Use of Goats in the Control of Gorse (*Ulex europaeus*)

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April, 2005

I INTRODUCTION

Gorse is native to western and central Europe, where it has been used for centuries as hedgerows and as reserve livestock forage and fodder. European emigrants have introduced gorse to over 15 countries or island groups worldwide. In New Zealand, gorse was once planted on large estates for the provision of sheep forage on land too poor to grow other crops (EPA). Gorse has become a major weed of agriculture and forestry on the West Coast of the U.S, and Canada, as well as in New Zealand, northwest Spain, Tasmania and Australia, and at high altitudes in Hawaii (EPA). Gorse is one of Tasmania's most widespread and troublesome weeds (http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/RPIO-4ZW4ET?). In California, gorse is found at elevations up to 400 m (1300 ft) in the eastern South Coast Ranges, South Coast and Peninsular Ranges, northern and central Sierra Nevada foothills, the San Francisco Bay region, western North Coast Ranges and on the North Coast into British Columbia.

Gorse is an early successional species found on disturbed sites, sand dunes, old fields, pastures, logged areas, and burned sites, particularly where winters are mild and some moisture is available year round. Gorse is extremely competitive, displacing cultivated and native plants. Gorse typically forms dense impenetrable thickets that exclude other vegetation and increase fire hazard. Mature plants contain some 2-4 % flammable oils. Older shrubs develop a central mass of dead material and are particularly flammable (CDFA, http://www.cdfa.ca.gov/phpps/ipc/weedinfo/ulex.htm).

Because of various allelopathic mechanisms, the soil is often bare under and between gorse plants, which increases erosion on steep slopes where gorse has replaced grasses or forbs. Spiny and mostly unpalatable when mature, gorse reduces pasture quality where it invades rangeland (EPA). The ability of gorse to fix atmospheric nitrogen enables it to colonize and dominate areas with poor soils. Gorse tolerates most soil types, including those derived from serpentine, but seldom grows in high calcium soils. It does best on acidic (pH 4.5-5.0) soils, and the thick litter produced by gorse tends to acidify the soil. Gorse extracts and retains nutrients such as calcium, magnesium, and sodium, which can change site nutrient dynamics and impoverish the soil.

Although it does not survive severe winter cold or arid climates, frost-damaged gorse can resprout from the crown. Day length may also affect its latitudinal distribution, as short-day conditions inhibit maturation and prevent thorn formation and flowering. Gorse prefers moderate to full sunlight and can die if heavily shaded. Gorse usually colonizes difficult terrain and inaccessible areas that escape routine mowing or cultivation (EPA). Its thick cuticle, prolific production of durable seed, and ability to resprout from stumps

and roots make gorse difficult to control once established. Repeated control efforts over several years are typically required to effectively suppress gorse (EPA).

II BOTANY

Gorse [*Ulex europaeus* L.] is a member of the legume family, Fabaceae. It produces an extremely deep and extensive root system, accessing water at great depth in the soil. Gorse stems and leaves end in a sharp spine, making the plants impenetrable to animals and unpalatable to livestock, except goats. The dark green leaves and stems are ridged and covered with a waxy cuticle to minimize water loss. This feature, coupled with its deep root system, allows gorse to proliferate in areas of very low rainfall (CDFA).

Life Cycle

Germination can occur year round when conditions are favorable. Most seeds germinate after the first fall rains, at roughly the same time as annual grasses and forbs. Fire, soil disturbance, and/or moisture can stimulate germination (EPA). Gorse seedlings and resprouts flower within six months to a year. Gorse flowers are bright yellow, pea-like, approximately 20mm long, and are borne all over the plant. The flower buds develop during February and March, however flowering occurs in two distinct seasons, spring and autumn. A small number of flowers may be present at other times if climatic conditions permit. The flowers are primarily pollinated by bees.

Seed pods mature as early as May in California, but not until mid to late summer in Oregon and Washington. When mature, the seed pods burst open, projecting seed up to 5 yards from the mother plant. Seeds may disperse to greater distances with human activities, water and soil movement, animals, and ants. Annual seed production averages 400 to 500 seeds per square yard; a mature stand of gorse can generate an annual seedbank of some 2 million seeds/acre. Gorse can also be spread by sprouting from roots or by rooting where branches contact soil. Plants may live for up to 30 years and seeds remain viable in the soil for up to 40 years.

III CONTROL

A) Fire

Controlled burns have been used to manage gorse worldwide for decades. If correctly timed, burning will reduce gorse biomass, destroy seeds still on the plants, kill seedlings, and reduce the number of years subsequent treatments will be needed to exhaust the seedbank (EPA). Burning may actually increase the density of gorse infestations over time by stimulating the germination of gorse seed beneath the burned bushes. At the same time, burning will destroy much of the grass beneath gorse, reducing competition for gorse seedlings. For all of these reasons, burning should not be undertaken unless it is part of an overall strategy employing other complimentary management practices.

Even if all above ground parts of the plant are destroyed by fire, gorse will often regenerate from its lignotuber, a swollen, modified stem section at its base. Burning can

be useful when combined with grazing by sheep or goats as it reduces the amount of foliage and stems and stimulates growth of softer green shoots which are far more palatable to grazing animals.

Fire can be very useful in reducing impenetrable thickets of gorse to ground level, to allow follow up herbicide spraying or grazing of regrowth. Fire will also stimulate seed germination, allowing a high proportion of the seedlings to be sprayed or grazed the following year, greatly reducing the seed bank. Burning is also beneficial when carried out several months after spraying when, under the best conditions, it reduces dead woody stems to ashes.

Gorse burns readily and extreme care should be taken when burning gorse near desirable vegetation, fences or buildings. Gorse growing under high voltage power lines should not be burned without consulting the power company, as gorse smoke is electrically conductive and can cause arcing from the high tension line to the ground.

Temperatures of 100°C (212°F) or more sustained for 15 minutes are required to kill gorse seed. During a typical prescribed burn, this degree of heat penetrates only about 1/2 of an inch of the soil surface. Slightly lesser temperatures actually break gorse seed dormancy, causing increased germination. Seeds heated to 80°C (176°F) for fifteen minutes will give 100% germination in the laboratory in about 12 days (EPA). Burning often stimulates a flush of seedling germination after the first rain following fire (CDFA). Burning efficacy can be improved by crushing the gorse first, allowing it to dry, and then burning against the wind.

B) Biological Controls

a. Insects

The gorse seed weevil (*Apion ulicis*) and spider mite (*Tetranychus lintearius*) are introduced biocontrol agents currently established in California. The seed weevil reduces gorse seed production, but cannot kill established stands. Heavy mite infestations can kill branches and are apparent by the dense webbing that covers the foliage (CDFA).

Apion ulicis is established in the western U.S. and is probably present in any well-established gorse patch. The weevil is blackish, pear-shaped, and 1/2 inch long, with a long curved snout. It lives on the gorse plant throughout all of its life stages. It is a strong flyer and can spread naturally over long distances, even over mountains. The female feeds on the blossoms, chewing a hole in the wall of the young seed pod through which she lays a cluster of about 10 yellow eggs. Four weeks later the eggs hatch into larvae and feed on the seed (EPA).

Weevils mate in the spring and can destroy up to 90 percent of the spring seeds, but *A. ulicis* has not been effective in controlling gorse either in New Zealand, where it was introduced in 1931, or in the U.S. Gorse flowers twice a year in temperate climates, and weevils have no effect on seeds maturing in fall and winter. Even heavily weevil-infested gorse patches continue to produce seed. Control practices such as burning often drastically reduce weevil populations. Even though the weevil does not provide

significant gorse control on its own, it does reduce spring seed production and damage foliage, which contributes to overall gorse suppression.

Larvae or pupae of *A. ulicis* can be found inside brown and hardened seed pods from early to late summer. To encourage the weevil, infested gorse plants should be allowed to persist to serve as a nursery for *A. ulicis* and help insure that it will be present in sufficient numbers to help suppress future gorse growth.

Tetranychus lintearius, a spider mite, was released in Oregon and California in 1993 and 1994. The mite has increased in numbers at almost all release sites and there has been some dispersal from the original sites; however, it is still too early to determine its impact. *T. lintearius* is one of the few biocontrols that actually kill gorse plants. Heavy infestations kill branches and produce a heavy webbing over the bush. The gorse mite does not hybridize with pest mite species and has remained specific to gorse in areas of release. The mite is killed by herbicides that are used to control gorse (EPA).

The gorse thrip (*Sericothrips staphylinus*) is a foliage feeder and was released in Tasmania in 1998. Its impact in the field is currently under investigation. This insect feeds on new growth and must be physically distributed because it is flightless. It has been successfully established in Hawaii but is not yet available in California (EPA).

The gorse soft shoot moth (*Agonopterix ulicitella*), also a foliage feeder, and the gorse pod moth (*Cydia succedana*), which destroys seeds in both spring and autumn, are additional agents that will be released in Tasmania and are expected to compliment the effects of other gorse agents already present there (Tasmanian Institute of Agricultural Research).

As with all biological control agents, these insects, if successful, will compliment gorse management. They will not destroy all gorse plants alone, and must be used in conjunction with other activities for maximum effect.

b. Cultural control

A British web site (http://www.konsk.co.uk/design/bracken.htm) reports the use of (native) gorse as a nurse species for forest tree reestablishment. This approach may have application on Marin RCD sites where conversion to woodland is the desired objective Planting acid-tolerant, fast-growing trees in gorse thickets may eventually shade out gorse without further management efforts. The technique has been used successfully in Oregon, New Zealand, and to a limited extent in Hawaii (EPA). To create planting spaces within the gorse patch, gorse plants, including root crowns, are removed by hand. Removing the plants randomly or in a checkerboard pattern results in a more natural appearing tree cover, but rows allow easier access for planting and maintenance. As tree seedlings are vulnerable to rodents sheltering in the gorse patch, they should be protected with a tree tube or wire cage. Tree seedlings should be at least 18 inches tall and 5/16 of an inch thick at the base or they may have difficulty competing with the gorse. The gorse must be kept cut back so it does not overtop the tree seedlings. It takes 10 to 15 years for

the shade from the trees to kill the plants and it is unlikely that all the gorse on a site will die due to this treatment (EPA).

C) Grazing

Gorse seedling establishment can be greatly reduced with suitable grazing management, however larger plants that are completely stripped of foliage generally recover unless bark stripped and grazing pressure is maintained for a sufficient length of time (An Peischel, pers.com. 2005).

According to LandCare Australia (2004), grazing alone will not control gorse, and is most effective after fire. Best control is achieved with high stocking rates, and goats are the most effective livestock. They prefer young shoots and flowers and can reduce bushes to stumps. Heavy grazing by sheep, goats or cattle may be effective in reducing shoot regrowth following a fire or after cultivation, but will rarely kill established plants. Grazing animals often pull out seedlings, roots and all.

Grazing by sheep is moderately effective for controlling gorse seedlings. After a gorse infestation has been removed and pasture established, it can be maintained by periodic heavy grazing by sheep during the spring and summer to prevent the establishment of gorse seedlings. Grazing needs to be carefully managed to avoid overgrazing and subsequent pasture damage, which would leave the area open to reestablishment of gorse

Sheep will browse gorse during spring or when alternative feed is in short supply. However significant control of established plants cannot be achieved with sheep unless large numbers are confined to gorse patches for most of the year. Goats prefer to browse young gorse shoots rather than graze actively growing pasture. They remove flowers and, browse gorse to stumps when the stocking rate is high enough. Unfortunately, well established gorse is not readily killed by browsing and is capable of recovery if the goats are removed from the area, even after several years of browsing.

In the gorse infested country of the New Zealand Midlands, Angora wethers are considered ideal for gorse control. Gorse is a moderately nutritious fodder and Angora goats will produce reasonable yields of mohair while browsing it. Gorse is not high enough quality feed for breeding does, however and is also estrogenic. As a result, gorse can be a problem for does going into the breeding season, although off season browsing of gorse is fine for does (An Peichel, pers. com., 2005). In areas where medium to high quality pasture is also available, breeding stock can be used. Cashmere and meat goats are also suitable for gorse control but sturdier fences are required for these larger goat breeds.

New Zealand experience suggests that a stocking rate of 3 Angora wethers per hectare of gorse infestation will contain gorse, while a rate of 5-6 wethers per hectare of gorse will almost totally prevent regrowth after burning. These stocking rates apply where sheep also graze the area, however, and are probably much too low except under continuous stocking, which, over the long term, is incompatible with native plant restoration objectives. This approach, however, might work to sustain non-specific herbaceous

cover while preventing gorse reestablishment in the initial phases of a gorse eradication program. To the extent practical, goats should be confined to gorse-infested areas to avoid possible negative impacts on desired vegetation.

Numerous New Zealand and Australian studies indicate that grazing by goats can be less costly than mechanical and chemical control methods. Goats can graze areas too steep or uneven for machinery, and do not pose the environmental dangers inherent with herbicides (EPA). Destruction of mature stands by cutting or burning, followed by high-density goat grazing (60 to 75 goats/acre), followed by a rotation of goats (25 goats/acre) and sheep (10 sheep/acre) may be most effective. Rotational grazing with cattle, then sheep, then goats is also effective. Cattle trample and kill some plants and make access easier for sheep and goats. Sheep then eat the remaining herbaceous forage, leaving the goats nothing but gorse (EPA).

The suggested New Zealand strategy is to burn the gorse immediately before the stock is introduced to the area. It should then be stocked with goats supported by large numbers of sheep during spring and early summer to reduce pasture availability, thereby forcing the goats onto the gorse. Presumably a period of vegetation recovery occurs prior to stocking the site. Goats prefer gorse to pasture during spring but will graze pasture readily in late summer-autumn when it has dried off. Reducing pasture carryover with sheep in the spring means that goat browsing pressure can be maintained on the gorse throughout the growing season.

Gorse may need to be grazed for at least five consecutive years to exhaust the soil seedbank and achieve complete kill of existing plants (EPA). Exclosures may be needed to protect patches of native or desirable vegetation within the treated area. According to "The Goat Farmer", a New Zealand journal web site, (http://www.caprine.co.nz/wa.asp?idWebPage=3278&idDetails=105), gorse can be successfully managed with subdivision and rotational grazing of goats. Goat productivity is improved by offering goats a mixed diet of both gorse and pasture. Removing mature plants first, allowing goats access to higher quality regrowth, can greatly assist the control program. Mature gorse can be prepared by crushing or cutting, followed by burning, allowing easy access by goats to regrowth. Goats can also be encouraged to graze into dense areas by feeding supplements such as hay in these areas. Browsing and trampling by goats can greatly reduce seedling establishment and crown re-growth (CDFA).

One successful New Zealand treatment involved gorse reduction with goats, followed with pasture seeding and fertilization and pasturing with sheep, which has kept the area gorse free. Multiple web postings by folks in New Zealand who have used goats, or seen them used, on gorse can be found at: http://www.lifestyleblock.co.nz/forum/topic.asp?TOPIC_ID=11357.

D) Physical Controls

Physical controls for gorse consist of removing plants by hand, or with machinery. As with grazing, after plants have been physically removed, gorse sprouting from the seedbank must be treated for several consecutive years. Mulching can be used as needed after removal. Stems of gorse plants can be chipped and used as mulch on site, as long as care is taken not to include live root fragments (EPA).

Regular slashing or mowing is not effective in eradicating gorse. These practices will eliminate most seed production and maintain plants at a low height, but plants will regrow vigorously if slashing ceases. Mechanical clearing is an ideal method of controlling large infestations on land that is suitable for sowing down to pasture. Bulldozers with rippers, or medium to heavy tractors with dozer blades and rippers attached can be used. Cutting off established bushes near the soil surface with dozer blades or hard equipment is another option. This treatment reduces soil disturbance, thereby stimulating less seed germination. In either case, follow-up management is vital for long term success. This includes establishment of a vigorous pasture to provide competition, grazing of gorse seedlings, and herbicide use on plants surviving grazing.

1 Manual Removal

Where gorse infestations are relatively small, manual removal can be effective. Manual removal can be applied selectively to individual gorse plants without disturbing other vegetation, and can be used on steep or uneven terrain (EPA). Seedlings can be killed by grubbing them out or cutting below the cotyledons. Young plants can be pulled by hand or with a weed wrench. If not thoroughly removed, root crowns will resprout. Plants should be pulled before they set seed and when the soil is moist in order to facilitate the removal of root crowns and root systems. Along the Pacific Coast, November through March is optimal for this activity. Missed portions of plants will resprout, and new seedlings will continue to develop from the seedbank for several years (EPA).

Plants too large to pull should be cut to the ground using a blade, pruning shears, hand saw, powered brush cutter, or chain saw. To minimize resprouting of stumps not removed, gorse should be cut when it has just started to flower, when food reserves in roots are low and seeds have not been produced (EPA). Plants that are cut and have not yet set seed can be left on the site to help smother regrowth and protect the soil, but should be chipped, composted or burned prior to replanting the site. Root crowns or root fragments may resprout and should be removed from the site or destroyed (EPA).

2 Mechanical Removal

Mechanical control is not selective and can damage desirable vegetation and disturb soil. As with manual removal, control efforts should be timed to pre-empt seed production. Mechanical control efforts must also include follow-up treatments (mechanical or other) to prevent resprouting of treated plants and seedlings. Cutting gorse at the soil surface and cultivating with tractor-driven rototillers has been shown to provide relatively good control if repeated at least once annually for three or four years. Rototillers should be set to till at least four inches deep to insure depletion of the majority of the gorse seedbank as unearthed seeds sprout and are killed by subsequent tilling (EPA).

Chaining by dragging a heavy chain between two bulldozers, has produced good results on San Bruno Mountain, California (EPA). Root raking involves physically lifting the gorse root system out of the ground. Less reliable are disking and rotary slashing, which tend to stimulate coppice growth (EPA).

E) Chemical control

Gorse is sensitive to foliar herbicide treatments during periods of active growth prior to or after flowering. The plant is most vulnerable just after flower drop in the spring or prior to flower drop when the plant is actively growing. By treating resprouts before shoots reach 6 inches in length, the amount of herbicide needed is greatly reduced. Herbicide is most effective when applied in late afternoon (as long as wind is not a problem) to take advantage of sap movement. Plants larger than 3 to 4 feet high should be cut back or burned and allowed to resprout before herbicides are applied. Crushing and burning in the spring, followed by an herbicide application at 4-8 weeks and at 9-12 months later may be highly effective (EPA). Once the soft young stems begin to harden, a surfactant may be needed to help the herbicide penetrate the waxy stems (EPA).

a) Foliar application

The optimum time for herbicide application is when gorse is actively growing. This is generally early spring to early summer, and after the autumn break. Extensive trial work and experience throughout Tasmania indicates that the most effective herbicide for gorse control is a mixture of triclopyr and picloram (e.g. Grazon DS®). Where thorough coverage of the bush can be achieved, one application will usually give complete control with no regrowth. However, treated bushes should be checked twelve months after the herbicide application and any regrowth treated.

Glyphosate and ammonium-thiocyanate are non-selective and will affect grasses, clovers and other broadleaf plants contacted by the spray. This will leave bare areas where gorse seedlings may re-establish.

Irrespective of the herbicide used, regrowth of well established gorse bushes after burning or mechanical control is not suitable for herbicide treatment until it is approximately 500 -1000mm high. Before this point there is not enough leaf area to absorb sufficient herbicide to kill the roots.

b) Cut stump treatment

Stumps of gorse left after removal of the top growth can be painted with an herbicide solution to prevent regrowth. This method of treatment is particularly useful where foliar application of herbicide may cause off-target damage, for example, in treating gorse growing on riverbanks or amongst desirable shrubs and trees. When applied in this manner in Tasmania, Grazon DS® is used at 1 part to 10 parts of water. Alternatively, Tordon Timber Control Herbicide® at one part to 20 parts of water, or 1 part glyphosate-based herbicide to 1 part water may be used. The herbicide solution must be applied immediately after top growth removal.

c) Post-herbicide treatment

In agricultural situations, gorse should be removed after spraying to facilitate the preparation of a seedbed, the sowing of seed and the spot treatment of regrowth. Removal will also reduce the fire hazard created by dead, dry plants. Sprayed gorse should not be removed until full brownout has occurred - at least six months after treatment. Gorse treated in autumn or winter may need to be left for up to 18 months before complete brownout. Burning of dead gorse will encourage the germination of gorse seed and other weeds which will rapidly cover bare areas left after the fire.

F. Integrated Vegetation Management

In most situations, the most effective long term control of gorse will be achieved by employing a combination of methods rather than by reliance on a single approach.

In agricultural situations, burning, cultivation, pasture establishment and grazing can be combined successfully. For shrubland areas, mechanical methods (chainsaw, brushcutter), grazing and revegetation can be combined to control gorse with minimal damage to surrounding vegetation.

In areas where post-treatment pasture establishment is impractical, such as gullies and rocky banks, spraying or cut-stump treatment may be the most economical and effective ways of preventing reinfestation. In these areas, grazing should be strictly controlled to prevent soil disturbance and encourage natural regeneration of grasses and other plants to compete with gorse seedlings.

Revegetation - Follow-up and Prevention

Once gorse has been controlled and the seed bank has been reduced over 2-3 years, it is essential to establish other vegetation to reduce the chance of gorse reestablishment and prevent soil erosion.. If the gorse provides critical habitat for native fauna, suitable replacement shrubs should be planted. On farm land, a strong competitive pasture needs to be established or cropping undertaken. Gorse seedlings are poor competitors and can be suppressed by competitive pasture and normal crop management practices. In non-farming or permanent pasture areas, revegetation with indigenous trees, shrubs and grasses to form a dense canopy can help prevent gorse reestablishment (Landcare, Australia)

Revegetation is critical in preventing gorse or other weed infestations in areas where the soil has been disturbed or the vegetation removed. In some situations is may be possible to encourage desirable vegetation that is already in place. Prior to revegetation, sprouts from gorse root crowns and seedlings should be killed. Return visits to control sprouts may be needed until the gorse seedbank is depleted. In some cases it may not be worthwhile to reseed until the gorse seedbank is depleted, as efforts to destroy new gorse sprouts and seedlings may also destroy the young growth of desired vegetation.

Some areas may be farmed to control gorse. Gorse thickets are first burned under conditions conducive to a hot fire (low relative humidity, high ambient temperatures). After the land is cleared, it can be farmed with hay or other crops for a few years, after

which it can be grazed again. The combined effects of extreme competition from pasture species and gorse de-foliation by grazing livestock has been shown to prevent gorse reestablishment (EPA).

IV CONCLUSIONS AND RECOMMENDATIONS

Gorse is an invasive woody perennial of ecological significance on limited, but growing, acreage within the Marin Resource Conservation District. All sources reviewed emphasized the need for an integrated approach to gorse control, employing some combination of fire, livestock, herbicides, biological control and follow-up management. Many agreed a five year treatment time frame was a minimum in most cases.

Goats have been used successfully to control gorse in Australia, Canada, California, Tasmania and New Zealand. A number of sources suggested using goats following fire as an alternative to herbicides. Given Marin Fire's on-going work with gorse control using fire, mechanical treatment and herbicides, it makes sense to partner with Marin Fire in any gorse control effort. However, before undertaking a gorse control or eradication program using goats, project objectives and time frame should be clearly defined.

V SOURCES

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