The Control of Rhododendron in Native Woodlands

Author: Chris Barron, (Killarney National Park Education Centre)
Edited by: Declan Little, Richard Nairn & Trevor Seery (Woodlands of Ireland)

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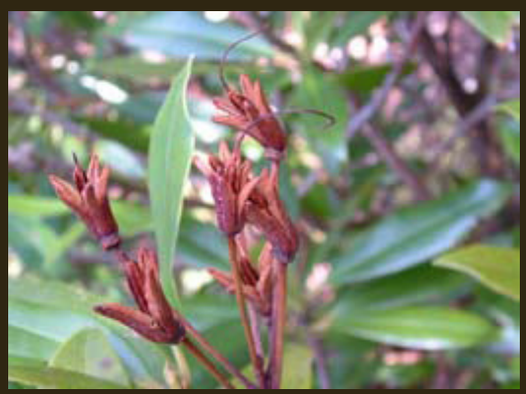

As an invasive species, *Rhododendron ponticum* represents one of the greatest threats facing native woodlands in Ireland. Its presence can have a dramatic impact on the woodland ecosystem, suppressing native ground flora and the natural regeneration of trees and shrubs. It is also difficult to control and eradicate, due to its profuse seeding, rapid growth rates and ability to resprout vigorously from cut stems. Rhododendron removal and control measures are expensive operations and require full commitment to a long-term plan incorporating initial treatment, follow-up operations and monitoring. However, with this commitment, rhododendron can be largely controlled on whole sites, allowing the native woodland ecosystem to recover and thrive.

This Native Woodland Information Note provides guidance regarding the control of rhododendron in native woodlands, based on international best practice and experiences gained in Ireland. Various steps are described, including initial site assessment, planning, treatments to kill and remove the rhododendron, follow-up operations, and monitoring. References are also included, to provide further reading and it is recommended that particular attention be paid to the NPWS publication, Higgins, G.T. (2008) Rhododendron ponticum: A guide to management on nature conservation sites. Irish Wildlife Manuals, No. 33.

This note strongly complements the Forest Service Native Woodland Scheme, as many projects under the scheme involve rhododendron control. In all cases, any proposed treatment must be detailed in full in the Ecological Survey and Management Plan as part of the application process, for assessment and approval by the Forest Service.

INTRODUCTION

The introduction by people of non-native species onto the island of Ireland is a significant component of our natural history. Over the centuries, many species have been introduced into our woodlands for a variety of reasons including game cover, amenity and aesthetics. However, some species have proven to be highly invasive under certain conditions and now require active management in order to minimise their negative impact on the woodland habitat. Common rhododendron (*Rhododendron ponticum*) and cherry laurel (*Prunus laurocerasus*) are two of the most widespread invasive species occurring in our woodlands. This Native Woodland Information Note focuses on rhododendron, but most of the management and control measures described can also be applied successfully to cherry laurel.

ECOLOGY AND LIFECYCLE

As with all invasive species, the successful management of rhododendron requires an in-depth knowledge of its ecology and lifecycle.

Range and growth habit

The genus Rhododendron is part of the heather family (Ericaceae). Its main and most continuous natural distribution is in the region of the Black Sea, although

Fig. 1 Rhododendron ponticum in flower. The copious flowers produced in late spring are very much admired, particularly by visting tourists (Photo courtesy of Chris Barron).

it is also native in parts of Portugal and southern Spain. Many species of this genus have been introduced into Britain and Ireland, but only Rhododendron ponticum (hereafter referred to as rhododendron) has naturalised to any significant extent. Since its introduction to England in 1763 and soon afterwards to Ireland, rhododendron has become widespread on suitable soils throughout both Britain and Ireland.

Rhododendron is an evergreen shrub, with dark green, waxy, oblong leaves and conspicuous pinkish-purple flowers (Fig. 1). It may grow to form thick impenetrable stands over large areas, with individual shrubs reaching heights of up to five metres. It spreads easily by seed but can also spread by layering. Rhododendron flourishes on acid soils, particularly in mild moist conditions. Once established, it forms dense, long-lived thickets, which cast a heavy shade to the detriment of the ground flora and the regeneration of trees and shrubs. As the diversity of ground flora is diminished through the encroachment of rhododendron so too is the diversity and abundance of insects and invertebrates that depend on the flora and the birds and animals that feed on the invertebrates. As rhododendron is very shade tolerant, it is a weed of woodlands and forests, as well as more open habitats.

Seed production and dispersal

A Rhododendron plant does not usually produce flowers until it is 10 to 12 years old. The seeds are cylindrical, c. 1.5 mm in length, with a frill of hairs at both ends. Each flower head can produce between 3,000 to 7,000 seeds which are mainly dispersed by wind to distances of up to 1km. The tiny frills of hairs are also thought to aid dispersal on the coats of animals in the relatively windless conditions under forest canopy. The distance travelled will depend on local conditions such as prevailing wind direction, local geography, and local vegetation types. The majority of seed is likely to be dropped much closer to the parent plant, especially within woodland.

Germination and seedling establishment

Most seeds will germinate under favourable conditions in about four to eight weeks. Light is essential, although the amount required is low (2-5% of full daylight). Germination will occur on a shaded forest floor but not when seeds are buried under soil or vegetation. Once seeds are released, the majority have a short period of viability and must germinate within that year although a small proportion appear to remain viable in the seed bank for longer. A dense herb layer helps prevent rhododendron establishment. For germination to be successful, the root must be able to access a reliable source of water almost immediately on emergence. Moss carpets and ground disturbance resulting from trampling, burning, and forestry operations (particularly scrub clearance and felling) are conducive to the germination of rhododendron seed. Other factors favourable to the formation of moss carpets, such as high humidity and rainfall, rocky slopes, and intensive grazing, also favour the establishment and spread of rhododendron.

At the end of the first growing season, the seedlings are small (2-5 cm tall), with a simple root system, and they are very susceptible to drought. At this stage, therefore, desiccation is considered to be the main cause of death, with seedlings most likely to survive in moist, sheltered sites where the roots have access to mineral soil.

Shade tolerance

Once established, rhododendron can grow under heavy shade. The plants possess characteristics which help them to survive in low light levels, including a low metabolic rate, resistance to disease, and the ability to increase leaf area in response to a reduction in light intensity. Being evergreen, rhododendron has the ability to make use of winter light conditions when the overhead deciduous canopy is leafless.

The ecological impact of rhododendron

Mature rhododendron invariably develops into an impenetrable understorey, with large, waxy leaves blocking out and reflecting sunlight and thereby preventing other vegetation from growing beneath. Rhododendron only allows approximately 2% of the total daylight to reach the woodland floor, compared with c.9% for an oak/holly canopy.

Light exclusion by rhododendron prevents regeneration, patterns of succession, and colonisation by other plant species, thus lowering plant diversity in any community where it becomes established, thus lowering the biodiversity value of that habitat. Changes in soil chemistry induced by rhododendron have also been reported. These include a reduction in cation mobilisation and the production of polyphenols, both of which can inhibit recolonisation by seedlings of other species.

It is widely accepted that populations of fauna are also negatively influenced by rhododendron. Bird numbers are lower in mature oak forests dominated by rhododendron. Very few insect species are associated with rhododendron. Due to its toxic nectar and poisonous leaves, the species is thought to be of little value as a food source. In addition, the leaves of rhododendron contain andromedo toxin that is highly poisonous if ingested by mammals. Hence, plants are generally avoided by grazing animals, thus giving rhododendron a significant advantage over native vegetation. Dead stems and foliage are also very resistant to decomposition with leaves persisting for many months while stems and branches persist for many years.

MANAGING RHODODENDRON

Its poisonous nature, vigorous reproductive strategy and affinity for acidic soils combine to make rhododendron a highly effective invader of natural habitats on acid soils. It has already infested many areas of native woodland and is widespread on blanket bogs and heaths. Rhododendron is one of the biggest conservation issues facing Irish native woodlands today.

The removal and control of rhododendron in an infested habitat is a major challenge and can only be carried out effectively by understanding the ecology of the species and by strategically planning the clearance work. In order to rid a habitat of rhododendron, a number of steps should be followed, including deciding on the most appropriate method or methods to be used. All habitats initially cleared of rhododendron must then be regularly and systematically re-visited to remove any seedlings that may have germinated and become established there.

Rhododendron clearance is an expensive and time-consuming task, and should therefore be well planned before any clearance work is initiated. Two of the main issues that must be considered at this stage are:-

- **Rhododendron is a prolific seed producer.** A medium sized plant is normally capable of producing c. 1 million seeds per year. However, a naturally seeded plant does not flower until it is 10-12 years old, therefore, in a newly infested area of woodland, this provides a window of opportunity to prevent serious infestation, through the immediate removal of young plants.
- **Rhododendron regrows vigorously when cut.** As a result, some method of stump killing or stump removal will always be necessary, as any plant that regrows from a cut stump will in most cases flower and subsequently seed within 3-4 years. It is therefore vital that provision is made to kill the root system as soon as possible with which ever control method has been decided upon, when planning the work otherwise the situation may only become worse with all of the previous effort being wasted.

The exact approach to rhododendron management will vary depending on certain site factors. In woodlands isolated from infested sites, and with well-defined boundaries and a relatively simple topography, it is possible to remove all rhododendron. On larger, more complex sites, the control of the rhododendron population to a manageable level may be a more realistic goal, at least in the short to medium term. Each site will have to be surveyed and the level of infestation assessed and mapped before deciding which method/s of control are to be used and what level of clearance is achievable in which kind of timeframe.

Planning rhododendron control

For all sites, the following steps should be followed.

1. The entire site and adjacent area must be surveyed and the level of infestation assessed and mapped. An accurate map will help to save time and resources later. The mapping and assessment of the level of infestation should be carried out as accurately as possible, as this will form the basis of the clearance programme. It is important to assess the level of infestation in each area of the site as this will determine how they will be prioritised for clearance and which method will be used in their clearance. A suggested assessment criteria is given in table 1 below.

Criteria for assessment	Approx. age of rhododendron	Degree of infestation
No rhododendron present	Not applicable	1 – Absent
Some rhododendron, but plants scattered and mostly small and not flowering.	Up to 12 years	2 – Slight
Rhododendron frequent but not clumping. Some flowering, many seedlings present.	Up to 24 years	3 – Moderate
Rhododendron abundant, some forming dense clumps, many seedlings.	Up to 30 years	4 – Severe
Plants forming dense thickets with almost total absence of ground flora.	More than 30 years	5 – Very severe

Table 1 Assessing the degree and extent of rhododendron infestation.

2. The **age, condition** and any **previous treatments** as well as the extent of the infestation of all stands should be noted and mapped. Details on the age, condition and previous treatments of the different stands of rhododendron will determine which areas will be prioritised for clearance work over others.

3. **Areas to be worked in should be prioritised.** Prioritisation should take into account a number of factors including the level of infestation, the resources available to carry out the work, the conservation value of the site, accessibility of the site and the terrain. For example, where resources will allow for clearance of the major seed producing stands within 2 or 3 working seasons, these should be targeted first. Other areas should be tackled as soon as possible dealing with the oldest first, to minimise the amount of seed production in the area. If there is a large amount of rhododendron present, scattered in various locations across a larger site and resources do not allow for clearance across the entire site within a relatively short period of time, then a deeper understanding of the situation is required. An area that has been seriously infested for the past 25-30 years will have little or no native vegetation beneath the canopy. So, in this case, it may be prudent to first clear any areas less seriously infested, which have not yet lost their native ground cover. Also, ideally work with the prevailing wind rather than against it, to help minimise seed dispersal into recently cleared areas.

   The approach described in NPWS **Irish Wildlife Manual 33 Rhodendron ponticum: A guide to management in nature conservation sites** is recommended for use in prioritising work areas. See Table 2.

Level of Priority	Site type
Level I. Highest Priority	Maintaining well cleared areas free of Rhododendron
	Maintaining uninfested areas free of rhododendron
	Consolidation of well cleared areas.
Level II. High Priority	Areas with slight to moderate infestation.
	Relatively small areas of severe infestation.
	Areas of very high conservation value e.g. containing rare or protected species, regardless of infestation level.
Level III Moderate Priority	Areas with moderate infestation levels.
	Areas with severe infestation levels acting as a seed source into clear, cleared and high priority areas.
Level IV. Low Priority	Large continuous tracts, with severe & very severe infestation, especially if terrain & access are difficult.

Table 2. Source: Higgins GT (2008)

4. Suitable conditions for the **recovery of the ground flora** must be created. This will reduce **'safe sites'** for rhododendron establishment and thereby **minimise reinfestation**. Therefore grazing pressure will have to be kept to a minimum to allow for regeneration of ground flora. This may be through culling, fencing or the use of dead hedging.

5. **Write a Rhododendron Management Plan.** The plan should encompass the entire site and include projections over a suitable time frame. It should describe the level of infestation in each defined stand and describe the clearance method proposed for those stands. It should also give a schedule for the initial clearance work and a timeframe for the follow-up work. Details of access to the site, the type of terrain and other site conditions as well as the locations of any sensitive/ protected species should also be included.

6. In all sites, **follow-up** work will be necessary to ensure that any small plants or seedlings which were either missed on the previous visit or have entered the site subsequently from adjacent seed sources, are removed before they reach the flowering age (10-12 years). Ideally remove them when they are c. 0.5 m tall. At this stage, they are more easily seen, and any young seedlings likely to die naturally through desiccation will have done so. The systematic checking of a woodland habitat for reinfestation is tedious but absolutely necessary if the area is to be maintained free of seed-producing rhododendron. Also, reinfestation brought about by poor follow-up will negate the considerable time and cost invested in the initial clearance.

7. To prevent seed production within a site once clearance is initiated, it is suggested in the NPWS Wildlife Manual 33 that two concepts must be adopted:
   - **i.** Zero tolerance of rhododendron within the work area (and preferably a cleared buffer zone)
   - **ii.** Do not allow new seed infestation to mature and itself become an on-site seed source.

Methods of Rhododendron Clearance

There are a variety of approaches to the control of rhododendron infestation. Some methods are more effective than others on particular sites and under certain conditions and therefore the best method of clearance must be chosen for individual sites depending on the local conditions, the level of infestation and the labour available to carry out the work. On a large complex site a number of different clearance methods might have to be employed depending on factors affecting the site such as access, the fragility of the site and levels of infestation in different locations on the site.

There is no single "right way" to control rhododendron (Higgins 2008), but which ever method is used, attention to detail and thoroughness of work is extremely important otherwise re-infestation will occur.

A number of clearance methods are described below, sources for others can be found in appendix 1

Cutting and removal

The first operation in this method of clearing rhododendron is the cutting of individual stems with hand or chainsaws. Stems should be cut as close to the ground as possible. The cut material will need to be removed from the area to allow for effective follow-up work, subsequent tree planting, etc., (Fig. 2). If the terrain and layout of the woodland are suitable, the material can be used to build a "dead hedge" around the area as a barrier to exclude grazing animals[1].

Burning under the supervision of personnel with fire experience is another option. Rhododendron material can be burnt green immediately after being cut. Fires should be located carefully so as not to damage any trees or other vegetation close by, and old tyres or diesel should not be used to start the fires. To protect the soil/peat, fires should be lit on sheets of corrugated iron. If burning is not an immediate option, the cut material can be piled neatly outside the treated area, allowing them to be dismantled easily to facilitate burning at a later stage (ideally 1-2 years later). Where burning is envisaged, contact should be made with the Local Authority to obtain permission under the Waste Management (Prohibition of Waste Disposal by Burning) (Amendment) Regulations 2015,

Fig. 2: Recently cut rhododendron bushes re-sprouting from the stumps, Glengarriff, Co. Cork. Note how the area has been cleared of all cut material to facilitate follow-up spraying.

Flailing is another method of rhododendron clearance and has recently been applied in Ireland. This involves the flailing of the thickets down to ground level, using a mechanical flail head mounted on a tracked machine. Although not suitable on all sites, especially those that are steeply sloping or very wet, it is very effective as it mulches the material upon contact.

Killing rhododendron

Some method of killing the plant must be used as rhododendron invariably grows back vigorously when cut, flailed or burnt without fully killing the root system. There are four main approaches which are used:- (i) Digging out the root system, (ii) Treating the cut stump with herbicide, (iii) Spraying regrowth and small plants with herbicide, and (iv) Stem injection.

Herbicides and Bioherbicides

All of the above approaches, except Digging out the root system requires the application of herbicide to kill the root system. Glyphosate (®Roundup) is currently the most commonly used herbicide but in recent years concerns have arisen over the use of it and links to cancer in humans and other environmental issues.

There are a number of alternative herbicides available on the market at present which can be used instead of Glyphosate[2]. These include Imazapyr (® Arsenal) and Triclopyr (® Garlon) and the currently banned (in the EU) Ammonium sulphamate (®Amicide). Also wood rotting fungus *Chondrostereum purpureum*, has been used as an effective bioherbicide in a number of trials in a bid to find an alternative altogether to chemicals.

1. Digging out

Digging the stumps out of the ground is an effective way of killing rhododendron. Its effectiveness is maximised by removing all viable roots, although this is also very labour intensive. Digging out can be carried out manually or, if the terrain allows, by machine (e.g. a tractor and chain). To prevent regrowth, as much soil as possible should be knocked off the root system, and the stumps should be turned upside down to expose the roots to the air and to allow the rain to wash off any remaining soil. After drying out stumps that are dug out should be burnt along with the

[1] *If piled appropriately, rhododendron brash can be used to build a very effective temporary barrier (which may last for 10-15 years) to deter sheep, cattle and deer from entering an area in which, for example, trees have been planted or natural regeneration is being encouraged. However, on sites with a risk of fire, ordinary fencing may be more suitable.*

[2] *See also Ward (1998) and the Pesticide Control Service, Department of Agriculture & Food, (www.pcs.agriculture.gov.ie) regarding current recommendations for chemical control.*

cut material. Depending on how it is done, digging out can result in some degree of soil disturbance, and so may not be an option on some of the more sensitive sites.

2. Direct stump treatment

Rhododendron kill can be achieved by direct stump treatment, whereby freshly cut stumps are painted or spot sprayed with a herbicide solution. Ideally this should be carried out when rain is not imminent, to avoid the solution from being washed off. Stems are cut as close to the ground as possible, and the fresh stump surfaces treated with herbicide immediately, i.e. within minutes. A vegetable dye is used to clearly identify which stumps have been treated. Painting of stumps with glyphosate (trade name Roundup) solutions is regarded as being most effective method of killing rhododendron outside the time of spring sap flow. Willoughby et al (2015) found Triclopyr (trade name Garlon) to be as effective at reducing stump regrowth as Glyphosate. In the same study they did find however that Triclopyr was absorbed more quickly than Glyphosate, making it more rainfast. They also found it more efficient than Glyphosate when being applied during the spring sap flow.

Table 3 shows a number of herbicides, hazard classification and application methods & rates recommended for use in the control of rhododendron by The Research Agency of the Forestry Commission (UK) (after Edwards 2006)

Surfactant additives are not appropriate for stump application. It is important when using this method to ensure that the cambium layer is treated with the herbicide and that it is applied as soon as possible after cutting.

Trials in Killarney National Park on stump treatment resulted in extremely successful kill rates among a range of plant sizes throughout all months of the year. Chemical concentrations from 10% to 20% have been used effectively (see Table 4.). A major advantage of stump treatment is that all initial clearance work can be carried out in a single sweep. Also, as the application of the herbicide is carried out with a hand-held applicator, spray drift is avoided and the impact to the surrounding non-target area is minimal. In addition, small volumes of herbicide are used.

Herbicide	Hazard Classification for Product	Selectivity	Application Methods & Rates
Glyphosate	Roundup ProBiactive and Envision -none	Non-selective	Cut stump -20% solution
	For other products, refer to practice guides and product labels		Foliar spray-2% solution (plus 2% Mixture B)
			Stem in-ection - 25% solution
Tridopyr	Irritant to eyes and skin	Perennials and woody weeds	Cut stump- 8% solution
	Harmful if swallowed or in contact with the skin		Foliars spray -2.5% solution
	Harmful to aquatic life		
2,4-D/dicamba/triclopyr	Irritant to eyes and skin	Annuals, perennials and woody weeds	
	Harmful if swallowed		Foliar spray- 7.5% solution
	Harmful to aquatic life		
Ajuvant (High Trees Mixture B)	Irritant to eyes and skin		
	Harmful if swallowed		Foliarspray - 2% total spray volume
	Harmful to fish		

Table 3 Triclopyr cannot be considered readily biodegradable.

Although stump treatments can result in total kill, regrowth from the cut stumps can occasionally occur, due to slow or incomplete absorption of the chemical by the plant due to weather conditions, timing of application or application error. This regrowth is usually slow and stunted. Carefully timed foliar application of herbicide to the regrowth will subsequently achieve full kill alternatively, if there is space on the stump to re-cut it closer to the ground and re-apply the herbicide, this can also be done.

An alternative option to using hand-held applicators is to use Ecoplugs (formulated as Ecoplug Max® (680 g kg-1 glyphosate); Monsanto 2009); or as Ecoplug Max® (720 g kg-1 glyphosate); Monsanto, 2016)), which are an encapsulated formulation of crystalline glyphosate currently used in the UK to prevent resprouting from cut stumps after tree felling, particularly on railway embankments and beneath electricity lines. In studies carried out by Willoughby et al (2017) Ecoplugs proved to be more effective than conventional sprays in killing rhododendron when used on cut stumps. The plugs are inserted into holes made in the stump using a battery powered drill. The manufacturers currently recommend Ecoplugs are applied no more than two days after initial cutting of the rhododendron (Monsanto 2009). It may be possible to use clay to plug holes filled with crystalline glyphosate rather than using plastic.

A wood rotting fungus *Chondrostereum purpureum*, has been used as an effective bioherbicide for the control of hardwood vegetation in North America and Europe. The fungus is also undergoing evaluation for control of

Stump Treatment & herbicide rates from Killarney National Park

Concentration	Volume of herbicide	Number of stumps treated
Water: Roundup	per stump	per 5L Roundup
5:1 (20%)	0.65ml	765
10:1 (10%)	0.30ml	1667

Table 4
Source : https://www.killarneynationalpark.ie/wp-content/uploads/2015/05/Direct%20Stump%20Treatment.pdf

species such as gorse, willow, birch and Rhododendron. When applied to cut stumps, *C. purpureum* can suppress the regrowth of the target vegetation. In recent trials by Willoughby et al (2015) it was found though, that synthetic herbicides were more effective at reducing the amount of regrowth on cut rhododendron stumps.

3. Spraying of regrowth and large seedlings

Stumps and large seedlings (less than 1.5 m in height) can be effectively killed by spraying the foliage with a suitable herbicide, typically glyphosate, Imazapyr or Triclopyr (see Table 2) Usually the cut stumps are allowed to regrow for 1-3 seasons before being sprayed (Fig. 3).

(e.g. Mixture B) can increase the rate of herbicide absorption and reduce the amount of 'dry-time' required after foliar herbicide application. Surfactants are often more environmentally damaging than the herbicides themselves and must be used with great care, especially adjacent to aquatic habitats. Liquid soap/washing-up liquid has been successfully used as an alternative to commercially available surfactants.

Spraying should only be carried out in near windless conditions, to maximise herbicide contact and absorbance of the chemical into the plant. Conversely, spraying in windy conditions should be avoided at all costs, as this will lead to herbicide drift, resulting in 'collateral damage' which will kill nearby native

Fig 3. Eco Plugs inserted into cut stump. Photo credit: Willoughby et al 2017

Fig 4. Eco Plugs and drill bit

Source https://www.forestresearch.gov.uk/research/the-use-of-ecoplugs-for-woody-weed-control/

There are a number of important considerations to bear in mind when spraying regrowth. Firstly, glyphosate must be applied in dry weather, which obviously poses a challenge under Irish conditions! Success is dependent on the plants being dry at the time of herbicide application and remaining dry for a sufficient time thereafter to allow the herbicide to be absorbed into the plant (at least 6 hours, preferably longer). The addition of a surfactant

flora, including herbaceous species and young regenerating trees. This delays the establishment of a ground cover and facilitates further rhododendron establishment.

Ensure at all times that chemical solutions do not enter watercourses, as this can have a severe impact on the aquatic habitat and on aquatic life. At all times, adhere to best practice regarding safety and environmental

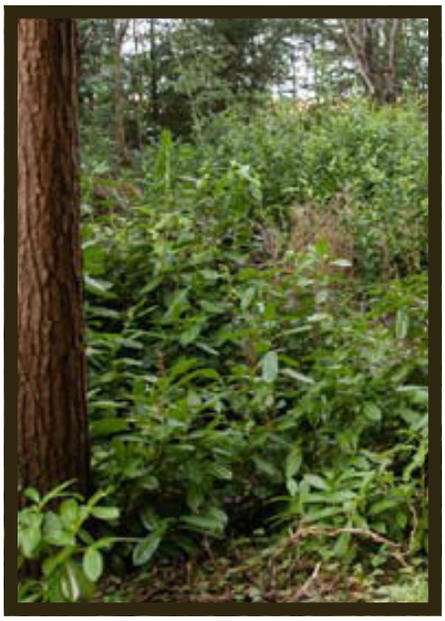

Fig 5: Cherry laurel regrowth suitable for foliar herbicide application, Clonbur, Co. Mayo.

protection, as set out in the manufacturer's guidelines, Ward (1998), and the Forest Service Forestry and Water Quality Guidelines and Forest Protection Guidelines.

As spraying is not 100% effective, some plants may require two or more applications before they are killed completely. Since cut stumps generally produce multiple shoots of regrowth, delaying the spraying for more than three years after the initial stump cutting can actually result in the infestation becoming even more severe. At this stage, the regrowth is likely to be too tall to be sprayed effectively, forming dense impenetrable thickets. Regrowth is also likely to flower more vigorously than naturally regenerated rhododendron.

4. Stem injection

Stem injection, using the 'drill and drop' method **(Edwards, 2006),** can be used for the control of established rhododendron bushes, where access to the main stem is possible and where the stem is large enough for a

EDWARDS, C. (2006). Managing and controlling invasive rhododendron. Forestry Commission Practice Guide.

Note: *Translocation within rhododendron stems is particularly poor in a tangential direction. In effect, spraying one part of a bush results in the death of that part only. It is therefore important to ensure full coverage of all foliage. It is usually necessary to retreat small pockets of regrowth for 2-3 years following initial spraying.*

Herbicide	Product rate	Optimal time of year
2,4-D/dicamba/triclopyr (200:85:65 1-1)	7.5% solution in water (maximum of 5L ha-1	July-September
Ammonium sul hamate e.g. Amcide	40% solution in water	Mav-June
Glvohosate (360 g L-1) e.g. Roundup ProBi active	2% solution in water plus 2% adjuvant* (High Trees Mixture B) (maximum of 10L ha-1)	March-October
Triclopyr(480g L-1) e.g. Timbrel	2.5% solution in water (maximum of 8L ha-1)	June-September

Table 5: Herbicides (including application rates, methods and timing) used in the control of rhododendron by foliar application.

hole to be drilled into it. One of the main advantages of this technique is that it facilitates the controlled application of herbicide to target plants, thereby reducing damage to other flora adjacent to treated bushes. It is a particularly useful method on difficult, sloping terrain, where other methods may be impractical. A handheld cordless drill with several re-chargeable batteries and a spot gun are the only tools required. A 25% solution of glyphosate (i.e. 1:3 mix with water) is recommended. No additives are required. Applications during March, April and October have been successful in giving complete control of target bushes.

The main steps involved in stem injection are as follows:

1. Stems to be treated should be greater than 3 cm in diameter. In order to maximise the potential of killing the entire plant, choose a position on the stem as close to the main root system as possible, and at least below the lowest fork.

2. Drill as vertically as possible into the stem to create a hole that will hold the herbicide solution. The drill bit used should be 11–16 mm in diameter, depending on the stem diameter. There is no upper limit to the size of stem that can be treated.

3. Apply the herbicide to the hole immediately after drilling. The recommended amount is 2 ml of herbicide solution per stem. Do not allow the herbicide to overflow from the hole. The use of a forestry spot gun with a calibrated 10 ml chamber is recommended, as this allows for the accurate application of a calibrated 2 ml of herbicide per hole.

4. It is recommended that each plant be marked immediately after treatment, to track progress. Treated plants can be marked with a spray of coloured paint or by attaching coloured biodegradable tape.

5. Applications can be made in light rain, provided that rainwater is not running down the stem into the application hole and washing the herbicide solution out into the surrounding area.

6. Bush death should occur between 9 and 31 months, depending on application date and bush size.

In Killarney National Park a similar method has been devised using a hand-held hatchet instead of the cordless drill. The hatchet is used to make a downward cut into the cambium and sapwood layers leaving a hinged notch on the plant stem. The notch is immediately treated with an herbicide solution using a handheld applicator, wetting all exposed areas to run off point. The stem notches should be cut near the base of each stem, with two notches applied to stems of up to 7cm and an additional cut for each extra 3.5cm increase in diameter. With this method leaf dieback begins 3-4 weeks after treatment carried out during the growing season (April – Sept) and will take longer if treated outside of this time. The plant will usually be completely dead within 12 months of this kind of treatment.

Treated bushes can be left standing on site to rot. However, bear in mind that standing, dead rhododendron may persist for 10 to 15 years. It can be considered unsightly and does inhibit access to the woodland for management operations. It can also pose a fire risk in areas where fires are common. Therefore, it may be better to cut and remove the treated bushes as soon as they are dead and it is possible to do so. The extremely heavy leaf fall

Stem Treatment Trials in Killarney National Park

Concentration Water: Roundup	Volume of herbicide per stem	Number of stumps treated per 1L Roundup
5:1 (20%)	0.50ml	1925
10:1 (10%)	0.26ml	3850

Table 6. Source :https://www.killarneynationalpark.ie/wp-content/uploads/2015/05/Stem%20Treatment.pdf

as a result of all of the plants on the site dying simultaneously can form a thick layer of "mulch" which will persist for many months due to them not being readily broken down naturally. This thick layer of dead leaves can seriously inhibit the progress of recolonization of the natural ground flora of the site. The effectiveness of control should be assessed initially every 12 months following the treatment.

Follow up operations

If the initial infestation was of the flowering age, or if there is a seed source nearby, a follow-up seedling removal operation will be necessary. The intensity of this operation will vary, depending on the degree of infestation, i.e. severe, moderate or slight (see Table 1). In cases where there is a possibility of stumps re-sprouting and subsequently flowering, the area should be systematically checked within 2-3 years. All woodland areas vulnerable to rhododendron establishment through seed influx should be checked every 6-8 years.

Rhododendron seedlings should be pulled manually, and either piled and burnt or removed from the site altogether. If large enough, they can also be hung securely from trees and left to dry out and die after knocking all soil from the roots. The vulnerability of the site to infestation (or reinfestation) can be reduced by encouraging the development of a dense ground cover, through the control of grazing pressure. Grazing pressure from livestock, deer and feral goats, will need to be controlled and should be managed at levels that will allow the natural regeneration of the native ground flora. This helps to suppress the emergence of young rhododendron plants. A reduction in the level of grazing pressure is typically achieved through fencing and culling.

A recent report by Mitchel et al (2019) on a long term study of the recovery of native vegetation after the removal of heavy infestations of rhododendron from Atlantic oak woodlands in Argyll, Scotland, suggests that flowering plants native to those woodlands do not recover once the rhododendron is removed, but that epiphytic and understorey bryophyte species recover well. Areas of oak woodland, cleared of heavy rhododendron infestation in Killarney National Park during the late 1980s and early 1990s have experienced a good recovery of a variety of native flowering plants and trees where grazing levels have been eliminated by the use of fencing and "dead-hedging". Also in Killarney, in woodlands cleared of rhododendron, where high levels of grazing pressure has continued, recovery of ground flora has been extremely limited and in many areas non-existent.

Adjacent rhododendron seed sources

If the adjacent seed source can be cleared, this should be undertaken at the same time as clearance work on the site itself. However, if the adjacent seed source is outside the control of management, the clearance and maintenance of a buffer zone around

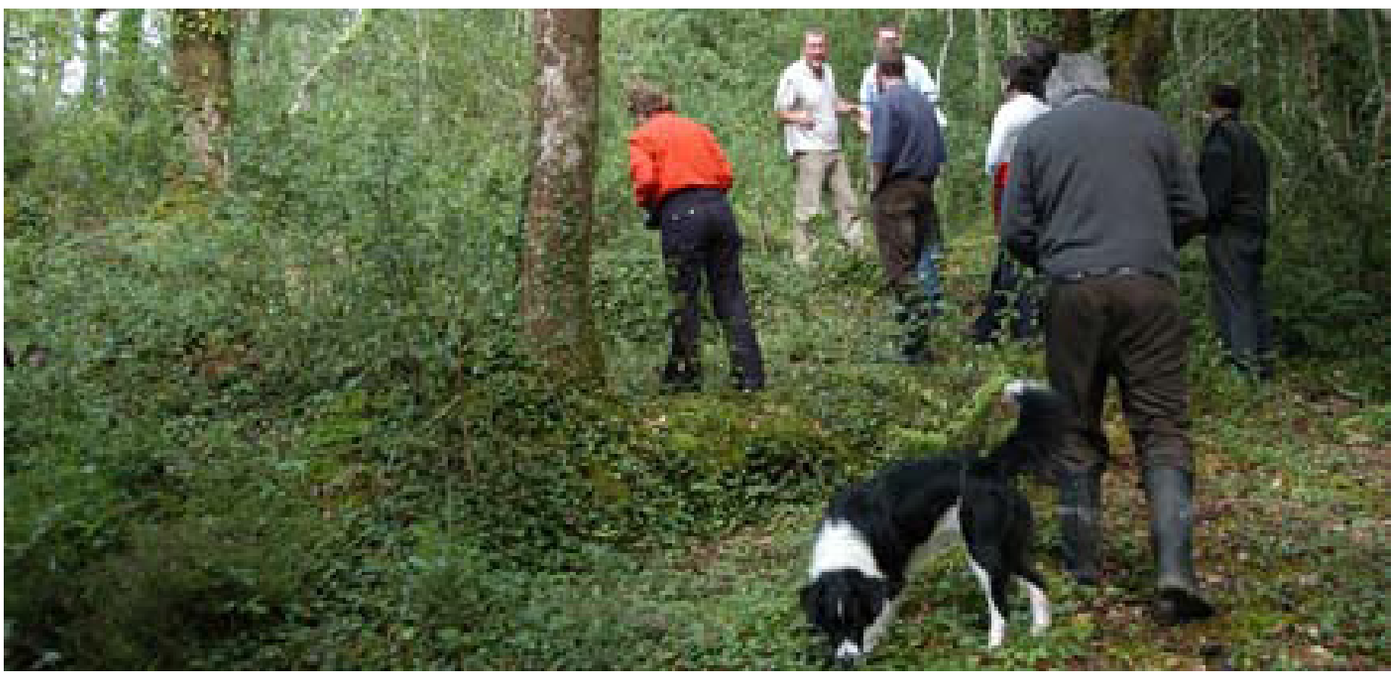

Fig 6: A native woodland formerly infested with rhododendron, subsequently cleared and now recovering successfully, Glengarriff, Co. Cork.

the site will minimise reinfestation from outside seed sources via seed dispersal. The buffer zone should be as wide as is practically possible.

Adjacent domestic gardens, arboretums, etc. can also represent a seed source. If possible, the owner should be encouraged to remove flower heads after flowering. As seed maturation usually takes six months, remove the heads by December as this will prevent seed dispersal which normally occurs between January and March.

Landscape Scale Approach

The presence of rhododendron is a major cause of designated habitats being classified as being in an unfavourable condition. In a report from 2017, The Forestry Commission of Scotland describe a landscape scale approach to prioritising control of Rhododendron across Scotland, by focusing primarily on Natura 2000 designated habitats in a number of different locations. The Scottish Forestry Commission feel that to be able to maximise value for money, the funds available to them should be targeted towards these priority habitats, with control focusing on entire populations of rhododendron using best practice clearance methods (Forestry Commission of Scotland (2017).

Quality control in rhododendron management

Whatever method is used to control rhododendron, there is always a risk that treatment will be only partially effective and that further action will be required to achieve total kill. The degree of success of the initial treatment method can be maximised by paying careful attention to the operational detail of whichever method is used. Even then, it is likely that some regrowth will occur. Because of this, it is vitally important that provision is made to re-visit sites to assess effectiveness of the clearance work and determine if further treatment is required, otherwise the site will become infested again.

CONCLUSIONS

Rhododendron (and laurel) poses a serious ecological threat to native woodlands in Ireland, particularly by displacing native vegetation and by preventing the natural regeneration of native flora. This results in the disruption of woodland succession and continuity, with a consequent reduction in woodland biodiversity. The future survival of badly infested woodlands may be seriously compromised and even impossible.

The control and/or eradication of this invasive alien species requires long-term planning, a good understanding of its ecology, and a thorough application of initial clearance and meticulous attention to detail in the follow-up programme such as stump uprooting and/or herbicide treatment (Fig. 3 & 4). Timing of clearance work and of herbicide application as well as consideration of weather conditions are very important factors and must be taken into account. The control of seedlings and the regrowth from cut stumps involves a process of rigorous, systematic checks, record-keeping, mapping and monitoring.

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REFERENCES AND FURTHER READING

Barron, C. 1998. The distribution of the Kerry Slug, Geomalacus maculosus, within the oakwoods of Killarney National Park, southwest Ireland: The influence of Rhododendron ponticum. A project prepared in partial fulfilment of B.Sc. in Countryside Management. Welsh Institute of Rural Studies, Aberystwyth.

Becker, D. 1988. Control and Removal of Rhododendron ponticum on RSPB Reserves in England & Wales. Unpublished Report. Royal Society for the Protection of Birds, Sandy, UK.

Cross, J.R. 1975. Biological Flora of the British Isles Rhododendron ponticum L. Journal of Ecology 63:345-363.

Cross, J.R. 1981. The establishment of Rhododendron ponticum in the Killarney Oakwoods, S.W. Ireland. Journal of Ecology 69:807-824.

Edwards, C. 2006. Managing and Controlling Invasive Rhododendron. Forestry Commission Practice Guide, Forestry Commission, Edinburgh.

Forestry Commission of Scotland (2017) An Approach to Prioritising control of rhododendron in Scotland.

Freeman, K. 1988. Woodland bird communities in Killarney National Park, with special reference to the effects of the alien shrub Rhododendron ponticum L. and its clearance. PhD. Thesis, University of Dublin.

Higgins, G.T. (2008) Rhododendron ponticum: A guide to management on nature conservation sites. Irish Wildlife Manuals, No. 33. National Parks & Wildlife Service.

Mitchell, R., McClean, J.,Burslem, D., Genney, D., Hall, J. & Pakeman, R. 2019. The effect of clearing invasive rhododendron on the native plant community of Atlantic woodland. Conservation Land Management17 (1), 24-29.

Monsanto (2009). Ecoplug Max® product label. www.monsanto-ag.co.uk.(Accessed 4/11/16 by Willoughby et al 2017)

National Parks and Wildlife Service, Killarney National Park, Co. Kerry (undated) https://www.killarneynationalpark.ie/about-us-killarney/rhododendron-control/ (accessed 14th Sept 2019)

Parrott, J. & MacKenzie N. (2013) A critical review of work undertaken to control invasive rhododendron in Scotland. A report commissioned by Forestry Commission Scotland and Scottish Natural Heritage

Rotherham, I. and Read, D.J. 1988. Aspects of the ecology of Rhododendron ponticum with reference to its competitive and invasive properties. Aspects of Applied Biology 16:327-335.

Shaw, M W. 1984. Rhododendron ponticum – Ecological reasons for the success of an alien species in Britain and features that may assist in its control. Aspects of Applied Biology 5:231-242.

Tabbush, P.M. & Williamson, D.R. 1987. Rhododendron ponticum as a Forest Weed. Forestry Commission Bulletin No. 73. HMSO, London.

Willoughby, I. and Dewar, J. 1995. The Use of Herbicides in the Forest. Forestry Commission Field Book No. 8. HMSO, London.

Willoughby, Ian H., Stokes Victoria J. & Edwards, Colin. (2017) Ecoplugs containing glyphosate

can be effective in preventing regrowth from Rhododendron ponticum stumps Scottish Forestry,71 (3), 33-39.

Willoughby, Ian H., Stoke, Victoria J. & Connolly Tom. (2017) Using Ecoplugs containing glyphosate can be an effective method of killing standing trees Forestry 90 (5), 719 – 727.

Willoughby, Ian H., Seier Marion K., Stokes, Victoria J.,. Thomas Sonal Varia, Sarah E. (2015) Forestry: An International Journal of Forest Research,88, 336–344

https://doi.org/10.1093/forestry/cpv004 Synthetic herbicides were more effective than a bioherbicide based on Chondrostereum purpureum in reducing resprouting of Rhododendron ponticum, a host of Phytophthora ramorum in the UK

Ward, D. (Ed.) 1998. Guidelines for the Use of Herbicides in Forestry (2nd Edition). Produced for the Forest Service by Coillte. Available from the Forest Service, Department of Agriculture and Food, Johnstown Castle Estate, Co. Wexford.

ADDITIONAL NOTE: PHYTOPHTHORA RAMORUM CAUSAL AGENT OF SUDDEN OAK DEATH DISEASE

Since first reported in the mid-1990s, significant numbers of oak trees and other plant species have been damaged or killed in California and other parts of the western United States by a newly described disease, commonly known as Sudden Oak Death, caused by a new species of fungus named *Phytophthora ramorum*. The same fungus had also been found in many EU countries, mainly on the shrub species *Rhododendron* and *Viburnum*.

Under the EU Plant Health Directive emergency legislation was introduced in 2002 to prevent the introduction into and the spread within the EU of *Phytophthora ramorum*.

Since 2003, annual surveys have been carried out throughout the EU including Ireland. *Phytophthora ramorum* has been found in 12 EU Member States. The vast majority of findings have been on plants of *Rhododendron* and *Viburnum* species. In relation to tree species, the fungus has been found in Britain on a range of tree species including a number of oak species, beech, ash, sycamore, Spanish chestnut and horse chestnut. In the Netherlands, the fungus has been found on beech and red oak.

In Ireland, the fungus has been found on *Rhododendron ponticum* in a number of forest locations and in Japanese larch plantations across the south of the country with containment/eradication measures being implemented. The fungus has also been detected in garden centres and nurseries on *Rhododendron* and *Viburnum*.

Forest owners are encouraged to report unusual symptoms of disease on *Rhododendron*, such as wilting, to their local Forestry Inspector.

Further advice is available from Forest Protection & FRM Section, Forest Service, Tel. 1890200510 (lo-call) or 01-6072651; e-mail forestprotection@agriculture.gov.ie

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