot, dry conditions; seeds mature while plants continue to flower (Leffel and Gibson 1973, Coastal Zone Resources Division 1978). In the North the species occurs as a perennial and reproduces by stolons, but in the South it tends to behave like an annual, reproducing primarily by seed.

#### DISTRIBUTION

White clover is native to the Near East and was well established in the United States by 1750. It grows in every continental state, above the Arctic Circle in Alaska, and above the upper timberline in Western mountains. Two major clover crop-producing centers of the United States are (1) all of the area from the 97th meridian eastward, and (2) irrigated lands from the Rocky Mountains westward (Fig. 1) (Leffel and Gibson 1973).

#### HABITAT REQUIREMENTS

White clover is most prevalent in the Eastern United States because of the greater occurrence of moist sites suitable for its growth. It is commonly found in pastures where it has been planted with other species and receives management attention. Species with which it is commonly associated are dallisgrass (*Paspalum dilatatum*), bahiagrass (*P. notatum*), bermuda grass (*Cynodon dactylon*), timothy (*Phleum pratense*), orchardgrass (*Dactylis glomerata*), alfalfa (*Medicago sativa*), rye (*Secale cereale*), smooth brome (*Bromus inermis*), reed canarygrass (*Phalaris arundinacea*), and tall fescue (*Festuca arundinacea*) including its varieties, Alta and Kentucky 31.

## Soils

White clover is adapted to soils of all textures, including hard pan clays, but is best suited to deep, fertile, silty loams or bottomland clays. It does not grow well on light-textured, droughty upland soils of medium to low fertility (SCS 1984). The preferred pH range is 6.0 to 6.5 (Coastal Zone Resources Division 1978), but white clover is tolerant of moderate alkalinity or acidity (to pH 5.5). This species will also grow on moderately saline soils but not on sodic soils. Plants tolerate alkalinity better when well fertilized with phosphorus and tolerate salinity better when the salts are leached downward by irrigation. White clover, especially Ladino, requires soils that are particularly high in phosphorus, lime, and potash (Leffel and Gibson 1973, Shaw and Cooper 1973, Vogel 1981, Thornburg 1982).

## Moisture

White clover requires 16 to 20 in. of mean annual precipitation with most of the moisture available during the growing season. It thrives in zones with more than 25 in. of precipitation and on lands under irrigation in dry regions (Merkel and Herbel 1973, Shaw and Cooper 1973, Thornburg 1982). Although it is not tolerant of extremely wet soils, this species can occasionally be grown on sites subject to intermittent flooding or seasonally high water tables (Turelle and Austin 1967). White clover is not resistant to drought.

## Shade

White clover grows best in full sunlight and is rated as medium in shade tolerance (Shaw and Cooper 1973). It suffers from reduced light in dense grass pasture and hay swards unless frequent grazing or mowing prevents the overgrowth of grass (Leffel and Gibson 1973). This species is sometimes used in revegetation of burned-over forests but dies out when plant succession results in increased overstory and shade (Pickford and Jackman 1944).

## WILDLIFE VALUE

Many birds and mammals utilize clovers (*Trifolium* spp.) for food and cover (Martin et al. 1951). Numerous studies have indicated widespread use, but clovers are difficult to distinguish in crop and stomach analyses and have frequently been reported only as *Trifolium* species. However, white clover is known to be readily foraged by wildlife and appears to be a preferred food

wherever it occurs (Graham 1942, Crawford et al. 1969, Shaw and Cooper 1973). Major wildlife species known to use white clover are listed in Table 1.

### Food

Birds reported to eat clover seeds are the mourning dove (Davis 1974), vesper sparrow (Best 1972), bobwhite (Robel 1969), sharp-tailed grouse (Harris 1967), and common snipe (White and Harris 1966). Blue grouse, ruffed grouse, and sage grouse feed on the leaves (Boag 1963, Phillips 1967, Martin 1970). Swenk and Selko (1938) found that clover was one of 3 major components in late autumn diets of sharp-tailed grouse in the Nebraska sandhills, and Kobriger (1965) reported that clovers were the most important summer dietary items of both adult and immature birds. Clover habitat was one of the vegetation types most frequently used by white-tailed ptarmigan on summer range in Colorado, and the leaves and seeds of clover were among their most important summer foods (May and Braun 1972).

Game birds that feed on white clover include the bobwhite (Davison 1958), sage grouse (Wallestad et al. 1975), ruffed grouse (Korschgen 1966), and spruce grouse (Jonkel and Greer 1963). Davison (1958) listed white clover as a choice food for bobwhite, i.e., one that is digestible, nutritious, and eaten readily when available. Studies of grouse food habits indicate seasonal utilization of white clover. Crop analyses showed that spruce grouse in northwest Montana fed on white clover while it was available during the fall (Jonkel and Greer 1963), and Wallestad et al. (1975) found that sage grouse in central Montana made it a part of their diets in late summer and early fall. Ladino clover, though limited in availability, was a highly preferred food of ruffed grouse in Missouri during the shift from winter mast to the herbaceous spring diet (Korschgen 1966).

The presence of clover is an attractant to white-tailed deer (Carbaugh et al. 1975), and clovers receive considerable use in habitat types where they are common (Kohn and Mooty 1971). Rumens analyses of white-tailed deer in Montana showed that forbs comprised 80% of summer samples; alfalfa and clover were the major forbs consumed (Martinka 1968). McCaffery et al. (1974) and Nixon et al. (1970) also reported clovers to be important herbaceous components of whitetail diets.

In the Black Hills of South Dakota, valley bottoms dominated by Kentucky bluegrass (*Poa pratensis*) and white clover are favored spring and fall feeding

Table 1. Wildlife species that utilize white clover for food and/or cover\*

<u>Common Name</u>	<u>Scientific Name</u>
<u>Waterfowl</u>	
American coot	<i>Fulica americana</i>
American pintail	<i>Anas acuta</i>
Mallard	<i>A. platyrhynchos</i>
Bufflehead	<i>Bucephala albeola</i>
Redhead	<i>Aythya americana</i>
<u>Upland Game Birds</u>	
Blue grouse	<i>Dendragapus obscurus</i>
Spruce grouse	<i>D. canadensis</i>
Sharp-tailed grouse	<i>Tympanuchus phasianellus</i>
Greater prairie-chicken	<i>T. cupido</i>
Sage grouse	<i>Centrocercus urophasianus</i>
Ruffed grouse	<i>Bonasa umbellus</i>
Willow ptarmigan	<i>Lagopus lagopus</i>
White-tailed ptarmigan	<i>L. leucurus</i>
Gray partridge	<i>Perdix perdix</i>
Ring-necked pheasant	<i>Phasianus colchicus</i>
Wild turkey	<i>Meleagris gallopavo</i>
Northern bobwhite	<i>Colinus virginianus</i>
California quail	<i>Callipepla californica</i>
Scaled quail	<i>C. squamata</i>
Mountain quail	<i>Oreortyx pictus</i>
Mourning dove	<i>Zenaida macroura</i>
Common snipe	<i>Gallinago gallinago</i>
<u>Songbirds</u>	
Horned lark	<i>Eremophila alpestris</i>
American robin	<i>Turdus migratorius</i>
Pygmy nuthatch	<i>Sitta pygmaea</i>
Red-winged blackbird	<i>Agelaius phoeniceus</i>
House sparrow	<i>Passer domesticus</i>
Smith's longspur	<i>Calcarius pictus</i>
Sharp-tailed sparrow	<i>Ammodramus caudacutus</i>
Lincoln's sparrow	<i>Melospiza lincolni</i>
Vesper sparrow	<i>Poocetes gramineus</i>
<u>Large Mammals</u>	
Mule deer	<i>Odocoileus hemionus</i>
White-tailed deer	<i>O. virginianus</i>
Elk	<i>Cervus elaphus</i>

(Continued)

\* Adapted from Graham 1942, Martin et al. 1951, and Crawford et al. 1969.

Table 1 (Concluded)

<u>Common Name</u>	<u>Scientific Name</u>
<u>Small Mammals</u>	
Woodland vole	<i>Microtus pinetorum</i>
Meadow vole	<i>M. pennsylvanicus</i>
Belding's ground squirrel	<i>Spermophilus beldingi</i>
Thirteen-lined ground squirrel	<i>S. tridecemlineatus</i>
Douglas' squirrel	<i>Tamiasciurus douglasii</i>
Eastern cottontail	<i>Sylvilagus floridanus</i>
Desert cottontail	<i>S. audubonii</i>
Hares	<i>Lepus</i> spp.
Snowshoe hare	<i>L. americanus</i>
Marmots	<i>Marmota</i> spp.
Woodchuck	<i>M. monax</i>
Raccoon	<i>Procyon lotor</i>
Porcupine	<i>Erothizon dorsatum</i>
Striped skunk	<i>Mephitis mephitis</i>

areas for white-tailed deer (Pase and Thilenius 1968). Schneeweis (1972) reported that white clover had a 17.4% frequency of occurrence in deer rumens collected from January through March in the Northern Black Hills. Bluegrass-white clover meadows are also feeding areas for songbirds, wild turkey, mule deer, hares, cottontails, and other small mammals.

Elk and mule deer also utilize white clover if it is available. The species has been rated high as a summer food for elk in Montana (Stevens 1966, Shaw and Cooper 1973); Stevens (1966) found that elk summer diet consisted of 76% forbs with white clover contributing significantly, especially during July. Mule deer in Montana and New Mexico have been reported to consume small amounts of clover (Lovaas 1958, Anderson et al. 1965), and a bite count study in Colorado showed that 3% of forage selected by mule deer was white clover (Wallmo et al. 1972).

### Cover

White clover provides excellent habitat for small farm game species and is especially effective when planted in mixtures with grasses and other legumes. Ellis et al. (1969) reported that Ladino clover seeded with red clover (*Trifolium pratense*) in old patches of standing corn provided good cover for bobwhites and cottontail rabbits. White clover is frequently

planted in wildlife food plots (Miller 1958, Wasser 1982), which also receive heavy use by cottontails. The gray partridge, ring-necked pheasant, greater prairie-chicken, and a variety of songbirds use clover patches for nesting or roosting cover (Grange and McAtee 1934). Good habitat for birds and small mammals can be created when white clover is planted for erosion control and land reclamation projects (Troeh et al. 1980).

## ESTABLISHMENT

### Site Selection

Sites considered for food plots should meet the habitat requirements for white clover or be amenable to cultural practices, such as fertilization and irrigation. Suitable sites include depleted pastures or rangelands, marginal or abandoned croplands, fencerows, road edges, drainageways, utility and pipe or powerline rights-of-way, disturbed lands, and idle lands within the home range of the targeted species (Scott and Hendrickson 1936, Allen 1949, Baker 1953, Atkins and Coyle 1960, Packard 1962). White clover may also be planted in forest openings or along old logging roads and trails in wooded areas. Small aspen groves in the Southwestern pine zone have been renovated for the benefit of deer and elk by the inclusion of white clover seedings; the small, moist, oasis-like plots are preferred habitats of these herbivores.

### Site Preparation

Plot design. White clover plantings should be designed to create as much edge as possible between existing cover and that being established, while incorporating the interspersion of cover types and feeding areas (Leopold 1936, Stoddard 1946, Baker 1953). Elongated plots with irregular borders are preferred because this design greatly increases the amount of available edge. To provide adequate cover, a plot should be at least 20 ft wide (Packard 1962), and the length should be several times the width. Large field plantings are more useful to wildlife when divided into strips (Kimball et al. 1956); row plantings may simulate the strip effect and are usually more beneficial than solid seedings (Schwendiman 1957). Plots may be designed to serve as corridors connecting cover types; e.g., grass-clover seedings used in waterways are more advantageous for wildlife when they connect roosting and feeding cover. Narrow road edges, fencerows, and other similar strips seeded to white clover and grasses may also provide travel lanes or nesting cover in

intensively cropped areas that contain little permanent cover (Joselyn and Tate 1972).

Mechanical treatment. A firm, weed-free seedbed must be prepared for good seedling establishment. Marginal croplands being retired from cultivation and those abandoned in the 2 years prior to planting clover are usually prepared by disking, harrowing, and cultipacking. Plowing is needed only when weeds are abundant or crop stubble interferes with drilling. On dry upland sites, sparse annual weeds can be controlled by chemical fallow, which retains moisture and nutrients for better stand establishment. Fields grown up in perennial weeds may need to be plowed and sown to a crop that will be intertilled a year before seeding grass and clover. Old fields grown up in grass or hay fields that are unproductive can be interseeded with special equipment that thins the sod in front of seed drops (Derscheid and Johnson 1977). These practices can also be applied to the preparation of a site for field strip planting (Decker et al. 1973, Leffel and Gibson 1973).

Waterways should be shaped with a dozer blade or graded and engineered to a design capable of withstanding a 25-year, 24-hour peak flow (Troeh et al. 1980). Roadsides, fencerows, and similar strips can be prepared by double-disking or disking with a cutaway disk or rotatiller. These areas can also be tilled, sprayed, and seeded in one operation with a rotaseeder (Joselyn and Tate 1972).

Mine spoils should be leveled to an acceptable grade and backfilled with topsoil before seeding with white clover. Mechanical scarification is usually necessary. The use of chisel plows on contours produces narrow furrows that promote better infiltration of water and leaves a seedbed suitable for broadcasting. A lightweight harrow can be used to scarify soils that are not compacted or firmly crusted. One disking is usually feasible; repeated disking may adversely alter the physical characteristics of mine spoils (Vogel 1981).

Soil amendments. Soils should be tested to determine fertilizer needs. Moderately to strongly acidic soils should be amended by adding lime to bring the pH up to 6.0. Soils in the Southeast will likely require from 1 to 2 tons/acre to reach this level (SCS 1984). This increases nutrient availability and favors greater nitrogen fixation by bacteria in the clover root nodules. Most Eastern soils require phosphorus, and sandy soils may need potash; these amendments should be worked into surface soils during seedbed

preparation (Leffel and Gibson 1973). Nitrogen fertilizers should be avoided because they hinder clover development by stimulating the growth of grasses (Gibson and Hollowell 1966). Soil specialists and county extension agents can help formulate an effective fertilizer program.

### Propagule Selection

Cultivars. Large, intermediate, and low-growing types of white clover have been developed. Most of the named varieties are of the large plant type and were either selected or bred from the Ladino strain; commercial seeds are usually from varieties of the intermediate type. Characteristics of commonly used cultivars are presented in Table 2.

Seed selection. Seeding is the only common method of establishing white clover, and commercial seeds are widely available and reasonably priced. All white clover seeds look alike; therefore, the only assurance of obtaining a particular variety is to buy certified seed (Gibson and Hollowell 1966, Leffel and Gibson 1973). Because cultivars exhibit much variation in longevity, growth pattern, and seeding characteristics, a variety should be selected that is adapted to the particular region where it will be planted and to the purpose for which it will be managed.

Germination and vigor. Smith (1940) found that 76% of white clover seeds germinated in 5 days. Burton (1940) reported germination of 95% in 28 days with scarified seed and 64% in 28 days with unscarified seed. Under ideal conditions seeds will germinate rapidly in 7 days (Wasser 1982). Vigor of seedlings is only fair. Good stands are not usually established until the second or third season, but this varies with growth conditions and length of growing season (Wasser 1982).

### Planting Methods

Time of seeding. White clover can be seeded in early spring, late summer, or early fall (Coastal Zone Resources Division 1978). Adequate moisture and lack of frost are major considerations in determining the time of seeding. Seeds should be planted in late summer only under humid and/or cool conditions, and fall planting should precede the first frost by at least 2 weeks. Most north-central and northeastern areas can be successfully seeded in either early spring or late summer. In the South, late summer and early fall dates are preferred because seedlings make good root development in cool, moist seasons, and this favors better survival the next summer. It is recommended

Table 2. White clover varieties in common use

Variety	Plant Type	Adaptation	Characteristics
Louisiana white, unimproved strain	Intermediate	South	Good flower and seed production
Louisiana S 1	Intermediate	Gulf Coast States	Good self-seeding
Ladino, unimproved	Large	Northeast, West Coast, irrigated Interior West	Larger, more productive type
Merit	Large	Central Corn Belt, Northeast, West	Winter hardy, resistant to drought and leafhoppers
Pilgrim	Large	Northeast, West, Canada	Uniformity of type
Regal	Large	Southeast	Summer productivity, persistent
Tillman	Large	Southeast	Summer productivity, persistent, disease resistant, good stolon branching

that planting be delayed until October if white clover is to be seeded on established grass sod (SCS 1984). Spring seedings may be affected by excessive weeds but are possible on moist soils that have supported sparse weed populations (Gibson and Hollowell 1966). White clover is planted from October 1 to November 12 in northern California and in December or early March in southern California (Jones and Brown 1942).

Seeding. Seeds should be inoculated with the proper strain of *Rhizobium* bacteria and sown in a firm seedbed by drilling or broadcasting (Coastal Zone Resources Division 1978, Wasser 1982). Any drill with a small seed hopper and metering device can be used to plant seeds at a depth of 1/4 to 1/2 in. To avoid planting too deeply, the furrow openers may be raised so the packer wheels can press the seed into the soil. A mechanical spreader, such as the cultipacker seeder, can be used for broadcasting seeds, which can then be covered by running a roller over the area. If the clover is sown on established

grass sod, the ground can be prepared by disking lightly, and the seed can be planted with a sod seeding machine (SCS 1984).

Seeding rates will vary, depending upon the region and whether white clover is sown alone or in mixtures. When it is planted in pure stands, 2 to 4 lb of seed/acre are usually sown (Leffel and Gibson 1973); however, up to 7 lb/acre have been used in California (Jones and Brown 1942). The rate of seeding white clover in pasture and hay mixtures ranges from 0.5 to 5 lb/acre (Jones and Brown 1942, Stefferud 1948, Smith 1962, Stewart 1970, Vogel 1981). Less seed (1 to 2 lb/acre) can be used if grass seeding rates are kept low to reduce the competitive effects on white clover. Smith (1962) felt that 0.5 to 1 lb of clover seed/acre should be adequate in mixtures. In humid zones white clover can be sown with a companion grain crop if the rate of seeding is one-half the normal rate and if it is mowed or harvested when the clover shows signs of wilting from competition. Seeding rates also vary according to the proportion of clover desired in the stand, with common recommendations for white clover ranging from 25% to 50%.

Planting mixtures. White clover is recommended for seeding in mixtures with several grasses and other legumes. Most grasses emerge better when planted at depths of 1/2 to 1 in., but clover is more readily established when planted at shallower depths. Because of this difference, mixtures of grasses and white clover are often sown separately and sometimes at an angle to each other; using this method results in more vigorous stands and less competition (Decker et al. 1973, Leffel and Gibson 1973). Grasses and legumes recommended for seeding with white clover include the following: Kentucky bluegrass, meadow fescue (*Festuca elatior*), tall fescue, orchardgrass, smooth brome, timothy, perennial ryegrass (*Lolium perenne*), tall oatgrass (*Arrhenatherum elatius*), alfalfa, alsike clover (*Trifolium hybridum*), red clover, and sweetclover (*Melilotus* spp.). If grass competition is markedly reduced, white clover often becomes naturalized in favorable sites, such as overgrazed bluegrass pastures after excessive grazing has been discontinued.

#### MAINTENANCE

White clover will become well established in one growing season in humid zones or with irrigation, but two seasons may be required for establishment in dry seasons or on dry soils. Grazing should usually be withheld during the

first year; however, it can sometimes be managed to control weedy competition if livestock are removed during moist periods and before the clover has become defoliated. Established stands should be grazed only after the plants are at least 6 in. tall. A 2-in., and preferably a 6-in., stubble should be maintained throughout any grazing regime. Pastures containing white clover should not be grazed in the fall until plants have become dormant. During spring and summer, however, plants may be defoliated every 15 to 30 days if adequate stubble is maintained for rapid regrowth (Gibson and Hollowell 1966).

White clover will sustain better production with rotational grazing (Smith 1962, Gibson and Hollowell 1966). Frequent, moderately close grazing of grasses growing in grass-clover mixtures will reduce plant competition and favor the clover (Leffel and Gibson 1973). Close grazing by wildlife or by both wildlife and livestock is a necessity to maintain white clover in wildlife areas that also contain grass species. Failure to permit close grazing will result in taller grasses overtopping and killing the low-growing clover (Morrison 1956).

Mowing during the stem-elongation stage of the seedling year may improve stand establishment, particularly when weeds are dense. Mowing tall weeds before seeds mature prevents their spread in established, older clover stands. If white clover is grown in association with brome grass and orchardgrass, better hay stands can be maintained by mowing when clover plants are 8 in. tall (Smith 1962).

White clover plants originating from properly inoculated seeds require no additional nitrogen but may need liberal applications of phosphorus, potash, and calcium, especially in eastern humid climates and in sandy, acidic soils. The soil pH should be maintained at 6.5. Soil test information, along with state fertilizer guides, may be used to determine annual fertilizer requirements (Decker et al. 1973).

In arid regions white clover needs frequent, light irrigation for good production and cover establishment. The surface soil should not be allowed to dry out during the first month after planting. Local weather and soil properties will determine the actual water requirements. It is common practice to irrigate pastures following each grazing or mowing unless soil moisture is adequate (Turelle and Austin 1967).

## CAUTIONS AND LIMITATIONS

White clover, like most legumes, occasionally causes bloat in animals, particularly cattle and sheep that have overfilled. If it is planted in mixtures with 40% grasses, the risk of losses by bloating will be minimized. Bloating problems may also be reduced by selective-grazing practices. These include: (1) grazing white clover for short periods of time to prevent overfilling; (2) grazing the more mature plants that are less succulent and of higher fiber content; (3) not grazing hungry animals that may overfill; and (4) feeding with the clover other roughages that are coarser but palatable (Wheeler 1950, Morrison 1956).

Common white clover is not so susceptible to disease as is Ladino. Crown or stem rot thins stands and occasionally destroys large areas during winter and spring months. Pepper spot, sooty blotch, and black patch frequently cause severe defoliation. Southern blight and root knot are highly destructive during summer months in the South. Root and stolon rots can be severe after the first harvest year in eastern areas (Hughes et al. 1962). Heavy infestations of potato leafhopper in spring and summer result in stunted growth and discoloration of the leaves; however, it is not usually a serious problem when the growth is removed every 15 to 20 days by mowing or grazing.

## LITERATURE CITED

- Allen, D. L. 1949. The farmer and wildlife. Wildl. Manage. Inst., Washington, D.C. 85 pp.
- Anderson, A. E., W. A. Snyder, and G. W. Brown. 1965. Stomach content analyses related to condition in mule deer, Guadalupe Mountains, New Mexico. J. Wildl. Manage. 29:359-366.
- Atkins, M. D., and J. J. Coyle. 1960. Grass waterways in soil conservation. USDA Agric. Leaflet. 477. 8 pp.
- Baker, M. F. 1953. Prairie chickens in Kansas. Univ. Kans. State Biol. Survey Misc. Publ. 5. 68 pp.
- Best, L. B. 1972. First-year effects of sagebrush control on two sparrows. J. Wildl. Manage. 36:534-544.
- Boag, D. A. 1963. Significance of location, year, sex, and age to the autumn diet of blue grouse. J. Wildl. Manage. 27:555-562.
- Burton, G. W. 1940. Factors influencing the germination of seed of *Trifolium repens*. J. Am. Soc. Agron. 32:731-738.
- Carbaugh, B., J. P. Vaughan, E. D. Bellis, and H. B. Graves. 1975. Distribution and activity of white-tailed deer along an interstate highway. J. Wildl. Manage. 39:570-581.
- Coastal Zone Resources Division. 1978. Handbook for terrestrial wildlife habitat development on dredged material. U.S. Army Eng. Waterways Exp. Sta. Tech. Rep. D-78-37. 391 pp.
- Crawford, H. S., C. L. Kucera, and J. H. Ehrenreich. 1969. Ozark range and wildlife plants. USDA Agric. Handb. 356. 236 pp.
- Davis, C. A. 1974. Mourning dove foods in semi-desert, south-central New Mexico. J. Wildl. Manage. 38:941-944.
- Davison, V. E. 1958. A summary and reclassification of bobwhite foods. J. Wildl. Manage. 22:437-439.
- Decker, A. M., T. H. Taylor, and C. J. Willard. 1973. Establishment of new seedings. Pages 384-395 In M. E. Heath, D. S. Metcalfe, and R. F. Barnes, eds. Forages. 3rd ed. Iowa State Univ. Press, Ames. 755 pp.
- Derscheid, L. A., and J. R. Johnson. 1977. Interseeding and modified renovation. S. Dak. Ext. Serv. Fact Sheet 422. 5 pp.
- Ellis, J. A., W. R. Edwards, and K. P. Thomas. 1969. Responses of bobwhites to management in Illinois. J. Wildl. Manage. 33:749-762.
- Gibson, P. R., and E. A. Hollowell. 1966. White clover. USDA Agric. Handb. 314. 33 pp.
- Graham, E. H. 1942. Legumes for erosion control and wildlife. USDA Misc. Publ. 412. 153 pp.
- Grange, W. R., and W. L. McAtee. 1934. Improving the farm environment for wildlife. USDA Farmers Bull. 1719. 61 pp.
- Harris, S. W. 1967. Fall foods of sharp-tailed grouse in Minnesota. J. Wildl. Manage. 31:585-587.

- Hughes, H. D., M. E. Heath, and D. S. Metcalfe. 1962. Forages. Iowa State Univ. Press, Ames. 707 pp.
- Jones, B. J., and J. B. Brown. 1942. Irrigated pastures in California. Calif. Agric. Ext. Serv. Circ. 125. 47 pp.
- Jonkel, C. J., and K. R. Greer. 1963. Fall food habits of spruce grouse in northwest Montana. J. Wildl. Manage. 27:593-596.
- Joselyn, G. B., and G. I. Tate. 1972. Practical aspects of managing roadside cover for nesting pheasants. J. Wildl. Manage. 36:1-11.
- Kimball, J. W., E. L. Kozicky, and B. A. Nelson. 1956. Pheasants of the plains and prairies. Pages 204-263 In D. L. Allen, ed. Pheasants in North America. Wildl. Manage. Inst., Washington, D.C. 490 pp.
- Kobriger, G. D. 1965. Status, movements, habitats, and foods of prairie grouse on a sandhills refuge. J. Wildl. Manage. 29:796-798.
- Kohn, B. E., and J. J. Mooty. 1971. Summer habitat of white-tailed deer in north-central Minnesota. J. Wildl. Manage. 35:476-487.
- Korschgen, L. J. 1966. Foods and nutrition of ruffed grouse in Missouri. J. Wildl. Manage. 30:86-100.
- Leffel, R. C., and P. G. Gibson. 1973. White clover. Pages 167-176 In M. E. Heath, D. S. Metcalfe, and R. F. Barnes, eds. Forages. 3rd ed. Iowa State Univ. Press, Ames. 755 pp.
- Leopold, A. 1936. Game Management. Charles Scribner's Sons, Inc., New York. 481 pp.
- Lovaas, A. L. 1958. Mule deer food habits and range use, Little Belt Mountains, Montana. J. Wildl. Manage. 22:275-283.
- Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American Wildlife and Food Plants. Dover Publ., Inc., New York. 500 pp.
- Martin, N. S. 1970. Sagebrush control related to habitat and sage grouse occurrence. J. Wildl. Manage. 34:313-320.
- Martinka, C. J. 1968. Habitat relationships of white-tailed deer and mule deer in northern Montana. J. Wildl. Manage. 32:558-565.
- May, T. A., and C. E. Braun. 1972. Seasonal foods of adult white-tailed ptarmigan in Colorado. J. Wildl. Manage. 36:1180-1186.
- McCaffery, K. R., J. Tranetzki, and J. Piechura, Jr. 1974. Summer foods of deer in northern Wisconsin. J. Wildl. Manage. 38:215-219.
- Merkel, D. L., and C. H. Herbel. 1973. Seeding non-irrigated land in New Mexico. N. Mex. Inter-Agency Comm. Rep. 10, Las Cruces. 95 pp.
- Miller, D. F. 1958. Composition of cereal grains and forages. Comm. on Feed Composition, Nat. Acad. Sci.-Nat. Resour. Council, Publ. 585. Washington, D.C. 663 pp.
- Morrison, F. B. 1956. Feeds and Feeding. 22nd ed. Morrison Publ. Co., Ithaca, New York. 1165 pp.
- Niering, W. A., and N. C. Olmstead. 1979. The Audubon Society Field Guide to North American Wildflowers, Eastern Region. Alfred A. Knopf, New York. 887 pp.

- Nixon, C. M., M. W. McClain, and K. R. Russell. 1970. Deer food habits and range characteristics in Ohio. *J. Wildl. Manage.* 34:870-886.
- Packard, G. 1962. The bobwhite in Kansas. *Univ. Kans. State Biol. Survey Misc. Publ.* 32. 11 pp.
- Pase, C. E., and J. F. Thilenius. 1968. Composition, production and site factors of some grasslands in the Black Hills of South Dakota. *USDA For. Serv. Res. Note RM-103.* 8 pp.
- Phillips, R. L. 1967. Fall and winter food habits of ruffed grouse in northern Utah. *J. Wildl. Manage.* 31:827-829.
- Pickford, G. D., and E. R. Jackman. 1944. Reseeding eastern Oregon summer range. *Oreg. Agric. Exp. Sta. Circ.* 159. 48 pp.
- Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. *Manual of the Vascular Flora of the Carolinas.* Univ. N. C. Press, Chapel Hill. 1183 pp.
- Robel, R. J. 1969. Food habits, weight dynamics, and fat content of bobwhites in relation to food plantings in Kansas. *J. Wildl. Manage.* 33:237-249.
- Schneeweis, J. C. 1972. Food habits of deer in the Black Hills. *S. Dak. Agric. Exp. Sta. Bull.* 606.
- Schwendiman, J. L. 1957. Well managed conservation seedings help wildlife. *Wash. Agric. Exp. Sta. Circ.* 295. Pages 31-33.
- Scott, T. G., and G. O. Hendrickson. 1936. Upland game birds in Iowa. *Iowa Ext. Serv. Circ.* 228. 32 pp.
- SCS. 1984. White clover. *USDA Soil Conserv. Serv., Mississippi Planting Guide.* Page 13.
- Shaw, A. F., and C. S. Cooper. 1973. The interagency forage, conservation, and wildlife handbook. *Mont. State Univ. Ext. Serv., Bozeman.* 205 pp.
- Smith, D. 1962. *Forage Management in the North.* William C. Brown Book Co., Dubuque, Iowa. 219 pp.
- Smith, D. C. 1940. The relation of color to germination and other characteristics of red, alsike, and white clover seeds. *J. Am. Soc. Agron.* 32:64-71.
- Stefferd, A., ed. 1948. *Grass. Yearbook of Agriculture.* U.S. Gov. Printing Off., Washington, D.C. 892 pp.
- Stevens, D. R. 1966. Range relationships of elk and livestock, Crow Creek drainage, Montana. *J. Wildl. Manage.* 30:349-363.
- Stewart, W. G. 1970. Irrigated pastures for Colorado. *Colo. Ext. Serv. Bull.* 469A. 26 pp.
- Stoddard, H. L. 1946. *The Bobwhite Quail.* Charles Scribner's Sons, Inc., New York. 559 pp.
- Swenk, M. H., and F. F. Selko. 1938. Late autumn food of the sharptailed grouse in western Nebraska. *J. Wildl. Manage.* 2:184-189.
- Thornburg, A. A. 1982. Plant materials for use on surface mined lands in arid and semiarid regions. *U.S. Dep. Agric. SCS-TP-154; EPA-600/7-79-134.* 88 pp.

- Troeh, F. R., J. A. Hobbs, and R. L. Donahue. 1980. Soil and Water Conservation for Productivity and Environmental Protection. Prentice-Hall, Inc., Englewood Cliffs, N.J. 718 pp.
- Turelle, J. W., and W. W. Austin. 1967. Irrigated pastures for forage production and soil conservation in the West. USDA Farmers Bull. 2230. 22 pp.
- Vogel, W. G. 1981. A guide for revegetating coal mine soils in the Eastern United States. U.S. For. Serv. Gen. Tech. Rep. NE-68. 190 pp.
- Wallestad, R., J. G. Peterson, and R. L. Eng. 1975. Foods of adult sage grouse in central Montana. J. Wildl. Manage. 39:628-630.
- Wallmo, O. C., W. L. Regelin, and D. W. Reichert. 1972. Forage use by mule deer relative to logging in Colorado. J. Wildl. Manage. 36:1025-1033.
- Wasser, C. H. 1982. Ecology and culture of selected species useful in revegetating disturbed lands in the West. U.S. Fish and Wildl. Serv. FWS/OBS-82/56. 347 pp.
- Wheeler, W. A. 1950. Forage and Pasture Crops. D. Van Nostrand Co., Inc., New York. 752 pp.
- White, M., and S. W. Harris. 1966. Winter occurrence, foods, and habitat use of snipe in northwest California. J. Wildl. Manage. 30:22-34.