

DISTRIBUTION AND HABITAT PREFERENCES OF THE INVASIVE ALIEN *ROSA RUGOSA* (ROSACEAE) IN ARCHIPELAGO SEA NATIONAL PARK, SW FINLAND

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Abstract. *Rosa rugosa* Thunb. is an invasive alien plant which was introduced from East Asia to Europe in the 19th century. Over the decades it has spread along the Finnish coast, including the archipelagos of the Baltic Sea. The shrub grows particularly along sandy beaches, stony shores and seashore meadows. There it leads to serious changes in coastal ecosystems and replaces native plant species. This paper presents the distribution and habitat preferences of *R. rugosa* in and near Archipelago Sea National Park in SW Finland. We identified 205 stands in the study area, 58% of them in protected areas. Systematic inventories do not cover the whole study area, so it is likely that dozens of stands remain undiscovered. Stands of the species were concentrated on the outer islands, where the archipelago's most characteristic flora and fauna occur. Data on the shore type and area of all stands were collected. The total area covered by *R. rugosa* was 7277 m² before control work started in 2008. The largest stand occurred on Örö Island, covering ca 2500 m² before its eradication, and the median size of all stands was 6 m². Five of the six largest stands were on sandy beach, but stony shore was the most common habitat type.

Key words: Baltic Sea, coastal habitats, invaded area, non-native species, population size

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INTRODUCTION

Invasive alien species have spread from their natural ranges to new areas as a result of human activities and are considered to have negative ecological impacts (terminology is discussed in Colautti & MacIsaac 2004). Invasive species have crossed geographical barriers that historically were natural borders of species ranges (Scalera *et al.* 2012). Invasive species have negative ecological, economic or social effects in the introduced range. The most harmful invasive species can create widespread and irreversible problems for entire ecosystems or regions.

Invasive alien plants have become a significant problem for biological conservation and ecosystem management, due to their negative effects on biodiversity (Nentwig 2007; Hejda *et al.* 2009; Goodenough 2010; Scalera *et al.* 2012). Along with habitat loss and degradation, invasive species

are one of the most serious threats to biodiversity worldwide (Walker & Steffen 1997; McGeoch *et al.* 2010). Introduced species are drivers of several extinctions, especially on islands (Veitch *et al.* 2011).

In Finland, *Rosa rugosa* Thunb. has been classified as a very harmful invasive plant due to its negative effects on native species and natural habitats (Niemi-Laitinen 2012). The purpose of this study was to identify the extent to which *R. rugosa* occurs in Archipelago Sea National Park, SW Finland. We focused on its distribution, habitat preferences, stand size and control. This is the first regional review of this species in Finland.

DISTRIBUTION OF *ROSA RUGOSA*

Rosa rugosa is a tall shrub originating from East Asia, where it occurs along sandy and gravelly coasts of the Pacific Ocean in Japan, Korea, China

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and Russia. The species was introduced to gardens in Europe as early as 1796 (Bruun 2005). It has become widely naturalized in Europe and North America from ornamental plantings, most often as a garden escapee (Hill *et al.* 2010). It is naturalized especially in parts of Northern and Northwestern Europe and is regarded as invasive along the coasts of the northwestern European Atlantic, North Sea and Baltic Sea, including the Baltic countries, Fennoscandia, northern Germany, Great Britain and Poland (Bruun 2005; Kelager *et al.* 2013). *Rosa rugosa* has been classified as an established or at least already naturalized invasive species in 22 European countries (Bruun 2005; Essl 2006; Weidema 2006).

The first Finnish record of naturalized *R. rugosa* is from 1919, after which the plant began to spread successfully in the 1930s (Erkamo 1949). *Rosa rugosa* occurs throughout the coastal area and the archipelago of Finland to Bothnian Bay, including the Åland Islands (Hæggström & Hæggström 2010; Lampinen & Lahti 2016). On the southern coast, on the archipelago of the Gulf of Finland and the Archipelago Sea it is most common. The situation is worst on the Hanko Peninsula on the southern coast of Finland, where the species has colonized several hectares of sandy beaches (Skytén 1978; Aspelund & Rytteri 2010).

ROSA RUGOSA AS A THREAT TO NATIVE SPECIES AND HABITATS

In Europe, *R. rugosa* mainly invades coastal habitats, especially sand dunes, but also vegetated shingle, grassland and low scrub, verges and waste ground. It can also become invasive in inland habitats such as *Calluna* heath (Isermann 2008b; Kollmann *et al.* 2009; Thiele *et al.* 2009). *Rosa rugosa* is a great threat to coastal ecosystems because it replaces native plant species and changes the composition of habitat types and suppresses natural vegetation of high conservation value (Kollmann *et al.* 2009; Thiele *et al.* 2010, 2011).

In Northwestern Europe, especially on shores of the North Sea and Baltic Sea, *R. rugosa* has been a major invader of sand dunes and is a significant problem in dune conservation (Reddersen 2006;

Weidema *et al.* 2007; Isermann 2008a, b; Jørgensen & Kollmann 2009). *Rosa rugosa* is among the 100 worst alien species in Europe (Essl 2006).

In contrast to North Sea dunes and more southern Baltic dune areas, in Finland *R. rugosa* is established on the shore, where its invasiveness was noted early (Jalas 1965). In these habitats it threatens native vegetation and leads to reduced diversity of native species (e.g., Skytén 1978; Rytteri *et al.* 2006; Rytteri *et al.* 2014). Shores support specialized flora and fauna and several red-listed species. *Rosa rugosa* is considered a threat to 21 species living on sandy beaches in Finland, mainly insects and vascular plants (Rassi *et al.* 2010; Niemivuo-Lahti 2012). Sandy beaches, dunes, shrub heaths and seashore meadows are particularly susceptible to overgrowth, and *R. rugosa* is one factor of this phenomenon. These habitats are classified as threatened in Finland (Raunio *et al.* 2008) and are listed in the EU's Natura 2000 program. Many of these habitats cover only small areas and are fairly rare.

STUDY AREA

The study area, Archipelago Sea National Park and its surroundings, is on the Baltic Sea in SW Finland (approx. 60°N, 22°E; Fig. 1). The area is in the hemiboreal zone (Ahti *et al.* 1968) and belongs to Kimitoön and Pargas municipalities. This national park is also known as Archipelago National Park or South Western Archipelago National Park. The park and its unprotected surroundings cover 151 km² of land and 2896 km² of sea, and contain 8384 islands or skerries (size at least 100 m²). Only 23% of the land area is protected. The rest, inside the boundary shown in Figure 1, is unprotected privately owned land.

Archipelago Sea National Park is unique due to its glaciation-affected geology, mosaic landscape and historical land uses. Nowhere else is there such a similar density of islands, and the number of species and habitat types is the highest in Finland. For example, 45 habitat types of the Natura 2000 program have been found in this area (Lindgren 2000). The number of red-listed species is exceptionally high, with 467 species

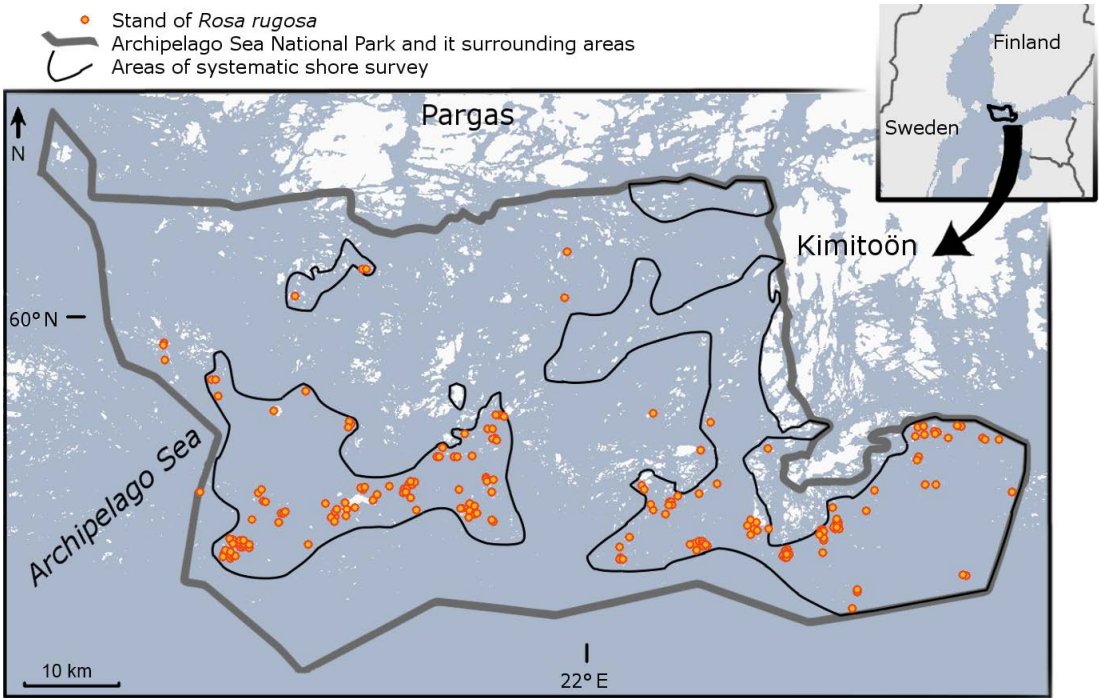


Fig. 1. Study area in SW Finland, areas of systematic shore survey, and distribution of stands of the invasive alien *Rosa rugosa* Thunb.

(Kuntu *et al.* 2014). Many habitat types cover small areas, so invasive species can have ruinous impacts on their biodiversity.

In the outer archipelago, the growing season lasts 191 days on average and the effective temperature sum (the sum of the positive differences between diurnal mean temperature and 5 degrees Celsius) is 1250–1300 (Kersalo & Pirinen 2009). The mean annual temperature is +6.5°C, and annual precipitation 549 mm. The prevailing winds blow from the southwest (20%), and the average wind speed is 7.1 m/s (Pirinen *et al.* 2012). The islands consist mainly of gneiss and granite bedrock with soil layers of moraine, sand or gravel deposition (<http://en.gtk.fi>). The highest point of the study area is 42 m a.s.l.

MATERIAL AND METHODS

The study is based mainly on systematic inventories of certain archipelago areas and partly on occasional records made during other activities. A systematic

inventory of the whole study area would have been a huge task due to the very high number of islands and skerries. We carried out systematic inventories of shores on 1150 islands and skerries during 2014–2016 (Fig. 1).

Other data on the occurrence of *R. rugosa* were collected from notes of Metsähallitus Parks & Wildlife Finland (manager of the National Park), Kastikka and Hatikka databases made by the Finnish Museum of Natural History, inventory reports and information from individual naturalists (Ikonen *et al.* 2009; von Numers 2011; Lampinen & Lahti 2016; <http://fieldjournal.org>; <http://karttapalvelu.lounaispaikka.fi>). Ornithologists have mapped the occurrence of *R. rugosa* on Jurmo Island. We used all data available from these sources up to July 2016 or collected in the field.

All records contain the location of the station, given with coordinates of the World Geodetic System (WGS84). Accurate information on stand size, habitat type and possible control measures are given. Yards and gardens were excluded from this study. The habitat types used in this study were sandy beach, stony shore (including also gravel, shingle and boulder shores), sea-shore meadows and dry meadows, rock outcrops, and dwarf shrub heaths (Raunio *et al.* 2008). We used the

non-parametric Kruskal-Wallis test (SPSS Statistics 21) to test whether the mean size of stands differs significantly between shore types.

RESULTS

Stands of *R. rugosa* were found at 205 sites in Archipelago Sea National Park and its surroundings (Fig. 1 & APPENDIX). Stand density was highest through the outermost part of the study area (Fig. 1). The most frequent stand loci were situated in the southwestern, southern and southeastern parts of the study area, which are part of an extensive moraine ridge.

Ninety-five stands were recorded in the national park, 23 were recorded in a privately owned nature reserve, and 87 records were from unprotected private land.

The two largest stands were on Örö (ca 2500 m² and 2000 m²), though control measures eradicated one of them and significantly reduced the other since the time of those records. The largest stand

was already known in 1963, when it covered only a few square meters (Kastikka database). The next largest stands were noted at Örskärs ören near Utö (304 m², Fig. 3), Stengrundet (126 m²), Långlandet (100 m²) and Estrevlarna (100 m²) (APPENDIX). The six largest stands account for 71% of the total area covered by *R. rugosa* in the study area. The distribution of the number of stands, and their total area (given in 6 size classes), are presented in Figure 2. Most of the stands were about a meter high, and the tallest stand was two meters high (Fig. 3).

Stand size and habitat type were known for 201 stands. Their total area was 7277 m² (median 6 m², range 0.5–2500 m²). In careful inventories in 2014 and 2016 only four old stands were not found.

The sizes given for the two largest stands on Örö Island are only estimates, not precise measurements. The estimates of their sizes before control measures were made afterwards; these are rather small stands now. All other stands for which size information is given were rigorously

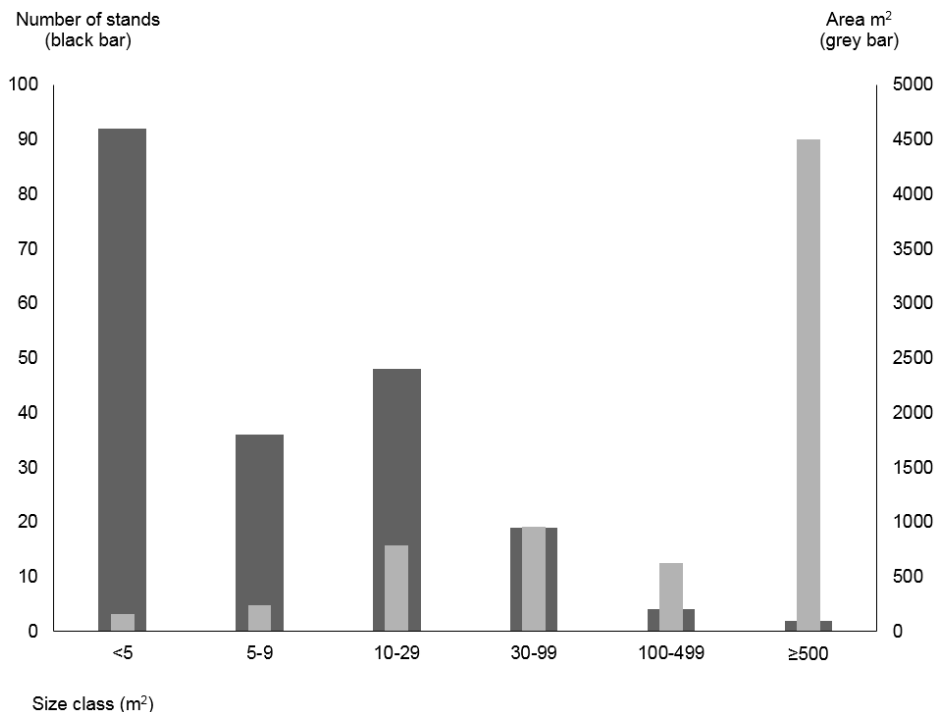


Fig. 2. Distribution of number of stands (N = 201) of *Rosa rugosa* Thunb., and their total area given in six size classes.



Fig. 3. One of the largest (A – 304 m²) and one of the tallest (B – 2 m) stands of the invasive alien *Rosa rugosa* Thunb. in the study area. Photo P. Kunttu.

measured. The number of stands and their sizes are shown, by habitat type, in Table 1.

Rosa rugosa occurs in many different habitats in Archipelago Sea National Park (Fig. 4). The most common habitat type was stony shore, where 47% of the stands were found, but most of the colonized area as well as the largest stands were on sandy beaches (Table 1). The mean size of stands differed significantly between shore types (Kruskal-Wallis test, Chi-square = 26.868, $p > 0.001$). The typical habitats of *R. rugosa* in Archipelago Sea National Park are presented in Figure 4.

Control measures and removal were performed at 45 sites (22% of all sites), but only eight stands can be considered eradicated (APPENDIX). Volunteers did most of this control work (38 cases). Based on their size and habitat type, the stand eradications on Örö have been the most important ones. Several control measures have been used:

manual uprooting, mechanical uprooting, herbicide treatment, and covering with a tarpaulin. The most typical control method has been manual uprooting and collection of all stems, rhizomes and roots to leave on rocks to dry; in some cases the plant material was burned. This type of control needs to be repeated for many years, and some roots may remain in the ground. Covering stands with tarpaulins for several years or shrivelling shrubs by ripping the leaves off may frequently prove to be more effective as control measures.

DISCUSSION

The area covered by *R. rugosa* in Archipelago Sea National Park is not as large as at some other localities in the Baltic region (e.g., Kollmann *et al.* 2009; Aspelund & Rytteri 2010), but there are many stands and they occur throughout the study

Table 1. Number of stands of the invasive alien *Rosa rugosa* Thunb. and their area according to habitat type; – no information available, stands not found.

Habitat type	Number of stands	Total area (m ²)	Median size (m ²)	Range (m ²)
Sandy beach	19	5356	16	0.5–2500
Stony shore	94	737	4.5	0.5–58
Seashore meadow and dry meadow	50	982	13	0.5–100
Dwarf shrub heath	9	60	6	0.5–17
Rock outcrops	29	142	1	0.5–30
Unknown	4	–	–	–
Total	205	7277	6	0.5–2500

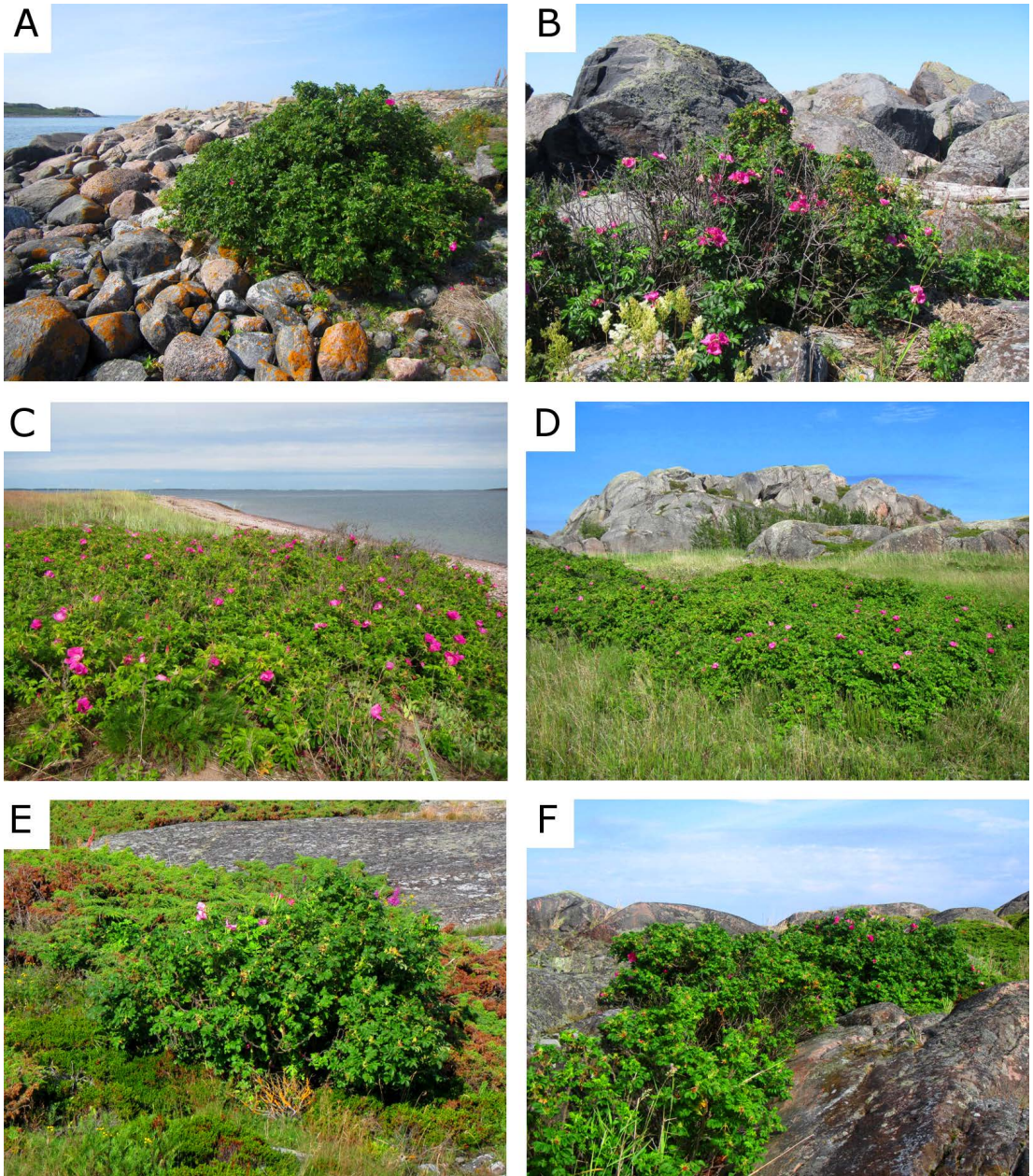


Fig. 4. Typical habitats of the invasive alien *Rosa rugosa* Thunb. in Archipelago Sea National Park and its surroundings: A – stony shore (middle-size stones), B – stony shore (boulders), C – sandy beach, D – seashore meadow, E – dwarf shrub heath, F – rock outcrop on seashore. Photo P. Kunttu.

area, so their potential for dispersal is high. Because there are many stands, and many small ones, now is the time to remove *R. rugosa* before the stands grow much larger and become really

problematic to remove. The islands and skerries are near each other, facilitating seed dispersal. In addition to the naturalized stands, *R. rugosa* is still used in gardens on many inhabited islands.

There are no data on the origin of the *R. rugosa* seeds coming to the archipelago. Presumably there are many origins: inhabited islands of this area, mainland Finland, the Hanko Peninsula, and the coasts of Estonia and Sweden. *Rosa rugosa* hips are extraordinarily buoyant and can float for up to 40 weeks in both freshwater and seawater. The seeds are also buoyant for several weeks on their own (Jessen 1958). They are dispersed by birds or waves, so their origin may be very far off on mainland Finland, inland, or overseas from Estonia, Russia or Sweden where *R. rugosa* is common (Tzvelev 2007; Ööpik *et al.* 2008; Tyler *et al.* 2015). The general circulation in the Baltic Sea is counterclockwise: northward along its eastern boundary and southward along the western one; there is no strong permanent sea current. Southwestern winds are predominant on Finland's southwest coast. The flow velocity of surface water in the Baltic Sea is 5–10 cm/s, that is, several kilometers per day (Leppäranta & Myrberg 2009).

The records of *R. rugosa* are concentrated in the outermost part of the study area. Probably one reason for this is that there are more suitable shore habitats there: the islands are flat, sandy or stony, and almost barren of forests. Basically, *R. rugosa* is able to grow anywhere perennial vegetation occurs.

The flora of the Archipelago Sea was studied widely by several researchers without documentation of the occurrence of *R. rugosa* (e.g., Olsoni 1946; Eklund 1958; Skult 1960; Stjernberg *et al.* 1974). The first records of naturalized *R. rugosa* in the study area were made in 1963 on Örö Island and in 1967 on Kuggskär Island. Much later, von Numers (2011) found *R. rugosa* on 17 islands which Eklund (1958) had studied.

Several areas have been systematically inventoried (Fig. 1), so the occurrences of *R. rugosa* in these areas are well known. For example, the central and northeastern parts of the study area are almost free of *R. rugosa*. Many areas in the outer part yielded numerous stands (Fig. 1). A large part of the most important area of its potential occurrence is now surveyed. There are still some unresearched island groups with gravel and shingle

shores, part of the Salpausselkä moraine ridge formation, which could contain stands. Probably there are at least dozens of undiscovered stands in the national park and its surroundings, but they are not likely to be larger than those found so far. Unfortunately, new stands will form in the future, making control work very challenging.

Altogether 46% of the stands were found in the national park, although only a minority of the land in the study belongs to the national park. The reason for this finding is that the park's islands are in the outer part, which apparently is the most favorable area for *R. rugosa* due to the character of its habitats.

Five of the six largest stands grew on sandy beach. This shows that *R. rugosa* can spread vegetatively more easily on sandy beach than for example on rock outcrops on seashores. This makes it possible to prioritize control measures. For example, on the sandy beaches of Jurmo Island, *R. rugosa* threatens the red-listed species *Ammophila arenaria* (L.) Link. (EN) and *Salsola kali* L. subsp. *kali* (EN), and the sandy beaches of Örö also have *Armeria maritima* subsp. *elongata* (Hoffm.) Bonnier (EN), *Dianthus arenarius* subsp. *borussicus* Vierh. (EN) and *Elymus farctus* subsp. *boreoatlanticus* (Simonet & Guin.) Melderis (VU) (Syrjänen 1995; Aspelund & Rytteri 2010; Kämäräinen 2013).

If the spread of *R. rugosa* is not successfully stopped, it will pose a serious threat to many native species and habitat types of the Archipelago Sea area. We already have examples of how it can become a severe problem for biodiversity in Finland (Rytteri *et al.* 2006; Aspelund & Rytteri 2010). At risk are not only shore habitats but potentially also semi-natural habitats like shrub heaths and different kinds of meadows if eradication is not done in time. Prevention of dispersal through practical legislation and raised public awareness are needed to reduce the current ecological problems related to *R. rugosa* invasion.

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APPENDIX. Stands of *Rosa rugosa* Thunb. in Archipelago Sea National Park and its surroundings, recorded mainly in 2010–2016. NP – national park, PNR – private nature reserve.

Locality	Site	Coordinates	Conservation area	Size [m ²]	Main habitat type	Note
Utö	Halfaskärs kläppen	59°48'41.565"N, 21°24'32.305"E	–			Not found 2016
Utö	Slevharu	59°49'47.047"N, 21°18'27.742"E	–	19	Rock outcrop	
Utö	Syndaskär	59°49'43.312"N, 21°25'43.696"E	–	18	Seashore meadow or dry meadow	
Utö	Syndaskär	59°49'42.887"N, 21°25'41.322"E	–	11	Rock outcrop	
Utö	Bokulla	59°50'1.946"N, 21°25'34.011"E	NP	14	Rock outcrop	
Utö	Huslandet (Bokulla)	59°50'17.909"N, 21°25'38.478"E	NP	2	Seashore meadow or dry meadow	
Utö	Utö, Kesnäs bukten	59°46'42.789"N, 21°22'17.031"E	NP	17	Seashore meadow or dry meadow	
Utö	Utö, Kesnäs	59°46'33.423"N, 21°22'21.439"E	NP	4	Stony shore	
Utö	Utö, S-shore	59°46'35.669"N, 21°22'46.626"E	NP	10	Stony shore	
Utö	Utö, SE-shore	59°46'39.305"N, 21°22'57.383"E	NP	3	Stony shore	
Utö	Utö, Enskär	59°47'1.268"N, 21°21'51.036"E	–	12	Stony shore	
Utö	Utö, Enskär	59°47'0.878"N, 21°21'51.744"E	–	1	Stony shore	
Utö	Utö, NE-shore	59°46'57.334"N, 21°22'8.02"E	–	6	Seashore meadow or dry meadow	
Utö	Trutgrund	59°46'45.497"N, 21°21'39.056"E	–	6	Stony shore	
Utö	Gråkobbarna	59°47'11.556"N, 21°23'45.599"E	–	2	Stony shore	
Utö	Menfölskär	59°47'15.008"N, 21°23'20.279"E	NP	1	Rock outcrop	
Utö	Gommaskär	59°47'19.275"N, 21°23'24.637"E	NP	1	Seashore meadow or dry meadow	
Utö	Gommaskär	59°47'19.275"N, 21°23'24.637"E	NP	46	Seashore meadow or dry meadow	
Utö	Gommaskär	59°47'16.752"N, 21°23'19.407"E	NP	64	Seashore meadow or dry meadow	
Utö	Gommaskär	59°47'18.343"N, 21°23'31.606"E	NP	1	Stony shore	
Utö	Stenskär	59°47'10.984"N, 21°23'9.519"E	NP	5	Stony shore	
Utö	Revsjär	59°47'33.661"N, 21°23'12.638"E	NP	1	Seashore meadow or dry meadow	
Utö	Sundskär	59°47'8.848"N, 21°24'22.294"E	NP	8	Sandy beach	
Utö	Sundskär	59°47'12.337"N, 21°24'25.884"E	NP	18	Seashore meadow or dry meadow	
Utö	Ormskär	59°47'35.55"N, 21°22'21.483"E	NP	7	Seashore meadow or dry meadow	
Utö	Ormskär	59°47'31.673"N, 21°22'8.127"E	NP	3	Stony shore	

APPENDIX. *Continued.*

Locality	Site	Coordinates	Conservation area	Size [m ²]	Main habitat type	Note
Utö	Ormskär	59°47'21.205"N, 21°22'20.822"E	NP	2	Stony shore	
Utö	Ormskär	59°47'12.173"N, 21°22'30.765"E	NP	5	Stony shore	
Utö	Örskär	59°48'36.354"N, 21°27'40.483"E	NP	4	Sandy beach	
Utö	Örskärs ören	59°48'57.31"N, 21°27'58.924"E	NP	304	Sandy beach	Also sandy meadow
Utö	Örskärs ören	59°48'56.323"N, 21°27'54.715"E	NP	2	Sandy beach	Also sandy meadow
Utö	Örskärs ören	59°48'55.054"N, 21°27'48.431"E	NP	88	Sandy beach	Also sandy meadow
Jurmo	Jurmo, harbour	59°49'35.321"N, 21°35'7.958"E	–	0.5	Stony shore	
Jurmo	Estrevlarna	59°48'50.353"N, 21°33'35.16"E	NP	100	Sandy beach	Control since 2010, covered
Jurmo	Estrevlarna	59°48'50.353"N, 21°33'35.16"E	NP	70	Sandy beach	Control since 2010, covered
Jurmo	Estrevlarna	59°49'1.789"N, 21°34'25.905"E	NP	1	Sandy beach	Uprooted 2016
Jurmo	Jurmo, Västerrevet	59°48'56.886"N, 21°33'45.088"E	NP	0.5	Sandy beach	Uprooted 2014
Jurmo	Jurmo, Lågnörs fladan	59°49'9.289"N, 21°34'30.215"E	NP	0.5	Sandy beach	Uprooted 2013
Jurmo	Jurmo, Tvåstenviken	59°49'12.562"N, 21°35'13.387"E	NP	1	Sandy beach	Uprooted 2010
Jurmo	Jurmo, Tvåstenviken	59°49'11.202"N, 21°35'10.578"E	NP	0.5	Stony shore	
Jurmo	Jurmo, Estnäs	59°49'29.808"N, 21°37'16.568"E	NP	1	Dwarf shrub heath	Uprooted 2010 and 2013, covered
Jurmo	Jurmo, Estnäs	59°49'27.699"N, 21°37'25.188"E	NP	1	Stony shore	
Jurmo	Jurmo, Estnäs	59°49'31.931"N, 21°37'0.396"E	PNR	1	Stony shore	Uprooted 2015
Jurmo	Sorgen	59°49'28.222"N, 21°36'17.414"E	NP	2	Sandy beach	Eradicated
Jurmo	Jurmo, Österrevet	59°50'0.777"N, 21°38'13.517"E	NP	0.5	Stony shore	Eradicated
Jurmo	Sorgen (Sorgenkläpparna)	59°49'21.047"N, 21°36'21.283"E	–	11	Stony shore	
Jurmo	Sanden	59°50'24.995"N, 21°39'33.474"E	NP	35	Sandy beach	Control started
Jurmo	Grundvik harun	59°49'26.011"N, 21°37'52.322"E	–	44	Seashore meadow or dry meadow	
Jurmo	Killingharu	59°49'31.953"N, 21°32'41.723"E	NP	1	Stony shore	
Jurmo	Gåsharu	59°48'28.696"N, 21°40'7.431"E	PNR	23	Seashore meadow or dry meadow	
Jurmo	Lökharu	59°49'6.332"N, 21°42'31.611"E	NP	9	Stony shore	
Jurmo	Stora Örskär	59°50'22.686"N, 21°41'43.432"E	PNR	24	Stony shore	
Jurmo	Stora Örskär	59°50'23.248"N, 21°41'42.12"E	PNR	4	Stony shore	

APPENDIX. *Continued.*

Locality	Site	Coordinates	Conservation area	Size [m ²]	Main habitat type	Note
Jurmo	Stora Örskär	59°50'21.02"N, 21°41'47.88"E	PNR	33	Seashore meadow or dry meadow	
Jurmo	Stora Örskär	59°50'18.481"N, 21°41'58.772"E	PNR	3	Seashore meadow or dry meadow	
Jurmo	Lilla Örskär	59°50'4.103"N, 21°41'9.919"E	PNR	42	Seashore meadow or dry meadow	
Jurmo	Lilla Örskär	59°50'4.11"N, 21°41'12.491"E	PNR	14	Stony shore	
Jurmo	Lilla Örskär	59°50'4.846"N, 21°41'13.854"E	PNR	65	Seashore meadow or dry meadow	
Jurmo	Lilla Örskär	59°50'4.547"N, 21°41'7.275"E	PNR	15	Stony shore	
Jurmo	Örskärs ören	59°49'56.964"N, 21°41'47.984"E	PNR	48	Seashore meadow or dry meadow	
Jurmo	Huslandet (Gaddarna)	59°47'20.137"N, 21°30'44.396"E	NP	2	Rock outcrop	
Jurmo	Norrkläpparna	59°50'19.106"N, 21°36'40.049"E	PNR	11	Stony shore	
Jurmo	Norrkläpparna	59°50'18.173"N, 21°36'40.2"E	PNR	1	Seashore meadow or dry meadow	
Jurmo	Norrkläpparna	59°50'18.223"N, 21°36'40.642"E	PNR	2	Seashore meadow or dry meadow	
Trunsö	Glasaskär	59°49'14.603"N, 21°47'29.047"E	NP	2	Stony shore	
Trunsö	Glasaskär	59°49'15.135"N, 21°47'31.022"E	NP	15	Stony shore	
Trunsö	Lökskär SE	59°49'15.849"N, 21°49'6.782"E	NP	1	Stony shore	
Trunsö	Lökskär SE	59°49'15.873"N, 21°49'6.586"E	NP	2	Stony shore	
Trunsö	Lökskär SE	59°49'16.069"N, 21°49'6.62"E	NP	1	Stony shore	
Trunsö	Långören (southern)	59°48'39.399"N, 21°50'47.332"E	NP	3	Stony shore	
Trunsö	Långören (southern)	59°48'34.365"N, 21°50'45.283"E	NP	27	Stony shore	
Trunsö	Kistskär	59°52'7.866"N, 21°46'49.909"E	NP	9	Seashore meadow or dry meadow	Uprooted 2014 and 2016, greatly reduced
Trunsö	Kistskär	59°52'10.352"N, 21°47'4.393"E	NP	1	Stony shore	Uprooted 2016
Trunsö	Kvessören	59°53'30.828"N, 21°50'10.861"E	–	58	Stony shore	
Trunsö	Kläpparna NW	59°53'31.531"N, 21°50'41.165"E	–	12	Stony shore	
Trunsö	Vitskären S-island	59°53'16.025"N, 21°50'53.624"E	–	12	Stony shore	
Trunsö	Vitskären S-island	59°53'16.001"N, 21°50'53.821"E	–	2	Stony shore	
Trunsö	Vitskären S-island	59°53'17.361"N, 21°50'46.394"E	–	4	Seashore meadow or dry meadow	
Trunsö	Vitskär	59°53'19.461"N, 21°47'41.409"E	–	6	Stony shore	Grew partly under black alders
Trunsö	Långören (western)	59°52'35.223"N, 21°45'17.109"E	–	8	Sandy beach	Uprooted 2014 and 2016, greatly reduced

APPENDIX. *Continued.*

Locality	Site	Coordinates	Conservation area	Size [m ²]	Main habitat type	Note
Trunsö	Garpharu E-skerry	59°48'42.599"N, 21°49'19.992"E	NP	25	Stony shore	
Trunsö	Ytterören	59°50'20.003"N, 21°46'57.896"E	–	34	Stony shore	
Trunsö	Salskärs pattrorna	59°50'47.765"N, 21°50'56.074"E	–	4	Stony shore	
Trunsö	Stora Salskär	59°50'46.716"N, 21°50'16.148"E	NP	16	Stony shore	
Trunsö	Stora Salskär	59°50'43.022"N, 21°50'16.078"E	NP	3	Stony shore	
Trunsö	Stora Salskär	59°50'52.172"N, 21°50'16.588"E	NP	4	Stony shore	
Trunsö	Alskär	59°48'58.872"N, 21°48'46.023"E	NP	15	Seashore meadow or dry meadow	
Trunsö	Grabbaskläppen	59°49'7.254"N, 21°49'4.777"E	NP	20	Stony shore	
Trunsö	Kummelskären S-skerry	59°49'46.509"N, 21°50'54.496"E	NP	4	Stony shore	
Trunsö	Långskär	59°49'24.162"N, 21°47'58.611"E	NP	5	Stony shore	
Trunsö	Harun	59°52'3.059"N, 21°45'3.064"E	–	30	Rock outcrop	
Trunsö	Harun	59°52'1.75"N, 21°45'7.585"E	–	5	Stony shore	
Trunsö	Stenkläppen	59°48'39.824"N, 21°51'8.864"E	NP	7	Stony shore	
Trunsö	Låga Sundskär	59°52'7.971"N, 21°48'28.157"E	NP			Not found 2014
Lökholm	Skogsskär	59°54'17.799"N, 21°51'15.875"E	–	26	Stony shore	
Lökholm	Skogsskär	59°54'18.094"N, 21°51'26.723"E	–	3	Stony shore	Grew under black alders
Lökholm	Sten-Kummelskär, N-skerry	59°54'12.111"N, 21°52'2.522"E	–	2	Stony shore	
Österskär	Norrkläppen	59°58'9.94"N, 21°15'28.825"E	NP	10	Stony shore	
Österskär	Bredskär, NE-skerry	59°58'4.128"N, 21°15'15.166"E	NP	8	Stony shore	
Österskär	Bredskär	59°57'59.791"N, 21°15'14.498"E	NP	0.5	Rock outcrop	
Österskär	Långharu, W-skerry	59°57'18.679"N, 21°14'32.937"E	NP	13	Stony shore	
Österskär	Råkläpparna	59°56'7.632"N, 21°20'36.964"E	NP	27	Seashore meadow or dry meadow	
Österskär	Kummelkläpparna	59°56'7.896"N, 21°20'12.261"E	NP	6	Seashore meadow or dry meadow	
Österskär	Värpeln	59°55'17.006"N, 21°21'9.415"E	NP	7	Stony shore	
Brunskär	Långlandet	60°2'18.77"N, 21°36'27.981"E	NP	100	Seashore meadow or dry meadow	
Brunskär	Lilla Rönnskär, S-skerry	60°0'51.506"N, 21°29'21.756"E	NP	11	Stony shore	
Brunskär	Rågskär, SE-skerry	60°2'19.521"N, 21°36'47.926"E	NP	13	Seashore meadow or dry meadow	

APPENDIX. *Continued.*

Locality	Site	Coordinates	Conservation area	Size [m ²]	Main habitat type	Note
Aspö	Snökobben	59°55'37.539"N, 21°30'38.329"E	PNR	0.5	Rock outcrop	
Aspö	Vidskär	59°54'35.262"N, 59°54'35.262"E	PNR	1	Stony shore	Grew partly under black alders
Aspö	Mossaskär	59°53'45.777"N, 21°35'36.064"E	NP	2	Seashore meadow or dry meadow	
Aspö	Mossaskär	59°53'41.411"N, 21°35'22.853"E	NP	3	Seashore meadow or dry meadow	
Aspö	Norpaskäret	59°53'32.934"N, 21°35'10.443"E	NP	2	Stony shore	
Knivskär	Knivskär	60°0'33.786"N, 21°58'34.264"E	–			Not found 2014
Stenskär	Lilla Tommoskär	60°3'13.354"N, 21°58'55.347"E	–			Not found 2014
Vänö	Inre Klovaskär	59°48'52.548"N, 22°9'25.41"E	–	7	Seashore meadow or dry meadow	Uprooted 2014–2016
Vänö	Söderön, W-skerry	59°50'33.138"N, 22°7'2.437"E	–	9	Stony shore	
Vänö	Söderön, W-skerry	59°50'30.583"N, 22°7'4.228"E	–	1	Stony shore	Uprooted 2014–2015
Vänö	Rönnskär	59°48'18.828"N, 22°5'33.857"E	–	1	Stony shore	
Vänö	Skeppaskär	59°48'57.097"N, 22°7'46.988"E	–	0.5	Stony shore	Eradicated
Vänö	Klobben	59°50'3.759"N, 22°13'1.731"E	NP	3	Stony shore	
Vänö	Enskär	59°49'27.334"N, 22°7'59.28"E	NP	10	Seashore meadow or dry meadow	
Vänö	Långmåsgrunden (eastern)	59°50'33.932"N, 22°14'54.265"E	NP	49	Seashore meadow or dry meadow	Uprooted 2015
Vänö	Stora Buskär	59°49'28.377"N, 22°9'51.635"E	NP	15	Seashore meadow or dry meadow	Uprooted 2013–2016, greatly reduced
Vänö	Stora Buskär	59°49'32.099"N, 22°10'5.689"E	NP	0.5	Rock outcrop	Uprooted 2013–2016
Vänö	Stora Buskär	29°10'7.514"N, 19°41'19.934"E	NP	0.5	Seashore meadow or dry meadow	Eradicated
Vänö	Bredlandet	59°49'56.253"N, 22°10'53.432"E	–	18	Stony shore	
Vänö	Ejskär	59°47'10.82"N, 22°12'28.239"E	NP	14	Stony shore	
Vänö	Ejskär	59°47'22.391"N, 22°12'30.429"E	NP	7	Stony shore	
Vänö	Ejskär	59°47'22.297"N, 22°12'31.406"E	NP	2	Stony shore	
Vänö	Krackskär	59°46'53.438"N, 22°12'49.549"E	–	15	Stony shore	
Vänö	Örskär (Ejrsåsen)	59°47'16.766"N, 22°13'8.804"E	NP	1	Stony shore	Uprooted 2015–2016
Vänö	Rottenskär	59°47'33.026"N, 22°13'2.875"E	NP	2	Stony shore	Control 2009 and uprooted 2015–2016
Vänö	Rottenskär	59°47'32.41"N, 22°13'3.734"E	NP	0.5	Dwarf shrub heath	Eradicated
Vänö	Örs ören	59°47'22.975"N, 22°13'25.51"E	NP	1	Rock outcrop	Uprooted 2015–2016

APPENDIX. *Continued.*

Locality	Site	Coordinates	Conservation area	Size [m ²]	Main habitat type	Note
Vänö	Örs ören	59°47'23.9"N, 22°13'26.919"E	NP	1	Stony shore	Control 2009, uprooted 2015–2016
Vänö	Örs ören	59°47'24.357"N, 22°13'26.147"E	NP	1	Stony shore	Control 2009, uprooted 2015–2017
Vänö	Örs ören	59°47'24.298"N, 22°13'27.183"E	NP	4	Stony shore	Control 2009, uprooted 2015–2018
Vänö	Kalkskär	59°46'35.324"N, 22°4'46.044"E	–	1	Rock outcrop	
Vänö	Kalkskär	59°46'35.404"N, 22°4'45.583"E	–	8	Dwarf shrub heath	Partly uprooted 2015
Vänö	Kalkskär	59°46'35.341"N, 22°4'46.491"E	–	0.5	Rock outcrop	
Vänö	Hemören	59°52'29.788"N, 22°13'10.502"E	–	90	Sandy beach	
Vänö	Elvingskär	59°47'5.97"N, 22°4'25.916"E	–	6	Rock outcrop	
Tunnhamn	Ängeskärs grunden S-skerry	59°54'26.973"N, 22°8'18.761"E	–	13	Stony shore	
Tunnhamn	Stora Dunsjär, E- skerry	59°53'59.389"N, 22°14'36.781"E	–	20	Stony shore	
Rosala	Stora Gallbyskäret	59°47'24.963"N, 22°26'39.763"E	–	40	Stony shore	Partly uprooted 2014
Rosala	Lilla Gallbyskäret	59°47'35.702"N, 22°26'35.856"E	–	1	Rock outcrop	Eradicated
Rosala	Ljusskär	59°46'49.116"N, 22°26'32.656"E	–	6	Rock outcrop	Eradicated
Rosala	Dömmaskär	59°44'38.523"N, 22°30'19.444"E	–	4	Stony shore	Uprooted 2014
Rosala	Dömmaskär	59°44'41.185"N, 22°30'19.663"E	–	0.5	Seashore meadow or dry meadow	Eradicated
Rosala	Måsskäret, S-part	59°47'48.672"N, 22°26'18.862"E	–	17	Stony shore	Uprooted 2015
Rosala	Måsskäret, S-part	59°47'49.803"N, 22°26'12.285"E	–	17	Dwarf shrub heath	Uprooted 2015
Rosala	Måsskäret, N-part	59°47'52.856"N, 22°26'11.674"E	–	5	Rock outcrop	
Rosala	Måsskäret, NE-skerry	59°47'57.241"N, 22°26'13.065"E	–	2	Rock outcrop	
Rosala	Nordanvädergrundet, N-skerry	59°49'41.752"N, 22°31'13.214"E	–	5	Stony shore	
Rosala	Örö, west shore	59°48'12.131"N, 22°18'35.666"E	NP	2000	Sandy beach	Control since 2008, greatly reduced
Rosala	Örö, west shore	59°48'21.638"N, 22°18'42.555"E	NP	2500	Sandy beach	Documented 1963, control since 2008, almost eradicated
Rosala	Örö, Balget	59°48'26.197"N, 22°19'32.572"E	NP	16	Sandy beach	Control 2015
Rosala	Örö, Solkuro	59°48'9.88"N, 22°19'1.497"E	NP	7	Stony shore	Grew partly under black alders, control 2015
Rosala	Syllskären	59°47'47.236"N, 22°18'41.066"E	NP	0.5	Dwarf shrub heath	
Rosala	Arlanden	59°48'8.608"N, 22°20'37.737"E	NP	25	Seashore meadow or dry meadow	

APPENDIX. *Continued.*

Locality	Site	Coordinates	Conservation area	Size [m ²]	Main habitat type	Note
Rosala	Stengrundet	59°52'20.142"N, 22°20'28.026"E	–	126	Sandy beach	
Rosala	Måskobben	59°50'23.308"N, 22°31'39.9"E	–	0.5	Rock outcrop	Uprooted 2016
Rosala	Lammgrunden (northern)	59°48'25.609"N, 22°27'50.684"E	–	1	Rock outcrop	
Rosala	Lammgrunden (northern)	59°48'27.058"N, 22°27'39.244"E	–	6	Dwarf shrub heath	
Rosala	Lammgrunden (southern)	59°48'18.424"N, 22°27'34.767"E	–	13	Seashore meadow or dry meadow	
Rosala	Lammgrunden (southern)	59°48'18.138"N, 22°27'33.971"E	–	2	Rock outcrop	
Rosala	Äggeskäret	59°48'11.746"N, 22°27'25.078"E	–	3	Rock outcrop	
Rosala	Äggeskäret	59°48'14.392"N, 22°27'16.431"E	–	7	Stony shore	
Rosala	Äggeskäret	59°48'11.578"N, 22°27'24.908"E	–	15	Rock outcrop	
Rosala	Gråskäret	59°47'56.494"N, 22°19'37.381"E	NP	20	Seashore meadow or dry meadow	
Rosala	Slamrorna, W-skerry	59°48'51.219"N, 22°28'5.06"E	–	6	Dwarf shrub heath	
Rosala	Kuggskär	59°46'38.152"N, 22°22'26.841"E	PNR	17	Dwarf shrub heath	
Rosala	Kuggskär, S-shore	59°46'35.857"N, 22°22'23.243"E	PNR	7	Stony shore	
Rosala	Kuggskär	59°46'42.384"N, 22°22'36.717"E	PNR	31	Seashore meadow or dry meadow	
Rosala	Kuggskär	59°46'42.201"N, 22°22'37.962"E	PNR	11	Seashore meadow or dry meadow	
Rosala	Kuggskär, W-shore	59°46'57.604"N, 22°22'17.659"E	PNR	24	Seashore meadow or dry meadow	Found 1967, partly uprooted 2012
Rosala	Kuggskär, E-shore	59°46'49.864"N, 22°22'46.914"E	–	40	Seashore meadow or dry meadow	
Rosala	Kuggskär, E-shore	59°46'48.993"N, 22°22'45.173"E	–	54	Seashore meadow or dry meadow	
Rosala	Kuggskär, W-shore	59°46'56.884"N, 22°22'16.539"E	PNR	7	Stony shore	
Rosala	Kuggskär, N-shore	59°47'0.442"N, 22°22'32.994"E	PNR	0.5	Stony shore	
Hitis	Yttersta Hamnskär	59°50'32.334"N, 22°37'35.251"E	–	0.5	Rock outcrop	Uprooted 2015
Hitis	Flintskär	59°50'4.039"N, 22°47'18.634"E	–	3	Stony shore	
Hitis	Salskären	59°50'34.879"N, 22°38'45.404"E	–	9	Stony shore	
Hitis	Fågelskäret SE-skerry	59°53'33.634"N, 22°37'13.84"E	–	3	Stony shore	
Hitis	Morgonlandet	59°45'33.976"N, 22°42'16.684"E	NP	0.5	Rock outcrop	
Hitis	Morgonlandet	59°45'34.37"N, 22°42'15.864"E	NP	6	Rock outcrop	Grew partly under black alders
Hitis	Lukargrunden (southern)	59°48'12.621"N, 22°26'51.492"E	–	10	Rock outcrop	

APPENDIX. *Continued.*

Locality	Site	Coordinates	Conservation area	Size [m ²]	Main habitat type	Note
Hitis	Lukargrunden (southern)	59°48'12.243"N, 22°26'50.837"E	–	0.5	Rock outcrop	
Hitis	Mellangrundet	59°53'11.07"N, 22°36'42.495"E	–	4	Seashore meadow or dry meadow	
Hitis	Rysskärs ören	59°53'33.377"N, 22°38'33.795"E	–	1	Stony shore	
Hitis	Rysskärs ören	59°53'33.813"N, 22°38'33.287"E	–	4	Dwarf shrub heath	
Hitis	Rysskärs ören	59°53'33.536"N, 22°38'33.71"E	–	6	Stony shore	
Hitis	Rysskobben	59°53'50.609"N, 22°40'57.612"E	–	3	Seashore meadow or dry meadow	
Hitis	Rysskobben, W-skerry	59°53'53.248"N, 22°40'52.245"E	–	17	Seashore meadow or dry meadow	
Hitis	Bengtskär	59°43'25.095"N, 22°29'55.93"E	–	1	Rock outcrop	
Hitis	Halsskäret	59°53'3.699"N, 22°45'39.451"E	–	6	Seashore meadow or dry meadow	
Hitis	Mankomskäret	59°49'17.953"N, 22°27'37.0"E	–	1	Rock outcrop	
Hitis	Kråklandet, S-skerry	59°53'37.779"N, 22°37'33.387"E	–	5	Seashore meadow or dry meadow	
Hitis	Norra Stenharun	59°53'28.983"N, 22°39'26.855"E	–	7	Stony shore	
Hitis	Prackgrundet	59°53'15.233"N, 22°36'17.927"E	–	24	Seashore meadow or dry meadow	
Hitis	Tjukan	59°52'56.712"N, 22°44'4.422"E	–	1	Stony shore	
Hitis	Tjukan	59°52'59.372"N, 22°43'54.682"E	–	2	Seashore meadow or dry meadow	
Hitis	Nickelskäret	59°52'1.655"N, 22°36'43.357"E	–	0.5	Stony shore	Uprooted 2015
Hitis	Hamnskäret	59°51'41.106"N, 22°36'28.825"E	–	1	Stony shore	Partly uprooted 2015