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Duncan J. Halley

Rhododendron growing wild in West Norway / Forvillet *Rhododendron* i Vestlandet

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COVER PICTURE
Rhododendron growing wild in West Norway (Tysnesøya) /Forvillet *Rhododendron* i Vestlandet (Tysnesøya) © DJ Halley

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Abstract

Halley, D.J. 2018. Census of potentially invasive Rhododendron in West Norway and the implications for management. NINA Report 1561. Norwegian Institute for Nature Research.

Rhododendron hybrids based on *R. ponticum baeticum* are the most serious invasive plant problem in north and west Britain and in Ireland, with outbreaks also in Benelux, Germany, Denmark, France, and New Zealand. Control costs millions of £ annually, and economic losses are considerable. The form creates large areas of dense cover which outcompetes native species, is inedible to grazing animals and is a reservoir for forestry diseases. The climate and geology in western/northern Great Britain and Ireland is very similar to that of Western Norway; the form is invasive in places with colder climates than some regions of coastal West Norway. In recent decades *Rhododendron* of many hybrid forms have become common in the region, often close to suitable wild habitat.

However, the forms of *Rhododendron* present in rural or town edge gardens, next to potentially suitable habitat for invasion, have not been studied in Norway. In June 2018, a census was conducted of six transects of 15 gardens each in such areas, to begin to provide structured data.

The forms of *Rhododendron* commonly planted in West Norway are not “species” as usually understood in colloquial speech. All are hybrids developed in many cases over more than 150 years, most of complex but only partly - or even completely - unknown genetic origin. All include genetic material from two or more wild species; usually more. These hybrid forms are usually interfertile.

70% of gardens contained one or more *Rhododendron*. The commonest type is a group of hybrids usually known as ‘parkrododendron’ in Norway; 48% of all *Rhododendron* belonged to this type. 21% belonged to white-flowered forms often called ‘fujirododendron’ in everyday speech, but in fact from a wide range of hybrid sources not necessarily including *R. brachycarpum.* 31% were other hybrid forms. Parkrododendron were commoner in coastal transects; white-flowered fujirododendron types were the most common in inner fjord transects.

Several of the hybrid forms commonly found, and sold, in West Norway are known to be in their 19th century origin a cross of British form *R. ponticum baeticum* and another species such as *R. catawbiense*, with complex and largely undocumented outcrossing, backcrossing, and internal genetic dynamics thereafter. *Catawbiense* and *ponticum* are considered by experts to be ‘barely distinguishable’, with consequent risk of misattribution of *ponticum*-based hybrids to *catawbiense.* Other hybrids include *R. ponticum* DNA through later rehybridisation. Forms sold as ‘*catawbiense*’ hybrids – most ‘parkrododendron’ sold in Norway are labelled ‘catawbiense hybride’ - may contain no *catawbiense* genetic material; the name should not be taken to indicate genetic origin without further evidence.

Wild *R. p. baeticum* is not hardy to oceanic climates, and hybrids based on other species may also become adapted to the climate. Several wild-reproducing populations, ascribed to three ‘species’, are already known to be established in Norway. For managers it is more useful to think in terms of overlapping ‘hybrid swarms’ of DNA in gardens and public spaces, of diverse and partially unknown origin. These generate millions of re-hybridised seeds annually. It can be expected that some of these seeds will ‘solve’ the problem of growing and reproducing in the wild, from time to time.

Rhododendron DNA in West Norway should be directly analysed, to assess the genetic material present and its invasive potential. Guides in Norwegian on effective techniques of removing invasive *Rhododendron* should be produced. Existing wild populations should be identified and eradicated; eradication at this stage is inexpensive. Once firmly established, control is expensive and extermination not practicable. New outbreaks should be expected to occur periodically, and be eliminated as they arise.

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Sammendrag

Halley, D.J. 2018. Taksering av potensielt invasive *Rhododendron* på Vestlandet og betydningen for forvaltning. NINA Rapport 1561. Norsk institutt for naturforskning.

Rododendronhybrider krysset fra *R. ponticum baeticum* utgjør det mest alvorlige problemet når det gjelder invasive planter i Nord- og Vest-Storbritannia samt Irland, og spredning er i tillegg registrert i Beneluxlandene, Tyskland, Danmark, Frankrike og New Zealand. Bekjempelsesarbeider koster millioner av pund årlig, og det er registrert store økonomiske tap som konsekvens av spredningen. De skadelige rododendronvarietetene skaper store områder med tett dekke som utkonkurrerer stedegne arter, er uspiselige for beitedyr og er et reservoar for skogssykdommer. Klimaet og geologien i vestlige / nordlige Storbritannia og Irland er tilnærmet lik vestnorske områder og de invaderende varietetene er registrert på steder med kaldere klima sammenlignet med kystnære områder i Norge. I de siste tiårene har ulike rododendronhybrider blitt vanlig som prydplante på Vestlandet, ofte i nærheten av egnete naturlige habitater.

Varietetene av rododendron som er vanlige i rurale områder ved siden av potensielt egnede naturlige habitater for invasjon, er ikke studert tidligere. I juni 2018 ble det gjennomført en analyse hvor seks transekter som inneholdt 15 hager hver ble undersøkt for å kunne gi strukturerte data.

Rododendronvarietetene som vanligvis er plantet på Vestlandet, er ikke "arter" i tradisjonell forstand. De er hybrider som i mange tilfeller er utviklet i over 150 år. De er svært komplekse, og kan ha delvis eller helt ukjent genetisk opprinnelse. Samtlige av disse hybridene inkluderer genetisk materiale fra to eller flere ville arter; ofte enda flere, og de kan som regel hybridisere med hverandre.

70% av hagene inneholdt en eller flere rododendronvarieteter. Den vanligste typen er en gruppe hybrider som kalles parkrododendron i Norge. 48% av alle registrerte rododendroner tilhørte denne typen. 21% tilhørte varieteter med hvite blomster, ofte omtalt som "fujirododendron" i dagligtale, men som faktisk er fra et bredt spekter av hybridkilder som ikke nødvendigvis inkluderer *R. brachycarpum*. 31% var andre hybridformer. Parkrododendron var vanligst i kystnære områder, mens hvitblomstrede fujirododendrontyper var de vanligste i indre fjordstrøk.

Noen av hybridformene som vanligvis finnes og selges i Vest-Norge, er en kryssing av britisk form *R. ponticum baeticum* og arten *R. catawbiense*, med komplisert og stort sett udokumentert utkryssing, tilbakekryssing, og intern genetisk dynamikk. *R. catawbiense* og *R. ponticum* anses av eksperter å være «knapt skillbare», med tilhørende risiko for feilidentifisering av *ponticum*-baserte hybrider til *catawbiense*-hybrider. Andre hybrider inkluderer *R. ponticum* DNA ved senere re-hybridisering. Varieteter solgt i Norge under merket '*catawbiense hybride'* – omtalt som 'parkrododendron' - kan til og med ikke inneholde noe genetisk materiale fra *R. catawbiense*. Navnet bør derfor ikke tas for å indikere genetisk opprinnelse uten ytterligere bevis.

Villtypen *R. ponticum baeticum* er ikke hardfør i forhold til et oseanisk klima. Hybrider basert på den og andre arter kan derimot tilpasse seg klimaet. Flere rododendronpopulasjoner, som tilskrives å forekomme fra tre ulike "arter" men faktisk fra hybrider, er allerede etablert i vill tilstand i Norge. For miljøforvaltningen er det mer fruktbart å se problematikken i form av overlappende "hybridsvermer" av DNA i hager og offentlige rom, som inkluderer mangfoldig og delvis ukjent genetisk opphav. Disse genererer millioner av re-hybridiserte frø årlig. Det kan forventes at noen av disse vil kunne overleve og reprodusere seg i naturen.

DNA fra rododendronvarieteter i Vest-Norge bør analyseres for å vurdere det nåværende

genetiske materialet og dets invasjonspotensiale. Det bør utformes protokoller på norsk om effektive teknikker for fjerning av invasiv rododendron. Eksisterende villpopulasjoner av invasive rododendronvarieteter bør identifiseres og utryddes; da utryddelse på dette stadiet er relativt billig. Når en invasiv form er etablert, bekjempelse er kostbar og utryddelse nærmest umulig. Nye utbrudd bør forventes å forekomme sporadisk, og bør dermed elimineres etter hvert som de oppstår.

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Contents

Foreword

The work in this report was financed by the Norwegian Environmental Agency, reference number 18S34B30; and we thank them for their support. I would also like to thank the several people in the field area who were happy to discuss the *Rhododendron* in their gardens with me, and to allow collection of samples of leaves and flowers, while I was conducting transects. Rakel Blaalid provided valuable constructive criticism of the draft, and translation of the abstract and figure legends into grammatical Norwegian.

30.11.2018 D.J. Halley

1 Introduction

Invasive forms of *Rhododendron* are a serious and costly environmental problem in some areas with climates like those of Western Norway (Vestlandet), such as western and northern Great Britain[1], and Ireland. Climate change is predicted to increase the proportion of Norway vulnerable to invasion by *Rhododendron* as the overall forecast is more precipitation and higher temperatures (Hanssen-Bauer *et al.* 2017). In recent decades, *Rhododendron* have become among the most common of all garden plants in Western Norway. Seed source for potentially invasive forms is now very widespread immediately next to suitable wild habitat.

In Britain and Ireland, a hybrid form based on *Rhododendron ponticum* regenerates rapidly on open ground, in forestry clear-cuts, and within existing open woodland. It develops into a dense single-species cover, preventing any other species from germinating. Existing woodlands, as older trees die off, become *Rhododendron* monocultures (Fig. 1, 4). The wood is of no timber value (Edwards 2006) and is unsuitable for domestic firewood, the foliage is toxic to both domestic and wild grazing mammals (*op.cit.*), and the nectar is toxic to several wild pollinators and to honeybees (Tiedeken *et al.* 2016). The area covered thus becomes very low in biodiversity, and is of little value both in terms of direct economic productivity and in ecosystem services. Such areas can be measured in units of square kilometres in parts of Britain and Ireland (e.g. Edwards 2006, Cullen 2011).

It and other rhododendron varieties can also be reservoirs for ecologically and economically important invasive plant pathogens such as *Phytophthora ramorum* and *Phytophthora kernoviae* (Sansford *et al.* 2009); a number of outbreaks of *P. ramorum* in *Rhododendron* in Norway have already been documented (Fjeld 2008; Sveen 2016; Mattilsynet 2017). Invasive outbreaks of British-form *Rhododendron ponticum* are also known from the Netherlands, Belgium, Germany, Denmark, France, and New Zealand (Milne 2017).

Rhododendron species often hybridise in the wild (e.g. Zhang *et al.* 2017 and references therein), and readily do so in cultivation. Patterns of genetic introgression are highly complex and variable. The usefulness of the species concept itself has been doubted for the group (e.g. Marciewicz *et al.* 2015). Hybrids are themselves normally fertile both with themselves and with other hybrid forms. The invasive form in Britain is a hybrid developed for robustness to acidic soils and an oceanic climate over several decades in the 19th century (Dehnen-Schmutz & Williamson 2006). It was widely planted in the 19th and early 20th centuries century. Although based on *R. ponticum* it is of unclear (and to a large extent undocumented) detailed origin, and has been subject to further natural selection from within its hybrid genome as it spread into the wild from gardens (a number of separate events are recorded): “Natural hybridisation has been important in the wild as in gardens, and even helped make *R. ponticum* a rampant invader” (Milne 2017). It is often cited in the literature as a classic example of a ‘hybrid swarm’, defined as ‘complex mixtures of parental forms, F_1 hybrids, backcross types and segregation products’ (Grant 1981), and is sometimes classified as *R. x superponticum* (Cullen 2011). It will be referred to here as ‘British form *ponticum*’.

Since 2010, further planting of *R. ponticum* has been illegal in the UK (Milne 2017). The ongoing cost of *Rhododendron* to the forestry industry alone is estimated as £9 million a year for Great Britain and £1 million a year for the island of Ireland (Kelly *et al.* 2013), both areas with much smaller forestry industries than West Norway. Extermination is considered impracticable; in Scotland efforts have to be prioritised strongly because of the extent of the problem and the costs involved (Forestry Commission Scotland 2016). In Argyll and Bute, a 6909km^2 local government district of Scotland (c. ¾ the size of Rogaland province), with a climate and geology very similar to coastal West Norway, a Forestry Commission report estimated cost of eradication at £9.3 million in 2008; £19 million in 2028; and £65 million in 2058, due to predicted further spread (Edwards & Taylor 2008).

[1] ‘Great Britain’ means the island of that name, comprised of England, Scotland, and Wales.

Recent recognition of the potential risk from invasive *Rhododendron* led to four *Rhododendron* species, *R. catawbiense R. brachycarpum, R. suchuenense* and *R. ponticum (baeticum[2])* being placed on the Norwegian Alien Species list as potentially invasive species.

Figure 1. *Pine woodland in the process of conversion to single-species cover of British hybrid R. ponticum, SW Ireland* / **Figur 1.** *Furuskog i gjengroing hvor den invasive britiske hybriden R. ponticum danner et tett og artsfattig bunn og feltskikt, Sørvest Irland. Photo: D.J. Halley*

[2] *Baeticum* is the Iberian subspecies, from which (with other species) the British invasive hybrid form is derived. It may not be appropriate to classify British invasive form *R. ponticum* as *baeticum* (Milne & Abbott 2000); or even as *ponticum* (Cullen 2011).

Figure 2. *British hybrid R. ponticum – covered hillside in West Scotland. This site is not classified as 'highest priority for control' (Forestry Commission Scotland 2016) /* **Figur 2.** *Den britiske hybriden R. ponticum dekker en fjellside i vest Skottland. Dette området er ikke klassifisert som et «prioritert område» for bekjempelse og kontroll av arten (Den skotske skogskommisjon 2016). Photo: D.J. Halley*

Figure 3. *British hybrid form Rhododendron ponticum in a forestry clearcut, Ireland. This site would require considerable expense before replanting, or reseeding by the conifers to right, is possible. If felled, the area of conifers to the right would also be colonised, preventing further forestry use without Rhododendron control costing >6000Nkr/ha (Dehnen-Schmutz et al. 2004). See also Edwards (2006) /* **Figur 3**. *Den britiske hybriden R. ponticum i et hogstfelt i Irland. Denne lokaliteten vil kreve en betydelig investering i bekjempelsesarbeid før nyplantning, eller naturlig foryngelse av bartrær er mulig. Dersom skogen ved siden av hogges, vil R. ponticum også invadere dette arealet og dermed forhindre skogbruk. Prisen på bekjempelse er estimert til >6000Nkr/ha (Dehnen-Schmutz et al. 2004; Edwards 2006). Photo: Freyja Degener*

Figure 4. *Early stage of invasion by British hybrid form R. ponticum, of existing birch woodland used for animal grazing, Donegal, Ireland. /* **Figur 4.** *Tidlig invasjonsstadium av den britiske hybriden R. ponticum i skog som benuttes til husdyrbeite i Donegal, Irland Photo: DJ Halley.*

Figure 5. *Rhododendron hybrid, stated to be 'ponticum' based, on sale at Hageland garden centre, Haugesund, 13.06.2018.* / **Figur 5**. *Rhododendron oppgitt antatt å være basert på «ponticum» til salgs på Hageland, Haugesund, 13.06.2018*. *Photo: DJ Halley.*

Figure 6. *Strong sales of Rhododendron, stated to be 'catawbiense hybride', Plantasjen garden centre, Stord, 13.06.2018* /

Figur 6. *Omfattende salg av Rhododendron, oppgitt være en «catawbiense-hybrid» til salgs på Plantasjen, Stord, 13.06.2018. Photo: DJ Halley*

Climate change is predicted to make West Norway significantly milder in winter than it is today (Hanssen-Bauer *et al.* 2017) and this is predicted to make larger areas of West Norway climatically suitable for invasive *Rhododendron* (Töpper & Blaalid 2017). However, while it is often assumed that West Norway is less mild in climate than NW Great Britain, it is important to note that large areas of Highland Scotland are in fact of closely similar climate and geology; and some inland regions of Scotland where invasive Rhododendron are a serious problem, are demonstrably colder and less oceanic in climate year-round compared to many coastal areas of West Norway (Halley 2015; and see here (especially video presentation, 11:30-13:45), for detailed comparison); www.senorge.no, https://www.metoffice.gov.uk/ for statistical databases.

In Norway, *Rhododendron* until recent decades were relatively unusual plants, mainly found in large gardens in towns (especially Bergen, Jørgensen 2003), and in botanical gardens. Over the last 50 years, however, they have become among the commonest garden plants in rural Norway, and are sold in large quantities in garden centres, and even in supermarkets, in the region. This has placed seed sources immediately next to large areas of potentially suitable wild habitat throughout inhabited parts of rural West Norway (see also Discussion).

However, a problem with assessment of how large the risk of invasive establishment is in West Norway is that the forms of *Rhododendron* present in rural gardens have not been described.[3] This limits assessment of the level of risk of invasive spread in the region. This report provides an initial survey of the forms of *Rhododendron* present in gardens and in public spaces in the region. These provide through sexual reproduction the variation in genetic material for wind-dispersed seeds, which are released into the wider environment in large numbers. The consequences for the potential of *Rhododendron* to become invasive in West Norway, how the issue should be conceptualised, and possible management responses, are discussed.

[3] The genetic origins of the commercial hybrids commonly sold by garden centres in Norway are in most cases only partially known, and taxonomic terms used on labels can be misleading (see Figure 11 and Discussion).

2 Methods

Six transects were surveyed for *Rhododendron spp.*, see Table 1 and Figure 7. Each was an area of rural or suburban settlement, where *Rhododendron* spp. growing in gardens were within wind dispersal range of potentially suitable habitat outside gardens. All were at 0-100m asl. The six transects were chosen to follow a cline from inland fjords to coastal locations. Annual precipitation is highest in transects 1-2, inland fjords; lowest in 5-6, coastal (due to topography); but always considerable and well distributed throughout the year. Seasonal variation in temperature is highest in transects 1-2, lowest in 5-6; again because of the effects of relative proximity to the ocean; but in all cases, the climate is mild and oceanic.

In each transect, fifteen gardens or garden-like public spaces (parks, open space of public buildings, etc.) were censused for *Rhododendron* spp. by visual observation and photography of individual bushes or groups of bushes, including detailed pictures of leaves and flowers. Only gardens where the whole of the garden was visible from the road and/or ground covered by Norwegian public right of access law were censused. Each *Rhododendron* species present was noted. Measurements and, in some cases, samples of leaves and flowers from the main types observed were taken from plants growing in public places, from gardens where the owner gave permission (I conversed with several owners in the course of collecting data, all of whom took a friendly interest in my work), and from two *Rhododendron* bushes found growing wild at the same location on Tysnesøya (see front page photograph)

Transect	**Location**	**Kommune**	**Coordinates (decimal)**
1	Ådland-Bjørkeheim	Samnanger	60.40N 05.72E
2	Eikelandsosen	Fusa	60.23N 05.74E
3	Humlevik-Hovland	Tysnesøya	60.05N 05.67E
4	Sagvåg	Stord	59.74N 05.45E
5	Mølstre	Sveiø	59.54N 05.28E
6	Storasund	Karmøy	59.55N 05.36E

Table 1. *Transect locations* / **Tabell 1**. *Oversikt over transekt lokalitetene*

Attempts were made to classify the *Rhododendron* observed to species level with the use of the detailed botanical keys contained in Cullen (2005). However, as the forms in Norwegian gardens are all hybrid cultivars, this approach was of little practical utility. It is more practicable, and more in conformity with the reality of what is growing in the transects, to classify by description of the hybrid forms observed rather than trying to 'shoehorn' what are in fact hybrids of diverse, often complex, and at best partially known genetic ancestry into one or other wild-type 'species'.

Classification by this method resulted in the types described in Table 2. This method is inherently imprecise, as phenotype and hybrid genotype are not closely correlated in this group; however, this imprecision reflects the reality that the hybrid forms grown in the region are of diverse and unclear ultimate origin (see Discussion). It also provides a good general overview of the forms commonly found and how they vary geographically.

A note was also made during each transect of the number of gardens apparently containing, and apparently not containing, *Rhododendron* bushes. For this count, the criterion was only that the majority of the garden space was visible; numbers are therefore higher than for the gardens where the number and type of *Rhododendron* were recorded.

Type	Form (characters visible in field only)	General Notes	Notes on ancestry
A	Shrub. Leaves dark green, oblanceolate, fully grown c.10 cm long. White flowers, sometimes tinged pink, with usually with many small yellow-green or brown spots on the upper lobe, funnel-shaped, about 5 cm wide, in clusters, usually open. See Figure 12.	Larger white-flowered shrubs types sometimes referred to colloquially as 'fujirododendron' in Norway though often not *brachycarpum*-based; the second commonest group of forms after 'parkrododendron'	Mostly apparently 'Cunningham's White' (see Discussion and Fig. 11 for ancestry of this form), 'Catawbiense Album', 'yakushimanum - group' (various hybrids said to be based on *R. degronium, = yakushimanum, e.g. Silberwolke*); *brachycarpum* – based hybrids; or related hybrids.
B	Shrub. Leaves broadly elliptic, smooth. Flower 4-6cm, lilac-lavender with a yellow-red blotch. Ball-shaped truss, 12-16cm in diameter. See Figure 13.	Several plants of this type in transects were labelled '*R. catawbiense grandiflorum'.* One of the forms included in what is usually called 'parkrododendron' in Norwegian.	*Grandiflorum* stated to be '*catawbiense* hybrid or selection'. In the 'hybrid tree' for *grandiflorum* the F1 pollen parent is said to be 'unknown'. Source
B*	Shrub, up to 4m though usually 1-2m. Leaves broadly elliptic to lanceolate, variable in width:length ratio, variably dark to bright green. Flowers campanulate to funnel-campanulate, 3-5cm, lilac-purple, usually with spots. See Figure 14.	A group of similar hybrid forms included in what is usually called 'parkrododendron' in Norwegian.	Indistinguishable in field from British form *R. ponticum.* (*R. catawbiense* and *ponticum* are 'barely distinguishable' even through detailed analysis of small anatomical structures, Milne 2017). Forms of this type commonly sold in garden centres as '*catawbiense hybride*' (Fig 6). NB hybrids sold under names such as '*catawbiense hybride*' do not necessarily contain *catawbiense* DNA (Brand 2015 and see discussion)
C	Small shrub, usually <1m. Dense. Leaves small and rounded, 'ribbed' on upper surface, scaly underside. Flowers funnel-campanulate, deep pink to crimson, c. 3cm wide, in clusters. See Figure 15.	'Dvergalperose' of 'Rosina', 'Scarlet Wonder' and related hybrid forms.	Often sold with 'species' name '*R. repens*' on label; an obsolete taxonomic term referring to several wild forms now considered separate species (Cullen 2005). *R. forresti* and similar species/subspecies ('Repens Group')- based hybrids
D	Small shrub, <1.5m, fairly open 'upright' form. Leaves c.6cm, semi-lanceolate. Flowers 6cm, open campanulate, bright red – crimson, clustered. See Figure 16.	'Nova Zembla' and related hybrids	Ancestry of these hybrids is little known; said to be 25% '*catawbiense*' (Fig 11), but see discussion of '*catawbiense*' as hybrid descriptor.
E	Medium, up to 2m. Leaves lanceolate, or rounded lanceolate, 8cm, dull orange cast to underside colour. Flowers small, 3cm, white, green spots on upper lobe, in dense clusters. See Figure 17.	'Mme Masson' and related hybrids	Mme Masson is an F1 hybrid of '*catawbiense*' and '*ponticum*', developed in 1849 in France. The '*ponticum*' was almost certainly, and '*catawbiense'* probably, a selectively bred cultivar, and each may have been previously hybridised.
F	Up to 2m, rather compact form. Leaves lanceolate, 'leathery', dark green. Flowers crimson-blood red, with red flecked yellow spots,	'Junifeuer' and related hybrids	'Junifeuer' is of German origin, very tolerant of cold winters. Complex and largely unknown ancestry (Fig.

	hemispheric clusters standing above foliage. See Figure 18.		11), but including *R. ponticum* and *R. maximum*
G	Large shrub, compact form, dense foliage. Up to 3m, leaves thick and elliptic to cuneate, dark green when not new, c-10-15cm. Flowers similar to F but larger, 10cm, bright red with duller reddish spots, and in globular 'sunburst clusters'. See Figure 19.	May be 'Markeeta's Prize' (which is known to be present in West Norway); or a similar hybrid.	Markeeta's Prize (like most tall red-flowered hybrids) is of very complex and largely unknown ancestry
H	Small bush, compact form, 1m or less. Leaves rather rounded, c. 5cm long, bright green. Flowers white, small, no spots, 3cm; planted as border in front of low wall. See Figure 20.	A small form of Cunningham's White or similar hybrid? Only at one site.	
X		Diverse other rhododendron hybrids, or rhododendron plants not classifiable to type; none common and most found only in one garden	

Table 2. *Classification of hybrid forms of Rhododendron found in transects* / **Tabell 2**. *Klassifisering av de ulike hybridene av Rhododendron observer langs transektene.*

Figure 7. *Transect locations* / **Figur 7.** *Kart over de ulike transekt lokalitetene.*

3 Results

Figure 8 indicates the number of gardens in each transect which contained one or more *Rhododendron* bushes, and those which did not. The number is larger than the number of censused gardens, because for the census the criterion was that the whole garden could be seen. For Figure 8, the criterion was that the majority of the garden was visible.

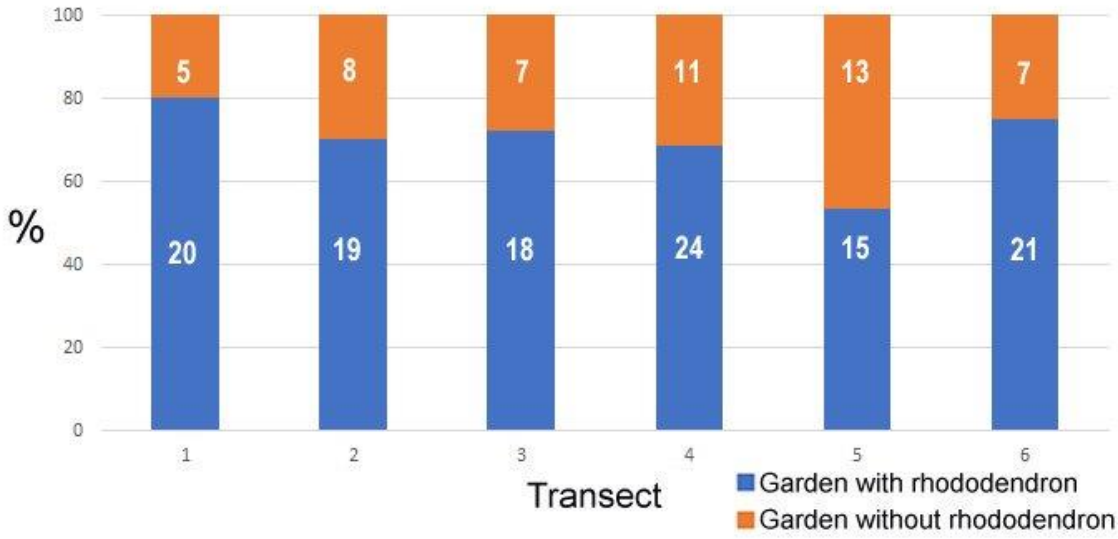

Figure 8. *Percentage of gardens with, and without, one or more Rhododendron bushes in each transect. Numbers within bars are the n for each category /* **Figur 8**. *Prosentvis fordeling over hager hvor en eller flere Rhododendron er observert/ fraværende i hvert transekt. Tallene i hver søyle representerer antall observasjoner innenfor hver kategori.*

Overall, 70% of gardens in the region contained one or more *Rhododendron* bushes, varying from 80% in Transect 1 to 54% in Transect 5. This may be an underestimate, as the criterion for inclusion was that the majority of the garden space was observable from the road or other public vantage point. However, it is clear from this data that *Rhododendron* are pervasive throughout town-edge and rural areas of West Norway, wherever there are houses and gardens. *Rhododendron* escapes in Britain and Ireland are initially normally less than 100m from the planted source (Harris *et al*. 2009), but even using this criterion the area of suitable habitat within seeding range must be very large.

The forms of *Rhododendron* were not evenly distributed (Figures 9 & 10). Type A, medium-large hybrid cultivars with white flowers, were the commonest type in transects 1 & 2, the two inner-fjord transects; uncommon in the 'inner island' transects 3 & 4, and not present in the outer coast transects, 5 & 6. Conversely, Type B ('*grandiflorum*' parkrododendron) and B* (other parkrododendron forms) were the majority of plants in transects 3-6. The difference between the three areas (fjord, inner island, coast) in proportions of *Rhododendron* types (collapsed into Type A, Type B & B*, and other) was highly significant statistically ($\chi^2 = 72.083$, 8df, $p < 0.00001$)

The reasons for this are not clear. Possibly Type A plants are, or are thought to be (and so planted in preference), more robust to the colder and snowier winters, and/or very wet year-round climate, of the inner fjords. It is possible that aesthetic preferences may also be a factor, to fit in with the 'traditional' appearance of the flowering fruit trees more common in the inner fjords.

The numbers of bushes in each transect also varied. This appeared to be simply a function of the average size of gardens – Transects 1 and 6 were in areas of *relatively* dense housing (though always detached houses (*eneboliger*)), with smaller gardens.

Two bushes of Type B* ('parkrododendron') were found growing wild between a road and a stream in Transect 3, probably seeded from nearby gardens; see cover photograph.

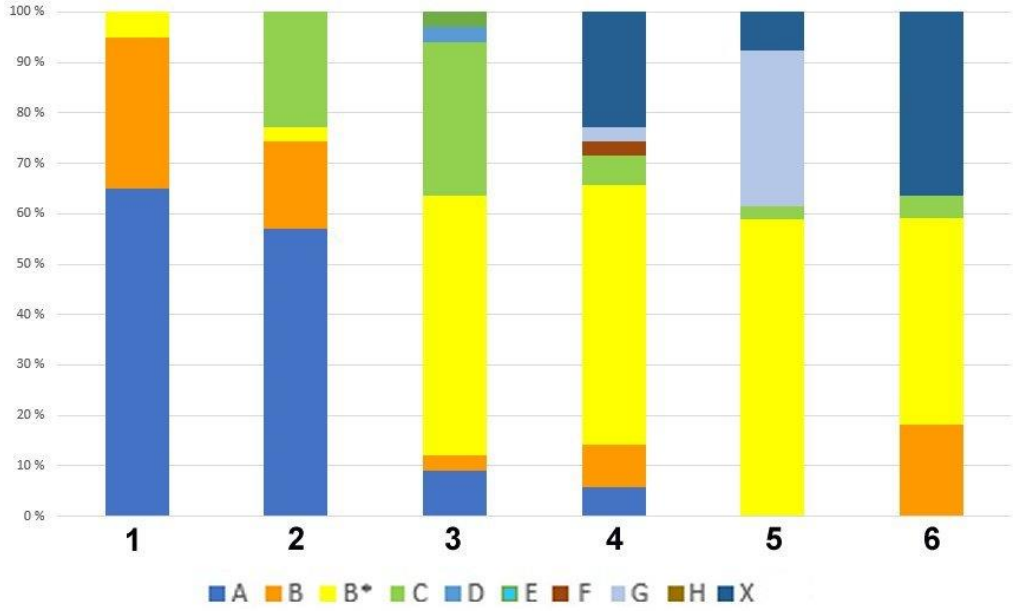

Figure 9. *Percentage of Rhododendron of each type (see Table 2) in each transect /* **Figur 9***. Prosentvis fordeling av de ulike Rhododendron varietetene observert i hvert transekt.*

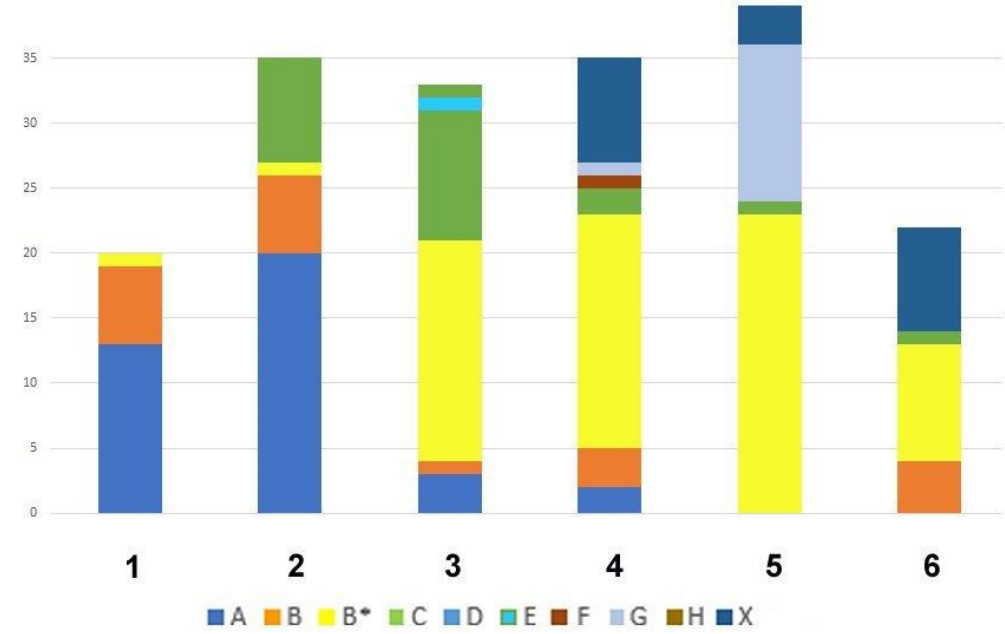

Figure 10. *Number of Rhododendron bushes of each type (see Table 2) in each transect* / **Figur 10.** *Antall Rhododendron busker (individer) observert for hver type i hvert transekt.*

4 Discussion

The six transects were chosen to provide as representative a sample of cultivated *Rhododendron* in areas adjacent to suitable habitat for invasive colonisation as practicable, within the resources available. Funding constraints prevented areas north of Bergen being surveyed, although there is no reason to think they would differ significantly in the pattern of *Rhododendron* hybrids present.

Although hybrids planted in gardens are sometimes ascribed to a named species of *Rhododendron*, it is important to note that *all* the common forms in Norwegian gardens are cultivated hybrids. Their genetic origin is usually partly, and sometimes wholly, unknown (Fig. 11) (and was often concealed as a trade secret in the 19th century, Milne 2017), with contradictory information found in the literature. For example, 'Cunningham's White', common and widely sold in Norway, is stated several times in Milne (2017) to be in its 19th century British origin an F1 (1st generation) cross of *ponticum and catawbiense*, certainly crossed with and probably retaining DNA from other genetic material hybridised in later, and capable of further hybridisation. In various internet sources (see also Fig. 11a) it is stated to be in origin an F1 cross of *ponticum* and *caucasicum*. However, British-form *ponticum* (as it existed in the middle 19th century, c. 75-100 years after initial importation[4]) is, according to all accounts, a founding species of this hybrid.

Figure 11a, b shows the stated descent of the varieties of *Rhododendron* on sale at Plantasjen Stord and Hageland Haugesund in June 2018 (Figure 6, Appendix 4), for which information on ancestry is available at www.rhododendron.org. Several of the 26 hybrids on sale, including '*R. ponticum variegata'* (presumably largely *ponticum* genetically), and the vaguely named '*Catawbiense hybride*' (the most common forms in Norwegian gardens and on sale in garden centres, known generically as 'parkrododendron', are of these types) are not found in the database.

It is important to note that trade names including the names of wild *Rhododendron* species may be misleading, and should not be taken as proof that the plant is 'basically', or even partially, that species. Examples include the use of '*yakushimanum*' and, especially, '*catawbiense*' in trade names. As Brand (2015) states: "Often, the large-leaf rhododendrons are all grouped together under the heading *R. catawbiense* for convenience. This organization gives the impression that these dozens/hundreds of cultivars are all selections or hybrids of this species. In fact, most are complex interspecific hybrids, **and many contain no *R. catawbiense* blood**" (Brand 2015; my bold type. 'Blood' is, in this case, a colloquial English usage meaning 'genetic material'). The commonest forms in gardens (B*) and on sale as '*catawbiense hybride*' fall into this category. The other main 'parkrododendron' on sale and in gardens, '*catawbiense grandiflorum*', is a large-flowered cultivar and only 'probably' a hybrid of *catawbiense* (Brand 2015), though certainly a hybrid of several species.

Figures 11a and 11b are intended only to indicate the complexity, and the very incomplete knowledge, of the sources of *Rhododendron* DNA present in West Norway (NB how often parent types, in the extreme the entire ancestry of the hybrid, are listed as 'unknown'). Other hybrids are available in nurseries in Norway now, others have been available in the past; and in addition, private imports and plantings will have occurred for more than a century (Jørgensen 2003). The stated ancestry of a hybrid, or one of its hybrid parents, is often a traditional assertion rather than a documented fact.

Note also that *R. ponticum*, if the ancestries in Figure 11 are taken at face value, comprises 50% of the genome of 'Cunningham's White' and 'Madame Masson', 25% + (since part of the ancestry is unknown and may contain more *ponticum* genetic material) of Cosmopolitan, and 12.5% (+) of the genome of 'Jeunifeuer' and 'Nova Zembla'. Many other cultivars probably contain *ponticum* DNA in the 'unknown' part of their ancestry, especially the pollen ancestor. Many hybrids, and most varieties of multiple hybrid ancestry, source in whole or part to 19th century Britain, where

[4] In 1763 (Dehnen-Schmutz & Williamson 2006)

R. ponticum of *baeticum* ancestral stock was by far the commonest variety in cultivation. "*R. ponticum* was regularly used in cultivar creation, but also would have crossed naturally with any related species growing beside it, especially if only one individual (*of the other species*) was present" (Milne 2017).

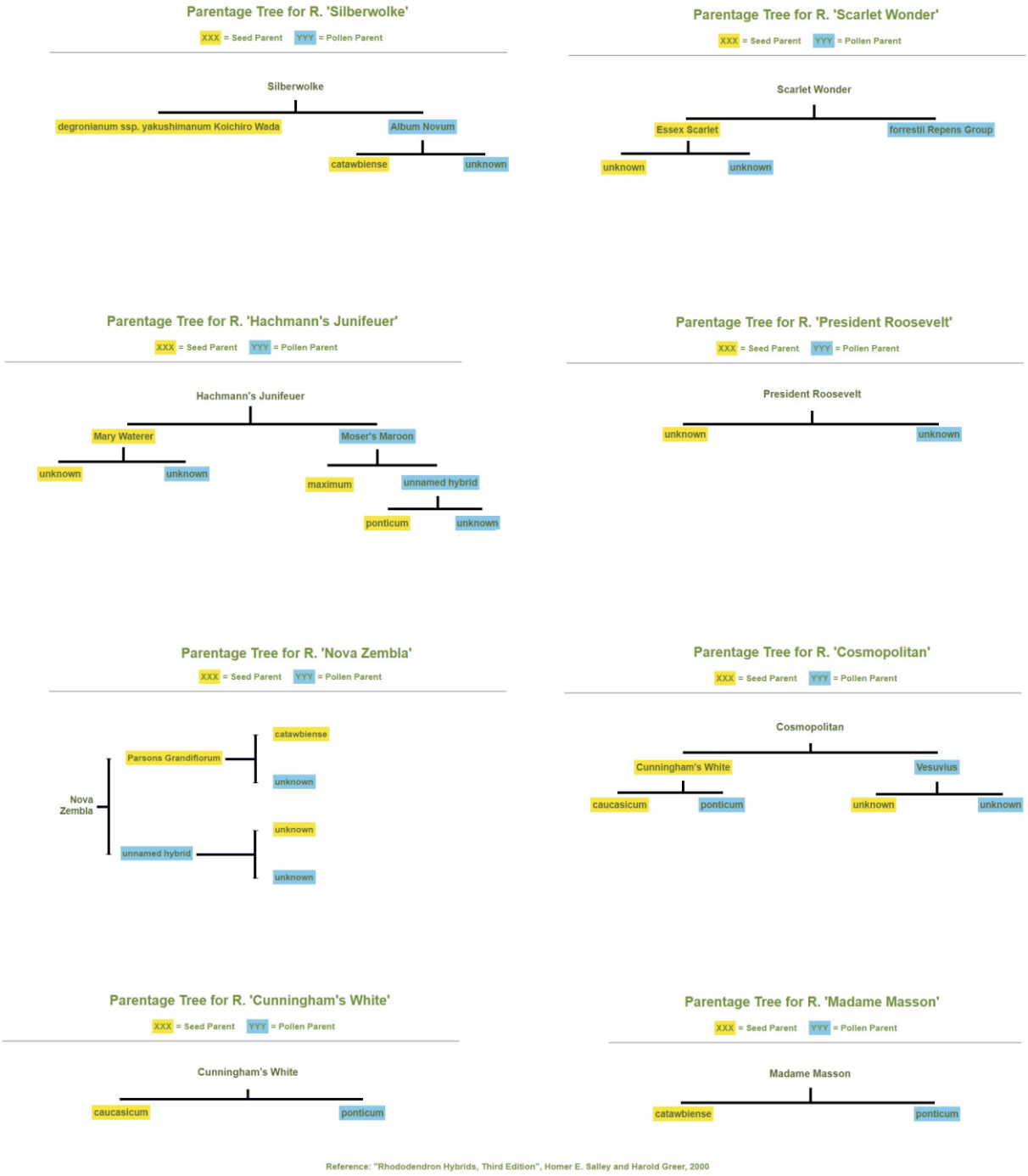

Figure 11a. *Stated ancestry of hybrid Rhododendron on sale in garden centres in Stord and Haugesund, West Norway, June 2018, where information available. See discussion of how secure parentage identification by this method (usually, reports by gardeners and horticulturalists) is. Eight of the hybrids on sale were not listed in this database/* **Figur 11.** Oversikt over oppgitt slektskap av ulike *Rhododendron* hybrider til salgs i hagesentre i Stord og Haugesund, Vest-Norge, Juni 2018. For åtte av hybridene tilsalgs var data ikke tilgjengelig.
Source / Kilde:: https://www.rhododendron.org/hybrid-search.asp, 22.10.2018

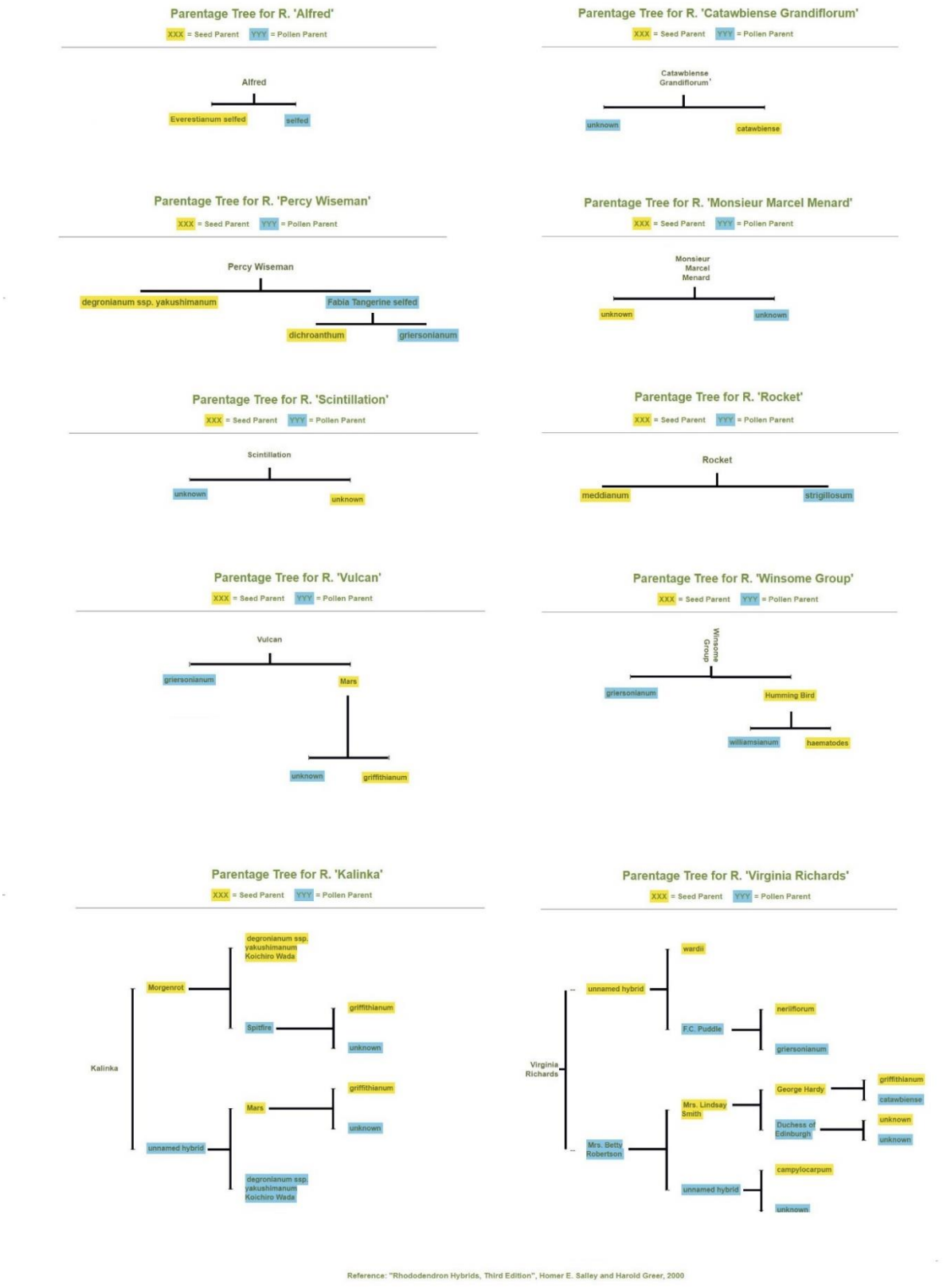

Figure 11b. *See legend for Figure 11a* / **Figur 11b.** *Se Figur 11a.*

Many commercial forms are produced by crossing two existing hybrid forms, and propagated commercially only by cloning. This is done because the seeds produced, even by self-crossing, show a wide variety of phenotypic characteristics, and do not often 'breed true' to the form of the parent plant (Milne 2017). In addition, grafting of hybrid varieties on to root stocks of other species/hybrids of *Rhododendron* is common, most frequently to *R. catawbiense* hybrid rootstock (and NB '*catawbiense*' rootstock may contain no *catawbiense* genetic material, Brand 2015). British *R. ponticum* was also commonly used in the past (Milne 2017). These rootstocks can develop their own stems, which produce seed (*op. cit.*), and are genetically separate individuals from the main stem and branches of the bush.

The real genetic situation in hybrids in West Norway will be rather more complex than Figure 11 indicates. This is because of backcrossing, genetic segregation, and the likely existence of additional hybrid sources to those cited by gardeners and which made their way into the historical records for named hybrids. However, Figure 11 does indicate that *R. ponticum* genetic material is widespread in West Norway. This will mainly source back to British populations of the 19th century, as by far the major centre of cultivation in that period (Jørgensen 2003, Milne 2017).

Much of the initial material in Bergen in the botanical garden and in the gardens of wealthy citizens, commercially imported in the 19th century, came from plant dealers in Amsterdam; but "undoubtedly must have originated in England from where the inspiration for the new garden style came from. I suspect that more than one of the Bergen businessmen brought individual examples from there which were not recorded, as there are old pictures from the 1860s showing relatively well grown examples" (Jørgensen 2003). The Botanical Garden in Bergen mainly obtained its new stock from the Botanical Garden in Edinburgh, Scotland (*op. cit*.).

While the forms of *Rhododendron* now found in gardens in Norway are the products of long-term cultivation and repeated hybridisation, dating back in many cases over 150 years, they are relatively new as common plants of the rural landscape. Because Norway did not have a rural class structure like that of Britain and Ireland, *Rhododendron* were largely confined to large towns and botanical gardens until the later 20th century (Jørgensen 2003).

Almost all initial spread into the wild takes place over short distances, <100m (Harris *et al*. 2009), strongly limiting potential for wild outbreaks from urban sources such as Bergen. However, *Rhododendron* of various hybrid forms are now more widespread in the rural landscape in West Norway, immediately adjacent to suitable wild habitat, than was the case in the rural landscape of N & W Britain and in Ireland, 1850-1950. There, *Rhododendron* plantings were largely confined during the period to the relatively few, relatively spaced out, ornamental gardens of upper class estates, and some plantings intended as cover for game birds and animals ('*vilt*') on some of the same estates (Milne 2017; Dehnen-Schmutz & Williamson 2006). As this study indicates, *Rhododendron* hybrids are present in the large majority of rural and town-edge gardens throughout West Norway.

Wild-type *catawbiense* and *ponticum* are "very similar" (Cullen 2008); "barely distinguishable" (Milne 2017), even when the detailed structures of leaves, flowers, etc. are examined minutely. Hybrids based on them are still less distinguishable by non-genetic methods. In any case, the distinction between them will not have been made, or they will frequently have been confused, when developing new forms in gardens and nurseries in the 19th-20th centuries. The commonest hybrid forms found in transects in this survey, and the forms widely sold in garden centres in Norway under the name '*catawbiense hybride*' - apparently (at present) mainly sourced from nurseries in Belgium - are indistinguishable in the field from British form *ponticum*[5] (known to contain genetic material from *R. catawbiense* and other *Rhododendron* species, see above). Plants sold as '*catawbiense*' hybrids may contain no *catawbiense* genetic material at all (Brand 2015; see above).

[5] I am originally from Scotland, and very familiar with British invasive form *ponticum*

It is stated in the Norwegian Alien Species List (2018) that British-form *R. ponticum* has never been securely identified in Norway. This may be true in a narrow sense; although given its prevalence in Great Britain, and the frequent commercial and personal contacts between Great Britain and Norway, especially West Norway, throughout the 20th century **this should not be assumed without direct genetic investigation**. However, the evidence indicates that in any case much or most of the British-form *R. ponticum* genome *is* present today in Norway in various hybrid forms. These include some of the commonest hybrids found in gardens and public spaces in this survey, and on sale in Norwegian garden centres. In this sense and in this case, the 'traditional taxonomy' focus of the database risks giving a misleading impression.

There are strong similarities in the current West Norwegian situation to the early stages of the development of invasive *Rhododendron* populations in Britain and Ireland. In the 18th century newly imported *R. ponticum baeticum* were sold as indoor plants, for the large houses of the upper classes (Dehnen-Schmutz & Williamson 2006). Hybrid *R. ponticum*-based *Rhododendron* were systematically developed for fecundity and for hardiness to the oceanic British climate in the 1820s-50s (*op. cit*; Milne & Abbott 2000). Written records indicate artificial selection for hardiness, and crossing with *R. catawbiense*, *R. maximum*, and *R. arboretum*. DNA studies confirm *catawbiense* and *maximum* genetic material, and a third unknown species, in British form *ponticum* (Milne & Abbott 2000). "The possibility also exists that introgression from some of the 500 other *Rhododendron* species cultivated in Britain has occurred" (*op. cit.*). The British invasive form also shows much higher rates of shoot growth and seedling recruitment than native *R. ponticum* from Iberia or from the Caucasus (Mejias *et al.* 2002, Erfmeier and Bruelheide 2004). It is this cultivar that will have been the basis of the '*ponticum*' cited by 19th century gardeners as the seed or pollen F1 generation parent of many other hybrids (for example Cunningham's White), not pure-form *R.p. baeticum*.

The hybrid forms produced by this process were widely planted in the upland hunting estates of the British and Irish upper classes in the later 19th and early 20th centuries for amenity and as shelter for game, but only became an invasive problem of significance in the 1930s; and a serious one causing large, and progressively increasing, economic losses from the 1950s-60s (*op. cit*.; Milne 2017; Dehnen-Schmutz & Williamson 2006).

Adaptation within the hybrid DNA of this form planted in estate gardens, further hybridisation with other *Rhododendron* forms planted in the same gardens, and natural selection of resulting wild seeded plants was followed by invasive spread of the successfully adapted genotypes (Milne 2017). Several separate instances are documented (Dehnen-Schmutz & Williamson 2006; Harris *et al.* 2009). Up to 20% of the genetic material in British invasive form *ponticum* may be from other species, the proportion varying with climate; the largest proportions being in areas with relatively colder winters, apparently as a result of natural selection within wild-reproducing populations (Milne & Abbott 2000; Milne 2017).

In this light, the observation in the last 20 years of the establishment of several populations of invasive *Rhododendron* populations in Norway, from separate non-wild source *Rhododendron*, appears consistent with both the pattern and the general timing of early-stage invasive establishment as documented in Britain and Ireland.

While the discussion above indicates that *R. ponticum* genetic material originating in the British form will be present in a significant proportion of the hybrids growing in Norway, it is important to recognise that it is quite possible for new hybrid seeds not containing *ponticum* DNA to become viable and invasive under West Norwegian conditions. The wild source population of British form *R. ponticum baeticum* grows in Andalucia, southern Spain (near the British possession of Gibraltar). It is a plant of mountain woodlands of "Hot Mediterranean" regional climate, with mean annual temperatures of c.18C, and average rainfall of c. 800-1100mm (Mejias *et al.* 2003). It was initially sold in Britain as an indoor ornamental bush for large houses (Dehnen-Schmutz & Williamson, 2006; Milne 2017). It was the first *Rhododendron* to be brought into cultivation simply because it grew near a British outpost relatively close to Britain, not because it was unusually

suitable for the British climate; and for this reason, was the first to become a common garden plant and to be bred for hardiness. There is no reason to think *R. ponticum baeticum* is unusually able to adapt to a cool, oceanic climate like that of N&W Great Britain or West Norway.

5 Conclusions

Rhododendron of diverse hybrid forms are present in 70% of rural/rural edge gardens in the West Norway region. These gardens are within the normal range of dispersal of wind-carried *Rhododendron* seeds to potentially suitable wild habitat.

There is a critically important identification issue for these hybrid forms as they are almost never, in their genetic origins, a single 'species'. Almost no individual *Rhododendron* in Norway, apart from a few in botanical gardens, are descended from a single wild species. In most cases their genetic origins are highly complex and only partially or even wholly unknown. There is also a serious risk of misattribution to incorrect 'base species', as indicated by, to give only one example, the fact that types sold as '*catawbiense*' hybrids are known in some cases to contain no *R. catawbiense* genetic material at all. The current gene pool within hybrid forms, even without further outcrossing, will also have been affected by internal genetic processes such as segregation and backcrossing.

Although the Norwegian Alien Species list must necessarily list by 'species', this risks giving the impression that the problem is one of a limited number of discrete species with discrete characteristics, and a discrete and uniform 'invasive potential'.

It is more useful to think of the problem of potentially invasive *Rhododendron* in terms of overlapping 'hybrid swarms' (Grant 1981; Milne & Abbot 2000) of genetic material producing millions of genetically varied, hybridised and re-hybridised wind-dispersed seeds every year. *Ponticum* (sourcing in many cases at least to *ssp baeticum* through the British form) and *catawbiense* DNA are both significant elements in this mix, if the ancestry cited for these hybrids in Figure 11 is even approximately correct.

In a sense, a large experiment in *Rhododendron* adaptation is taking place in West Norway, as it did a century ago in the similar climate of west and north Britain and Ireland. It must be expected that the seeds generated from the diverse genetic material available will also 'solve' the problem of growing and reproducing in the wild in the West Norwegian climate from time to time. A number of cases where this has already happened are known (see cover photo and Fremmedartsbasen 2018): for forms ascribed to *R. catawbiense* in Sjøholt, Ålesund, Tingvoll (two places) and Skodje; ascribed to *R. brachycarpum* in Surnadal; and ascribed to *R. suchuensis* in Ho (requires confirmation). Several other instances are known but not as yet formally documented (Rakel Blaalid *pers. comm.*).

There is no reason to think *ponticum* in particular was, in its initial Andalucian wild-type form, unusually well suited to adaptation to a cool, oceanic climate compared to many of the other ancestral species of the *Rhododendron* forms currently present in West Norway. Hybrids predominantly based on other species or species combinations may also develop invasive forms, over time.

It is therefore important to confirm directly what genetic difference there is between these hybrid forms and known invasive types, rather than assuming it, as *the genetic origins of cultivars on sale and in gardens are often partially or even wholly unknown or when given, often little more than assertions*. It is also important to assess whether any differences in the range of genetic material found means that the hybrid forms planted in Norway, and then dispersed annually in large quantities as (often re-hybridised) seeds, will not be likely to generate invasive genotypes over time. Until this is carried out a realistic basis for assessing the level of risk will be lacking[6].

It would also be useful to produce through historical research, an overview of the sales of rhododendron hybrids in space and time. DNA analysis of preserved/older living specimens could map their genetic types, and shifts over time; this would allow a better understanding of potential

[6] I am not a DNA researcher, so this recommendation is not self-interested!

hybridization probabilities and internal genetic processes in the Norwegian *Rhododendron* genetic 'cloud'.

Once the genetic material in modern hybrids on sale in Norway, and rehybridization processes producing seed which disperses into the wild are better understood, it might be possible to regulate garden centre sales towards hybrid forms that clearly have little invasive potential in their current, or probable subsequent re-hybridised, genetic makeups, without compromising their amenity value for the general public and interest for enthusiasts.

The management priorities should be:

- To produce easily accessible information in Norwegian on effective methods of killing wild-growing *Rhododendron* (Edwards 2006; Appendix 2).
- To identify new wild-growing *Rhododendron* populations in the early stages, ideally the first generation in the wild, when eradication is simple and inexpensive (*op. cit*.)
- To publicise the above, and the reasons for the general public to assist with it.[7]
- To eradicate each outbreak early, when it is producing only thousands, not millions, of seeds a year; and *to eradicate as soon as possible the known wild populations of Rhododendron in Norway* (all currently small).

Experience of plant invasions indicates that eradication is only practicable if done when populations are small (Mack & Lonsdale 2002). Given the measures above, there is no reason why ongoing *Rhododendron* control in Norway should not be an occasional, and inexpensive, operation; measurable in thousands of kroner per decade.

The alternative, if an invasive form does become firmly established, is ongoing and significant annual expenditure for control (not eradication)[8].

[7] Without suggesting any negative view of *Rhododendron*, as attractive garden and amenity plants. Efforts should be made to actively involve *Rhododendron* enthusiast clubs as good citizens, from the earliest stages.

[8] For *Rhododendron* this has been measured in one British study as £526 (6080Nkr, 2001 exchange rate)/ha treated (Dehnen-Schmutz *et al.* 2004); currently an estimated £9 000 000 is spent every year by commercial forestry operations alone in Great Britain, to control (not remove) *Rhododendron* on their properties (Kelly *et al.* 2013). West Norway's commercial forestry sector is several times larger, in areal extent, than Great Britain's.

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7 Appendix 1 – Control methods for invasive *Rhododendron*

Adapted from (e.g. by converting Imperial weights (lbs) to metric (kg)), and reprinted with the permission of, the Department of Wildlife and National Parks, Republic of Ireland. The methods presented are simple, inexpensive, and systemic – they kill the *whole* plant including the roots. They use materials available in any hardware store (and owned in any case by most households in rural districts in Norway).

These methods are also available at https://www.killarneynationalpark.ie/about-us-killarney/rhododendron-control/.

See also the detailed methods described in Edwards (2006), available online at https://www.forestry.gov.uk/pdf/fcpg017.pdf/$FILE/fcpg017.pdf.

In Norwegian situations, the first three methods will be most frequently suitable, as wild-living plants have not usually reached sizes and forms requiring the chainsaw methods. The Stem Treatment has been the single most effective method in Ireland.

KILLARNEY NATIONAL PARK

Control Methods For Rhododendron

Stem Treatment

MAKE A DOWNWARD CUT INTO THE CAMBIUM AND SAPWOOD LAYERS USING A SHARP HAND AXE OR SIMILAR IMPLEMENT LEAVING A HINGED NOTCH ON THE PLANT STEM.

STEM NOTCHES SHOULD BE TREATED IMMEDIATELY USING A HAND APPLICATOR, WETTING ALL EXPOSED AREA OF THE NOTCH TO THE RUN OFF POINT. ADD DYE TO HERBICIDE SOLUTION TO INDICATE TREATED STEMS.

STEM NOTCHES SHOULD BE POSITIONED NEAR THE BASE OF EACH STEM AND BELOW THE LAST BRANCH, THIS ALLOWS FOR MORE EFFECTIVE DISTRIBUTION OF HERBICIDE THROUGH THE PLANTS TRANSPORT SYSTEM.

THE NUMBER OF NOTCHES PER PLANT IS DETERMINED BY THE NUMBER OF STEMS AND STEM DIAMETER. TWO CUTS SHOULD BE APPLIED TO STEMS UP TO SEVEN CM IN DIAMETER AND AN ADDITIONAL CUT FOR EACH THREE AND A HALF CM OF STEM DIAMETER.

LEAF DIE-BACK BEGINS 3-4 WEEKS AFTER TREATING PLANTS IN THE GROWING SEASON (APRIL TO SEPTEMBER) AND CAN TAKE SEVERAL WEEKS LONGER OUTSIDE OF THIS PERIOD. PLANT DEATH IS USUALLY COMPLETE WITHIN TWELVE MONTHS OF INITIAL TREATMENT.

BEST RESULTS WERE ACHIEVED IN KILLARNEY NATIONAL PARK TRIALS FROM FEBRUARY TO SEPTEMBER

Volume of Herbicide used in Stem Treatment

CONCENTRATION H2O: GLYPHOSATE	VOLUME HERBICIDE PER STEM (ML)	NUMBER OF STEMS TREATED PER 1L GLYPHOSATE	
5:1 (20%)	0.50	1925	(Successfully trialled in KNP)
10:1 (10%)	0.26	3850	(Successfully trialled in KNP)

ADVANTAGES:

Good kill rate | Minimal herbicide usage | Low volumes of herbicide solution required | No soil disturbance
Minimal risk of herbicide drift | Eliminates brash handling | Can be applied in showery weather
Minimal equipment required | Cost effective

DISADVANTAGES:

Requires mainly dry weather | All plant stems require treatment | Second large scale work phase if dead plants are to be removed
Not suitable for dense stands of multi-stemmed plants or small diameter multi-stemmed plants
Standing dead plants and subsequent litter may pose a fire threat | Standing dead plants may inhibit follow-up management of site

CRITICAL SUCCESS FACTORS:

Access to plant stems | Correct number of notches per stem | Correct application of herbicide

This Method Is Most Efficient On Single Stem Plants
But Can Also Be Effective On Accessible Multi-stemmed Plants

For further information contact Peter O'Toole at Killarney National Park :: Phone: 087 6781614.

KILLARNEY NATIONAL PARK

Control Methods For Rhododendron

Pull, Snip and Treat

(seedlings and saplings)

SEEDLINGS UP TO 15CM ARE PULLED BY HAND, ANY OF WHICH SNAP OFF AT THE ROOT ARE SPOT SPRAYED WITH A HERBICIDE SOLUTION.

REMOVE ANY SOIL OR MOSS ATTACHED TO ROOTS OF PULLED PLANTS, THIS WILL ENSURE PLANT DEATH.

SAPLINGS UP TO 3CM IN DIAMETER ARE CUT TO GROUND LEVEL WITH A SECATEURS. LOW CUT IS ESSENTIAL FOR SUCCESS.

SPOT TREAT REMAINING CUT STEMS WITH A HERBICIDE SOLUTION, ADD DYE TO MARK TREATED STEMS.

BEFORE APPLYING METHOD
RHODODENDRON SEEDLINGS AND SAPLINGS WITH RECOVERING NATIVE VEGETATION.

AFTER APPLYING METHOD
WITH LITTLE OR NO DISTURBANCE TO SOIL OR NATIVE VEGETATION.

Volume of Herbicide used in Snip & Treat Method

CONCENTRATION H2O: GLYPHOSATE	VOLUME HERBICIDE PER STEM (ML)	NUMBER OF STEMS TREATED PER 1 L GLYPHOSATE	
10:1 (10%)	0.13	7000	(Successfully trialled in KNP)

ADVANTAGES:

Good kill rate | Minimal herbicide usage | Effective all year round | Minimal damage to non-target vegetation | Minimal soil disturbance

DISADVANTAGES:

Dry weather required for treated saplings

CRITICAL SUCCESS FACTORS:

Dry weather | Correct application of method

This Method Is Recommended For Control Of Seedlings And Saplings

For further information contact Peter O'Toole at Killarney National Park :: Phone: 087 6781614.

KILLARNEY NATIONAL PARK

Control Methods For Rhododendron

Cut, Break and Treat

MULTI-STEMMED PLANT ON ROCKY GROUND.

CUT PLANT AND CLEAR BRASH.

REMAINING STEM SHOULD BE 15-20CM HIGH.

BREAK STEMS AWAY FROM ROOTSTOCK WITH A LIGHT (3kg) SLEDGE.

TREAT EXPOSED ROOT WITH HERBICIDE SOLUTION. ADD DYE TO INDICATE TREATED ROOTS.

SUCCESSFULLY TREATED ROOT, ONE YEAR LATER.

ADVANTAGES:

Good kill rate | Single work phase | No risk of herbicide drift | Low volumes of herbicide solution used | Minimal soil disturbance
Effective all year round | No standing dead plants | No chain damage | Minimal disturbance to surrounding vegetation

DISADVANTAGES:

Dry weather required

VOLUME OF HERBICIDE USED IN CUT, BREAK & TREAT METHOD

CONCENTRATION H2O: GLYPHOSATE	VOLUME HERBICIDE PER ROOT (ML)	NUMBER OF ROOTS TREATED PER 1L GLYPHOSATE	
10:1 (10%)	0.33	300	(Successfully trialled in KNP)

CRITICAL SUCCESS FACTORS:

Dry weather | Root broken to ground level | Immediate treatment

This Method Is Recommended For Multi-Stemmed Bushy Plants On Rocky Ground

For further information contact Peter O'Toole at Killarney National Park :: Phone: 087 6781614.

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Control Methods For Rhododendron

Stem and Plant Base Treatment Using Chainsaw

This is a versatile, fast, efficient and cost effective control method.

FOR THIS METHOD APPLY CUTS, WITH CHAINSAW TIP LOW TO BASE OF STEMS, TO CREATE A RESERVOIR FOR HERBICIDE SOLUTION, AND AVOID RUNOFF.

MULTI-STEMMED PLANTS ARE TREATED BY APPLYING CUTS INTO THE BASE OF PLANTS, SO THAT ALL STEMS ARE OPEN TO HERBICIDE TAKE-UP.

ALTERNATIVELY TREAT MULTI-STEMMED PLANTS WITH LESS ACCESSIBLE BASES BY APPLYING CUTS TO EACH STEM AS SHOWN ABOVE.

LARGE DIAMETER STEMMED PLANTS ARE TREATED BY APPLYING TWO OR THREE CUTS LOW TO BASE OF STEMS.

SMALLER DIAMETER SINGLE STEMMED PLANTS DEPENDING ON SIZE ARE TREATED WITH ONE CENTRAL CUT OR TWO SIDE CUTS LOW TO BASE OF STEMS.

PLANTS LYING LOW TO GROUND ARE TREATED BY MAKING ONE, TWO OR THREE CUTS (DEPENDING ON STEM DIAMETER) WITH SAW TIP INTO STEMS LOW TO BASE OF PLANTS.

15% herbicide solution was found to be most effective in Killarney National Park trails.

- Apply herbicide solution with hand held applicator immediately to fresh saw cuts, to the point of run-off, add dye to solution to indicate treated cuts.
- Effective all year around in Killarney National Park trails, plant death is usually complete within twelve months of initial treatment.
- Note: leaf death took several weeks longer during October to March trials.

ADVANTAGES:

Can be used for control of most rhododendrom plant types | Excellent kill rate | Cost effective
Low volumes of herbicide solution required | Minimal risk of herbicide drift | No soil disturbance
Eliminates brash handling | Effective in light showery weather | Chain friendly

DISADVANTAGES:

Second large scale work phase if standing dead plants are to be removed | Potential fire risk
Standing dead plants and subsequent litter may inhibit regeneration and site management

CRITICAL SUCCESS FACTORS:

Correct application of method by competent chain saw operators

For further information contact Peter O'Toole at Killarney National Park :: Phone: 087 6781614.

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KILLARNEY NATIONAL PARK

Control Methods For Rhododendron

Direct Stump Treatment

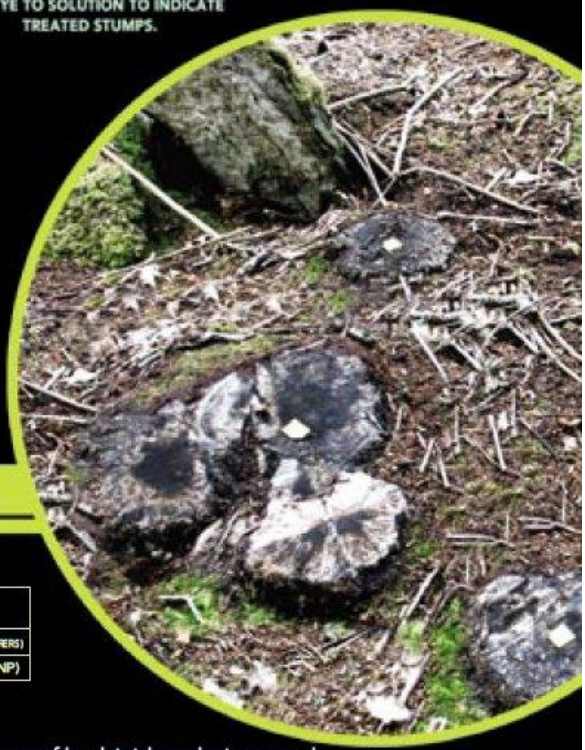
TACKLING SERIOUS INFESTATION OF RHODODENDRON

LOW CUT 2 TO 4 CM REDUCES THE NUMBER OF GROWTH NODES ON STUMPS LEADING TO A BETTER KILL RATE.

DURING DRY WEATHER APPLY HERBICIDE SOLUTION IMMEDIATELY AFTER CUTTING. ADD DYE TO SOLUTION TO INDICATE TREATED STUMPS.

WET ALL VISIBLE AREAS OF CUT STUMP ESPECIALLY CAMBIUM AND BARK.

IN WET WEATHER STUMPS SHOULD BE CUT 15 TO 20 CM HIGH AND RE-CUT IN DRY WEATHER AND TREATED AS ABOVE.



SUCCESSFULLY TREATED STUMPS

VOLUME OF HERBICIDE USED IN DIRECT STUMP TREATMENT

CONCENTRATION H2O: ROUNDUP	VOLUME HERBICIDE PER STUMP (ML)	NUMBER OF STUMPS TREATED PER 5L ROUNDUP	
5:1 (20%)	0.65	765	(AS RECOMMENDED BY MANUFACTURERS)
10:1 (10%)	0.30	1667	(Successfully trialled in KNP)

ADVANTAGES:

Single work phase (weather permitting) | Good kill rate | Low volume of herbicide solution used
No risk of herbicide drift | No soil disturbance | Effective all year round | No standing dead plants
Clean site for follow-up management | Site in recovery after initial work phase

DISADVANTAGES:

Dry weather required | Low cut necessary | Chain damage over stony ground | Not suitable for layering plants

CRITICAL SUCCESS FACTORS:

Dry weather | Low cut | Immediate treatment

This Method Is Recommended For Most Rhododendron Ponticum Situations

For further information contact Peter O'Toole at Killarney National Park :: Phone: 087 6781614.

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8 Appendix 2 – Transect data

Transect	Garden	Types	Notes	Transect Data
1	1	A		Date:11.06.2018
1	2	A		Start location 60.405882N 5.723290E
1	3	A		Start time 09:15
1	4	AAA		Samnanger
1	5	AA		
1	6	AA		NB all transects: counted only where whole
1	7	B		Garden could be seen
1	8	A		
1	9	AB		
1	10	B		
1	11	C		
1	12	B	Labelled as *R cataw-biense grandiflorum*	
1	13	B		
1	14	A		Transect area gardens with Rhododendron: 20
1	15	B		Transect area gardens with no Rhododendron: 5
2	1	ABC		Date:11.06.2018
2	2	AC		Start location 60.238447N 5.742416N
2	3	B*	B* = similar to B but flowers smaller and less intense in colour. Flower and leaves indisting-uishable from British *ponticum*	Start time 14:00
2	4	AB	B really very pink A?	Eikelandsosen
2	5	A		
2	6	AA	Leaves dull, matte, lanceolate, smaller inflorescences than typical A -3cm?	
2	7	A		
2	8	B		
2	9	A		
2	10	AAAAAAAA		
2	11	BBCCCC	BB possibly pinkish AA-but leaves not lanceo-late?	
2	12	ABC		
2	13	A		

2	14	A		Transect area gardens with Rhododendron: 19
2	15	AC		Transect area gardens with no Rhododendron: 8
3	1	AA	2nd A very pale B?	Date: 11-12.06.2018
3	2	DE	D: 6-lobed, bright red, open form corolla, small lanceolate leaf c.6x2.5cm E: 8x2.5cm very lanceolate leaf, orange cast to underside.	Start location 60.051130 5.574438
3	3	B*B*		Start time 19:45
3	4	B*B*	Growing wild by stream bank, not in garden or public space	Tysnesøya
3	5	C		
3	6	BB*		
3	7	B*		
3	8	B*		
3	9	B*		
3	10	B*CG		
3	11	B*B*		
3	12	B*		
3	13	AB*B*B*B*	A:?	
3	14	B*B*		Transect area gardens with Rhododendron: 18
3	15	CCCCCCCC	Long row	Transect area gardens with no Rhododendron: 7
4	1	AB*XXXXXXXX	Large carefully kept garden, with unusual Rhododendron hybrids planted	Date: 12.06.2018
4	2	BC		Start location 59.746017N 5.454711E
4	3	B*		Start time 12:18
4	4	B*		Sagvåg, Stord
4	5	AB*		
4	6	B*C		
4	7	B*B*B*		
4	8	B*		
4	9	B*FG	Many bushes in slightly overgrown garden	
4	10	B		
4	11	B*B*		

4	12	B?B*	B? white flowers but otherwise like B - just a white form?	
4	13	B*		
4	14	B*B*B*		Transect area gardens with Rhododendron: 24
4	15	B*		Transect area gardens with no Rhododendron: 11
5	1	B*		Date: 12.06.2018
5	2	B*		Start location 59.5134989N 5.2826141
5	3	B*		15:50
5	4	B*		Mølstre, Sveio
5	5	AB*C		
5	5b	B*	Error in count	
5	6	B*XX	Last two new planted, labelled 'Marie Fortie' hybrid, 'Percy Wiseman' hybrid	
5	7	B*		
5	8	?		
5	9	B*B*B*B*B*B*B*B*B*B*B*B*B*B*B*	Many B* planted as border omsorgssenter	
5	10	HHHHHHHHHHHH	Many planted, amenity, Svei sentrum. Unknown hybrid variety.	
5	11	B*		
5	12	B?	Not B* - darker, more lanceolate leaves; umber underleaf	
5	13	B*		
5	14	B*B*B*B*B*B*B*B*B*B*B*B*B*B*B*	Row of bushes	Transect area gardens with Rhododendron: 15
5	15	B*B*B*B*B*B*B*	Row of bushes	Transect area gardens with no Rhododendron: 13
6	1	B*		Date: 13.06.2018
6	2	C		Start location 59.551024N 5.363044E
6	3	B*		09:40
6	4	B	Deep pink/violet flowers	Karmøy
6	5	ABB	In row, BAB. 'A' leaves much more lanceolate than B.	
6	6	B*		
6	6b	B*,XXXXXXXX	Error in count. X= Possibly A??. Row 8 small bushes. Like 'umber underleaf' type T5S12	
6	7	AB*GG		

6	8	B*		
6	9	B*		
6	10	B*		
6	11	XXX	3 bushes lanceolate leaves	
6	12	X	lanceolate grounds old Håland skole	
6	13	B*		
6	14	B?	Flowers typical 'B*', most but not all leaves lanceolate	Transect area gardens with Rhododendron: 21
6	15	A?		Transect area gardens with no Rhododendron: 7

9 Appendix 3 – Examples of *Rhododendron* types in the transects

See Table 2.

Figure 12: *Type A.*

Figure 13: *Type B.*

Figure 14: *Type B*.*

Figure 15: *Type C.*

Figure 16: *Type D.*

Figure 17. *Type E.*

Figure 18. *Type F. All seen were no longer in full bloom. The picture in full bloom on left is not from the transects in this study*.

Figure 19. *Type G.*

Figure 20. *Type H.*

10 Appendix 4 – *Rhododendron* hybrids on sale at Plantasjen Stord and Hageland Haugesund

(June 2018)

Alfred
'Catawbiense hybride'
Cosmopolitan
Cunningham's White
Delta
Grandiflorum
Graziella
Junifeuer
Kalinka
Madame Masson
Marcel Menard
Monsieur Fortier
Nova Zembla
Percy Wiseman
Polaris
Ponticum variegata
President Roosevelt
Rocket
Roseum Elegans
Rosina
Scarlet Wonder
Scintillation
Silberwolke
Virginia Richards
Vulkan
Winsomme

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NINA Report

The Norwegian Institute for Nature Research, NINA, is as an independent foundation focusing on environmental research, emphasizing the interaction between human society, natural resources and biodiversity.

NINA was established in 1988. The headquarters are located in Trondheim, with branches in Tromsø, Lillehammer, Bergen and Oslo. In addition, NINA owns and runs the aquatic research station for wild fish at Ims in Rogaland and the arctic fox breeding center at Oppdal.

NINA's activities include research, environmental impact assessments, environmental monitoring, counselling and evaluation. NINA's scientists come from a wide range of disciplinary backgrounds that include biologists, geographers, geneticists, social scientists, sociologists and more. We have a broad-based expertise on the genetic, population, species, ecosystem and landscape level, in terrestrial, freshwater and coastal marine ecosystems.

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