Guide for the Control of Invasive Trees in Natural Areas in Cyprus: Strategies and Technical Aspects

Submitted to the Cyprus Department of Forests, Republic of Cyprus

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This guide is submitted to the Department of Forests of the Republic of Cyprus in the frame of the ecology consultancy related to the Restoration Program of the Amiantos Asbestos abandoned mine, Troodos National Forest Park.

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Foreword

The purpose of this work is to provide detailed technical guidelines for the control of alien invasive tree species, namely *Acacia saligna* (Labill.) H.L. Wendl., *Ailanthus altissima* (Mill.) Swingle, *Robinia pseudoacacia* L., as well as one shrub species *Dodonaea viscosa* L. (Jacq.).

The control techniques detailed in this work are all related to targeted chemical control methods (TCCM) and are based on the results of research, experiments and studies carried out by the author over the past 8 years in Israel and in Cyprus (Dufour-Dror, 2007, 2008, 2010, 2012, 2013).

The techniques used in TCCM were developed for the control of invasive trees in natural areas, including riparian habitats and other sensitive ecosystems.

These guidelines include three sections: In the first section a background to principles, advantages and limits of targeted chemical control methods is presented. The second section focuses on the planning of control management steps prior to their implementation in the field, with a special focus on objectives and strategies that need to be defined before action. In the last section the technical steps recommended for the practical implementation of the three main types of targeted chemical control methods addressed in this guide are displayed and fully detailed.

1 – Targeted Chemical Control Methods – Background

1.1 – Principles of targeted chemical control methods

The main principle of targeted chemical control methods (TCCM) is to apply the herbicides directly, and only, on specific plant individuals selected for control. TCCM were originally developed in order to remove specific invasive alien plant taxa from natural and protected areas without harming native species and sensitive habitats (see Tu *et al*. 2001; Burn 2003).

Therefore, the primary objective of TCCM is to prevent non-target effects by direct applications on selected target plants. For this reason TCCM generally do not involve herbicide spraying for the treatment of ligneous species, but are restricted to direct applications of herbicides on the woody parts of developed plants. Targeted chemical control methods of woody invasive plants can be performed with five different techniques: **Drill-Fill**, **Cut-Stump**, **Frilling**, **Stem-Scrape** and **Ring-Barking**. The last two techniques are suitable, respectively for some vine species and for shrubs or trees that do not sucker or reshoot when damaged. Since these guidelines are designed to control the golden wreath wattle (*Acacia saligna*), the tree-of-heaven (*Ailanthus altissima*), the black locust (*Robinia pseudoacacia*) and the varnish tree (*Dodonaea viscosa*), all characterized by their high ability to resprout and sucker, the techniques recommended and detailed in this work are limited to Drill-Fill, Cut-Stump and Frilling.

1.2 – Advantages of targeted chemical control methods

The TCCM have several major advantages over other control methods:

Since the techniques are target-specific, very small volumes of herbicides are required and this reduces, very significantly, the risks of polluting the surrounding environment. This is particularly valuable when working in or near riparian habitats where organisms are very sensitive to herbicide pollution.

In addition, this also reduces considerably the non-target effect, i.e. the killing of native plant species growing next to invasive plants.

The techniques used in TCCM do not require removing plant root systems, so soil disturbance is minimized, and therefore the establishment of new individuals of invasive plants is not facilitated, as this occurs in disturbed sites.

The equipment needed in order to apply TCCM techniques are light and easy to carry, so most of the trees can be accessed and controlled *in situ*.

Lastly, TCCM are cost-effective as small amounts of herbicides are used; TCCM are also easy to perform and do not require great technical proficiency and qualifications in order to be properly applied in the field.

1.3 – Limits of targeted chemical control methods

Despite the obvious and undisputable advantages of the TCCM one can point out several limitations and constraints associated to TCCM:

Controlling each individual may be time consuming in some cases, especially when multi-stems individuals must have all their trunks controlled. For instance, controlling *Acacia saligna* or *Ailanthus altissima* populations in sites previously burned, will require more time as all resprouting trees develop several trunks following a fire. The same applies for trees that were felled and regrew after a clear cut. In these cases, the need to control each trunk increases the duration of the control.

Moreover, since TCCM requires direct access to each individual in the field, the control may take more time in the case of remote trees or individuals established in sites where access is difficult, such as cliffs.

Finally, unlike some biological control methods, TCCM do not act directly on seed banks. The progressive depletion of the seed bank in a site where TCCM are used, results from the elimination of seed bearers and this is a slow process. Yet, in terms of the risk posed to local ecosystems, TCCM are definitely safer than biological control as no alien bioagent is introduced into the natural habitat. Although some biological control have proved so far very efficient, biological control cannot be 100% safe (Simberloff 2011).

The TCCM are the most appropriate and the safest methods for the control of alien invasive trees in small and medium infestations in natural areas.

2 – Planning Control Objectives And Control Strategies

The planning of a control management program is crucial as it defines the objectives of the control program and determines the strategy, i.e. the procedure of the control actions in the field.

Control objectives can be diverse as not all control programs necessarily aim at eradication, as in some cases, this is an unattainable goal. Moreover, all the individuals in an infested area cannot be controlled at once; therefore priority must be given to some trees and these should not be selected randomly.

2.1 – Aims of invasive tree control management programs

It is important to set the objectives of the control program *before* starting the fieldwork.

Four types of objective can be achieved in invasive plant control: (1) eradication, (2) reduction of the extent of the infested area, (3) reduction of the density of invasive individuals within the infested area, and, (4) containment (Figure 1).

There is no doubt that **eradication** is the best objective a control management program can aim at and achieve. Eradication is not only the removal of all individuals in the area considered, but also the absence of re-establishment of new individuals in the initial infested area for at least 3 to 5 consecutive years (Rejmanek & Pitcairns 2002, Panetta & Lawes 2005). Because of the extremely long seed dormancy of species such as *Acacia saligna* (50 years), post-eradication monitoring is absolutely necessary, and must last over decades.

Often, for various reasons related to terrain conditions, legal status of adjacent areas, and money or resources constraints, eradication is not a realistic goal and cannot be achieved, at least in the short term. In these cases, other and different objectives must be considered:

Another possible objective is the **reduction of the extent of the infested area** which is achieved by the control of some of the individuals of the invasive tree, initially located on the outer boundaries of the infested area. The control action then results in a reduction of the extent of the infested site.

Another possibility is to aim for the **reduction of the invasive tree density within the infested area**. In this case, the control program does not necessarily lead to a reduction of the total area infested by the invasive tree, but it lowers the density of individuals and consequently decreases the intensity of the threat posed by the invasive tree on the local ecosystem.

A last option is to decide to freeze the extent of the infested area, i.e. to prevent the establishment of further individuals beyond the present boundaries of the infested site. In this case the objective of the control program is **containment**.

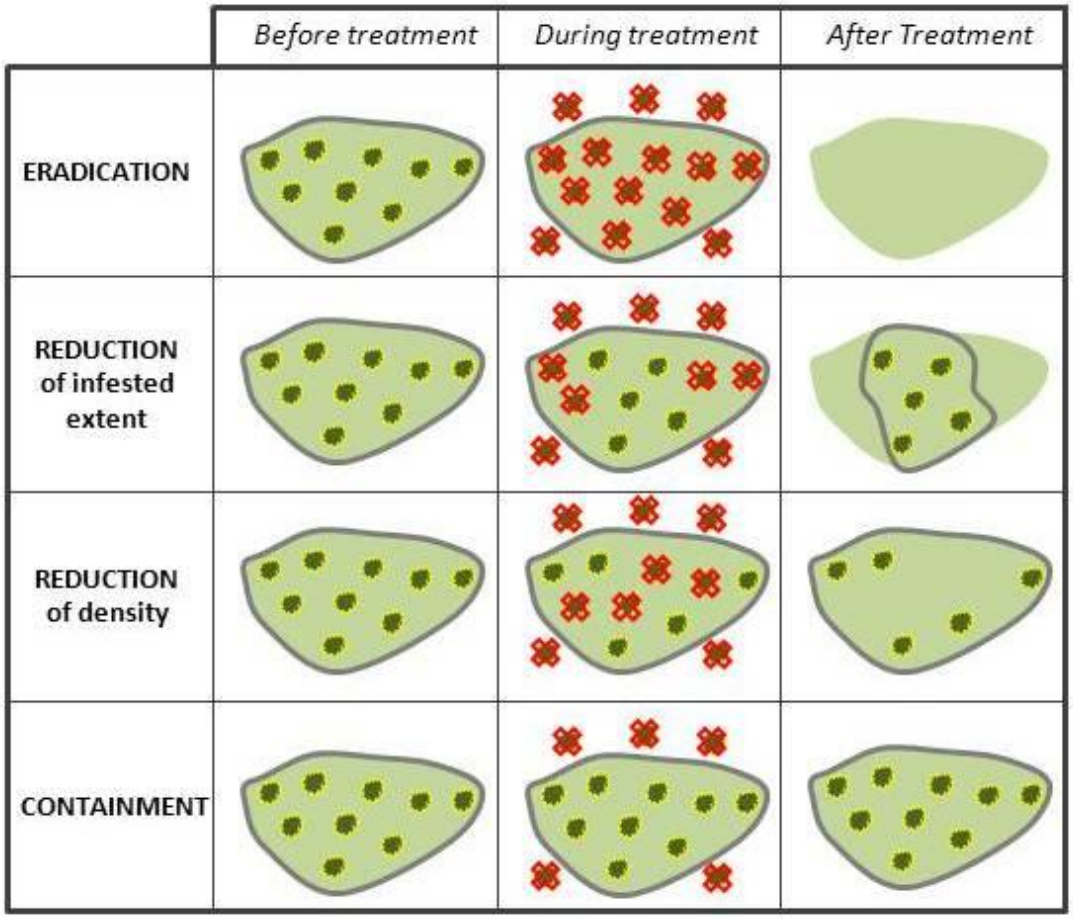

Figure 1: Possible objectives of invasive tree control

Even though eradication is the ultimate objective in an invasive tree control program, the reduction of the extent of the infestation, the reduction of the tree density, or the containment of the foci, are all indisputably worthwhile objectives. Their achievement will always improve the situation of the natural ecosystems infested. The impossibility to attain total eradication does not mean that control management programs are pointless and should not been carried out. Stopping the spread of an invasive tree, i.e. *containment*, is already a great achievement in terms of natural ecosystem protection.

2.2 – Field strategy rules for a better invasive tree control efficiency

Because control should not be implemented from anywhere on any individuals, several rules should be followed in order to implement the control program with the greatest efficiency:

(1) Before starting control operations in the field it is recommended to map the **potential seed sources**, i.e. groups or isolated trees, located outside the perimeter of the area under control but adjacent to it, e.g. private gardens, urban parks, street trees, roadsides etc. External seed sources, if left uncontrolled, will inevitably lead to the re-emergence of new

individuals of the invasive tree in the area under control. When external seed sources are located and mapped it is necessary to include them in the control program, even if these are situated outside the area initially defined for the implementation of the control program.

(2) **A mapping of** groups and isolated **individuals of the tree species targeted for control *within* the area considered** is necessary prior to any control action. The mapping enables to know the distribution pattern of the tree to be controlled and consequently to locate loose foci versus dense foci, as well as isolated trees. This stage is very important because it enables identification of **which trees should be controlled first**: Priority must be given to isolated individuals, located at the outermost boundaries of densest foci in order to progressively and systematically reduce the surface area of the infested site. Loose foci should be controlled secondly, and the last stage of the control should be the removal of the densest foci (Figure 2). Controlling densest foci first is tempting but experiences show this may lead to skip over isolated trees that will then continue to act as seed sources.

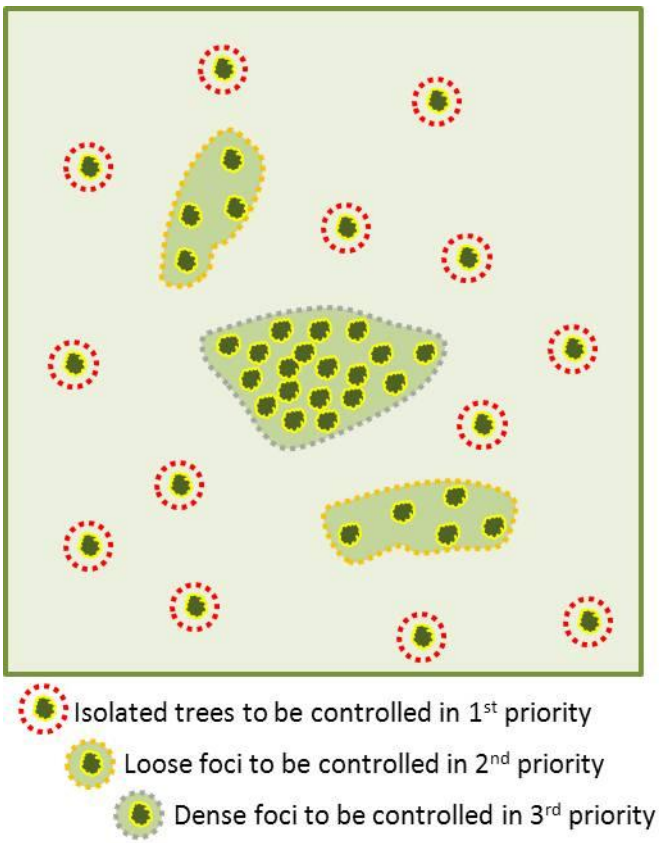

Figure 2: Prioritization of control among a population of an invasive tree according to the distribution pattern of its individuals in the area targeted for control.

(3) It is advisable to **take into account the features of the hydrographic systems**, i.e. streams and rivers, when planning which sites should be controlled first, particularly when the control takes place in large areas over relatively long periods. This is relevant particularly for invasive tree species whose seed dispersal occur primarily through water floods and runoff. In that case it is better to **start the control in upstream areas**, and to continue with control operations in downstream sites where the largest and the densest foci are likely to be found.

(4) Finally, in order to lower the rate of seed accumulation in the soil in the area targeted for control, it is better **to neutralize in priority the largest seed bearers**, and/or the **female trees in the case of dioecious species**, e.g. *Ailanthus altissima or Schinus terebinthifolius* (Figure 3). The control of female individuals may be a very effective stage toward containment when resources and materials are limited.

Figure 3: A female individual of Ailanthus altissima bearing seeds in early November in Israel. Female specimens of Tree-of-Heaven are conspicuous as numerous fruits remain attached to the tree until the mid-winter, long after all the leaves have shed.

2.3 – The need for follow-up and returning control actions

If properly performed TCCM generally lead to death rates of 80-95% after the first implementation. In order to attain mortality rates of 100% it is necessary to plan and carry out returning control actions. These should take place in the frame of a follow-up program three months to one year after the first control operations (see 3.1.3). The follow-up itself is necessary in order to determine which individuals lost their vitality after the first treatment and which trees still show signs of vitality and therefore require an additional control.

When the aim of the control is eradication, it is crucial to plan and to carry out post-eradication monitoring in order to prevent the re-establishment of new seedlings. In the event of the emergence of new individuals it is necessary to control them as soon as possible

and always before they start to produce seeds. One should keep in mind that invasive trees can produce seeds as early as two years after germination, for instance *Acacia saligna*. Therefore post-eradication monitoring should be planned and carried out no more than one year after the first control, and then once a year for 5 consecutive years, until no new individuals are spotted.

3 – Targeted Chemical Control Methods for Invasive Trees: The Technical Steps

The following section details the materials, technical steps and implementation timetable for the three TCCM relevant for the species considered: Drill-fill, cut-stump and frilling.

Drill-fill and cut-stump should be used for controlling mature trees and sapling with a base diameter (BD) greater than 5cm.

Frilling is suitable for young saplings and seedlings with a BD less than 5cm.

3.1 – Drill-fill

Drill-fill gives the best results for invasive tree control with species characterized by a high resilience and resprouting ability. Because drilling represents a localized wound in the tree structure, it is less likely to trigger intense root suckers development as that happens when the main trunk is cut down.

3.1.1 – Materials

Tools

- A gasoline engine drill is necessary for drilling the holes around the trunk where the herbicide is about to be injected. A full gas container is needed to refill the drill. An electric drill, powered by batteries is lighter to carry but batteries will usually run-down within 2 hours of work.

- Drill bits of 1 to 2 cm diameter are needed. It is important to bring a set of 8-10 drill bits as some are expected to break off during the drillings.

- Syringes of about 40ml will be used to inject the herbicide into the sapwood.

- A plastic can of about 0.5 liter with a hermetic cover which can easily be opened and closed is recommended in order to carry small volumes of herbicide from tree to tree. This will avoid frequent refill of the syringe directly from the main 5 liters herbicide bottle. Using a small can of herbicide for most refills will reduce the risks of spilling accidents. Even if the small can accidentally falls down, the pollution damage will remain much more limited than if the main herbicide bottle falls over during refill operations.

- A hand pruner is required in order to cut thin stems in the case of multi-stems individuals.

- Full protective gear is necessary, particularly latex gloves and a clean water container

(about 10 liters) that will be necessary for washing skin, eyes or other body parts in case of contact with the herbicide. The person who operates the drill must wear chainsaw boots and chainsaw protective trousers. A full protective gear is compulsory.

- Bark marking paint is needed in order to mark trees that were controlled.

Herbicides

- The two main herbicides recommended are glyphosate (trade name: Round-up) or triclopyr (Garlon). Glyphosate is generally considered to be more environmentally safe than triclopyr as it degrades more rapidly in the soil. In addition, glyphosate is significantly cheaper than triclopyr. *Acacia saligna*, *Ailanthus altissima*, *Robinia pseudoacacia* are all sensitive to glyphosate. The effect of glyphosate on *Dodonaea viscosa* is not well known and in this case it may be preferable to use triclopyr as it is considered to be a more aggressive herbicide.

3.1.2 – Implementation

Since the sap flow ceases very quickly in the area where the plant tissue is damaged (drilled, cut or frilled) it is **crucial to apply the herbicide within 10 seconds of a drill being made**. Therefore, in order to ensure maximum control efficiency, a pair of two workers is necessary with one worker drilling and the other injecting the herbicide. This way the time elapsing between the drill and the application of the herbicide is minimal.

Step 1: Once the tree to be controlled is selected the workers wear the protective gear, including the latex gloves for the person injecting the herbicide. One pours some herbicide from the main bottle into the small can and fills up the syringe with **undiluted herbicide** from the small can. The main bottle and the small can must then be sealed.

Step 2: Determining the **volume of herbicide to be injected**: The volume to be injected in ml is twice the value in cm of the base diameter of the targeted tree. For example if a tree has a trunk base diameter of about 25cm (visually estimated) then a volume of 25 x 2 = 50 ml will have to be injected in the trunk.

Step 3: Holes are drilled into the lower part of the trunk, preferably close to the base and around the trunk, 5-10 cm apart. The holes are drilled with an angle of ca-45^{o} so the herbicide injected will not spill over from the trunk (figure 4). Herbicide must be **injected immediately, within 10-15 seconds, after each hole is drilled**. Holes should not be too deep in order to remain in the sapwood area. It is **necessary to drill as many holes as needed in order to inject the volume previously calculated** for the targeted tree (figure 5).

⚠ When multi-stems trees need to be controlled it is necessary to drill each trunk individually. Small trunks should be treated with the frilling technique (see 3.3). The thinnest stems must be cut with a hand pruner and controlled with a few drops on the cut. However, when controlling *Ailanthus altissima* trees, the control can be limited to the main

(largest) trunk, provided the different individuals are clearly distinguished, particularly in dense infestations.

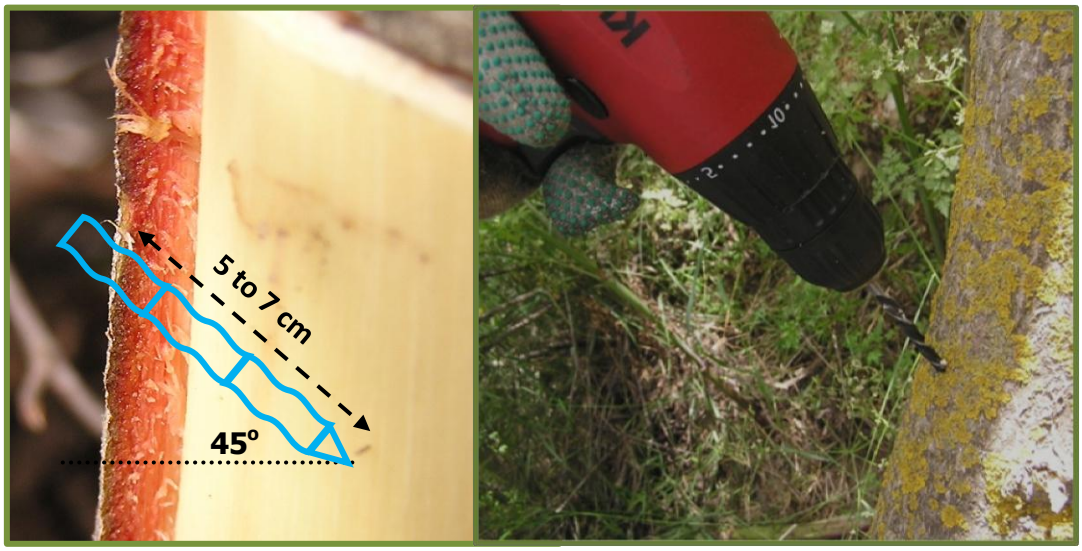

Figure 4: Drilling in the sapwood prior to injection.

Figure 5: Drill-fill in an Ailanthus altissima trunk (Cyprus). It is crucial to inject the herbicide within10-15 seconds of a hole being drilled. Control programs where the injection was made too late, failed. For this reason the best way to comply with this rule is to work in pairs.

Step 4: The controlled tree is marked with the paint. It is recommended to number the trees.

Step 5: The fifth step consists of returning control actions (see 3.1.3 below).

Step 6: The last step is the felling of dead trees once they have lost their vitality. It is recommended to wait until the end of the second blooming season, i.e. 14-15 months after the initial treatment, before felling the dead trees. It is always very tempting to remove the trees as soon as possible but the felling of trees at a too early stage might lead to root sucker development and eventually to the recovery of the individuals. Therefore, it is wiser to wait until after the second blooming season before removing the dead trunks (figure 6). The removal of the dead wood from the site will cause disturbance to some degree and it is necessary to pay attention to potential damages inflicted to the vegetation cover and soil while dragging and moving away the dead trees.

Figure 6: The remaining of an Acacia saligna stump, felled two years after being controlled by drill-fill with glyphosate (Israel). The absence of basal sucker shows the individual is dead.

3.1.3 – Timetable

First control

Targeted chemical control methods apply a systemic herbicide directly to the water-nutrient transport system so that the active chemicals circulate through the roots and finally kill the plant (Muyt 2001). As a consequence, the **herbicide must be applied when the sap flow is**

the most intense, that is during the growing season, before the development of inflorescences, and preferably not during the hottest hours of the day when the tree experiences some stress and reduces the speed of the sap flow.

It then follows that the control must be undertaken in February for *Dodonaea viscosa* which blooms very early; generally during the months of March-April for *Acacia saligna* and *Robinia pseudoacacia*; and slightly later, toward late April, early May for *Ailanthus altissima* (figure 7).

Returning control

A **first returning control** can be performed **within 3 months** after the first control in the unlikely event that absolutely no effects of the herbicide are detectable on the foliage of the targeted trees. Such a situation can happen if it turns out that the initial control **was not performed properly**, for example when the herbicide was injected with a delay exceeding the time lapse mentioned above (10-15 seconds).

A **second**, and generally last, **returning control** should be performed **one year** after the initial treatment (figure 7). Only the trees displaying signs of vitality, even if only to some degree, will have to be drill-filled again, according to the same procedure detailed above.

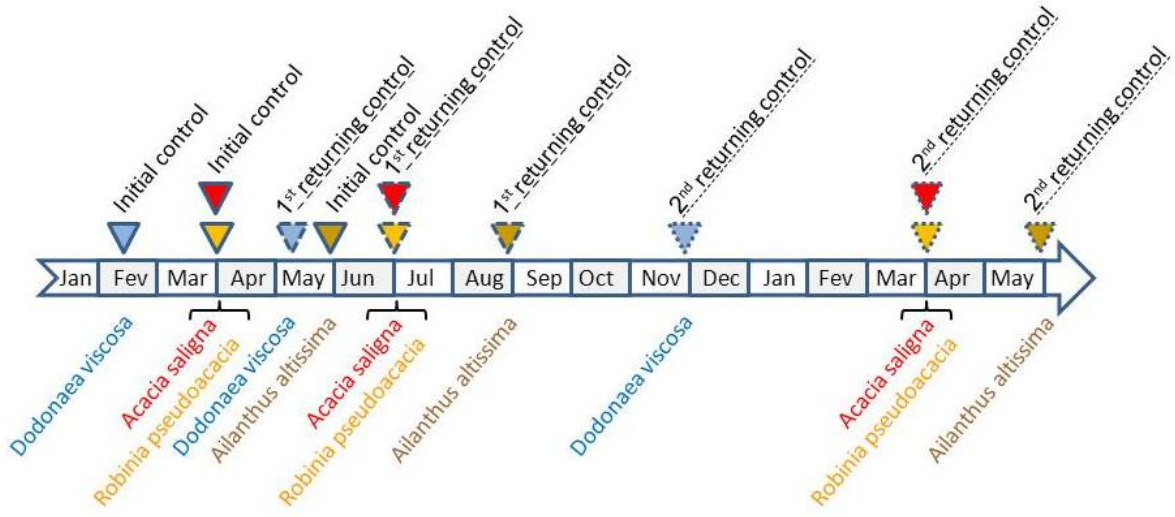

Figure 7: Chronology of control operations related to drill-fill

3.2 – Cut-stump

The cut-stump is the second type of TCCM widely used in order to control alien invasive trees. With the cut-stump technique the trunks are cut down prior to herbicide application. Herbicides are not injected into the sapwood as it is with drill-fill but applied onto the stump.

3.2.1 – Materials

Tools

- A chainsaw is necessary for cutting the trees. A full gas container is required for refilling the chainsaw reservoir. A hand pruner will be of some help in order to cut thinner stems.

- Paint brushes will be used to apply the herbicide onto the stump. It is recommended to use preferably a 2 inches (5 cm) brush. Larger brushes will result in the use of excessive quantities of herbicide that will eventually be wasted.

- Similarly to the drill-fill procedure, it is highly recommended to use a plastic can of about 0.5 liter with a hermetic cover which can easily be opened and closed. It will be used to carry small volumes of herbicide from tree to tree instead of carrying the main 5 liters herbicide bottle. Using a small can of herbicide will reduce the risks of spilling accidents. Pollution damage will remain much more limited than if the main herbicide bottle is continuously moved from one tree to another.

- Full protective gear is necessary, particularly latex gloves and a clean water container (about 10 liters) that will be necessary for washing skin, eyes or other body parts in case of contact with the herbicide. The person who operates the chainsaw must wear full protective gear including: chainsaw boots, head, face and hearing protection (hardhat systems), chainsaw resistant upper body protection, chainsaw protective pants trousers, as well as chainsaw gloves. Full protective gear is compulsory.

Herbicides

- As opposed to drilling, the cutting and felling of the targeted trees is a drastic wound that inevitably triggers resprouting reaction and root-sucker development. Therefore one may prefer to use triclopyr (Garlon) considered somewhat more aggressive than glyphosate (Round-Up). Yet, trials performed in Cyprus with both herbicides in cut-stump did not show significant differences between the effects of the two products, so it can be concluded that they are interchangeable.

3.2.2 – Implementation

For the very same reason explained in section 3.1.2 it is **crucial to apply the herbicide within 10 seconds of the trunk being cut** so the chemical compound can penetrate into the

sapwood and get diffused into the whole plant, down to the roots by the flow of water-nutrient vessels system. Just as with the drill-fill procedure, so too here it is recommended that a pair of workers carry out this process to ensure maximum control efficiency, as one cuts the tree with the chainsaw while the second immediately applies the herbicide.

If the cutting of a tree i**s likely to take longer than 30 seconds, avoid cut-stump and use drill-fill instead** (Muyt 2001).

Step 1: Once the tree to be controlled is selected, both workers wear the protective gear, including the latex gloves for the application of the herbicide, and one pours a small volume (ca-0.5 liter) of **undiluted herbicide** from the main herbicide bottle into the small can. The bottles must then be sealed again.

Step 2: While the trunk is being cut with the chainsaw at about 15 cm to 20 cm above the ground, the second worker dips the brush in the herbicide contained in the small can. As soon as the tree is felled (carefully) the herbicide is **applied thoroughly over the outer rim of the freshly cut stump** (figure 8). The herbicide should not run off the surface of the stump, so it is necessary to apply only the quantity required in order to cover the outer rim of the stump. It is not recommended to cut the trunk as close as possible to the ground, in order to keep open the possibility to later drill-fill the individual if it turns out that returning control is necessary (figure 9). However it is essential to make the cut below the lowest branches.

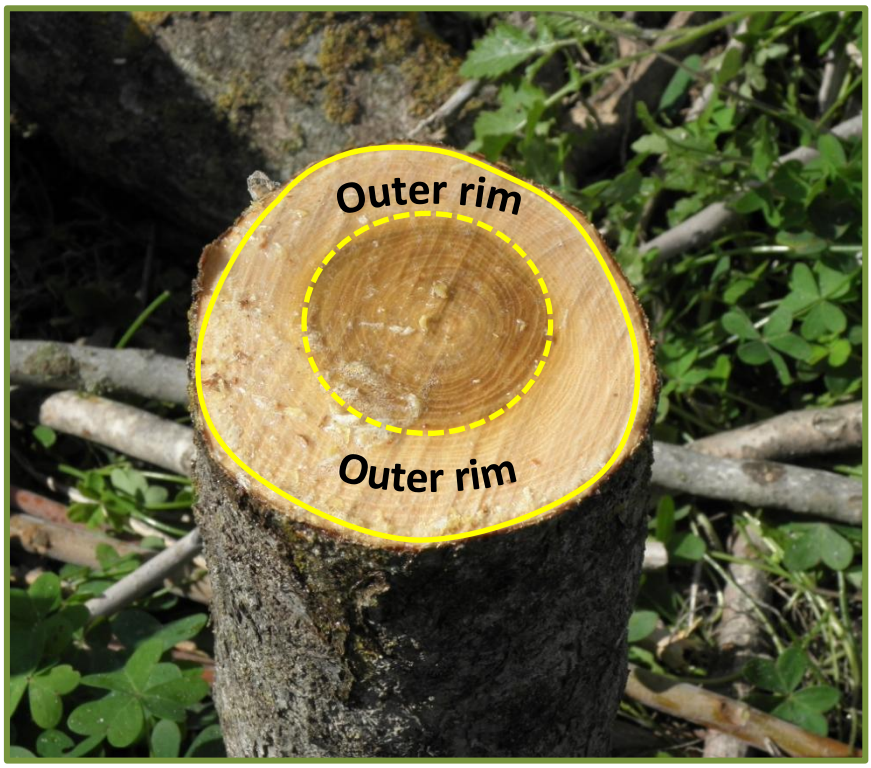

Figure 8: The herbicide should be applied over the outer rim of the stump in order to be absorbed into the moist sapwood so it can circulate down to the roots.

When multi-stems trees need to be controlled it is necessary to **apply herbicide on each trunk individually**, including small trunks. The thinnest stems must be cut with a hand pruner and brushed like larger trunks, although with a minute amount of herbicide. This procedure must be applied to all four species considered here, including *Ailanthus altissima*.

Figure 9: Cut-stump: a pair of workers is necessary in order to apply the herbicide with the brush (right) immediately after the trunk is cut (left). If the cutting of a tree is likely to take longer than 30 seconds, avoid cut-stump and use drill-fill.

Step 3: The third step consists of returning control actions (see 3.2.3 below).

3.2.3 – Timetable

First control

Similarly to drill-fill, the cut-stump procedure should take place during the growing season. Since trees are felled in the cut-stump technique it is crucial to ensure, prior to control, that targeted trees do not bear fruits. Felling trees with mature fruits may enhance dispersal of seeds.

The seasons for the cut-stump are similar to those recommended for drill-fill operations: February for *Dodonaea viscosa* which blooms very early; March-April for *Acacia saligna* and *Robinia pseudoacacia*, and toward late April, early May for *Ailanthus altissima* (figure 7).

Returning control

A **first returning control** can be performed **within 3 months** after the first control if resprouting shoots or root suckers emerge (figure 10). In that case **the returning control must be performed with drill-fill** according to procedure detailed in section 3.1.

If necessary a **second returning control** can be performed **one year** after the initial treatment. Only individuals which have developed root suckers and/or basal shoots will have to be drill-filled again, according to the same procedure detailed in section 3.1.

Figure 10: Resprouting basal shoots emerging after the failure of a cut-stump control of Acacia saligna in Israel.

3.3 – Frilling

Frilling is a TCCM suited for young saplings and seedlings (BD<5cm) that are too small to be drilled, and whose exposed cut surface is too limited in order to apply enough herbicide.

Filling is a highly efficient technique that enables above 95% of the individuals to be killed after the first treatment. Returning controls are generally limited to very few individuals.

Frilling is the simplest TCCM and the easiest to apply. In many cases frilling is a crucial control technique as it kills young individuals before they start to set seeds. It is generally the most common technique used in containment programs in order to prevent the development of new individuals.

3.3.1 – Materials

Tools

- A knife is needed to frill away the bark layer.
- Small paint brushes, 0.5 inches large, or small syringes, 20 ml, will be used to apply the herbicide on the cuts. It is recommended to use small tools for the herbicide application in order to avoid the use of too large quantities of herbicide.
- Similarly to other TCCM techniques, it is highly recommended to use a 0.5 liter plastic can with a hermetic cover which can easily be opened and closed. It will be used to carry small volumes of herbicide between the saplings and it will reduce the risks of spilling accidents.
- Latex gloves are necessary as well as a clean water container (about 10 liters) that will be necessary for washing skin, eyes or other body parts in case of contact with the herbicide.
- Bark marking paint is needed in order to mark seedlings and saplings once controlled.

Herbicides

- As previously mentioned the two main herbicides recommended are glyphosate (trade name: Round-up) or triclopyr (Garlon). *Acacia saligna*, *Ailanthus altissima*, *Robinia pseudoacacia* are all sensitive to glyphosate. The effect of glyphosate on *Dodonaea viscosa* is not well known and in this case it may be preferable to use triclopyr as it is considered to be a more aggressive herbicide.

3.3.2 – Implementation

For the same reasons previously detailed, it is **crucial to apply the herbicide within 10 seconds of the frills being made**. A pair of two workers may help to ensure maximum control efficiency; yet, experiments conducted in Israel showed that a single person can

perform the frilling work if trained properly. It is crucial however, to ensure that the time elapsing between the frill and the application of the herbicide must be very short.

Step 1: Once the sapling or the seedling to be controlled is selected, one needs to put on the latex gloves and pour some herbicide from the main bottle into the small can. Then one fills up the syringe with **undiluted herbicide** from the small can. Before getting to the targeted saplings it is important to verify that the herbicide bottle and the small can are not left opened but are well sealed.

Step 2: The **volume of herbicide applied is a function of the number of frills** made around each stem: The **number of frills** shall be **equal to the value in cm of the basal diameter + 2**, e.g. a 3 cm diameter sapling will be treated with 3 + 2 = 5 frills.

Step 3: The frills must be made around the stem, preferably on the lower part and always below the lowest branches (figure 11). The frills should be 5-10 cm apart and not all at the same height. The herbicide must be applied **within 10-15 seconds after each frill**.

Step 4: The controlled saplings and seedlings should be marked with the paint in order to find them easily during the follow-up.

Step 5: The fifth step consists of returning control actions (see 3.3.3 below).

Figure 11: The two main steps of frilling on a young sapling of Acacia saligna in Israel

3.3.3 – Timetable

First control

Like drill-fill and cut-stump, frilling must be performed **when the sap flow is the most intense**, i.e. during the growing season, before the development of inflorescences, and preferably not during the hottest hours of the day when individuals experience some stress and reduce the speed of the sap flow.

Therefore, frilling must be performed in February for *Dodonaea viscosa,* in March-April for *Acacia saligna* and *Robinia pseudoacacia*, and in late April early May for *Ailanthus altissima* (figure 12).

Returning control

Returning control is rarely needed when using frilling properly but the follow-up may reveal individuals that keep showing signs of vitality after the treatment. A **first, and generally unique returning control,** can be performed **within 3 months** after the initial treatment in the unlikely event that absolutely no effects of the herbicide are detectable on the foliage of the targeted saplings and seedlings. In the previous experiments carried out in Israel on young individuals of *Ailanthus altissima* and *Acacia saligna,* second returning control was never needed as 90 to 95% of the targeted saplings and seedlings died off after the initial treatment, and 100% after the first returning control (figure 13).

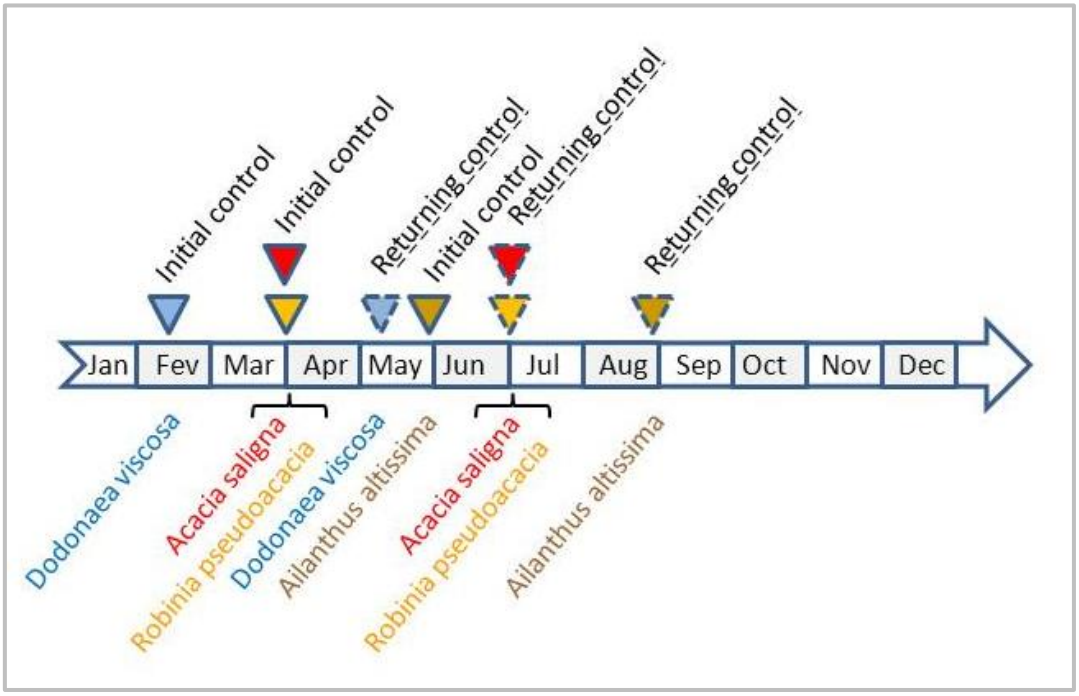

Figure 12: Chronology of control operations related to frilling

Figure 13: Dead sapling of Acacia saligna controlled by frilling in Israel

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