Chapter 1 – MANUAL & MECHANICAL CONTROL TECHNIQUES

Manual and mechanical techniques such as pulling, cutting, and otherwise damaging plants, may be used to control some invasive plants, particularly if the population is relatively small. These techniques can be extremely specific, minimizing damage to desirable plants and animals, but they are generally labor and time intensive. Treatments must typically be administered several times to prevent the weed from re-establishing, and in the process, laborers and machines may severely trample vegetation and disturb soil, providing prime conditions for re-invasion by the same or other invasive species.

Manual and mechanical techniques are generally favored against small infestations and/or where a large pool of volunteer labor is available. They are often used in combination with other techniques, for example, when shrubs are pulled and cut, and re-sprouts and seedlings are treated with herbicides or fire several weeks or months later.

When using manual and mechanical methods, it is especially important to thoroughly clean and inspect all equipment and clothing before moving it off-site. This will lessen the probability of spreading the weed(s) to the next worksite.

In addition to the tools described here, the Wildland Invasive Species Team web page reviews other innovative tools. See http://tncweeds.ucdavis.edu/tools.html.

A. WEED PULLING

Pulling or uprooting plants can be effective against some shrubs, tree saplings, and herbaceous and floating weeds. Annuals and tap-rooted plants are particularly susceptible to control by hand-pulling. Weed wrenches and other tools are surprisingly powerful and can enable you to control large saplings and shrubs that are too big to be pulled by hand. It is not as effective against many perennial weeds with deep underground stems and roots that are often left behind to re-sprout.

How To: Minimize soil disturbance by pulling out weeds slowly and carefully, and replace soil to disturbed areas where possible. Trampled and disturbed areas can provide optimal germination sites for many weeds. Minimize trampling by limiting the number of people in the site and the amount of time spent there. Whenever a manual technique is used, it is wise to wear gloves, a long-sleeved shirt, and long pants. Some plants can cause moderate to severe skin irritation, especially when their stems and leaves are crushed and broken. Even the flimsiest weeds can leave hands raw and bleeding after several hours of pulling.

The advantages of pulling include its small ecological impact, minimal damage to neighboring plants, and low (or no) cost for equipment or supplies. Pulling is extremely labor intensive, however, and is effective only for relatively small areas, even when abundant volunteer labor is available.

1. Hand Pulling

Hand pulling is easy to plan and implement, and is often the best way to control small infestations, such as when a weed is first detected in an area. Hand pulling may be a good alternative in sites where herbicides or other methods cannot be used. The key to effective hand pulling is to remove as much of the root as possible while minimizing soil disturbance. For many species, any root fragments left behind have the potential to re-sprout, and pulling is not effective on plants with deep and/or easily broken roots.

Hand pulling has been effective against a variety of invaders in natural areas scattered across the U.S. For example, hand pulling by volunteers has successfully controlled *Centaurea diffusa* (diffuse knapweed) in the Tom McCall Preserve in northeast Oregon. Yellow bush lupine (*Lupinus arboreus*) was also controlled in coastal dunes in California by pulling small shrubs by hand. Larger shrubs were cut down with an ax, and re-sprouting was uncommon (Pickart and Sawyer 1998). Hand pulling has also been fairly successful in the control of small infestations of *Centaurea* spp. (thistles), *Melilotus officinalis* (white and yellow clover), and *Lythrum salicaria* (purple loosestrife) at TNC preserves scattered across the country.

2. Pulling Using Tools

Most weed-pulling tools are designed to grip the weed stem and provide the leverage necessary to pull its roots out. Tools vary in their size, weight, and the size of the weed they can extract. The Root Talon is inexpensive and lightweight, but may not be as durable or effective as the all-steel Weed Wrench, which is available in a variety of sizes. Both tools can be cumbersome and difficult to carry to remote sites. Both work best on firm ground as opposed to soft, sandy, or muddy substrates.

<u>Root Talon</u>

The Root Talon is an inexpensive and lightweight tool shaped something like a pick-ax with a plastic handle and metal head. It has a specialized claw and gripping device that allow the user to grab the plant stem and provide leverage to pull-up and remove the plants. It is best used for pulling shallow rooted plants such as sapling trees and herbs with sturdy stems. Plants that have been pulled using the Root Talon include young tree-of-heaven (*Ailanthus*), Scarlet wisteria (*Sesbania punicea*), and buckthorn (*Rhamnus* spp.). The Root Talon is not effective against deep-rooted plants, because it does not provide enough leverage. In addition, it is difficult to use the Root Talon to pull spiny plants because the plant stems (and spines) must be put into the gripping flange by hand. Advantages of the Root Talon are that it is lighter and less expensive than the Weed Wrench (see below), and provides easier and more effective control than hand pulling.

At the time of printing, the Root Talon retailed for $47 plus $5.25 shipping through Lampe Design, LLC, 262 South Griggs Street, St. Paul, MN 55105, (612) 699-4963, jklampe@worldnet.att.net or on the web at www.buckthorn.com.

<u>Weed Wrench</u>

The Weed Wrench provides more leverage than the Root Talon. Its all-steel frame is capable of withstanding more strain than the plastic handle of the Root Talon. It comes in four sizes, from the "mini", which weighs 2.4 kg (5.25 lbs) and is capable of pulling weeds with stems up to 2.5 cm (1.0 in) in diameter, to the "heavy", which weighs 10.5 kg (24 lbs) and can handle weeds up to a diameter of 6.25 cm (2.5 in). Larger Weed Wrenches provide more leverage and pulling power. It is best to choose the smallest size needed, however, because larger Weed Wrenches are heavy and can be difficult to carry and use in remote sites.

Manufacturers of the Weed Wrench claim it is capable of handling any plant that can fit within the "jaws" of the wrench, as long as the plant stem is stronger than the anchoring strength of the roots. The Weed Wrench can be used on herbaceous plants that have a stem or bundle of stems strong enough to withstand the crush of the jaws. It has been used successfully to pull acacia (*Acacia melanoxylon*), buckthorn (*Rhamnus cathartica*), Russian olive (*Elaeagnus angustifolia*), multiflora rose (*Rosa multiflora*), willow (*Salix* spp.), tamarisk (*Tamarix* spp.), bush honeysuckles (*Lonicera* spp.), Scotch broom (*Cytisus scoparius*), French broom (*Genista monspessulanus*), and Brazilian pepper (*Schinus terebinthifolius*) at preserves across the mainland U.S. In Hawaii, the Weed Wrench has been used to pull Strawberry guava (*Psidium cattleianum*) and small saplings of Karaka nut (*Corynocarpus laevigatus*) from the Kamakou preserve on Molokai (Hawaii).

For more information, contact The Weed Wrench Company, at 2852 Willamette Street #403, Eugene, OR 97405, 1-877-484-4177, connect@weedwrench.com. You can also view their website at http://www.weedwrench.com.

B. MOWING, BRUSH-CUTTING, WEED EATING

Mowing and cutting can reduce seed production and restrict weed growth, especially in annuals cut before they flower and set seed (Hanson 1996). Some species however, re-sprout vigorously when cut, replacing one or a few stems with many that can quickly flower and set seed. For example, yellow starthistle (*Centaurea solstitialis*) can be controlled by mowing at the onset of flowering (when approximately 2 to 5% of the seed heads are flowering), but if mowed earlier, native species are negatively impacted and yellow starthistle is able to re-sprout (Benefield et al. 1999). Be sure to consider the biology of the weed before cutting.

How To: Mowing and cutting are often used as primary treatments to remove aboveground biomass, in combination with prescribed burning or herbicide treatments. It is important to collect the cut fragments of species capable of re-sprouting from stem or root segments to prevent them from washing or blowing into uninfested areas.

C. STABBING

Some plants can be killed by severing or injuring (stabbing) the carbohydrate storage structure at the base of the plant. Depending on the species, this structure may be a root corm, storage rhizome (tuber), or taproot. These organs are generally located at the base of the stem and under the soil. Cutting off access to these storage structures can help "starve" or greatly weaken some species.

How To: To sever a taproot, place a flat-nosed spade, pruning saw, or knife at the base of the plant and push it as far below ground as possible. To prevent re-sprouting, the taproot should be severed below the caudex or root crown (where the stem becomes the root).

The stabbing technique has been used to control baby's breath (*Gypsophila paniculata*) in Michigan (J. McGowan-Stinski, pers. comm.). The stabbing of root corms has also been an effective control technique for large (two yr old) plants of burdock (*Arctium lappa*) and wild parsnip (*Pastinaca sativa*) in Illinois and Wyoming (W. Kleiman, pers. comm.).

D. GIRDLING

Girdling is often used to control trees or shrubs that have a single trunk. It involves cutting away a strip of bark several centimeters wide all the way around the trunk. The removed strip must be cut deep enough into the trunk to remove the vascular cambium, or inner bark, the thin layer of living tissue that moves sugars and other carbohydrates between areas of production (leaves), storage (roots), and growing points. This inner cambium layer also produces all new wood and bark.

How To: To girdle a tree, cut parallel lines approximately three inches or more apart around the circumference of the tree. The cuts can be made using a knife, ax, or saw, and should be slightly deeper than the cambium. Strike the trunk sharply between the cuts using the back of an ax or other blunt object. The bark should come off in large pieces and prevent the tree from any further growth. It is important not to cut too deeply into the trunk because this could cause the tree to snap and fall in high winds. To determine the depth of the cambium, make two short test cuts and strike the bark between the cuts. After several strikes the bark should come off intact, exposing the cambium and wood (xylem) below.

Girdling is effective against pines, some oaks, and some maples. It typically requires less labor than cutting and removal, is inexpensive, and kills only the targeted plant. It also leaves no residue except the standing trunks. In addition, a dead standing tree (snag) can provide valuable wildlife habitat, and if left to decay, allows the nutrients of the tree to be returned to the system, rather than being removed and deposited elsewhere. A few species, notably black locust (*Robinia pseudoacacia*) and tree of heaven (*Ailanthus altissima*) should not be girdled because they respond by producing many fast growing root and stem sprouts. Therefore, before girdling, find out if the target species responds by re-sprouting. If so, use another control technique, such as hack and squirt herbicide applications or if you do girdle return at 1 to 4 month intervals to cut, burn, or herbicide all re-sprouts for at least 2 years.

Girdling has been used successfully on preserves in New York state to control quaking aspen (*Populus tremuloides*) and bigtooth aspen (*Populus grandidentata*). Girdling can also be used in combination with herbicides. Black locust (*Robinia pseudoacacia*) and quaking aspen (*P. tremuloides*) in New York and Wisconsin, respectively, were controlled successfully using girdling with herbicide. This method, however, was not successful, in controlling tropical ash (*Fraxinus uhdei*) on the Kamakou preserve on Molokai, Hawaii.

E. MULCHING

Mulching can be used on relatively small areas, but will often stunt or stop growth of desirable native species. Mulching cannot control some perennial weeds because their extensive food reserves allow them to continue to grow up through the mulch.

How To: Cover the ground and/or seedlings with mulch (hay, grass clippings, wood chips, etc.) or other type of ground cover (newspaper clippings). This prevents weed seeds and seedlings from receiving sunlight necessary to survive and grow.

Hay mulch was used in Idaho with some success to control the spread of Canada thistle (*Cirsium arvense*). This hay mulch was applied several feet deep to established plants, and even though these plants were not completely eliminated, flowering rates were much suppressed by the end of the growing season.

F. TILLING

Tilling, or the turning-over of soil, is often used for weed control in agricultural crops. Its use in wildland management is largely limited, however, to restoration sites where soils are already badly disturbed. Tilling is effective against annuals and shallow-rooted perennials, but small fragments of some species, particularly those perennials with rhizomes, can often resprout following tillage. Tilling should be completed before seeds develop and are shed onto the soil. The best control is achieved when the soil remains dry, so that remaining plant fragments dry out. Moist soils help the fragments survive and re-grow.

How To: "Primary" tillage equipment is initially used to turn over soil and cuts roots at depths of six inches to two feet to prepare the soil for planting. "Secondary" tillage equipment, or equipment designed to work only the top six inches of soil, is used mainly to control weeds.

Many types of secondary tillage equipment are available. Equipment ranges from small hand-pushed models, to tractor mounted power-driven tillers. The appropriate model depends on the size and type of the habitat.

G. SOIL SOLARIZATION

Soil solarization is the technique of placing a cover (usually black or clear plastic) over the soil surface to trap solar radiation and cause an increase in soil temperatures to levels that kill plants, seeds, plant pathogens, and insects. In addition, when black plastic or other opaque materials are used, sunlight is blocked which can kill existing plants (Katan et al. 1987). Soil solarization however, can cause significant biological, physical, and chemical changes in the soil that can last up to two years, and deter the growth of desirable native species.

Soil solarization is used in horticulture and for a few high value agriculture crops like strawberries. This method has not been used extensively for weed control in natural settings. The effectiveness of soil solarization depends, in part, on how susceptible weed seeds are to temperature increases. It is most effective against winter annual weeds that germinate under cool conditions (Elmore 1990). Summer annuals and other species adapted to higher temperatures, which germinate during warmer parts of the year, are less susceptible.

Soil solarization is most effective during the summer months, and may be less effective in cooler climates (DeVay 1990). The higher the temperature, the more quickly a kill is achieved. Solarization is effective only if done in wet soil. Where soils are typically dry, they must first be irrigated until soil from the surface to 50 to 60 cm deep is at field capacity (Grinstein & Hetzroni 1991).

How To: Polyethylene plastic film is the most useful for soil solarization (DeVay 1990). Less expensive thin films (1-1.5 mil) are more effective than thick films (2, 4, and 6 mil). Clear and black films both trap infrared radiation that is re-radiated from the soil surface, therefore keeping the soil hot. Transparent film allows more radiation to reach the soil than black films, as it lets visible light in, causing even greater temperature increases. Because black films exclude visible light however, they stop photosynthesis, which can be enough to kill some young annuals and perennials given sufficient time (Elmore 1990). Double layers of film have been found to increase soil temperatures by three to ten degrees over single layers (DeVay 1990).

Soil solarization is beneficial in that it releases nutrients that are tied up in the organic component of the soil, and that it can kill unwanted plants without the use of chemicals (Stapleton 1990). However, solarization leaves an open substrate that can be readily invaded by new organisms, both native and non-native once the plastic is removed (Stapleton 1990). The influx of nutrients that results from solarization can be advantageous to restoration efforts, but can promote aggressive, ruderal plants that typically thrive in nutrient-rich soils.

H. FLOODING

In situations where the water level of a wetland or riverine system can be manipulated, flooding can be used to control some plant species. Some species, however, have vegetative buds or underground storage organs that can survive several months or more under flooded conditions.

In Vermont, flooding was used successfully to kill seeds and seedlings of common buckthorn (*Rhamnus cathartica*). Flooding was also used in combination with herbicide to successfully control the spread of autumn olive (*Elaeagnus umbellata*) and reed canarygrass (*Phalaris arundinacea*) in Ohio. At Wertheim NWR on Long Island, NY, *Phragmites australis* was controlled by burning and then flooding with several feet of water in impounded areas.

REFERENCES

Benefield, C.B., DiTomaso, J.M., Kyser, G.B., Orloff, S.B., Churches, K.R., Marcum, D.B., and G.A. Nader. 1999. Success of mowing to control yellow starthistle depends on timing and plants branching form. California Agriculture 53(2): 17-21.

DeVay, J.E. 1990. Historical review and principles of soil solarization. *In:* DeVay, J.E., Stapleton, J.J., and C.L. Elmore (eds.), Soil Solarization. United Nations, Rome.

Elmore, C.L. 1990. Use of solarization for weed control. *In:* DeVay, J.E., Stapleton, J.J., and C.L. Elmore (eds.), Soil Solarization. United Nations, Rome.

Grinstein, A. and A. Hetzroni. 1991. The technology of soil solarization. *In* J. Katan and J.E. DeVay (eds.) Soil Solarization. CRC Publications, Boca Raton: 159-170.

Hanson, E. 1996. Tools and techniques. Chapter 3 *in* Invasive plants. J. M. Randall and M. Marinelli, eds. Handbook #149. Brooklyn Botanical Garden, Inc., Brooklyn, New York. 111 pgs.

Katan, J., Grinstein, A., Greenberger, A., Yarden, O. and J.E. DeVay. 1987. First decade (1976-1986) of soil solarization (solar heating)-A chronological bibliography. Phytoparasitica 15:229-255.

Pickart, A.J. and J.O. Sawyer. 1998. Ecology and restoration of Northern California coastal dunes. California Native Plant Society. Sacramento, CA. 152 pgs.

Stapleton, J.J. 1990. Thermal inactivation of crop pests and pathogens and other soil changes caused by solarization. *In:* DeVay, J.E., Stapleton, J.J., and C.L. Elmore (eds.), Soil Solarization. United Nations, Rome.

Date Authored: April 2001