Verbascum thapsus

Common-Name: Common Mullein

The following description of *Verbascum thapsus* is taken from Abrams (1951), Munz and Keck (1973), and Gross and Werner (1978).

Verbascum thapsus is a biennial, perennial or, rarely, an annual with a deep tap root. In its first year it produces a low vegetative rosette up to 60 cm in diameter which overwinters and is followed in the succeeding growing season by a stout flowering stem 5-18 dm tall. The basal leaves are oblong-obovate to obovate-lanceolate and 10-40 cm long including the petiole. The flower stem is longitudinally ridged by the bases of decurrent leaves and is densely woolly with branched hairs. Cauline leaves are elliptic-lanceolate, decurrent, and gradually reduced up the stem.

The inflorescence is a spike-like raceme 20-50 cm long and approximately 3 cm in diameter. It is usually very dense; rare axillary racemes may arise from the upper leaves. The sessile flowers are usually one per axil with pedicels less than 2 mm and slightly irregular with rotate corollas. The calyx consists of 5 lanceolate or ovate sepals, 7-9 mm long with caudate tips. The corolla is 20-25 mm broad consisting of five yellow (rarely white) petals.

Fruit is an ovoid, stellate-pubescent capsule 3-6 mm long, which splits into two valves at maturity. There are numerous brown seeds, 0.5-1.0 mm long which are six-sided and have angular lateral surfaces with rows of pits.

Verbascum thapsus is native to Europe and Asia (Semenza et al. 1978). It was probably introduced into North America several times as a medicinal herb. It was introduced in the mid-1700s to Virginia as a piscicide (fish poison) and spread rapidly. It quickly became so well established that an 1818 flora of the East Coast described it as a native. By 1839 it had spread as far as Michigan (Gross and Werner 1978) and became widely naturalized on the Pacific Coast by 1876 (Brewer et al. 1876).

Since ancient times *V. thapsus* has been used as an anodyne- pectoral and remedy for coughs and diarrhea. The leaves may provide some stimulatory effects when smoked. Mullein was recorded by Aristotle as a fish poison. It is often grown as an ornamental. A methanol extract from the plant has been effective against mosquito larvae (Gross and Werner 1978).

Mullein is currently found in neglected meadows and pasture lands, along fence rows and roadsides, and in industrial areas throughout North America (Spencer 1957, Semenza et al. 1978). It occurs in areas where the mean annual precipitation is 50-150 cm and the growing season is at least 140 days. Dry sandy soils are preferred but mullein is common in chalk and limestone districts in England. In Canada it grows abundantly in, but is not restricted to, pastures with well-drained soils and a pH of 6.5-7.8 (Gross and Werner 1978).

Mullein may produce 100,000-180,000 seeds per individual plant, each seed averaging 0.067 mg (Gross 1980, Gross and Werner 1982). Seeds have no specialized structures for long distance dispersal. The capsule splits open when mature; movement of the stalk by wind or a large animal is required to release the seeds from the parent. Seeds are dispersed as far as 11 m, although 93% of them fall within 5 m of the parent plant (Gross and Werner 1978).

Seeds may remain viable for over 100 years (Kivilaan and Bandurski 1981), and viable seeds have been found in soil samples archaeologically dated from A.D. 1300 (Gross and Werner 1978).

Mullein seeds may germinate under a wide variety of environmental conditions (Semenza et al. 1978). Germination is completely inhibited below 10 C and at constant temperatures above 40 C (Semenza et al.

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1978). Chilling during the winter lowers the temperature requirement for germination, thus seeds brought to the surface in the autumn by soil disturbance are able to germinate early the next spring (Baskin and Baskin 1981).

Semenza et al. (1978) found that only 35% of seeds germinated in the dark, compared to 93% germination in the light. This light sensitivity varies seasonally (Gross 1984), but on the whole, only those seeds which lie at or near the soil surface (0.5 cm or less) will be able to germinate (Gross 1980). If seed burial occurs due to subsequent disturbance or heavy rains rapidly sifting the seeds below the soil surface, germination may be reduced or prevented altogether through light deprivation (Gross 1980).

If mullein seeds are already present in the soil, mullein seedlings are likely to be the initial colonists in newly disturbed sites because the seeds ar e viable for so long. If the seeds are not present when the disturbance occurs or when a field is abandoned, then the limited dispersal ability of seeds will probably not enable mullein seed to arrive and establish while bare ground is still available. Gross and Werner (1982) observed mullein seedlings to emerge almost entirely on bare sites.

Gross (1984) compared seedling emergence on bare and vegetated sites. On bare soil 50% of the total emergence occurred within 9 days of sowing. This took 30 days on vegetated soils. Seedling growth rates were 4-7 times faster on bare soils, producing 2000 times more biomass within the same time period (Gross 1984). Seedlings did not establish in small experimentally created openings (15 x 15 cm), but they did colonize larger openings (0.5 square meters or more) such as those created by animal digging. The necessity of bare ground for seedling emergence and establishment means that there is only a narrow "window in time" during which mullein colonization may occur (Gross and Werner 1982). Within this time frame, the earliest emerging seedlings have the highest probability of successful establishment (Gross 1980).

Seedling emergence is limited by its rosette growth form. Its lateral spread does not enable it to rapidly grow above surrounding vegetation to reach stronger light (Gross and Werner 1982). In bare soils this growth form may be a very effective mechanism for suppressing growth and emergence of nearby seedlings (Gross 1984).

During the first summer after germination, a plant produces a tap root and a rosette of leaves. During this vegetative stage the plant increases in size throughout the growing season and is vernalized by low temperatures in autumn and winter (Baskin and Baskin 1981). Vernalization is required to induce flowering the following spring (Gross 1981).

Most rosettes less than 15 cm in diameter at the arrival of winter have a high (greater than 63%) chance of dying before the end of their first winter. Rosettes that are less than 9 cm in diameter by October of their first year do not flower. The probability of flowering increases steadily with rosette size. All rosettes with a diameter greater than 41 cm by October flower the subsequent year (Gross 1981).

Flowering begins in late June of the second year and peaks in early August (Gross and Werner 1978). Rarely do plants remain vegetative for a third year (Gross 1981). Flowers mature on the stalk from the bottom to the top in successive spirals. At any one point in time these flowers appear in a loose spiral pattern up the raceme. Growth of the stalk is indeterminate. The length of the flowering period appears to be a function of stalk height. Taller stalks continue to flower into late September and early October (Gross and Werner 1978).

Although the flowers are visited by a wide variety of insects, only short- and long-tongued bees are effective vectors for cross-pollination. Flowers are also autogamous, self-pollination occurring at the end of the day if cross-pollination has not occurred (Gross and Werner 1978). After this single reproductive event the entire plant dies (Baskin and Baskin 1981). Vegetative reproduction was not observed by any of the authors cited.

Verbascum thapsus populations are likely to be ephemeral at a particular site once they have colonized it. This is due to the necessity of bare ground for seedling emergence combined with the fact that mullein is monocarpic. The persistence of any population depends upon its ability to continually recolonize the local area. The rate of recolonization depends upon the local distribution and abundance of patches of bare ground therein. The rapid reduction of bare ground within an early successional field can result in only a single germination successfully reproducing before the population "disappears" into a dormant seed pool (Gross and Werner 1982).

A population of *V. thapsus* may extend over several hectares or along several kilometers of roadway. Salisbury (1942) reported densities of 5.2 flowering plants/square meter in coppiced woodlands in England two years after they were cut. A three-year-old field observed by Gross and Werner (1978) had an average density of one flowering plant per square meter and a mean height of about 1.2 m. The following year there were only 0.021 rosettes per square meter, despite an abundant seed crop the previous spring. All of these rosettes were immature, non- flowering plants. No seedlings were found. Plants within a 12-year-old field were found at a lower density than that of the three-year-old field (0.17/square meter) and were much shorter (48 cm). Gross and Werner (1978) concluded that mullein populations are quite ephemeral in undisturbed sites, depending heavily on long-lived seed pools for long-term species survival.

Mullein is easily outcompeted in areas with a densely vegetated ground cover but readily grows in disturbed sites. Because of its low dispersal rate, the establishment of mullein in a particular site depends primarily on the presence of dormant seeds in the soils. It is an ephemeral plant which is eventually displaced by other plants in undisturbed sites.

V. thapsus occurs on TNC's Santa Cruz Island, Northern California Coast Range, and McCloud River preserves in California.

Manual removal of plants before flowering, the establishment of a dense vegetative cover, and minimizing the availability of bare soil are probably adequate to control mullein.

Monitoring is needed to determine the effectiveness of management practices.

Detailed observations focused on the vegetational change of the affected area over time will help to determine what method of control would be most efficient.

No quantitative monitoring studies of mullein were discovered in this research. Since it is not considered a major agricultural weed in California, there is apparently little interest or funding available for detailed sampling programs. Whatever monitoring may be done is probably qualitative: Has it invaded a site? Does it re-establish itself following control treatment?

Does mullein significantly outcompete native plant species? Does the establishment of mullein alter the local natural plant succession? Casual observation suggests the persistence of mullein in open, sunny areas. Does mullein truly persist in the same area for many years? What factors contribute to its persistence?

Weed control involves three fundamental objectives: prevention, eradication and control.

From a practical viewpoint, methods of weed management are commonly categorized under the following categories: physical, managerial, biological, chemical controls, and prescribed burning (Watson 1977). Physical methods include both manual and mechanical methods. Managerial methods include the encouragement of competitive displacement by native plants and prescribed grazing. Biological control is usually interpreted as the introduction of insects or pathogens which are highly selective for a particular weed species. Chemical control includes both broadcast and spot application. Prescribed burning includes both broadcast burning or spot treatment with a flame thrower.

The most desirable approach is that of an integrated pest management plan. This involves the optimum use of all control strategies in an attempt to control weeds. This approach is generally accepted as the most effective, economical, and environmentally sound, long-term pest control strategy (Watson 1977). The use of various control techniques should be compatible with each other. Broadcast herbicide application, for example, may not work well with certain managerial techniques (i.e., plant competition).

Manual methods of control use hand labor to remove undesirable vegetation. These methods are highly selective and permit weeds to be removed without damage to surrounding native vegetation.

The Bradley Method is one sensible approach to manual control of weeds (Fuller and Barbe 1985). This method consists of hand weeding selected small areas of infestation in a specific sequence, starting with the best stands of native vegetation (those with the least extent of weed infestation) and working towards those stands with the worst weed infestation. Initially, weeds that occur singly or in small groups should be eliminated from the extreme edges of the infestation. The next areas to work on are those with a ratio of at least two natives to every weed. As the native plant stabilizes in each cleared area, work deeper into the center of the most dense weed patches. This method has great promise on nature reserves with low budgets and with sensitive plant populations. More detailed information is contained in Fuller and Barbe (1985).

Hand Pulling: This method may be used to destroy the seedlings of any weed. Seedlings are best pulled after a rain when the soil is loose. Plants should be pulled as soon as they are large enough to grasp but before they produce seeds. Pulling the rosettes before flowering will prevent the deposition of more seeds into the soil, although there may still be a large dormant seed reserve underground.

Hand Hoeing: Plants can be destroyed readily while they are still small by hand hoeing, either by cutting off their tops or by stirring the surface soil so as to expose the seedlings to the drying action of the sun. The object of hoeing is to cut off weeds without going too deeply into the ground and doing damage to the roots of desirable vegetation.

Hand Digging: The removal of rootstocks by hand digging is a slow but sure way of destroying mullein. Such a technique is only suitable for small infestations and around trees and shrubs where other methods are not practical.

Mechanical methods of control use mechanized equipment to remove above-ground vegetation. Two common mechanical methods are scarification and mowing.

Scarification: Scarification involves the use of plows or discs to uproot plants. This technique results in various degrees of soil disturbance and may create erosion problems. Soil disturbance is likely to provide excellent bare ground areas highly suited for mullein establishment. This technique is not recommended except in regularly plowed fields. Regular cultivation is adequate to control mullein (Gross and Werner 1978).

Chopping, Cutting or Mowing: Mullein may be trimmed back by tractor-mounted mowers on even ground or by scythes on rough or stony ground. If only a simple cutting can be made, the best time is when the plants begin to flower. Repeated mowing will prevent the flower stalk from bolting, but the basal rosette will increase in size. If mowing is discontinued, the plant will then bolt and produce flowers. Damage to the terminal raceme (e.g., clipping) will cause increased growth of axillary branches (Gross and Werner 1978).

Biological Competition: Sowing native plant species which have the potential to outcompete weedy exotics for important resources is usually a preventive method of weed control. In some cases later successional plants may be encouraged to take root among the unwanted vegetation. Once established these may displace the mullein by competing for water or nutrients or by shading out the lower growing plants.

Prescribed Grazing: The dense cover of trichomes on the leaves makes mullein unpalatable to cattle and sheep. Because livestock avoid eating mullein, its presence in overgrazed or poor pastures represents a further degradation of the pasture (Gross and Werner 1978).

In many areas of California the use of Angora and Spanish goats is showing promise as an effective control for weedy species such as poison oak, scotch broom, blackberries, pampas grass, giant reed, and thistles (Daar 1983). With such a broad diet, goats may also be effective in controlling mullein.

Chickens, surprisingly enough, are known to effectively digest (and destroy) all weed seeds passing through their crops and they can thoroughly graze back vegetation in areas up to one acre in size. Releasing chickens into an area after the mature plants are removed allows them to scratch and peck out weed seeds and potentially reduce the weed seed bank in the soil (Andres 1979).

The term "biological control" is used here to refer to the use of insects or pathogens to control weeds. The introduction of exotic natural enemies to control plants is a complex process and must be thoroughly researched before implementation to prevent biological disasters. Such tools are not normally suitable for preserve managers to implement.

Insects: A curculionid weevil (G*ymnaetron tetrum*), specific to *V. thapsus*, was introduced to North America from Europe before 1937. The larvae mature in the seed capsules and destroy up to 50% of the seeds. There are eight other species of Coleoptera which are injurious to mullein but have not been reported in North America (Gross and Werner 1978).

Pathogens: Two organisms which cause disease in *V. thapsus*: *Erysiphe cichoracearum* [powdery mildew] and *Phymatotrichum omnivorum* [root rot]) are also destructive to economically important plants such as various vegetables and cotton (Gross and Werner 1978). The USDA (1960) lists additional micro-organisms on *V. thapsus*: *Cercospora verbasciola, Phoma thapsi, Phyllosticta verbaciola, Heterodera maroni, Meloidogyne sp., Mycosphaerella verbasciola, and Ramularia variabilis.* Westcott (1960) also reports *Septoria verbasciola* and *Oidium pyrinum* on mullein. Six species of leaf-inhabiting, parasitic fungi are reported also (USDA 1953).

Please notify the California Field Office of The Nature Conservancy of any field observations in which a native insect or pathogen is observed to have detrimental effects on mullein. These reports will be used to update this Element Stewardship Abstract. Management techniques which may encourage the spread of such species-specific agents may be desirable in controlling *Verbascum*.

Detailed information on herbicides are available in such publications as Weed Science Society of America (1983) or USDA (1984), and will not be comprehensively covered here. This publication gives specific information on nomenclature, chemical and physical properties of the pure chemical, use recommendations and precautions, physiological and biochemical behavior, behavior in or on soils and toxological properties for several hundred chemicals.

Broadcast application of herbicides have become the mainstay of most weed control efforts today. This may be due to the illusion that it is a "quick fix" method of eradicating undesirable vegetation. Most herbicides so applied are non-selective and will kill most, if not all, of the vegetation sprayed. Those species which survive the treatment may, after repeated sprayings, form an herbicide-resistant vegetation cover, thus creating a moredifficult problem to deal with. Such broadcast spraying may also killoff native plants which have the ability to outcompete exotic weeds.

Broadcast herbicide application may be most effective where the weed infestation is very dense and needs to be killed and desiccated prior to burning. It may also be useful following the removal of mature plants so as to reduce the soil seed bank.

A single application of a 2,4-D/2,4,5-T mixture of 16 oz/acre in June or early September (the rosette stage) supposedly provides control of *V. thapsus*. Muzik (1970) reported that the epidermal hairs on the leaves protect the plant from aqueous solutions of 2,4-D because the droplets are held away from the leaf surface. Lade et al. (1974) suggested that good long-term control can be achieved with an initial application of Tebuthiuron at 4-6 lbs/acre. Repeated applications at half the initial rate will suppress regrowth.

Spot chemical methods consist of various techniques for manually applying herbicides to individual plants. These methods are highly selective as only specific target plants are treated. Spot applications are most efficient when the density of stems to be treated is low. In applying herbicides it is recommended that a dye be used in the chemical mixture to mark the treated plants and thus minimize waste.

Jones and Stokes Associates (1984) reviewed a variety of spot chemical techniques. The following is an excerpt from this report. The two techniques are listed in order of increasing possibility of herbicide exposure to the environment or to humans in the vicinity of treated plants.

Basal/Stem sprays: High concentrations of herbicides in oil or other penetrating carriers are applied, using backpack sprayers, to the basal portion of stems to be killed. The oil carrier is necessary for the mixture to penetrate the vascular system. This method gives good root kill, especially in the fall when vascular fluids are moving toward the roots.

Herbicide pellets: Pelletized or granular herbicides are scattered at the bases of unwanted plants. Subsequent rainfall dissolves the pellets and leaches the herbicide down to the root system. The optimal time for treatment is towards the end of the rainy season. This minimizes leaching of the chemicals beyond the root zone.

Flame Thrower: A flame thrower or weed burner device can be used as a spot treatment to heat-girdle stems. This technique has the advantages of being less costly than basal and stem herbicide treatments and is suitable for use during wet weather and snow cover; it cannot be used during periods of wildfire hazard.

Broadcast Burning: Large areas of weed infestation may be burned in order to remove the standing mature plants. This may be accomplished with a pre-spray of herbicide to kill and desiccate plants. Burning is best followed by either repeated burning, to exhaust the soil seed bank or by revegetation with fast growing, aggressive native species.

Mullein depends on the presence of bare soil to germinate and establish. Because of their longevity, seeds may accumulate over a long period of time and establish readily in freshly disturbed sites. Management suggestions include the use of a pre-emergent herbicide to reduce the viable seed bank. This is unnecessary where land is left undisturbed. Manual removal of rosettes before the development of a sizeable tap root, or at least prior to flowering, with minimal soil disturbance would be the most cost-effective control technique. Encouragement of a dense vegetative ground cover would also reduce seedling establishment success.

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