RISK ASSESSMENT SUMMARY SHEET

Updated: October 2020

Butterfly bush (*Buddleja davidii)*

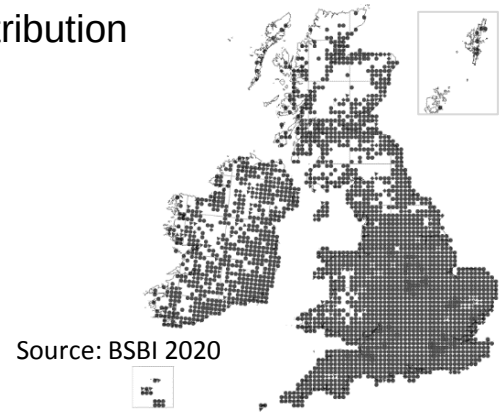
- A very popular garden shrub with a woody stem and purple flower spikes
- Widespread in GB, well established in southern England, more sparse towards north of Scotland, prefers disturbed sites
- Prolific reproduction by seed, which disperse long distances
- Often forms large stands along transport networks (rail, road, canals), where it can cause substantial damage and requires regular maintenance
- Can displace native species and may have some negative impacts on butterflies and pollinators

History in GB

From China, originally introduced to GB in1896 and first recorded outside cultivation in 1922. From the 1950s it spread rapidly, establishing across much of GB, where it is still increasing range and frequency. Invasive elsewhere in the world, including New Zealand and America, where it has been found to displace native species.

Native Distribution

GB Distribution



Source: BSBI 2020

Impacts

Environmental (moderate, high confidence)

- Grows vigorously in dense thickets, displacing native species; however, research into this impact in GB is minimal (there is more evidence from elsewhere, including NZ and USA).
- Potential negative impacts on butterflies and pollinators. Leaves are not a good substitute for native species in terms of food for caterpillars. Highly attractive flowers might decreasing pollinator visits to native species.
- On the other hand, the plant is thought to provide a rich nectar source for some butterflies and moths in cities and the countryside.

Economic (major, high confidence)

- In 2010 estimates to cost the GB economy £961,000 per annum.
- A dominant plant on transport networks in GB, particularly rail, where it blocks site lines and causes damage to brick work and other hard structures.
- Can damage old building and brickwork by growing in cracks.

Social (minimal, high confidence)

- Few negative social impacts, although dense stands can alter the aesthetics and amenity use of areas.

Introduction pathway

Horticulture – a very popular ornamental introduction, with 100 varieties available through the RHS Plantfinder

Spread pathway

Natural (rapid, high confidence) – one plant can produce millions of seeds, which are dispersed long distances by wind, water and along transport corridors

Human mediated (rapid, high confidence) – widely planted in gardens across the country, from which escapes easily occur

Summary

	Response	Confidence
Entry	VERY LIKELY	VERY HIGH
Establishment	VERY LIKELY	VERY HIGH
Spread	RAPID	HIGH
Impact	MODERATE	HIGH
Overall risk	MEDIUM	HIGH

GB Non-native Species Rapid Risk Assessment (NRRA)

Rapid Risk Assessment of: *Buddleja davidii* (Butterfly Bush)
Author: Susan Kathrin Ebeling, Naturhistorisk Museum Aarhus, Denmark

Version: Draft 1 (July 2018), Peer Review (August 2018), NNRAP 1 (September 2018), Draft 2 (March 2019), NNRAP 2 (March 2019), Draft 3 (June 2019).
Signed off by NNRAP: March 2019
Approved by Programme Board: September 2020
Placed on NNSS website: October 2020

1 - What is the principal reason for performing the Risk Assessment? (Include any other reasons as comments)

Response: *To assess rapidly the risk associated with this species in Great Britain.*

2 - What is the Risk Assessment Area?

Response: *Great Britain*

3 - What is the name of the organism (scientific and accepted common; include common synonyms and notes on taxonomic complexity if relevant)?

Response: *Buddleja davidii* Franch.., common names: butterfly bush, summer lilac, orange eye

4 - Is the organism known to be invasive anywhere in the world?

Response: Yes.

B. davidii is native to China and is highly invasive in New Zealand (Watt et al. 2010). In Oregon/USA, it is classified as a B-rated noxious weed under quarantine (Oregon Dept of Agriculture, 2018).

5 - What is the current distribution status of the organism with respect to the Risk Assessment Area?

Response: *Buddleja davidii* was introduced in 1896 and first recorded outside cultivation in 1922 in Merioneth (NNSS 2018). It is a very popular garden plant and has since escaped cultivation on several occasions due to its highly dispersible seeds. *Buddleja davidii* is common throughout GB, particularly in southern England, with decreasing densities northwards to northern Scotland. It is particularly associated with towns and cities and the transportation network between them, e.g. railways and roads.

6 - Are there conditions present in the Risk Assessment Area that would enable the organism to survive and reproduce? Comment on any special conditions required by the species?

Response: Yes.

Buddleja davidii has already escaped human cultivation and is able to survive and reproduce in the Risk Assessment Area. In both its native and introduced range, *B. davidii* establishes on naturally or anthropogenically disturbed sites such as walls and rock faces (e.g. Wilson, 1913; Rishbeth, 1949; Segal, 1969; Owen and Whiteway, 1980; Miller, 1984), riparian corridors (Reichard, 1996; Bellingham et al., 2005; Tallent-Halsell, 2008) and quarries, urban waste grounds, abandoned

cultivated areas, clearcut forests, and along transport corridors (Godefroid et al., 2007) and thrives on a wide range of soil types.

7 - Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment Area or sufficiently similar for the organism to survive and thrive?

Response: Yes.

Climatic conditions within parts of the current distribution of the species (non-native area) are similar to the Risk Assessment Area, for example in New Zealand, Spain and France. There, the Horticultural hardiness zones are similar to where *B. davidii* is already established in the Risk Assesment Area.

8 - Has the organism established viable (reproducing) populations anywhere outside of its native range (answer N/A if you have answered 'yes' to question 4)?

Response: N/A

9 - Can the organism spread rapidly by natural means or by human assistance?

Response: Yes.

B. davidii has been introduced to Europe and later on to other continents for ornamental reasons. Hence, the species has been and is being spread by human assistance rapidly. Currently there are more than 180 cultivars and hybrids of *B. davidii* available (Stuart 2006), whereof 109 are listed in the RHS Plant finder (RHS Horticultural Database, assessed 06/2018; http://apps.rhs.org.uk/horticulturaldtabase/). Several of the known cultivars of *B. davidii* show invasive potential (Anisko and Im, 2001; Moller, 2003; Ream, 2006). Short maturation time, millions of wind-dispersed seeds per plant (Campbell 1984, Kreh 1952, Brown 1990) and a high rate of germination positively contribute to its range expansion by natural means.

10 - Could the organism itself, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment Area?

Response: Yes

In Europe transportation routes have been negatively affected by the species (Reinhardt et al. 2003, Blacker 2000). *B.davidii* already forms thick stands in GB, displacing native species and causing damage to built structures (Williams *et al* 2010). It also causes impacts elsewhere in the world. For example in New Zealand, where *B. davidii* is outcompeting kanuka stands (*Kunzea ericoides*; Smale 1990) and pine seedlings in plantations (Kay & Smale 1990). In Oregon/USA it displaces native willows (University of Oregon 2017).

Entry Summary

Estimate the overall likelihood of entry into the Risk Assessment Area for this organism (comment on key issues that lead to this conclusion).

Response: *very likely*
Confidence: *very high*

Comments:

B.davidii was introduced to the Risk assessment Area as an ornamental plant in 1896 and first recorded outside cultivation in 1922. It is among the most popular garden plants with more than 100 cultivars distributed in the Risk assessment Area (RHS Horticultural Database 2018, Tallent-Halsell, 2008). As a consequence of its highly dispersible seeds it frequently escapes cultivation.

Establishment Summary

Estimate the overall likelihood of establishment (comment on key issues that lead to this conclusion).

Response: *very likely*
Confidence: *very high*

Comments (state where in GB this species could establish in your comments, include map if possible):

B. davidii establishes in natural and disturbed areas and is able to tolerate a wide range of physical conditions (e.g. Tallent-Halsell and Watt, 2009). It establishes on walls and rock faces, quarries, urban waste grounds, abandoned cultivated areas and along transport corridors (e.g. Wilson, 1913; Owen and Whiteway, 1980; Miller, 1984, Reichard, 1996; Bellingham et al., 2005; Tallent-Halsell, 2008).

B. davidii is already widely established in the Risk Assessment Area. After being introduced to the Risk Assessment Area it began to colonise wasteland and building sites in 1930 (Owen & Whiteway 1980). Still, *B. davidii* is mainly associated with human disturbed sites, such as railway banks and quarries.

The current worldwide distribution of *B. davidii* indicates the core distribution to be in warmer humid regions including temperate, Mediterranean and subtropical climates (Tallent-Halsell and Watt, 2009). After Köppen climate classification *B. davidii* prefers Cs (Warm temperate climate with dry summer) and Cw (Warm temperate climate with dry winter), but also tolerates Cf (Warm temperate climate, wet all year) (https://www.cabi.org/isc/datasheet/10314).

Spread Summary

Estimate overall potential for spread (comment on key issues that lead to this conclusion).

Overall response: *rapid*
Confidence: *high*

Sub scores:

Natural spread only:
Response: *rapid*
Confidence**:** *high*

Human facilitated spread only:
Response: *rapid*
Confidence**:** *high*

Comments (in your comments list the spread pathways and discuss how much of the total habitat that the species could occupy has already been occupied):

Following the first record of this plant outside of cultivation in 1922 it is now widespread across the whole Risk Assessment Area. Tallent-Halsell and Watt (2009) indicate that the majority of this spread has been recent, with an 83% increase in its distribution since 1984 (based on a comparison of 10km^2 occupied).

B. davidii first became naturalised on a significant scale in the Risk Assessment Area in the 1930s. But after World War II populations of the species experienced a rapid expansion due to the sudden availability of "open" sites by bomb damage (Owen & Whiteway 1980). The creation of new habitats is likely to happen through construction sites, extension of industrial areas, the abandoning of old buildings and the expansion of transportation networks. The latter particularly facilitates the spread of the species over large distances by creating distribution corridors.
B. davidii is a popular garden plant in the Risk Assessment Area and the spread of seeds from private gardeners or nurseries depend on pruning practices (Ream 2006). Cutting back plants after flowering to encourage branching is recommended (Ream 2006) and could therefore be a crucial factor for reducing the spread through human gardening.

The Non-native Species Secretariat reports, that *B.davidii* "has rapidly spread throughout the lowland Britain and is still increasing its range and frequency" (Squirrel, J. 2015). However, the maps of *B. davidii* in Britain suggest, that at for example at a 10x10 km scale, the range appears almost saturated. On a smaller scale, however, expansion may still continue.

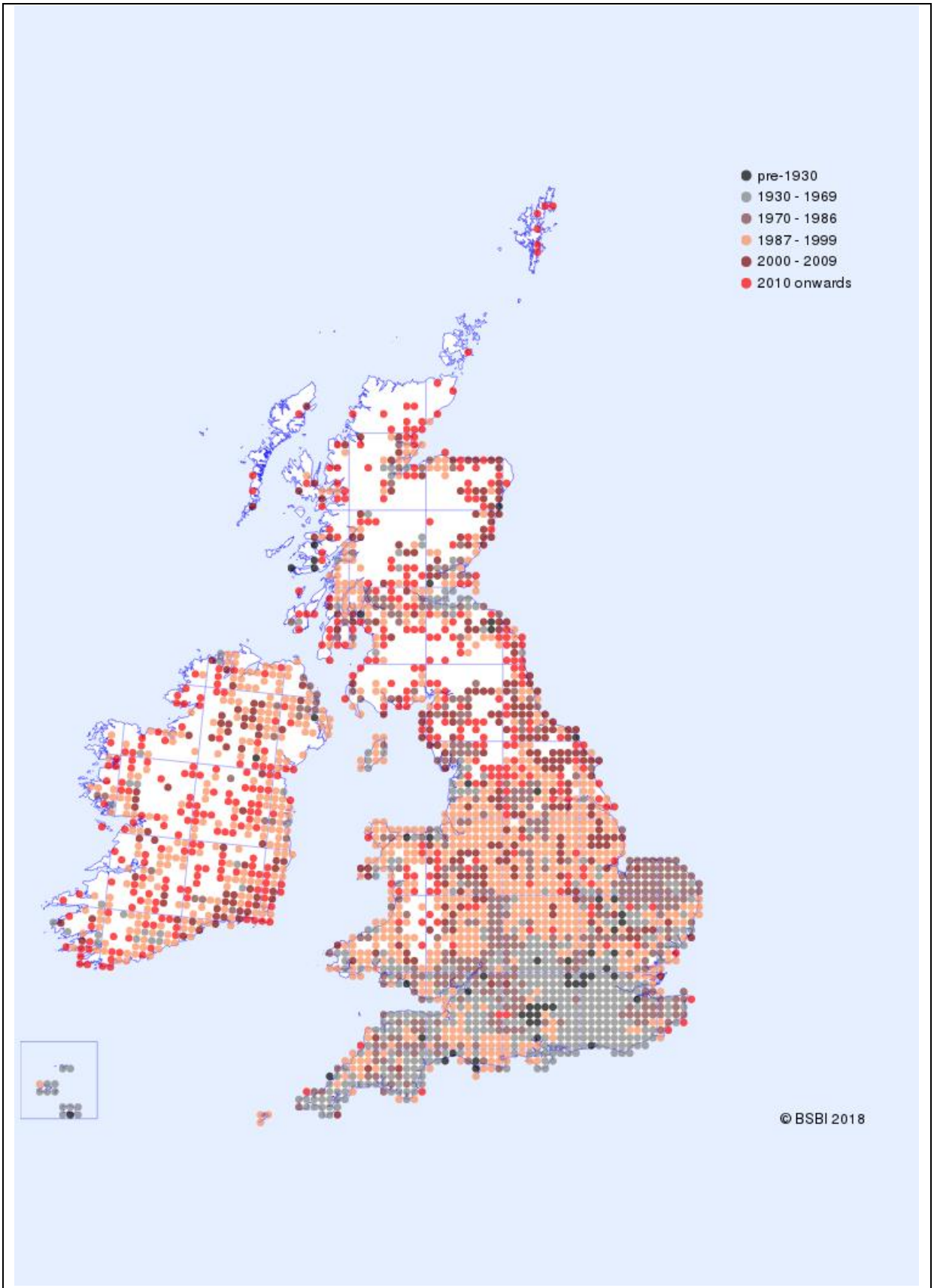


Figure 1: Spread history of *Buddleja davidii* in the Risk Assessment Area between 1930 and 2018. Source: Botanical Society of Britain & Ireland (https://bsbi.org/maps). Please note that this map has the oldest date category on top where there is more than one time-period observation in a cell.

Natural spread

One key factor for *B. davidii*'s spread is the high propagule pressure with a dispersal of a large amount of seeds. A single mature *B. davidii* individual can produce millions of seeds in one flowering season; however, estimates of the number of seeds produced vary (100,000 to 3,000,000) among cultivars (Miller, 1984; Brown, 1990; Wilson et al., 2004b; Thomas et al., 2008c). The majority (95%) of seeds of one individual were dispersed 10 m, or further, from the parent (Miller, 1984). *B. davidii* seeds are also reported to be water-dispersed (Miller, 1984; Webb et al., 1988; Brown, 1990), which may have a major impact in the Risk Assessment Area.

Human facilitated spread

In the 1950s and 1960s *B. davidii* became a popular garden plant, which is demonstrated by the high number of cultivars (more than 100) whereof 20 won at least once the Royal Society's Award of Garden Merit (RHS Horticultural Database 2018). Thus, the frequent plantings of cultivars are often the source of naturalised populations, and increase the propagule pressure again when not managed. Anisko & Im (2001) and Ream (2006) found that certain cultivars have a higher invasive potential then others due to the number of seeds produced per infructescense and/or their germination rate.

So far *B. davidii* has only occupied disturbed areas such as transport corridors, quarries, abandoned cultivated areas and urban waste grounds (Owen & Whiteway 1980, Godefroid et al. 2007) in the Risk Assessment Area. Especially along transport corridors, the species grows prolifically (Wiliams et al. 2010). The low pressure drag created by trains most likely has spread *B. davidii* seeds throughout railway networks in Europe and North America (Blacker, 2000). Nevertheless, the occurrence of *B. davidii* in semi-natural habitats in New Zealand (e.g. river beds and plantation forests, revegetation areas) shows the potential of the species to become a serious weed.

Impact Summary

Estimate overall severity of impact (comment on key issues that lead to this conclusion)

Overall response: *moderate*
Confidence: *high*

Sub-scores

Environmental impacts:
Response: *moderate*
Confidence**:** *high*

Economic impacts:
Response: *major*
Confidence: *high*

Social impacts:
Response: *minimal*
Confidence: *high*

Comments:

Since the 1950s *Buddleja davidii* has rapidly spread throughout Britain (Carlsson 2017) and is still increasing its range and frequency (Squirrel 2015). Due to its fast and prolific reproduction, and high

tolerance to a wide range of climatic and abiotic conditions, the species may have an impact on native plants in the Risk Assessment Area.

Environmental impacts

The species' vigorous growth and capability of forming dense thickets means it may crowd out native vegetation by suppressing germination and thus disrupting natural succession patterns (http://www.invasives.org.za/legislation/item/681-chinese-sagewood-buddleja-davidii; Williams, 1979; Smale, 1990; Brockerhoff et al. 1999). However, there is relatively little literature investigating this impact

The impact of *B. davidii* on butterflies and pollination has generated some controversy. Although eleven species of butterfly caterpillars were found to feed on *B. davidii* (Owen & Whiteway 1980), more recent literature indicates that the species is not an important food-plant for caterpillars (https://www.invasiveplantatlas.org/subject.html?sub=11608, https://plantright.org/watch/buddleja-davidii/; https://www.naba.org/pubs/bg172/bg172_Butterflybush_Issue.pdf) and thus the species cannot substitute native plant species equivalently. It is also assumed, similar to *Lythrum salicaria* (Brown et al. 2002), that the high attractiveness of *B. davidii* flowers might negatively affect the pollination success of native plant species by a decreasing the number of pollinator visits. On the other hand, *B. davidii* provides a rich nectar source for butterflies, moths and other insects in cities as well as in the countryside. This might become relevant since wildflowers are in decline following habitat loss and land use changes which causes a significant reduction of nectar sources (Stout and Morales 2008).

Economic impacts

B. davidii is considered as "the plant that dominates Britain's railways" (Gupta 2014). Williams et al (2010) estimated that *Buddleja*-control costs the British economy £961,000 p.a. . This includes damage on old buildings, mainly because it germinates in crumbling brickwork, and requires clearance from railway lines (Williams et al 2010).

Economical burden may occur if the species becomes widely established in important conservation areas, especially brownfield sites. The costs for controlling *B. davidii* in those semi-natural sites, to allow natural vegetation to develop, could be substantial (https://butterfly-conservation.org/sites/default/files/1.bc-position-statement-on-buddleia-updated-2015.pdf
On the other hand, the sale of this very popular garden plant economically benefits the horticulture and nursery trades (Tallent-Halsell & Watt 2009).

The formation of monocultures could alter the aesthetics of areas used for recreation. The extensive root system and the ability to grow in rock faces and walls, may displace paving and brickwork, which would lead to unappealing sights and the associated necessity for refurbishments (Sheppard, Shaw & Sforza, 2006).

Social impacts

B. davidii is an ornamental species, and popular among many in the Risk Assessment Area due to its decorative flowers and as a nectar source for butterflies.

Although toxic compounds have been isolated from *B. davidii*, there are no reports of intoxications by this species so far. Thus the impact on health is to be considered low.

Climate Change

What is the likelihood that the risk posed by this species will increase as a result of climate change?

Response: *medium*
Confidence: *medium*

Comments:

The current distribution of *B. davidii* indicates the core distribution to be centred in warmer humid regions including temperate, Mediterranean and subtropical climates (Tallent-Halsell & Watt, 2009). Kriticos et al. (2010) assessed the future climate suitability using a process-oriented climate suitability model, demonstrating that the potential distribution of *B. davidii* increases most noticeably in the northern United States and southern Canada, northern and eastern Europe, and to a lesser extent in the south-western part of the South Island of New Zealand.

In the Risk Assessment Area, increased flooding is a main threat commonly identified as a result of future climate change (https://www.greenpeace.org.uk/what-we-do/climate/climate-change-how-it-affects-britain/). As *B. davidii* seeds are reported to be water-dispersed (Miller, 1984; Webb et al., 1988; Brown, 1990), they can be washed downstream and establish new populations (ISSG, 2018). Thus, the dispersal of seeds may increase in terms of distance and time with increasing flooding risks. Additionally, *B. davidii's* characteristic of regenerating from buried stems, stumps and roots (Tallent-Halsell unpubl.) after the event of flooding does not restrict its spread.

Conclusion

Estimate the overall risk (comment on the key issues that lead to this conclusion).

Response: *medium*
Confidence: *high*

B. davidii is already present and well established in the Risk Assessment Area. Records of the species have been increasing since the 1980's and it seems likely that this trend will continue in the future. *B. davidii* is a popular garden plant and thus a constant source of escapes, bearing the risk of recurring establishments of invasive populations.

Among the already affected habitats are semi-natural habitats, for example abandoned quarries. There is an additional risk that *B. davidii* could also establish along riverbanks and forest edges, not least because of the increased probability of flooding events in the future, as a result of climate change.

Expected impacts mainly concern economic harm and harm to native biodiversity, as *B. davidii* forms dense thickets that suppress germination of native vegetation and thus disrupt natural succession patterns.

The highest economic impact refers mainly to the management costs of railway lines. Control is difficult and costly, and eradication will be almost impossible because *B. davidii* is already so widely distributed and planted.

Management options (brief summary):

1 - Has the species been managed elsewhere? If so, how effective has management been?

Response: Yes.

The species is currently only managed in areas where it causes damages or where it impairs the usage of buildings and transportation networks. This management is generally labour intensive, because *Buddleja* is a woody species, with the effectiveness of taken measures varying depending on site conditions. Railway companies in the Risk Assesment Area cut down large plants before removing or killing the stumps. Small plants are sprayed with herbicides.
In 2006 a potential biocontrol agent, the defoliator *Cleopus japonicus* was introduced and released in New Zealand.

2 - List the available control / eradication options for this organism and indicate their efficacy.

Response:

The control of *B. davidii* is problematic due to the plants' pronounced resistance to mechanical and herbicide treatments. Repeated treatment of the same infestations are common and necessary in the Risk Assessment area to prevent or at least control regrowth (Clay & Drinkall 2001).

1. Physical/mechanical control

Physical removal on a small spatial scale may help in the early stages of invasion. Young shrubs can be dug up, but this method is not recommended for mature plants (Tallent-Halsell and Watt, 2009). In forest plantations in New Zealand, *B. davidii* is controlled by aerial sowing of cover grasses such as *Holcus lanatus* (Yorkshire fog) in the autumn, prior to planting, which has been found to effectively suppress the growth of young *B. davidii* seedlings (Tallent-Halsell and Watt, 2009).
Additionally, it is recommended to prune the shrubs prior to seed set and dispersal (Ream 2006). In contrast, pruning increases flowering and fruiting (https://www.bto.org/volunteer-surveys/gbw/gardens-wildlife/gardening/pruning).

2. Biological control

The beetles *Cleopus japonicus* and *Mecysolobus erro* are specialised herbivores feeding on leaves and stems respectively. *Cleopus japonicus* is used as a biological control agent in New Zealand. There it shows the ability to suppress growth of *Buddleja* seedlings, but the agent does not appear to colonise newly planted forests quickly enough to benefit forestry. *Cleopus japonicus* helps to reduce *B. davidii´*s density, which reduces the amount of herbicides used on the remaining weeds and speeds up thinning operations
(https://www.landcareresearch.co.nz/__data/assets/pdf_file/0007/62494/Toni_Withers_Buddleia_leaf_weevil.pdf)

3. Chemical control

Glyphosate herbicide without surfactants has been reported to be effective against small shrubs (Ream, 2006), whereas large shrubs with heavy pubescent leaves were less vulnerable to foliar application. Direct and precise application, such as painting cut stumps is more effective than spraying (Ream, 2006; Zazirska and Altland, 2006). Treatment with triclopyr or imazapyr has not been effective (Ream, 2006). In New Zealand, *B. davidii* is typically controlled in recent clearcut stands using herbicides that are usually aerially applied immediately before (i.e. glyphosate and metsulfuron) and then again after (i.e. terbuthylazine and hexazinone) planting of plantation conifers

(Tallent-Halsell and Watt, 2009).

Because stem and root fragments readily regenerate, debris piles should be burned, composted or otherwise treated in such a way to kill all seeds, stems and root fragments (Tallent-Halsell and Watt, 2009).

3 - List the available pathway management options (to reduce spread) for this organism and indicate their efficacy.

Response:

Dead-heading is the recommended method to reduce the spread of *B. davidii* by seeds (Turnbull, 2004; Ream, 2006; Savonen, 2009), but this practice has been linked to reducing the quality of the shrub in subsequent years and increasing the plant's susceptibility to disease (Warr et al., 2002; Tallent-Halsell and Watt, 2009).

Most production nurseries prune plants before seed mature, eliminating the seed source effectively.

1. A general cessation in trading and planting *B. davidii* – very effective to prevent creating further potential sources for further spread.

2. Advice on control and disposal of plant components – for example by providing information on how to remove seed producing stems (pruning).

3. Breeding new cultivars, which are sterile.

4 - How quickly would management need to be implemented in order to work?

Response:

The management is recommended to start as soon as plants are detected in unintended habitats. The establishment of plants can best be prevented by an early removal of seedlings and young sprouts. If plants are already well established, and the mechanical removal is not possible or expected to be incomplete, cutting and burning of flower-heads as soon as they appear will be an effective measure to contain further spread (Ream 2006).

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Provide here a list of the references cited in the course of completing assessment

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