Risk assessment

Cotoneaster

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September 2014

Naturalis
Biodiversity
Center

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This report was commissioned by the Invasive Alien Species Team of the Netherlands Food and Consumer Product Safety Authority.

My colleagues Dr. Filip Verloove, Dr. Leni Duistermaat and Dr. Johan van Valkenburg are acknowledged for their valued suggestions for improvement.

1. Introduction

Cotoneaster divaricatus

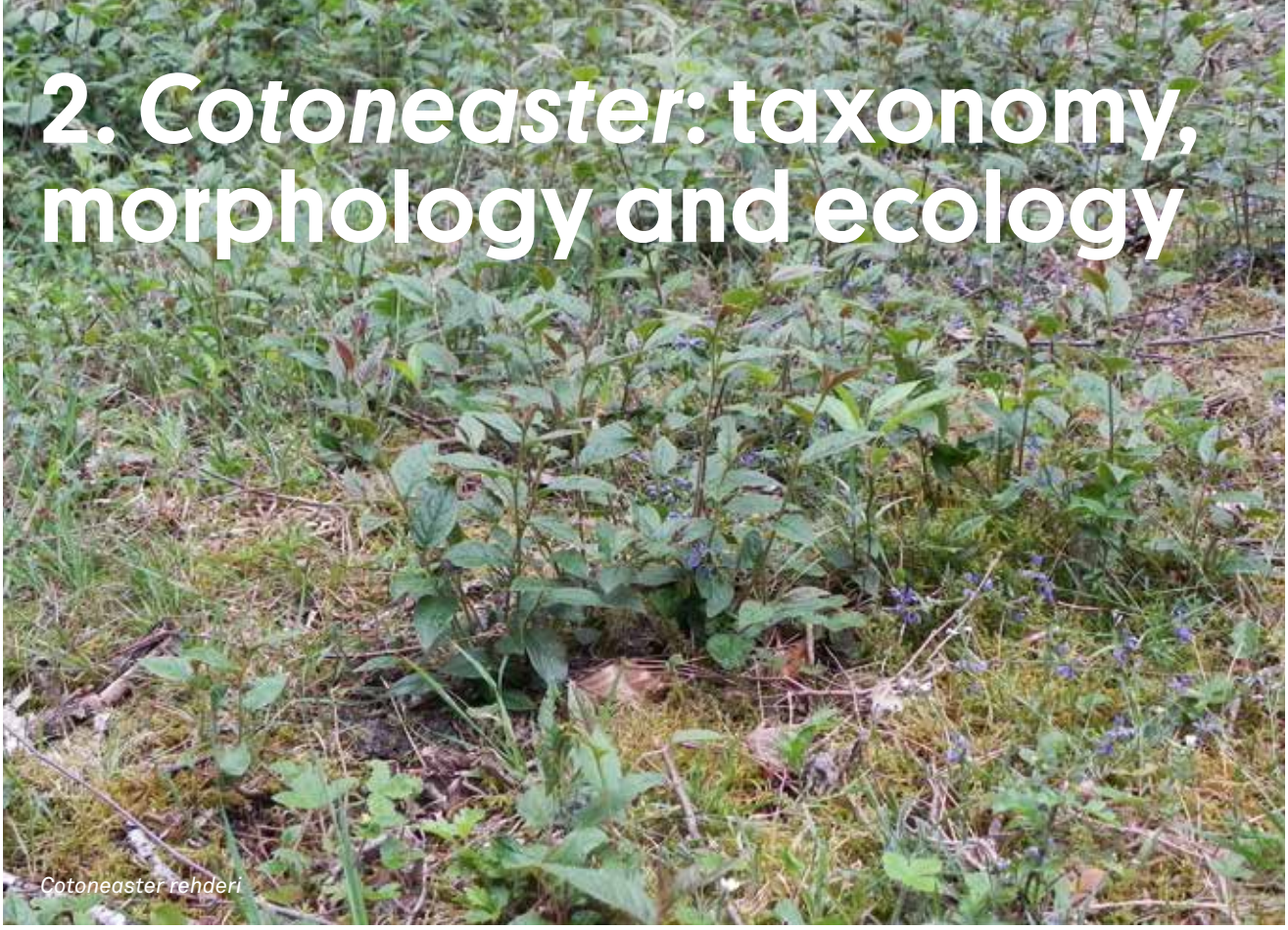
Exotic, invasive plant species have a negative impact on biodiversity, economy and/or public health. *Cotoneaster* species are potentially invasive alien plant species. For this reason the Invasive Alien Species Team of the Netherlands Food and Consumer Product Safety Authority has requested a risk assessment for *Cotoneaster*.

The current risk assessment will focus on the situation in the Netherlands and discuss the following subjects:

- Determination of what *Cotoneaster* species are potentially invasive in the Netherlands
- Probability of entry
- Probability of establishment in the Netherlands
- Probability of spread
- Identification of endangered areas based on the results of the probabilities of entry, establishment and spread
- Impact of *Cotoneaster* spp. in respect to ecological, economical and public health aspects
- Management options to eradicate the species
- Management options to control further spread and reduce impact.

This report is based on published literature, either in print or on the internet.

2. *Cotoneaster*: taxonomy, morphology and ecology



Cotoneaster rehderi

2.1. Taxonomy

Cotoneaster is a genus in the family of the *Rosaceae* (incl. Malaceae). The number of species in the genus differs according to the adopted species concept and ranges from some 50 to over 400 species. The majority of species is found in the Himalaya and south-western China. A few species are endemic to Europe, only 1 species, *Cotoneaster integerrimus* Medik., is indigenous in the Netherlands (Verloove, 2013b).

The taxonomy of *Cotoneaster* is extremely problematic: some of the *Cotoneaster* species found as escapes in Europe are naturalized ornamental species of unknown origin and often cultivars or hybrids not found in the wild. The classification by Dickoré and Kasperek (2010) aims to classify species according to the generally accepted botanical standards into species, thus regrouping the many, often too many "micro species" into fewer taxonomic units. However, lumping of species into clearly recognizable species by Dickoré and Kasperek is also unsatisfactory as some of these clearly recognizable species, e.g. *Cotoneaster ascendens* and *Cotoneaster horizontalis*, have been unnecessarily lumped. Therefore we will use here the suggested taxonomy by Verloove (2013b) who also integrates the taxonomic insights of Fryer and Hylmö (2009), who base their classification on taxonomical principles used in horticulture bearing in mind that all Cotoneaster species found in the Netherlands are escaped from cultivation.

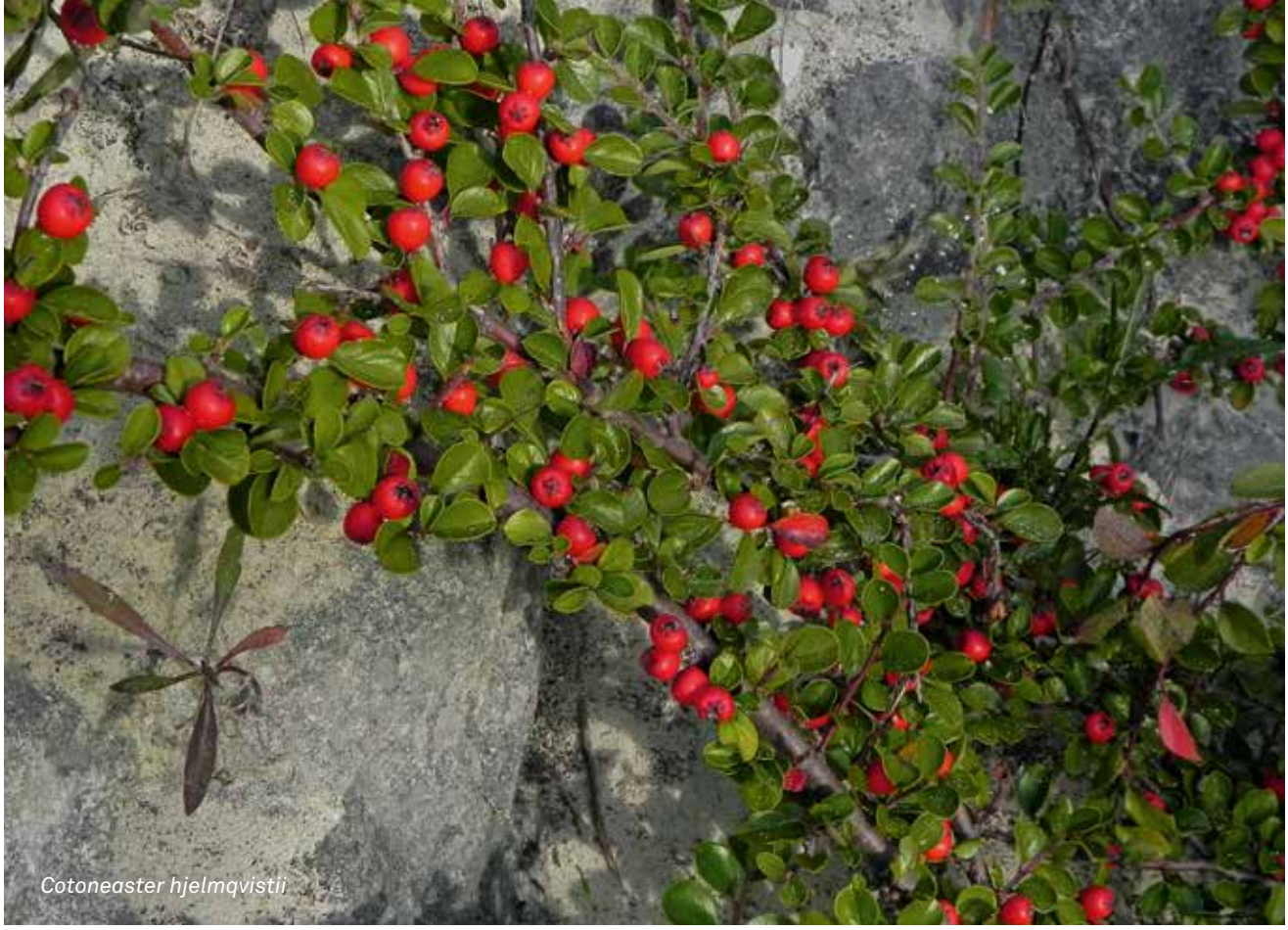
Apomixis, the phenomenon whereby plants reproduce asexually and therefore produce identical copies of the mother plant, yields many so-called "micro-species" which show only minute differences (Verloove, 2013b). The majority of taxonomic literature accepts apomixis and hybridization in *Cotoneaster* as a cause of the many closely resembling "micro-species". Some species are diploid and reproduce generatively whereas the majority of species is tetraploid of which the major part reproduces apomictically (Hensen, 1966). A few cultivars are triploid and infertile. Dickoré and Kasperek (2010), however, state that apomixis in *Cotoneaster* has never been convincingly proven.

Another problem is the fact that for correct identification the plant needs to be visited 3 times, viz.:

- When flowering: petals upright (flower more or less closed) or spreading (flowers open), their colour, colour and number of anthers, number of flowers per inflorescence,
- When fruiting: colour and form of the ripe fruit, number of stones (seeds) per fruit,
- In winter (January): deciduous or evergreen; here are some exceptions in that some species are semi-evergreen (like *C.* ×*watereri*) and some evergreen species may still loose a large amount of their foliage during a severe winter.

2.2. Morphology

Evergreen or deciduous shrubs, rarely small trees; branchlets mostly round in cross-section, rarely



Cotoneaster hjelmqvistii

slightly angular; leaves alternate, simple, shortly petiolate; margin of leaf blade entire. Flowers in cymes, small clusters or solitary; sepals 5, persistent, short; petals 5, erect or spreading, imbricate in bud, white, pink, or red; stamens 10-20(-22); ovary inferior or semi-inferior, 2-5-loculed; 2 ovules per carpel; styles 2-5, free; stigmas dilated. Fruit a drupe-like pome, red, brownish red, or orange to black, with (1-)2-5 bony seeds. (Fryer & Hylmö, 2011, Lingdi & Brach, 2003).

A complicating factor is that in Germany it is reported that established populations show increased plant size and leaf size relative to the original description of the species (John & Frank, 2008).

2.3. Ecology

The natural habitats in China where *Cotoneaster* species are found are mountain regions, forests, slopes, thickets, river valleys, river banks, grassy sites, often on rocky or calcareous sites, at altitudes of 800-4100 m (Lingdi & Brach, 2003).

One species is indigenous to the Netherlands, *C. integerrimus* Medik., a rare and local species found in thickets on calcareous soil.

Cotoneaster species need full sunlight to produce flowers in the Netherlands. Fruits are favoured by birds, particularly blackbirds and other thrushes (Crofts & Jefferson, 1999). Distribution of *Cotoneaster* is therefore easy, but generally only over short distances linked to the roost locations of birds (Verloove, 2013a).

Plants can also reproduce from node-rooting fragments and are self-layering, so plants can also spread by vegetative means (Pilkington, 2011).

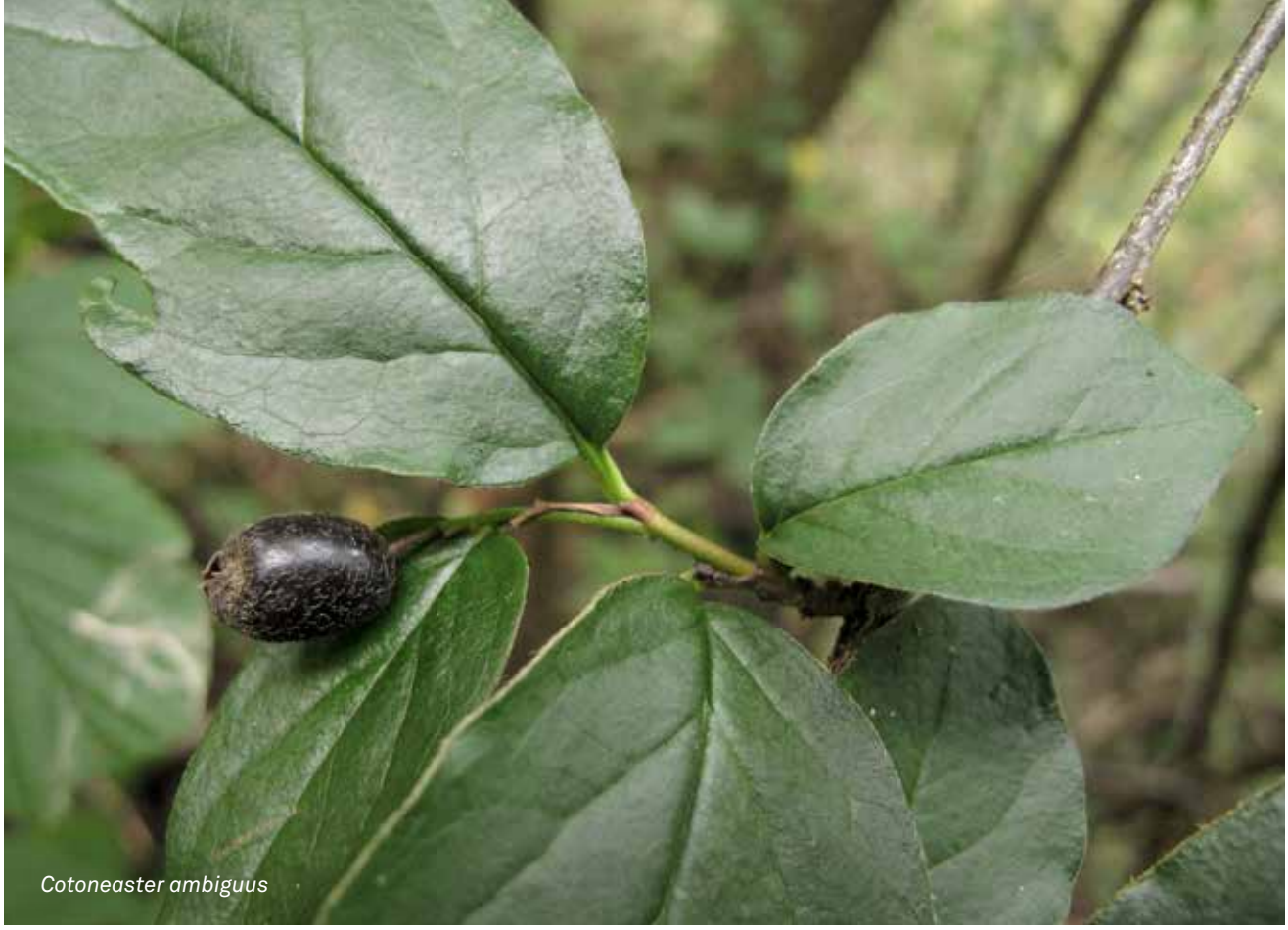
3. Risk assessment

Cotoneaster ambiguus

3.1. Selection of species

A large number of *Cotoneaster* species is planted as an ornamental in the Netherlands. This may be in private gardens but they are also often found along roadsides, in parking lots, and other borders of 'public space'. They are appreciated for their colourful berries and are used as cover crop or in hedges.

An inventory has been made to identify those *Cotoneaster* species that have been found as an escape from cultivation or naturalized in the Netherlands. Moreover, the situation of Cotoneaster in Belgium has also been used as in Belgium the situation is thoroughly studied, taxonomical problems have been solved and specific field studies have been performed (Halford et al., 2014, Manual of the alien plant in Belgium, 2014, Verloove 2013a and 2013b). This inventory has been based on a thorough taxonomic study of over 600 herbarium specimen and on field observations performed in areas where naturalized *Cotoneaster* species have been reported in the Netherlands. These reports



Cotoneaster ambiguus

were received from 2 terrain owners viz. *Natuurmonumenten* and the national forest service (*Staatsbosbeheer*) or were taken from the website regrouping field observations on plants and animals in the Netherlands: waarneming.nl.

The species for which naturalization in the Netherlands has been confirmed are:

- *Cotoneaster ambiguus*
- *Cotoneaster bullatus* s.s.
- *Cotoneaster dielsianus*
- *Cotoneaster divaricatus*
- *Cotoneaster hjelmqvistii*
- *Cotoneaster horizontalis*
- *Cotoneaster rehderi*
- *Cotoneaster salicifolius*
- *Cotoneaster ×suecicus*
- *Cotoneaster ×watereri*

In the rest of this report the characteristics of different species will be as much as possible contributed to following sensu lato species, bearing in mind that misidentifications are frequent:

- *Cotoneaster bullatus* sensu lato (s.l.): *C. bullatus* sensu stricto (s.s.), *C. rehderi*
- *Cotoneaster horizontalis* s.l.: *C. horizontalis* s.s., *C. ascendens*, *C. hjelmqvistii*

The risk assessment will be given for 2 groups of Cotoneaster species, viz. the small-leaved and the large-leaved species. The reason for this distinction is the different behaviour of the 2 groups, particularly the different habitats they threaten: the small-leaved species pose a potential threat for calcareous grasslands and the large-leaves species for dune habitats. Within a group there is more information for one species than for another, but behaviour and invasiveness are quite similar. Moreover, terrain managers like Natuurmonumenten use this distinction as well to focus activities and not to get lost in difficulties associated with species identification (Siebel & Reichgelt, 2014).

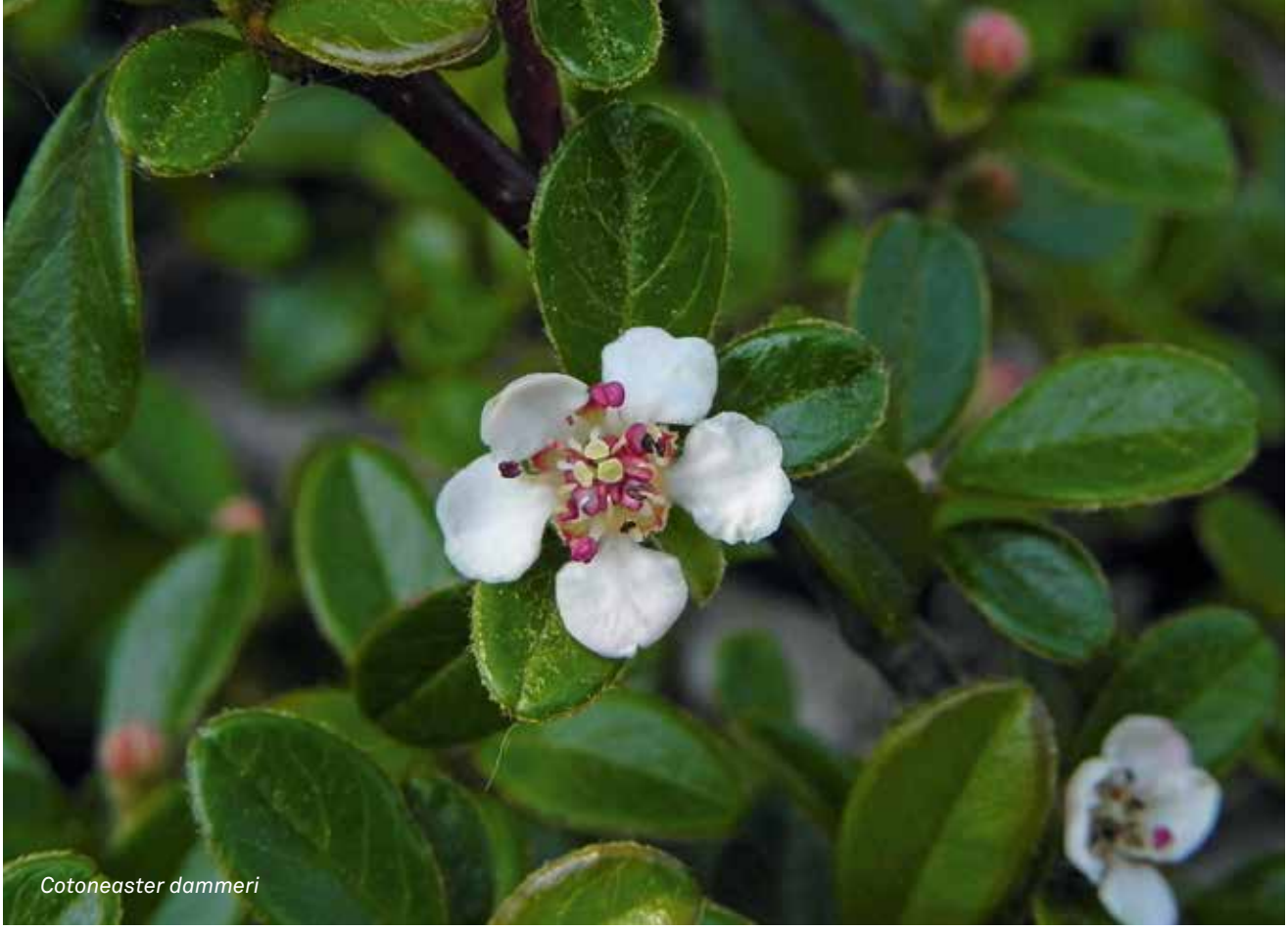
Table 1. Distinction of Cotoneaster species in 2 groups

Small-leaved cotoneasters	Large-leaved cotoneasters
Cotoneaster ascendens	*Cotoneaster ambiguus*
Cotoneaster dielsianus	*Cotoneaster bullatus*
Cotoneaster divaricatus	*Cotoneaster rehderi*
Cotoneaster franchetii	*Cotoneaster salicifolius*
Cotoneaster hjelmqvistii	
Cotoneaster horizontalis	

3.2. Entry

Cotoneaster spp. have been imported and are currently sold through nurseries and garden centers as ornamental species. For the Netherlands 36 species are traded commercially (de Koning et al., 2009), but it should be noted that the identification of these species is troublesome and may not be correct.

For *Cotoneaster horizontalis* it is known that it has been introduced in the UK in 1880 (GB Non-native species secretariat, 2014). Five other species were cultivated in Britain since 1898-1908 (Online atlas of



Cotoneaster dammeri

the British and Irish flora, 2014). The Kew Botanic Garden had 23 species of Cotoneaster in its collection in 1902 (RBG, Kew, 1902).

The overall risk of entry for both groups is high.

3.3. Establishment

Although Cotoneaster species have been planted in the Netherlands for a century, the naturalization started probably only since the 1980's; this has been noticed but goes unexplained so far (Verloove, 2013a).

The distributional information for the Netherlands presented hereunder regarding field observations is extracted from the National Databank Flora and Fauna (= NDFF; Stichting Gegevensautoriteit Natuur, 2009-2014), information on herbarium vouchers is extracted from the national herbarium database Brahms (Naturalis Biodiversity Center, 2014).

It is noted that the high number of observations for *C. horizontalis* most probably include misidentifications of the 2 other species closely related to *C. horizontalis* and part of the wider species concept *C. horizontalis* s.l., viz. *C. ascendens* and *C. hjelmqvistii*.

In the framework of this study additional collections in the Netherlands have been made from naturalized populations:

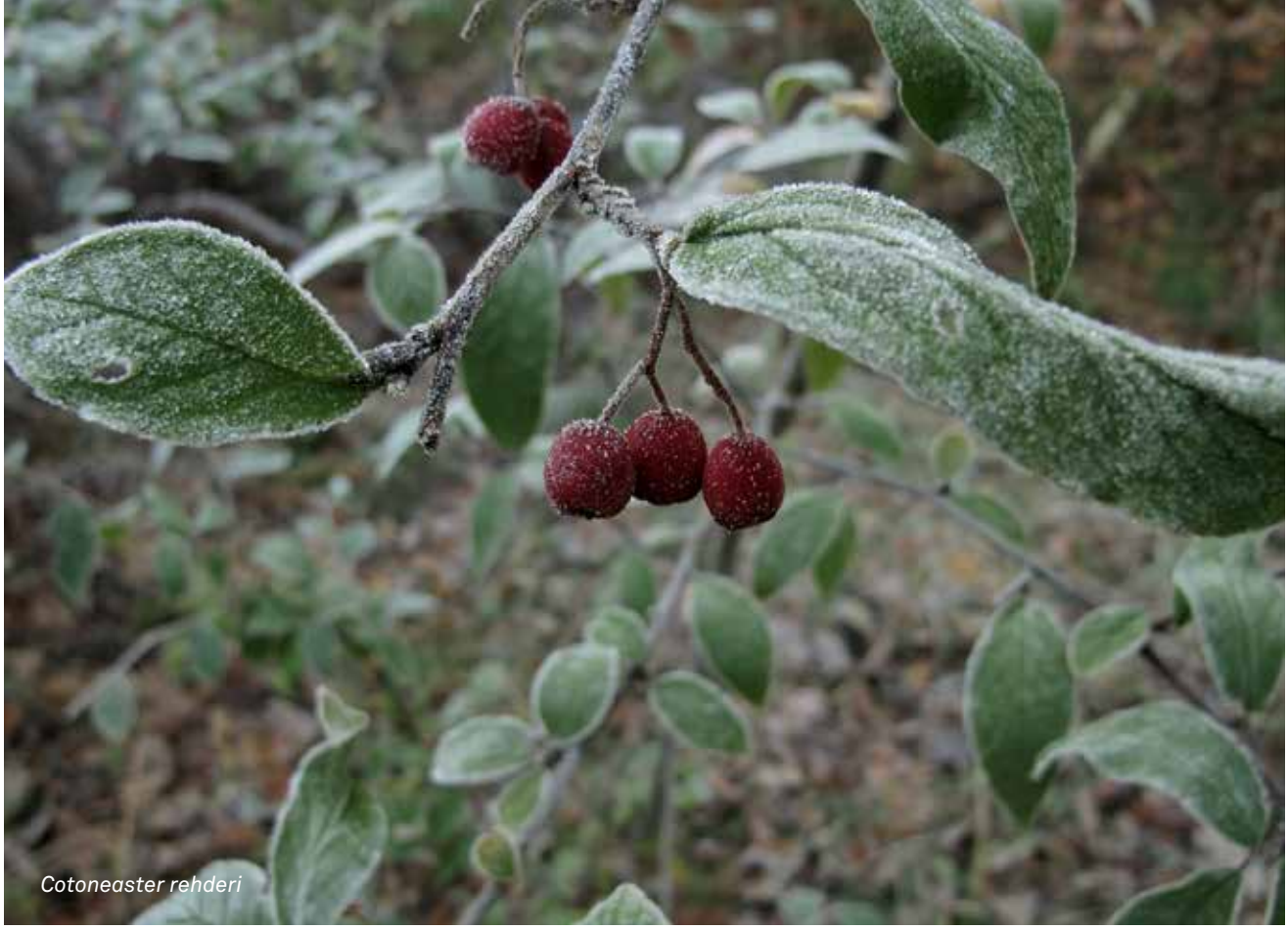
- *Cotoneaster ambiguus* in the Noord-Oost Polder
- *Cotoneaster dielsianus* and *C. bullatus* s.l. in the dunes in the west of the country
- *Cotoneaster hjelmqvistii* and *C. divaricatus* on marl in the southern part of the province of Limburg
- *Cotoneaster horizontalis* on a calcareous slope in the south of the province of Limburg

Cotoneaster ambiguus

In Belgium it is known from at least two locations where it is fully naturalized. It was discovered in spontaneous scrub on sandy soil and on a former demolition site (Manual of the Alien Plants of Belgium, 2014). Claims from Central-Europe (Dickoré & Kasperek, 2010) refer to *Cotoneaster villosulus*.
In the Netherlands it is not recorded in NDFF field observations. However, in the framework of this risk assessment it has been collected once from the Noord-Oost Polder. Here it was found locally abundant with numerous individuals as understorey in deciduous forest. The risk of establishment in the Netherlands is high.

Cotoneaster ascendens

In Belgium, *Cotoneaster ascendens* always seems to grow on stony substrate (old walls, concrete canal banks), usually in half-shade, whereas in the British Isles, it is confined to open woodland (Manual of the Alien Plants of Belgium, 2014; Stace, 2010). In the Netherlands this species is not found in NDFF field observations nor as herbarium voucher. Based on the observed establishment in Belgium, but the rareness of similar habitats in the Netherlands, the risk for establishment is medium.



Cotoneaster rehderi

***Cotoneaster bullatus* s.l.**
Cotoneaster bullatus s.l. comprises several species of which only the following are found in the Netherlands: *C. bullatus* sensu strico (s.s.), *C. rehderi.*
This species rarely occurs in large numbers, although it is one of the *Cotoneaster* species most frequently found in Belgium. In the Netherlands it is found in the coastal dunes in the province of Noord Holland and has been collected 4 times. It has been found in wooded dunes under pine trees and forms locally dense thickets. Moreover, it resprouts vigorously after cutting back the stem. It has not been recorded in the NDFF field observations. The habitats it populates in Belgium are widely varying from natural sites (deciduous and coniferous woodland, coastal dunes, foot of hedges) to man-made ones like railway tracks, urban wasteland, coal mining heaps, old walls, abandoned railway yards, and gravel pits (Manual of the Alien Plants of Belgium, 2014). The risk of establishment in the Netherlands is high.

Cotoneaster dielsianus
Cotoneaster dielsianus mostly occurs with single shrubs in Belgium. Small but more or less stable populations are rare and seem to be restricted to warmer and drier areas, especially near the coast (Manual of the Alien Plants of Belgium, 2014). In the Netherlands the species is 5 times recorded in the NDFF field observations. This species has been collected 4 times from the National Park Zuid Kennemerland (province of Noord Holland) in open wooded dunes with deciduous and/or pine trees. In this habitat large *Cotoneaster* populations occur. The risk of establishment in the Netherlands is high.

Cotoneaster divaricatus
It is naturalized in Belgium (Verloove, 2013b), France (Farille & al. 2010), Germany (Dickoré & Kasperek 2010), Great Britain (Stace 2010) and Scandinavia (Karlsson 2002). In Central Europe it is the most commonly naturalized species of the genus (Dickoré & Kasperek, 2010). In Belgium it is mainly found in coastal dunes, particularly in nature reserves. *Cotoneaster divaricatus* predominantly occurs on calcareous, dry, sandy soils, in either natural (coastal dunes) or artificial (sand raised sites) habitats (Verloove, 2013b). In the Netherlands it is not know from NDFF field observations; it has been collected once in 2013 from a former marl quarry in the south of the province of Limburg. Here it occurs abundantly mixed with *C. hjelmqvistii* on the cliffs and the edges of the cliff of the quarry. The risk of establishment in the Netherlands is high.

Cotoneaster franchetii
This species is naturalized in France (Farille & al., 2010) and Great Britain (Stace, 2010). Furthermore it is known from Austria, Germany, Ireland and Spain (Dickoré & Kasperek 2010). Its cultivation in Belgium and the Netherlands is recorded as common (De Koning et al., 2009). It is commonly found in the wild in Belgium, generally as scattered shrubs particularly in the climatologically milder coastal areas and in cities. Dense naturalized populations are found in scrub in coastal dunes. It is confined to dry,

sun-exposed localities, often on calcareous soils (Manual of the Alien Plants of Belgium, 2014). Moreover, it is one of the major invasive plants in Australia, New Zealand and the USA. In the Netherlands it has not been recorded in the NDFF field observations nor as a herbarium voucher collected in the wild, but represents a potential threat to dune ecosystems. In urban areas young flowering and fruiting plants are found. The risk of establishment in the Netherlands is high.

Cotoneaster hjelmqvistii
Due to the general confusion with *C. horizontalis* it is probably more widespread than currently known. In Belgium, it is found on a wide variety of habitats ranging from natural ones (calcareous slopes, coastal dunes, deciduous woodland) to man-made ones (coal mining heaps, quarries, former ash, gypsum or chalk deposits, abandoned railway yards, old walls, foot of fences, hedges or pergolas in gardens, cemeteries, etc.) (Manual of the Alien Plants of Belgium, 2014). In the Netherlands there have been no NDFF field observations and 4 herbarium vouchers. In the framework of this risk assessment study it has been collected once in 2013 from a former marl quarry in the south of the province of Limburg. Here it occurs abundantly mixed with *C. divaricatus* on the cliffs and the edges of the cliff of the quarry. Besides, it has once been collected from mixed forest in the province of Gelderland. The risk of establishment in the Netherlands is high.

Cotoneaster horizontalis
This species also occurs in a wide range of habitats in Belgium, ranging from man-made ones (coal mining heaps, railway sidings, abandoned gravel pits and industrial areas, old walls, cemeteries, etc.) to natural ones (mainly calcareous grassland and scrub in coastal dunes). It is usually confined to dry, sun-exposed sites, mostly on calcareous substrates (Manual of the Alien Plants of Belgium, 2014). In the Netherlands there are 443 NDFF field observations and in the national herbarium there are 2 vouchers of this species. It usually occurs as single individuals or in relatively small numbers, but in suitable habitats it may quickly develop dense and large thickets (Manual of the Alien Plants of Belgium, 2014).

In Belgium, *C. horizontalis* is included in the black list of invasive species and is categorized as “A2” meaning: restricted range, high environmental impact (Belgian Biodiversity Platform, 2000-2014). The risk of establishment in the Netherlands is high.

Cotoneaster salicifolius
Cotoneaster salicifolius was observed in Belgium mainly as solitary plants, only once it has been recorded as an invasion with numerous plants. In Belgium it favours dry, stony and sunny habitats often on calcareous soil whereas the closely related *C. ×watereri* prefers shade of semi-shade. In the national herbarium two collections are included, probably both from planted material. There are 19 NDFF field observations for this species.

The overall risk of establishment of small-leaved and large-leaved cotoneasters in the Netherlands is high.

3.4. Spread

It is known from Belgium that 3-year-old plants of *C. horizontalis* do already produce fruits (Piqueray et al., 2008). As mentioned under “Ecology” *Cotoneaster* berries are easily dispersed by birds. The ample supply of diaspores near urban centers has also been mentioned as source from where cultivated *Cotoneaster* species might spread. Several species or hybrids seem to propagate largely vegetatively while being able to develop persistent clones, e.g., from garden rubbish (Dickoré & Kasperek, 2010).

Spread and establishment seem to be associated with the presence of resting places for birds in the vicinity of build-up area as revealed in a study in Belgium: this might explain the occurrence of *Cotoneaster* species at the edge of pine and poplar forests and in man-made habitats like abandoned railway yards or industrial terrains, coal mining heaps, and stone, clay or sand pits (Verloove, 2013b).

After germination of seeds deposited by birds species thrive only in habitats that are dry, sunny or in (semi-)shade, calcareous and stony. This represents exactly the conditions as those for the indigenous *Cotoneaster integerrimus* (Verloove, 2013b).

A detailed study of the distribution of *Cotoneaster horizontalis* in Belgium showed that it is found much less frequently in the east of the country where soil conditions are more acidic (Piqueray et al., 2008).

Based on the widely available propagules and vectors, the overall spread potential of small-leaved and large-leaved cotoneasters in the Netherlands is high.

3.5. Endangered areas

In the Netherlands, the endangered areas for *Cotoneaster* species are coastal dunes, abandoned marl pits and calcareous grasslands. Coastal dunes and calcareous grasslands are valuable ecosystems with highly valued but vulnerable plant species. Calcareous grasslands are considered biodiversity hotspots as they are the most species-rich habitats in western Europe (Piqueray et al., 2008).

Cotoneaster horizontalis invading calcareous grasslands in Belgium proved to affect significantly 4 dry grassland specialist species. Impact assessment indicated that the presence of *C. horizontalis* is associated with changes in both the structure and the composition of the community by decreasing structural diversity and species richness (Piqueray et al., 2008).

3.6. Impact

3.6.1. Ecological impact

It has been shown for *Cotoneaster horizontalis* that it has a negative impact on a number of dry grassland specialist species in dry calcareous grasslands in Belgium. This will also be true if this species would establish in the highly-valued dry calcareous grasslands in the southern part of the province of Limburg; in the past it has been observed here.

Cotoneaster species like *C. dielsianus* and *C. bullatus*, that have established in the coastal dune area, have a similar potential: they are reported to be able to shade out and smother indigenous (and more vulnerable) species (Sigg, 1996; FACT, 2003). Both vegetation types, the coastal dunes and the dry calcareous grasslands, are Natura 2000 areas and as such need to be protected from alien invasive plants.

For other species no ecological impact studies are known from the Netherlands or neighbouring countries, but the ecological behaviour of other *Cotoneaster* species is considered to be similar.

If not managed Cotoneaster species can locally lead to permanent change in vegetation structure in coastal dune areas and marl quarries. Their fruits being favoured and easily dispersed by frugivorous birds may progressively accelerate this process and increase the area affected.

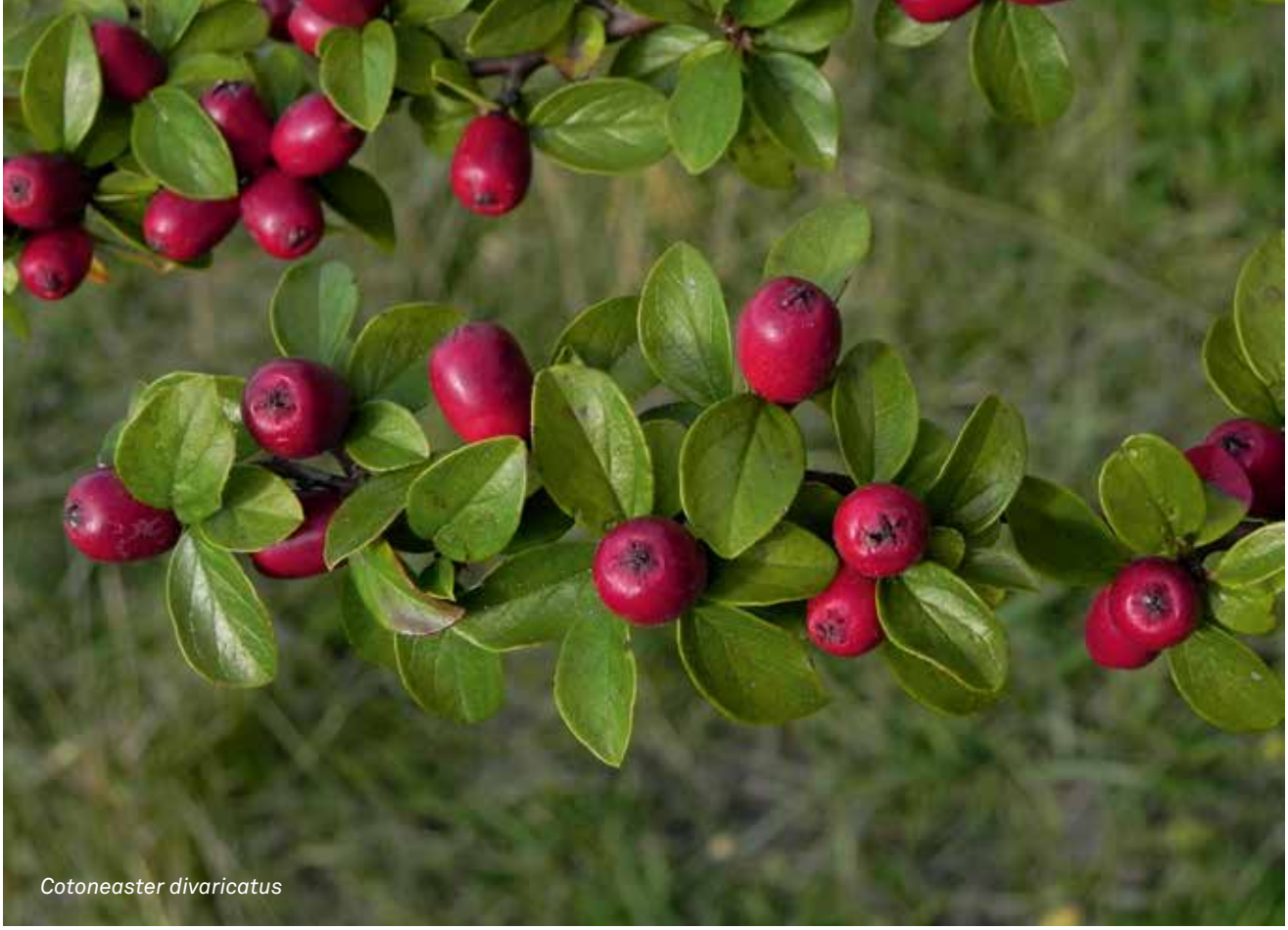
The potential level of ecological impact of small-leaved and large-leaved cotoneasters in the Netherlands is high.

3.6.2. Economic impact

The direct economic impact of infestations with *Cotoneaster* is limited to the costs involved in eradication operations. *Nauurmonumenten*, owner of the National Park Zuid Kennemerland, has started a combined eradication programme for *Prunus serotina*, *Cotoneaster dielsianus* and *Cotoneaster bullatus*. The *Cotoneaster* bushes are cut, dug out or removed by small-scale sod removal. This is the only *Cotoneaster* eradication programme know in the Netherlands.

Cotoneaster species are host plants for fireblight, *Erwinia amylovora*, a bacterial disease in fruit trees. It is prohibited to plant *Cotoneaster salicifolius* and *C. ×watereri* in buffer zones located around commercial tree nurseries (NVWA, 2014).

The potential level of economic impact of small-leaved and large-leaved cotoneasters in the Netherlands is low.



Cotoneaster divaricatus

3.6.3. Social impact

The only issue which may be mentioned here is the fact that it is known for *Cotoneaster* to cause contact dermatitis (Weller & Ormerod, 1996). Education and raising awareness of the potential flaws of *Cotoneaster* might be necessary to inform the public of potential ecological damage from *Cotoneaster* from private gardens, parks and other urban plantings.

The potential level of social impact of small-leaved and large-leaved cotoneasters in the Netherlands is low.

4. Risk management

Cotoneaster dielsianus

4.1. Prevention of deliberate plantings

It has been suggested in Belgium to stop sale of *Cotoneaster horizontalis* to prevent further infestations of this species, but this is unlikely as the plant has many assets as ornamental species (Piqueray et al., 2010). For the Netherlands, it will be difficult as well to ban sale of *Cotoneaster* species as it is an appreciated and widely traded group of ornamental plants.

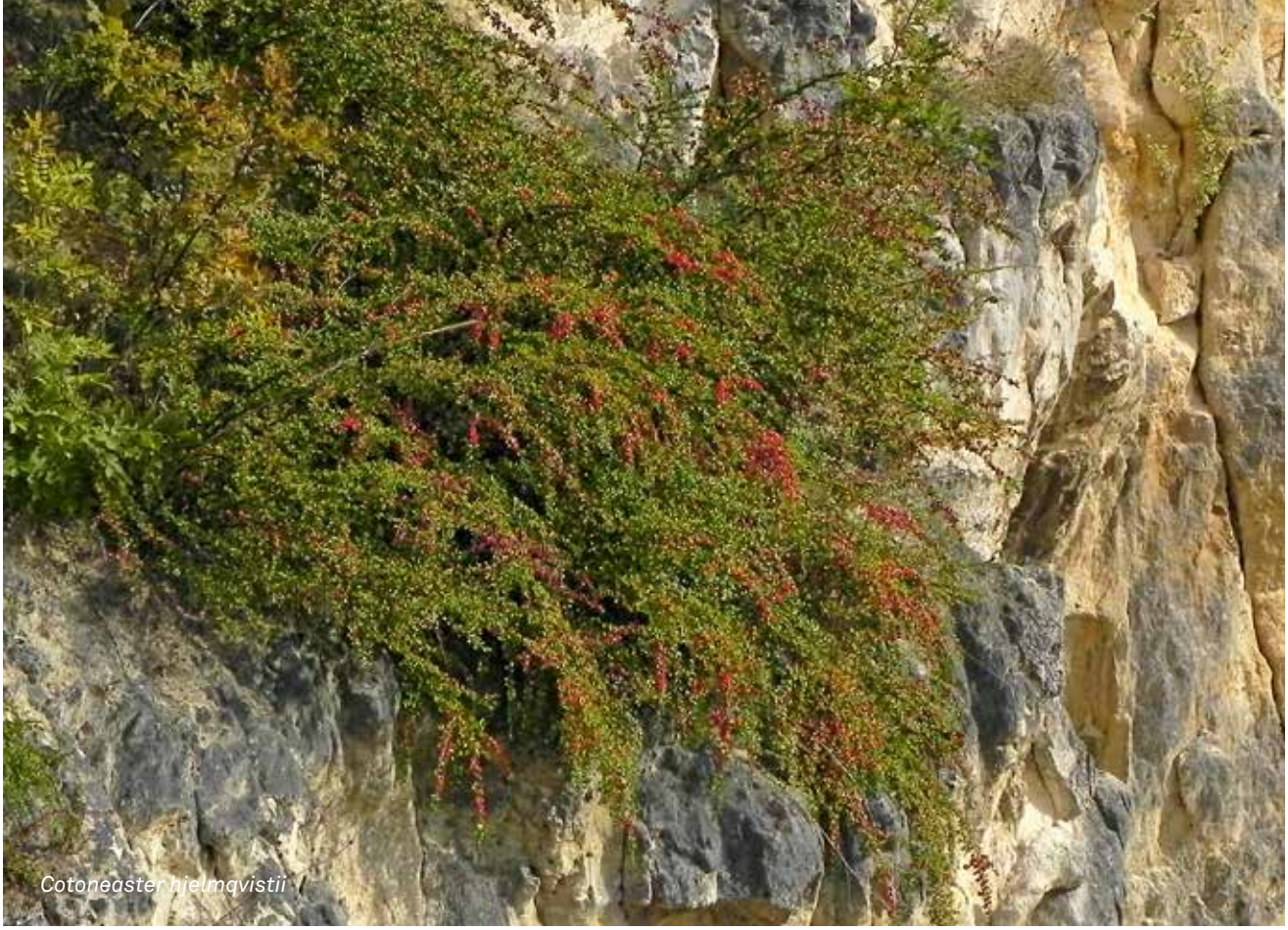
Berney (2002) reports for Australia that residents were offered free indigenous ornamental plants when they would remove the cotoneasters they had in their gardens. This lead to 17 tonnes of *Cotoneaster* being removed and an increased awareness of the public about the issue of invasive plants. In the United Kingdom, planting or causing to grow in the wild of 5 species of *Cotoneaster* is prohibited since 2010. These 5 species are: *Cotoneaster horizontalis*, *C. integrifolius*, *C. simonsii*, *C. bullatus* and *C. microphyllus* (National Archives, 2014).

4.2. Prevention of dispersal

As described earlier dispersal of the species is by birds, that eat the fruits and distribute the seeds. Prevention of birds feeding on the fruits is out of the question. Unwise disposal of garden waste, which is also reported to be able to trigger establishment of *Cotoneaster*, should receive ample attention (Dickoré & Kasperek, 2010).

4.3. Eradication and control

Cotoneaster species produce strong and wide-growing but superficial root systems. While young they can still be uprooted using a weed wrench. Both the stump and the shallow roots should be removed as both can re-sprout (GOERTS, 2005). When older they have produced many branches from ground level, these can be cut and painted with 100% glyphosate, which is a very effective method (Sigg, 1996). Roundup Max in a dilution of 1:32 (i.e. 16 ml product in 500 ml water) was applied on cut stumps preferably in the month of September when the plant reallocates nutrients to the root system (Halford et al., 2014). Siebel (2013) reports that this treatment is effective for shrubs with a diameter of over 2 cm, smaller shrubs still show some re-sprouting from the roots. When cutting in September is done care should be taken not to spread the fruits, which can easily fall off the cut branches in this season. The seedlings around these bushes can be smothered by mulch or black plastic, hand-pulled or sprayed. Seeds may remain viable for up to 5 years (Pilkington, 2011) hence new seedlings need to be removed for up to 5 years after eradication of the larger shrubs. Hand cutting at ground level reduces the vigour of the *Cotoneaster* bushes but does not result in eradication; this should be done before fruit set (half of August). Repeated cutting (twice a year for 2 years) proved insufficient to deplete and kill *C. horizontalis* bushes (Halford et al., 2014). Burning is ineffective at controlling regeneration (Crofts & Jefferson, 1999).



Cotoneaster hjelmqvistii /

Preventing seed-set is also essential as young shrubs (3 years old) can already produce seed. Therefore, smaller bushes (less than 2 cm diameter) also need to be cut to prevent the formation of fruits and seeds. Sod removal is another method effective for areas where there is a dense vegetation cover of *Cotoneaster*: in this way young bushes and seedlings are removed, but also the upper layer of soil with the roots and seeds. This, however, is a costly method (Siebel, 2013).

Monitoring and control is of the utmost importance: *Cotoneaster* species are difficult to eradicate as they can sprout from remaining roots after uprooting, they readily produce fruits and seeds at a young age. Costs for eradication increase sharply when plants are left to establish and disperse (Siebel, 2013).

In the Netherlands it is suggested to communicate to terrain managers around vulnerable sites where *Cotoneaster* has been observed and request removal of planted *Cotoneaster* from their terrain (Siebel, 2013).

Grazing of infested areas is not advised in the Netherlands, as *Cotoneaster* is slightly poisonous to animals and is the very last shrub to be browsed. For the removal of *Cotoneaster* bushes from the steep to upright sides of former marl quarries no suitable technique has been developed yet (Siebel, 2013 & 2014).

4.4. Conclusions

It is clear that in the Netherlands *Cotoneaster* species are increasingly found naturalized in nature areas. From the experiences in Belgium we can deduct that more *Cotoneaster* species will be found and that more populations or ephemeral occurrences will be recorded.

The major problem is that *Cotoneaster* can develop more or less dense thickets that out-compete indigenous, vulnerable and valuable species. The habitats which run the highest risk in the Netherlands are the calcareous grasslands in the very south of the country and the coastal dune area. Both habitats are Natura 2000 areas, in which areas the Netherlands commits itself to halting loss of biodiversity. The rare and valuable vegetation types found here run the risk of becoming less species-rich and less diverse in vegetation structure.

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Annex 1

Risk assessment scores using the ISEIA protocol

The following risk assessments is based on E. Branquart (Editor), 2009. Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium. version 2.6 dated 7-12-2009, commonly referred to as the ISEIA - Invasive Species Environmental Impact Assessment - protocol. These guidelines are published at: http://ias.biodiversity.be/documents/ISEIA_protocol.pdf.

This protocol aims to assess environmental risks only and do not take into consideration the direct impact of non-native species on human interests.

In Belgium, the ISEIA protocol has also been adopted and *Cotoneaster horizontalis* obtained a total score of 11.

The risk categories are scored as follows:
Score 1: risk is low
Score 2: risk is medium
Score 3: risk is high

The different scores are detailed for every type of risk in the ISEIA protocol. Here we also use the distinction between the two groups of *Cotoneaster* species: the small-leaved and the large-leaved ones.

Small-leaved Cotoneaster species

Risk of **small-leaved *Cotoneaster* species**	Risk category
Dispersion potential or invasiveness	3
Colonization of high conservation value habitats	3
Adverse impacts on native species	3
Alteration of ecosystem functions	2

Dispersion potential or invasiveness: *Cotoneaster* fruits are favored by birds and therefore easily spread. As *Cotoneaster* is widely planted, fruits are readily available. Its capacity for vegetative spread (rooting from stem fragment with nodes of self-layering) further increase its dispersion potential. Moreover, seeds remain viable for up to 5 years. The score for this category is high (score 3).

Colonization of high conservation value habitats: In the Netherlands small-leaved cotoneasters have been found in coastal dunes; in dry calcareous grasslands it has not been found yet, but more small-leaved species have been found on calcareous sites in Belgium. Both vegetation types are Natura 2000 areas. An infestation has also been found in former marl quarries, a calcareous habitat, implying dry calcareous grasslands are at risk. The overall risk is assessed to be high (score 3).

Adverse impacts on native species: From experience particularly in Belgium it is clear that both vegetation structure as well as vegetation composition is affected by *Cotoneaster*. From the infestation studies in the Netherlands it is clear that Cotoneaster has a negative impact on other, more vulnerable species. As small-leaved *Cotoneaster* species can form large, monospecific stands, the risk is high. The adverse impact on native species therefore is high (score 3).

Alteration of ecosystem functions: It is documented that *Cotoneaster* does influence vegetation structure, but whether whole ecosystems are altered in the Netherlands is not shown nor likely. It is clear that the impact can not be considered as 'negligible' (score 1). Developments as observed in Belgium may well occur in the Netherlands. Therefore the risk of this category is assessed to be medium (score 2).

The ISEIA score for small-leaved *Cotoneaster* is 11.

Large-leaved Cotoneaster species

Risk of **large-leaved *Cotoneaster* species**	Risk category
Dispersion potential or invasiveness	3
Colonization of high conservation value habitats	3
Adverse impacts on native species	3
Alteration of ecosystem functions	2

Dispersion potential or invasiveness: *Cotoneaster* fruits are favored by birds and therefore easily spread. As *Cotoneaster* is widely planted, fruits are readily available. Its capacity for vegetative spread (rooting from stem fragment with nodes of self-layering) further increase its dispersion potential. The score for this category is high (score 3).

Colonization of high conservation value habitats: In the Netherlands large-leaved cotoneasters have been found in coastal dunes. In Belgium, more large-leaved species are found in coastal dunes habitats, therefore the risk for the Netherlands is also high. Coastal dunes are Natura 2000 areas. The overall risk is assessed to be high (score 3).

Adverse impacts on native species: From experience particularly in Belgium it is clear that both vegetation structure as well as vegetation composition is affected by *Cotoneaster*. From the infestation studies in the Netherlands it is clear that *Cotoneaster* has a negative impact on other, more vulnerable species. As large-leaved *Cotoneaster* species can form large, monospecific stands, the risk is high. The adverse impact on native species therefore is high (score 3).

Alteration of ecosystem functions: It is documented that *Cotoneaster* does influence vegetation structure, but whether whole ecosystems are altered in the Netherlands is not shown nor likely. It is clear that the impact can not be considered as 'negligible' (score 1). Developments as observed in Belgium may well occur in the Netherlands. Therefore the risk of this category is assessed to be medium (score 2).

The ISEIA score for large-leaved *Cotoneaster* is 11.

Annex 2

Photo credits

page 3: *Cotoneaster divaricatus*: detail of flower with two front petals removed to show the pink anthers. (Photo by E. Boer)
page 4: *Cotoneaster rehderi*: invasion in a coastal dune forest after mowing. (Photo by J.L.C.H. van Valkenburg)
page 5: *Cotoneaster hjelmqvistii*: fruiting shrub in an abandoned marl quarry near Maastricht. This species closely resembles *C. horizontalis*. (Photo by E. Boer)
page 6: *Cotoneaster ambiguus*: undergrowth in a mixed deciduous forest “Voorsterbos” in the Noord-Oost polder. (Photo by H. Duistermaat)
page 7: *Cotoneaster ambiguus*: this large-leaved cotoneaster has ripe black berries. (Photo by H. Duistermaat)
page 8: *Cotoneaster dammeri*: petals in this flower spread, a clear feature for some Cotoneaster species. (Photo by E. Boer)
page 9: *Cotoneaster rehderi*: fruiting shrub after the first frost in fall, found in coastal dune forest. (Photo by H. Duistermaat)
page 12: *Cotoneaster divaricatus*: detail of fruiting branch of a shrub found in an abandoned marl quarry. (Photo by E. Boer)
page 13: *Cotoneaster dielsianus*: flowering shrub with the typical erect petals (“closed flower”) in coastal dune forest. (Photo by H. Duistermaat)
page 14: Two species of Cotoneaster in an abandoned marl quarry, on the left side of clump *C. divaricatus* with more reddish fruits and spreading branches, on the right side *C. hjelmqvistii* with more orange fruits and adpressed habit. (Photo by E. Boer)