Japanese knotweed: the "nightmare plant" haunting Scania.

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Abstract

Invasive alien species (IAS) are one of the most important direct drivers of biodiversity loss and changes in ecosystem services. Over the last 20 years IAS are estimated to have cost the EU at least 12 billion euro per year. These costs continue to increase. Many IAS are expanding their territory, and thus both the current as well as future threat they pose must be taken into account. There is currently a lack of knowledge regarding the costs of IAS, as well as how they spread, and how they can be controlled. One such IAS present in Scania is japanese knotweed, a tall herb with far reaching rhizomes, that originates from East Asia. Japanese knotweed can both outcompete native flora and negatively affect infrastructure like buildings and roads. The aim of this project was to provide an overview of the Scanian knotweed problem, with special focus on Ängelholm municipality. Our field survey found a significant knotweed presence within Ängelholm. Knotweed stands were found in a variety of habitats including parklands, grasslands, forests and along Rönne stream. My survey of how Scanian municipalities perceive the japanese knotweed situation found that there was a problem throughout much of Scania, that many municipalities are only in recent years becoming aware of, with no clear guidelines for control efforts.

1. Introduction

1.1. Invasive Alien Species – definitions and effects

Invasive alien species (IAS) are defined by the European Union as ”species whose introduction and spread outside their natural ecological range poses a real threat to biodiversity and the economy” (Sundseth, 2016), and by the Swedish Environmental Protection Agency as ”foreign species which threaten biodiversity” (Swedish Environmental Protection Agency, 2019a). For a species to be considered alien in Sweden it must have established itself as part of Swedish nature at a time later than the year 1800 (Strand *et al*., 2018). IAS occur in every major taxonomic group, with terrestrial plants being by far the most common (Sundseth, 2016).

IAS are one of the most important direct drivers of biodiversity loss, as well as of changes in ecosystem services. The other most important drivers are habitat loss, climate change, overexploitation and pollution (Millenium Ecosystem Assessment, 2005). IAS can pose a direct threat to human health (Swedish Environmental Protection Agency, 2019b). One example of this is giant hogweed (*Heracleum mantegazzianum*), the sap of which can cause blisters on human skin when combined with sunlight (Swedish Environmental Protection Agency, 2019c).

There are currently 392 known IAS in Sweden (Fig. 1), as well as 84 potentially invasive species and 993 species which are unknown in regards to their invasiveness (NOBANIS, 2020). The number of IAS continues to increase (Swedish Environmental Protection Agency, 2019b). Climate change may lead to an increase in the spreading of IAS, since a higher temperature can increase reproduction and seedling survival for certain species that are already present in Sweden (Wissman and Hilding-Rydevik, 2020). This is a new issue for Sweden, with new regulation (Sveriges Riksdag, 2018), and an issue of which more knowledge is needed (Wissman and Hilding-Rydevik, 2020).

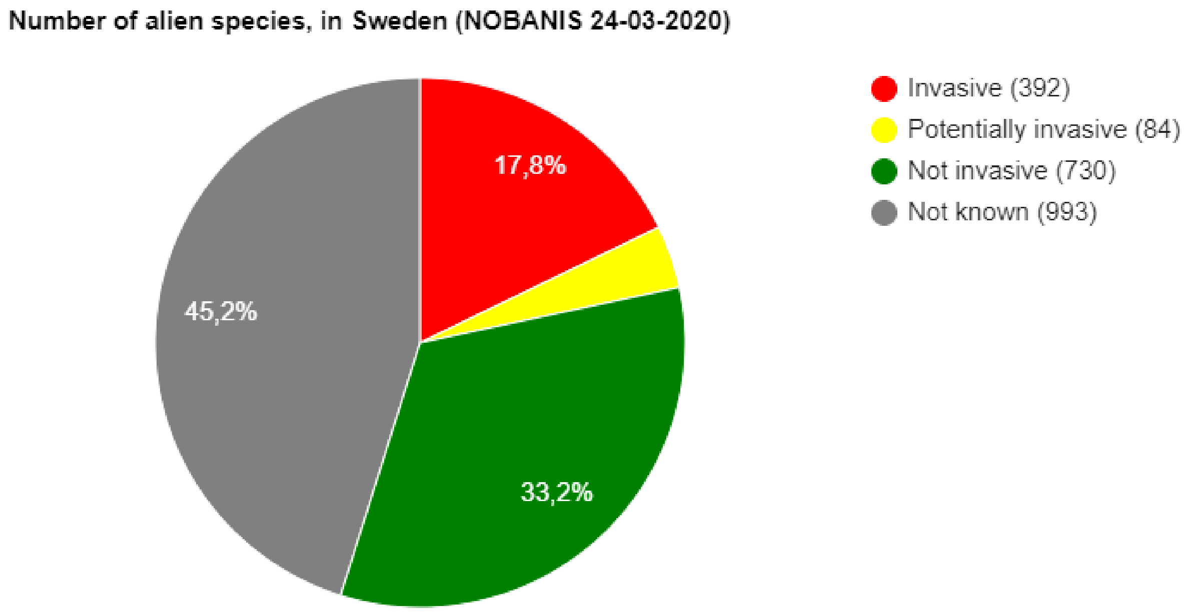

Figure 1. Number of alien species in Sweden. (NOBANIS, 2020).

IAS are covered in one of the Swedish environmental quality objectives. These objectives consist of a generational goal, 16 environmental quality objectives and several milestone targets (Swedish Environmental Protection Agency, 2020a). The objective ”A Rich Diversity of Plant and Animal Life” addresses the issue of IAS (Swedish Environmental Protection Agency, 2019b). The purpose of this objective is to preserve biodiversity as well as individual species, and to make sure that people have access to a high quality, biologically diverse environment. Part of the objective is for IAS not to threaten biodiversity. The objective is set to be reached by 2020, but it is not expected to be met (Swedish Environmental Protection Agency, 2019b).

1.2. Regulation of IAS in the EU

Out of the 12 000 alien species within the European Union 10-15% are considered to be invasive (Sundseth, 2016). Numbers of IAS in the EU have risen exponentially during the past 50 years, as a result of a more globalised economy (Genovesi and Shine, 2004). Over half of all IAS in the EU are terrestrial plants (Sundseth, 2016). IAS are introduced to the EU in a variety of ways. They can be introduced intentionally, for example for use in farming or horticulture – the most common case for invasive plant species – or unintentionally, as contaminants of other commodities or as ”hitchhikers” on vessels or equipment (Sundseth, 2016).

The EU Biodiversity Strategy is a strategy that aims to halt the loss of biodiversity and ecosystem services in the EU, as well as to help stop global biodiversity loss by 2020 (European Commision, 2019a). Target 5 of the Biodiversity Strategy concerns IAS. The target requires that by 2020 ”invasive alien species are identified, priority species controlled or eradicated, and pathways managed to prevent new IAS from disrupting European biodiversity”. Two specific actions were included to help achieve this target:

- Action 15: ”Make sure that the EU Plant and Animal Health legislation includes a greater concern for biodiversity.”
- Action 16: ”Provide a legal framework to fight invasive alien species (European Commision, 2019b).”

EU regulation 1143/2014 on Invasive Alien Species (the IAS Regulation) entered into force in 2015, fulfilling Action 16. The regulation provides a set of measures for dealing with IAS across the EU. These measures can be divided into three distinct categories: prevention, early detection and rapid eradication, and management. The IAS Regulation also includes the list of Invasive Species of Union Concern (the Union list) (European Commision, 2019c). This lists the species that are subject to the IAS Regulation. The Union list first entered into force in 2016, containing 37 species (European Commision, 2016). The list is continuously updated. The latest update was in 2019, the list then containing 66 species (European Commision, 2019d). The focus of this study, japanese knotweed (*Fallopia japonica*), is currently not on this list (European Commision, 2019d).

1.3. Regulation of IAS in Sweden

The goal of Swedish work for control of IAS is to protect Swedish biodiversity. This is to be done by, amongst other things, fulfilling the demands of both EU and Swedish regulations (Swedish Environmental Protection Agency, 2019d). In 2018 new Swedish legislation (2018:1939) was passed to complement the EU IAS regulation (Sveriges Riksdag, 2018). That same year the Swedish Species Information Centre published a risk classification of 1033 potentially invasive species (Strand *et al.*, 2018). The goal of this classification was to categorize alien species by what risk they may pose to native biodiversity in Sweden, now or in the future. The reason for this national risk classification is that many IAS that are or may become problematic in Sweden are not on the Union list of concern (Swedish Environmental Protection Agency, 2020b).

Of the 1033 species that were risk evaluated by Strand et al. (2018), 877 were deemed to be IAS, 585 of which were terrestrial plants (Tab. 1). All three species of knotweed mentioned in my study (japanese knotweed, giant knotweed and Bohemian knotweed) are among these IAS (Strand *et al*., 2018). This risk classification is to be the basis of a national list of IAS, tied to prohibitions, of which a first draft is planned to be ready in 2021 (Swedish Environmental Protection Agency, 2020b). The other terrestrial species that are being evaluated for a national list are large-leaved lupine (*Lupinus polyphyllus*), beach rose (*Rosa rugosa*), Caucasian stonecrop (*Sedum spurium*), sycamore maple (*Acer pseudoplatanus*), small marsh flower (*Cotula coronopifolia*), spreading cotoneaster (*Cotoneaster divaricatus*), Canada goldenrod (*Solidago canadensis*) and American mink (*Neovison vison*) (Swedish Environmental Protection Agency, 2020b).

Table 1. An overview of the number of species investigated in the 2018 risk classification by the Swedish Species Information Centre, organized by organism group (Strand *et al*., 2018).

Organism group	Number of evaluated species	Number of species for risk classification	Number of classified species	Number of species with final verdict
Algae	28	26	26	22
Fungi	310	148	69	35
Vascular plants	3175	1807	605	568
Lichens	1	1	1	1
Mosses	4	4	4	4
Fish	50	32	39	38
Hymenoptera	72	1	2	2
Marine invertebrates	258	55	53	37
Mammals, birds, amphibians and reptiles	138	103	78	72
Fresh water invertebrates	75	33	34	30
Beetles	291	9	9	8
Butterflies	166	30	8	6
Other terrestrial invertebrates	458	23	105	54
	5026	2272	1033	877

The responsibility for dealing with IAS in Sweden is divided between different agencies (Swedish Environmental Protection Agency, 2019e). County Administrative Boards are responsible for taking actions to exterminate all IAS listed by the EU (except those that are widely spread throughout the country), as well as supervising those species and notifying the Swedish Environmental Protection

Agency (EPA) (for terrestrial species), or the Swedish Agency for Marine and Water Management (HaV) (for aquatic species), when these species are found. The County Administrative Boards also have a responsibility to take actions to manage widely spread IAS, even those that are exempt from extermination requirements (Swedish Environmental Protection Agency, 2019e).

Municipalities are responsible for managing IAS in public spaces such as municipality-owned land, and other land that the municipality manages (Swedish Environmental Protection Agency, 2019e). A municipality can also ask that the County Administrative Board delegate its responsibilities regarding IAS to the municipality. Municipalities are responsible for waste management, and thus to make sure that IAS waste is not allowed to become a source for spreading. A municipality responsible for performing environmental supervision has an obligation to report any EU-listed IAS encountered to the proper authority (EPA or HaV) (Swedish Environmental Protection Agency, 2019e).

The Swedish EPA and HaV are responsible for IAS at a national level (Swedish Environmental Protection Agency, 2019e). They are to provide guidance in regards to the implementation of regulations regarding IAS, as well as provide underlying information, and also make certain decisions. These agencies are also responsible for deciding which actions are to be taken against widely spread IAS and trying IAS-related permission applications (such as for conducting research on an IAS). They also sometimes take over responsibility for extermination of IAS (when it is deemed that actions will be more efficient if taken at a national level) (Swedish Environmental Protection Agency, 2019e). The Swedish EPA and HaV are currently in the process of suggesting IAS of national concern, and are as a first step evaluating 10 species each (Swedish Environmental Protection Agency, 2020b).

The Swedish EPA can also grant a subsidy, (Lokala naturvårdssatsningen, LONA) meant to stimulate engagement in long-term conservation efforts, to municipalities (Swedish Environmental Protection Agency, 2020c). This can be granted for management of IAS (Swedish Environmental Protection Agency, 2020d). If japanese knotweed was to be included on a national list of IAS, municipalities would however no longer be able to receive LONA funding to combat japanese knotweed, since LONA funding is not granted to remove a species that the municipality has an obligation to remove (Swedish Environmental Protection Agency, 2020d).

Other agencies, industries, corporations and property owners also have different responsibilities, decided by the Swedish EPA (Swedish Environmental Protection Agency, 2019e).

1.4. Control of IAS

The most prominent path for introduction of invasive alien plants across the world is through the global trade of ornamental nursery stock (Hulme *et al.*, 2017). The majority of these plants are purchased by the general public. The most cost effective, as well as most environmentally friendly, way of managing IAS invasions is often to prevent introduction and/or establishment (Hulme *et al.*, 2017). Education allowing the general public to make informed choices in regards to which plant species are safe to purchase is often considered the main mechanism through which consumers can reduce the risk of invasive plant introduction (Hulme *et al.*, 2017).

Hulme *et al.* (2017) proposes four categories of control methods for the global trade in ornamental nursery stock to prevent the spread of invasive alien plant species:

- Pre-border restrictions on the import of invasive plants, implementing either a blacklist or a

whitelist for such plants. A blacklist would be a list of plants that may not be imported, while all others are permitted. A whitelist, in contrast, is a list of permitted plants, with all plants not on the list being banned (Hulme *et al*., 2017). The time delay between the introduction of a species and that species becoming invasive is one factor making including all alien species when attempting to control IAS necessary (Tschan, 2018).
- Post-border banning of invasive plant species from sale. This can however be ineffective if the target species is already widespread in the region in question (Hulme *et al*., 2017).
- Codes of conduct and industry self regulation. For these to be effective there should be consequences for non-compliance, consisting of bad publicity and brand image. It is therefore vital to monitor compliance with codes of conduct, as well as ensure public disclosure, in order for them to be successful (Hulme *et al*., 2017).
- Shifting consumer values towards native and non invasive plant species (Hulme *et al*., 2017).

1.5. Potential costs of IAS

The costs of IAS can be very large (Wissman *et al*., 2015). Over the last 20 years IAS are estimated to have cost the EU at least 12 billion euro per year, with costs continuing to increase (Sundseth, 2016). In Sweden the costs of IAS were recently estimated to be between 1.1 and 4.5 billion SEK per year (SLU Artdatabanken, 2020a).

The costs of IAS are not only monetary, but can come in the form of loss of biodiversity (Wissman and Hilding-Rydevik, 2020) (for example through invasion of species rich road verges [Tschan *et al*., 2018]). IAS can potentially out-compete native species. In this case they often do not only harm the species they replace but also others which depend on said species. Native species often fill a role in the ecosystem of which they are part in a way that alien species can not (in that they generally can not be benefitted from as much by other native species) (Wissman and Hilding-Rydevik, 2020). There is also a risk of IAS spreading diseases to native species, as well as functioning as hosts to other organisms that may themselves become IAS (Wissman and Hilding-Rydevik, 2020). IAS can also cause harm to human health or decrease in yield (Wissman *et al*., 2015). In urban environments IAS generally contribute less to green infrastructure than native species, as studies have shown that a higher number of alien species leads to a lower number of pollinating insects (Wissman and Hilding-Rydevik, 2020).

Many IAS are currently expanding their territory (in part due to a changing climate), and thus both the current as well as future threat they pose must be taken into account (Wissman *et al*., 2015). Costs of exterminating an IAS are much lower if this is done before it has had a chance to spread and become an acute problem (Wissman *et al*., 2015). There is currently a lack of knowledge regarding the costs of IAS, as well as how they spread, and how they can be controlled (Wissman *et al*., 2015). The current situation in Sweden, with recent regulation that aligns with the EU regulation on IAS, as well as ongoing risk classification, has brought with it new responsibilities for Swedish municipalities.

1.6. Japanese knotweed invasion in Ängelholm municipality

The study area of this report was Ängelholm, a municipality located in the northwest of Scania (Fig. 3). Ängelholm municipality covers an area of 1283.34 ha, and has a population of ca 41 000 inhabitants (Ängelholms näringsliv, 2016). The varied landscape of Ängelholm has been compared to ”a miniature Sweden”, and includes sea, open landscape and deciduous forests (Ängelholm municipality, 2012). The municipality contains five nature reserves: Magnarps strandmarker, Hålebäckseröd, Ängelholms strandskog, Prästängen and Djursholmsmossen (Ängelholm municipality, 2019). These reserves contain natural values that are considered to be threatened by the presence of knotweeds (Ängelholm municipality, 2010). On Artportalen stands of japanese knotweed have been reported throughout Ängelholm municipality (SLU Artdatabanken, 2019a). In urban areas, japanese knotweed poses a threat to residents' property, through its ability to damage house foundations and water pipes (Wissman *et al*., 2015).

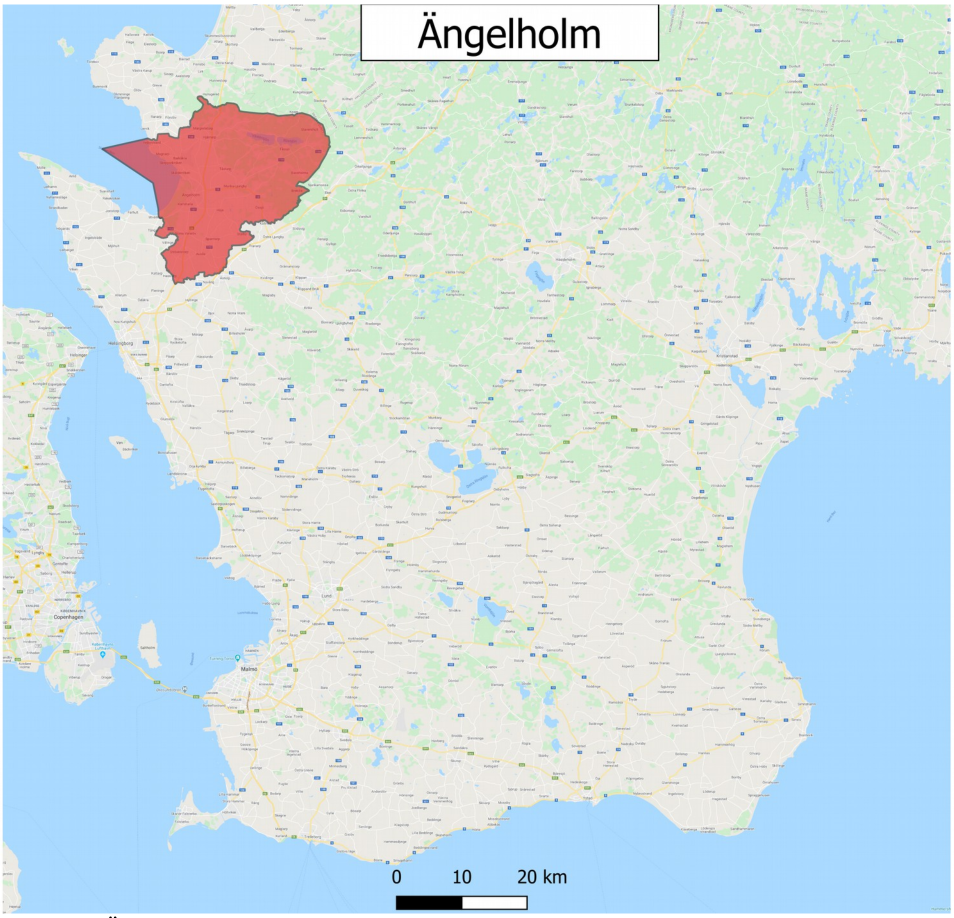

Figure 3. Ängelholm municipality.

The municipality works towards the Swedish environmental objectives from six directions: good water quality, living nature and a healthy ecosystem, efficient use and production of energy, a sustainable transport system, healthy inhabited environment, and procurement with an environment and sustainability perspective. These all aim to help reach the Swedish generational goal (Ängelholm municipality, 2012), which aims to ”hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden’s borders” (Swedish Environmental Protection Agency, 2019f).

1.7. Project aims

The overarching aim of this project was to provide an overview of the occurrence of knotweeds (*Fallopia* spp.) in Ängelholm municipality, and a compilation of data for mitigation measures of knotweed species. To achieve this purpose I used four methodologies:

1. a field survey of knotweeds in Ängelholm municipality
2. a literature study on the impact of japanese knotweed as an invasive species, as well as methods for controling it
3. a survey on the japanese knotweed situation in Scanian municipalities
4. a compilation of material for an action plan for control of japanese knotweed in Ängelholm municipality.

The field survey investigated the presence of knotweeds in Ängelholm municipality, as well as factors that could potentially affect knotweed abundance and performance. The following hypotheses were investigated:

- Does knotweed differ in abundance and performance depending on land use type?
- Does knotweed abundance and performance decrease with increased shade (using tree cover as proxy)?
- Is knotweed abundance and performance higher in environments with higher levels of human management?
- Is there a negative correlation between stand area and density?

The aim of the second part was to compile information on the impact of japanese knotweed invasions, as well as on different control methods for japanese knotweed and the effectiveness of these methods.

The aim of the third part was to investigate the japanese knotweed situation in Scania. I investigated the following questions:

- How much of a problem does japanese knotweed present in Scanian municipalities?
- What methods have been used to combat japanese knotweed, and what have the results been?
- How aware is the general public of the problems caused by japanese knotweed?
- What is the attitude towards cooperation between municipalities in regards to dealing with japanese knotweed?

The aim of the fourth part was to provide material for an action plan for japanese knotweed in Ängelholm municipality.

2. Methods

2.1. Japanese knotweed species description

Japanese knotweed (Fig. 4) is a member of the buckwheat family (Polygonaceae). The prefered scientific name given by World Flora Online is *Reynoutria japonica*, but other accepted names include *Fallopia japonica* and *Polygonum cuspidatum* (WFO, 2019). There are two common varieties of the species: *var. japonica* and *var. compacta*. The former is the main variety to be found as an invasive weed (CABI, 2019). The species is a perennial, herbaceous plant which originates from east Asia (Swedish Environmental Protection Agency, 2019g). It is invasive throughout the temperate regions of the world (Koutika, 2011), and is included on the IUCN list of the 100 most invasive alien species (IUCN, 2008).

Japanese knotweed can grow to a height of 1.5-2.0 m (Balohg, 2008). The shoots have hollow, upright, bamboo-like stems. The leaves are large and heart-shaped, with smooth edges (Soll, 2004), and do not grow at the lower section of the stems. The stems grow in dense colonies, connected underground by rhizomes (Balohg, 2008). They are often reddish or red-speckled. While the stems are killed by hard frost, they may remain throughout winter as bare stalks (Soll, 2004). The flowering period of japanese knotweed lasts from July to September (Balohg, 2008), with the small white or greenish flowers growing in dense clusters from the leaf joints (Soll, 2004).

Figure 4. Japanese knotweed (*Fallopia japonica*).

In most of its introduced range japanese knotweed lacks extensive sexual reproduction (CABI, 2019), as all stands are part of a single clone (Hollingsworth and Bailey, 2000). However, germination of seeds have been observed in the United States, indicating that knotweed spread by seed is a realistic possibility there (Bram and McNair, 2004). Japanese knotweed can also hybridize with giant knotweed, *Fallopia sachalinensis*, and thus reproduce sexually (forming the hybrid Bohemian knotweed, *Fallopia x bohemica*) (CABI, 2019). Climate warming increases the viability of the seeds thus produced, allowing for sexual reproduction even at the northern distribution limit of knotweeds (Groeneveld *et al*., 2014). On its own japanese knotweed in Europe reproduces vegetatively, with rhizomes that can spread to a distance of at least 7 meters, and possibly up to 20 meters, from the parent plant (Soll, 2004). These rhizomes can penetrate to a depth of at least 2 meters into the soil. Knotweeds can also spread rapidly through the rooting of root and stem fragments (Soll, 2004). Rhizome fragments as small as 0.7 grams can form new plant colonies (Swedish Environmental Protection Agency, 2019g). This also allows japanese knotweed to spread along waterways, such as rivers and ditches (Soll, 2004).

Japanese knotweed can tolerate a wide range of soil types and climates, and thus survive in many different types of environment (CABI, 2019). It can be found in both wet and dry environments (Wissman *et al*., 2015), and is known to grow at a pH of 3,0 to 8,5 (Beerling *et al*., 1994). The northern distribution limits for the species is controlled by the length of the growing season and minimum temperature (Beerling, 1993). One factor that can negatively affect japanese knotweed is shade, though it can survive in shady areas (CABI, 2019).

2.2. Field survey of knotweeds in Ängelholm municipality

For this project three people performed a field survey of knotweed species in Ängelholm municipality. The survey took place between 2019-10-01 and 2019-10-17. The main interest of the field survey was japanese knotweed, but as we were not able to reliably tell japanese knotweed and Bohemian knotweed apart we noted all knotweeds that we found during the field survey as simply ”knotweeds”. The exception is giant knotweed, which was noted as such. Thus any findings of knotweeds refers to japanese knotweed or Bohemian knotweed.

When the objective of a survey is to find occurrences of a specific species, such as for this one, it is generally preferable for it to be biased towards certain areas, rather than sampling at random (Rew *et al*., 2006). The field survey was focused on municipality land but we also surveyed certain other areas, either because they were of special interest or because they were adjacent to municipality land that we were surveying. The field survey focused on four types of areas: nature reserves, known areas with a large quantity of knotweeds, stretches along Rönne stream, and areas with knotweed sightings reported to Artportalen (SLU Artdatabanken, 2019a). In addition we noted sightings of knotweeds in gardens. For garden stands, as well for stands of giant knotweed, we did not note the additional data regarding surrounding environment and stand properties that we did for other knotweed stands found on public land.

2.2.1. Inventory in nature reserves

I chose to include Ängelholm's five nature reserves (Fig. A1-A7), as they are areas of special interest (Ängelholm municipality, 2010), where the presence of knotweeds could pose a threat to valuable nature. The inventory method consisted of three people walking or slowly cycling along established paths within the reserves, while looking as far as possible to both sides. (How far we could see in either direction varied greatly depending on the surrounding vegetation, but I estimate the average distance to be about 20 meters, with minimum being approximately 10 meters and maximum approximately 40). Figure 5 gives an example of such a path, and an idea of the general visibility. When we encountered knotweeds near the edge of the nature reserve we continued surveying for a distance of 50 meters, regardless of if this took us past the border of the reserve. If we then found additional knotweed sites we continued for 50 meters more. Knotweed stands were generally easy to detect, since it is a tall herb, with a distinct appearance even in autumn (Fig. 4).

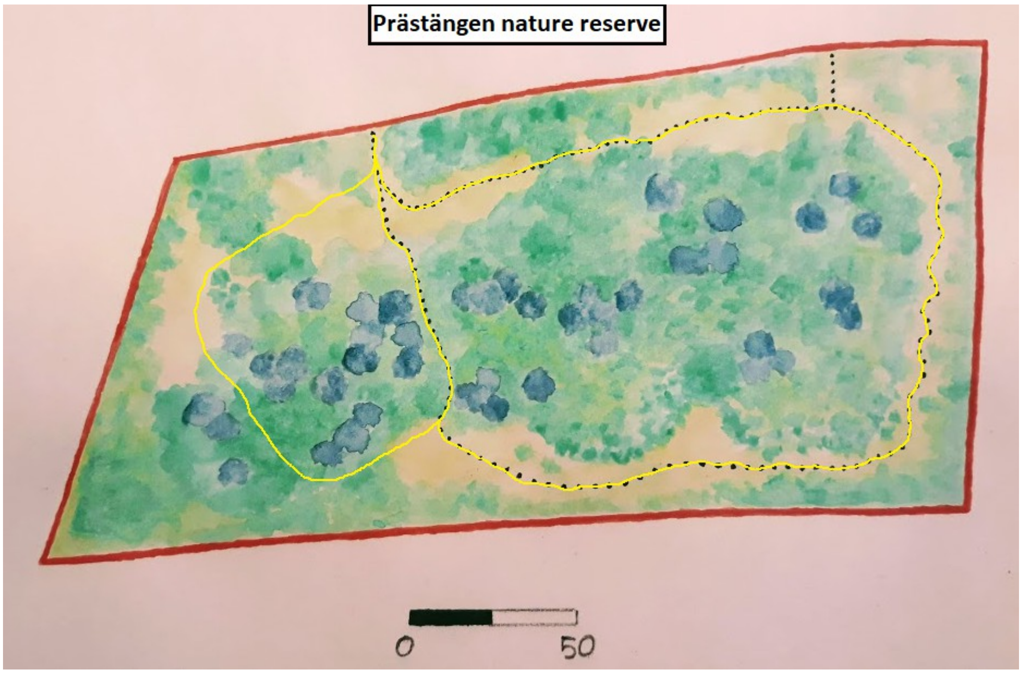

Figure 5. Surveyed path within Prästängen nature reserve (yellow path) (redrawn from map by the Scanian County Administration Board [2020] with our path added in yellow).

2.2.2. Inventory in residential areas with known large knotweed presence

In Havsbaden (Fig. A3) near central Ängelholm, an area known to house a large quantity of knotweeds, we performed a thorough survey where we canvassed public areas (streets and green areas such as parks, small woodlands and wastelands) counting the total number of knotweed stands (Lunds universitet, 1992). This was done in order to produce a clearer picture of the presence of knotweeds in these areas.

2.2.3. Inventory along Rönne stream

I included a stretch along Rönne stream, as knotweeds are often found along waterways (Beerling *et al*., 1994; Soll, 2004; Chmura *et al*., 2013). When surveying along a stretch of the stream (Fig. A4), located in the center of Ängelholm, we walked along one bank while looking at both sides of the stream, to the best of our abilities. We thus performed our survey along a modified line transect (Lunds universitet, 1992), using the river as the line. When we spotted knotweeds on the opposing bank we crossed at the nearest possible place and backtracked in order to collect data at the noted site. While we tried to stay as close to the stream as possible this was often difficult, because of the difficult terrain close to the water .

2.2.4. Searching for stands reported to Artportalen

A proportion of the sites reported in Artportalen were chosen for our survey (SLU Artdatabanken, 2019b), and we searched within the radius given on Artportalen for each specific stand. I chose sites that were in close proximity to areas we were surveying. If the expected knotweeds were found we also searched in an approximate 50 m radius circle around the site (where the surrounding terrain allowed it).

2.2.5. Data collected

When we found knotweeds we noted the date and time of finding, as well as coordinates taken using Google Maps on our mobile phones. We measured the size of the total knotweed stand, defined as area (m^2) calculated from length and width, taken at the longest and widest parts, measured with a tape measure. (This did not take into account the shape of the stand, and thus does not actually give an accurate representation of size but rather an idea of comparative size in relation to other stands.) This included any offshoots of plants some way apart from the rest of the stand. When there was an apparent main stand, defined as a visibly denser part of the total stand (Fig. 6), we measured the size of this in the same way. We estimated total stand and (when present) main stand density as categories of increasing density: 1-3. These were based on a rough estimate of the amount of individual stems (Lunds universitet, 1992) relative to a typical stand, with 1 being visibly less dense, 2 being as dense as a typical stand, and 3 being visibly denser. We then noted traits of the surrounding environment presented in Table 2. When we made an observation that did not fit into any of the previous categories we took additional notes.

Figure 6. Knotweed stand with denser part (main stand) in the background, and less dense part in the foreground.

Table 2. Noted traits of the surrounding environment.

Trait	Categories	Criteria
Surrounding land type.	Forest, Gravel, Mixed (where stands were spread out over two types of land), Grass, Parkland, Shrubs and Sand.	Based mostly on vegetation, as well as substrate when relevant.
Tree canopy cover.	0-33%, 34-66% and 67-100%	Abbreviated percent scale (Liljelund and Zetterberg, 1986), estimated by sight.
Human interference level	High and low.	Based on land type (high=Gravel, Mixed, Grass and Parkland, low=Forest, Shrubs and Sand).

2.2.6. Data analysis

Statistical tests were performed in IBM SPSS Statistics 25. All quantitative data were tested for normal distribution (total stand area and main stand area) using Shapiro-Wilk tests. As neither was normally distributed Kruskal-Wallis tests were used to test for significant difference in total stand area, as well as main stand area, depending on land type, as well as depending on canopy cover. Since density data were categorical Kruskal-Wallis tests were also used to test for significant difference in total stand density, as well as main stand density, depending on land use type, as well as depending on canopy cover. A χ^2-test was used to test for occurence in relation to canopy cover. To test the difference between levels of human interference, a χ^2-test was used for occurrence, and Mann-Whitney U-tests for total and main stand area as well as total and main stand density. To test for correlation between area and density, Spearman Rank tests were used to test for correlations between total stand area and total stand density, total stand area and main density, main stand area and total stand density, as well as main stand area and main stand density. The tests are listed in Table B1-B2 in Appendix B.

2.3. Literature study of japanese knotweed impact and management methods

I searched for literature study material using Google scholar and LUBsearch from 2019-10-01 to 2020-02-29. I included search terms such as ”fallopia japonica” ”reynoutria japonica”, ”knotweed impact” and ”knotweed management”. When I found a suitable study I also searched its references for other studies related to my topic. I also included grey literature, such as agency reports and fact sheets. .

2.4. Survey regarding japanese knotweed in Scania

For this survey I have contacted 33 municipality employees, representing 32 municipalities, and interviewed 24 of these. When reaching out to Hässleholm municipality I was advised to contact two municipality employees, and did so. All interviews were conducted by phone or via email.

I conducted semi-structured interviews by using a list of standardized questions and, when appropriate, asked follow up questions specific to the topic at hand (Justesen and Mik-Meyer, 2011). This list can be found in Appendix D. All questions are open questions, allowing the interviewee to provide additional information they thought relevant, following the semi-structured approach (Justesen and Mik-Meyer, 2011). For phone interviews I noted down answers as a cohesive text. When answering questions via email most interviewees answered each question separately, but some chose to answer as one cohesive text. In order to be able to give an overview of interview data I have summarised the answers to some questions and divided them into categories.

Interview subjects were chosen to provide as good an overview of the japanese knotweed situation in Scania as possible. I began with interviewing by phone employees of two municipalities suggested to me by Ängelholm municipality. I thereafter contacted all the other municipalities in Scania, either via phone or via email. When I found an appropriate person to contact I sent them the standard questions directly. Otherwise I sent an email to the municipality customer service asking for someone to interview. In these cases I sometimes got replies briefly describing the municipality's japanese knotweed situation. If these answers provided the information I needed I did not follow up with the standard questions. The replies to the questions were compiled and presented in graphs.

2.5. Material for action plan

I chose to focus on parts of the action plan for japanese knotweed in Ängelholm municipality for which my other work for this project provided information. These parts were *Background*, *Occurrence*, *Management methods* and *Current efforts*.

3. Results

3.1. Inventory of knotweeds in Ängelholm municipality

3.1.1. Occurrence

The survey found 77 knotweed stands, of which five were giant knotweed and 72 were either japanese knotweed or Bohemian knotweed. An overview of the surveyed areas and our findings, as well as additional maps showing specific areas can be found in Appendix A (Figs. A1-A7). Knotweed sites with coordinates are shown in Table C1 in Appendix C.

Of the five nature reserves, Magnarps strandmarker, Hålebäckseröd, Ängelholms strandskog, Prästängen and Djurholmsmossen, we only found knotweed in two, Hålebäckseröd and Magnarps strandmarker. In Hålebäckseröd nature reserve we found two stands of knotweed, shown in Fig. A6, and in Magnarps strandmarker we found one stand (Fig. A5). (For clarification, the map also shows a garden stand close enough to the edge of the reserve that it may appear to be inside it, as well as stands reported to Artportalen inside the reserve, which we did not find. Neither of these are counted amongst our findings within the reserve.)

In residential areas with known large knotweed presence (Havsbaden) we found 22 stands of knotweed, whereof two were in gardens, and two were giant knotweed (Fig. A3).

Along the chosen section of Rönne stream we found 13 knotweed stands whereof two were in gardens and one was giant knotweed. Roughly half of the surveyed stretch ran through the center of town, and the rest through residential areas. All stands but one were located in the centre of town. They were fairly evenly distributed on both banks. The stands could be divided into three groups separated by over 500 meters: one of nine stands, one of three, and one consisting of a solitary stand (Fig. A4).

When searching for stands noted on Artportalen we found a total of 39 knotweed stands in Ängelholm municipality.

Stands in our study varied in size from 0.06 m^2 to 1717.9 m^2, with an average area of 161.5 m^2. Main stands varied in size from 2.25 m^2 to 760.5 m^2, with an average area of 34.3 m^2.

3.1.2. Findings depending on land use type

The highest number of knotweed stands were found in the Parkland category (24 stands, making up 35.3% of total stands), followed by Forest (19 stands, 27.9%) (Fig. 7). 20.6% of stands (14 stands) were found in Grass, 10.3% (seven stands) in Shrubs, and 2.9% (two stands) in Mixed. The lowest numbers (one stand each) were found in Sand and Gravel (both at 1.5%).

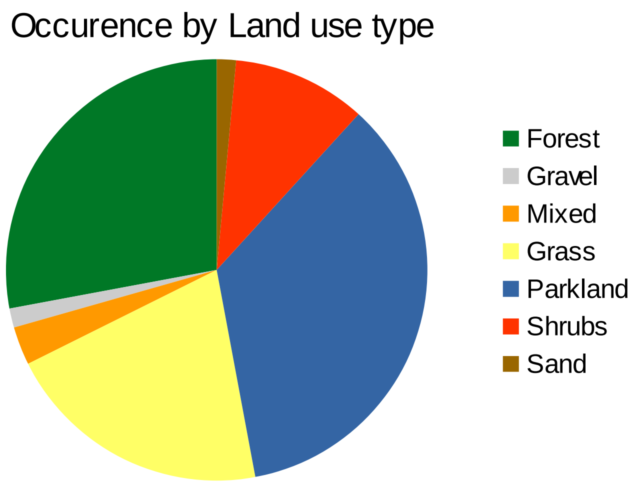

Figure 7. Number of knotweed stands by land use type (N=68).

Main stand area (Tab. 3) did not vary significantly depending on land use type (Kruskal-Wallis, H=3.989, p=0.551).

Table 3. Main stand area by land use type, means and standard deviations.

Land use type	Forest	Gravel	Mixed	Grass	Parkland	Shrubs	Sand
Mean area (m^2)	148.5	10.23	0	17.72	189.3	6.4	12.48
Standard deviation	274.1	0	0	3.4	241.8	0	0

Neither did total stand area (Tab. 4) (Kruskal-Wallis, H=3,557, p=0,736,).

Table 4. Total stand area by land use type, means and standard deviations.

Land use type	Forest	Gravel	Mixed	Grass	Parkland	Shrubs	Sand
Mean area (m^2)	166.3	27.59	45.17	127.8	223.3	80.69	40.32
Standard deviation	372.0	0	14.83	313.1	338.5	53.0	0

There was no significant difference in main stand density depending on land use type (Kruskal-Wallis, H=3.356, p=0.763). There was also no significant difference in total stand density (Kruskal-Wallis, H=10.970, p=0.089) depending on land use type. (No table of densities is included, since it is categorical data.) However, there may be a trend that total stand density differs between different land use types, with the densest stands more commonly found in grassland and stands with the lowest density in parkland (Fig. 8).

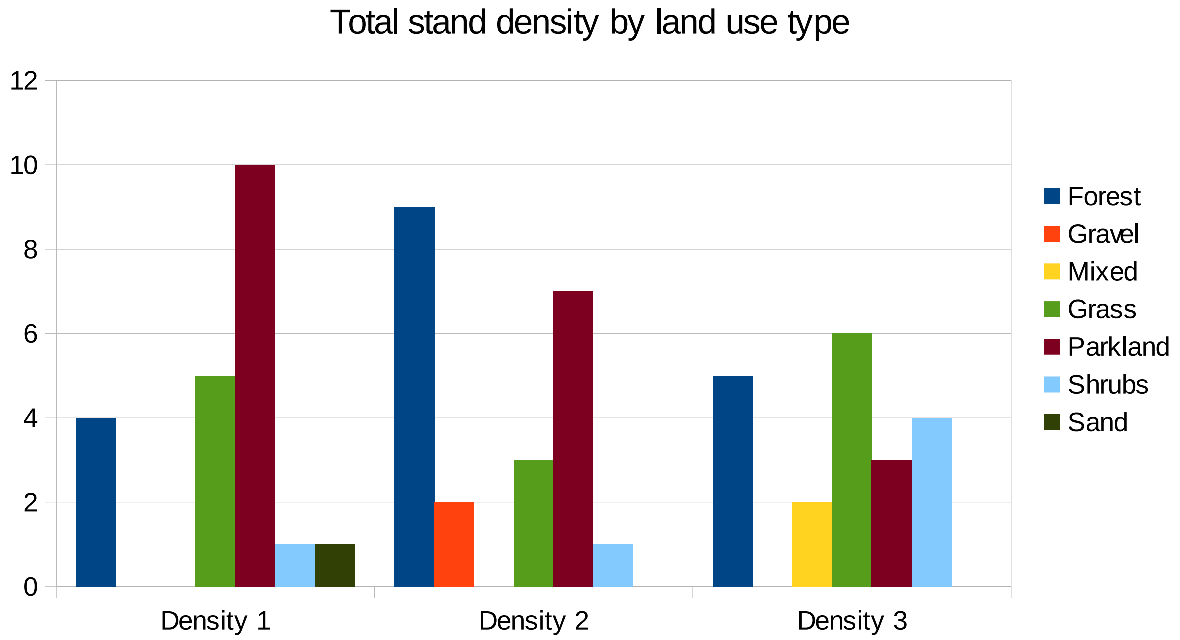

Figure 8. Mean total stand density depending on land use type, with density classes 1-3 on the x-axis and number of stands in each category on the y-axis (N=63). Density classes are defined in Tab. 2.

3.1.3. Findings depending on human interference level

Human interference level had no significant impact on knotweed occurrence (χ^2 test, χ^2=3.358, p=0.067), though there can be said to be a trend showing higher occurrence of knotweeds in high interference areas (Fig. 9). There was also no significant difference in main stand area (Independent Samples Mann-Whitney U-test, p=0.968) or total stand area (Independent Samples Mann-Whitney U-test, p=0.212), nor on main stand (Independent Samples Mann-Whitney U-test, p=0.923) or total stand (Independent Samples Mann-Whitney U-test, p=0.339) density depending on human interference level.

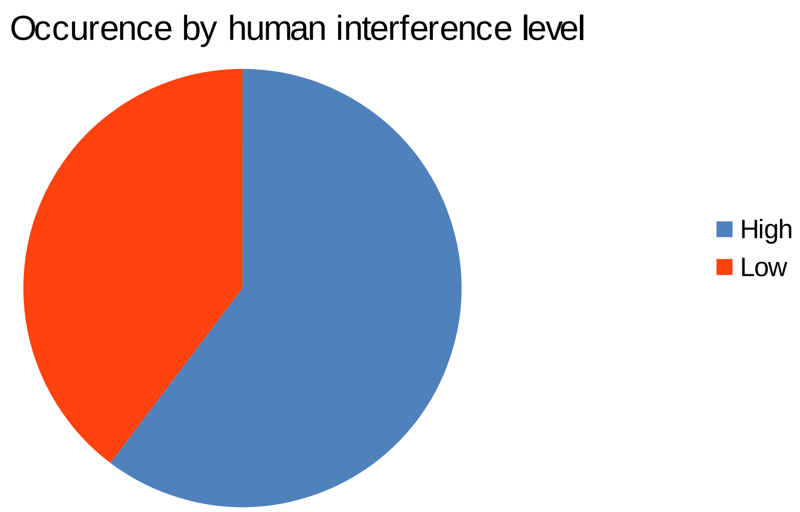

Figure 9. Number of knotweed stands divided by human interference level (N=68). The human interferencve level is defined in Tab. 2.

3.1.4. Findings depending on canopy cover

There was no difference in main stand area or total area depending on canopy cover (Kruskal-Wallis test, H=3.162, p=0.206 and Kruskal-Wallis test, H=3.162, p=0.506, respectively). There was also no difference in main stand density or total stand density depending on canopy cover (Kruskal-Wallis test, H=5.077, p=0.079 and Kruskal-Wallis test, H=3.402, p=0.183, respectively), though there can be said to be a trend showing a negative correlation between level of canopy cover and main stand density (Fig. 10).

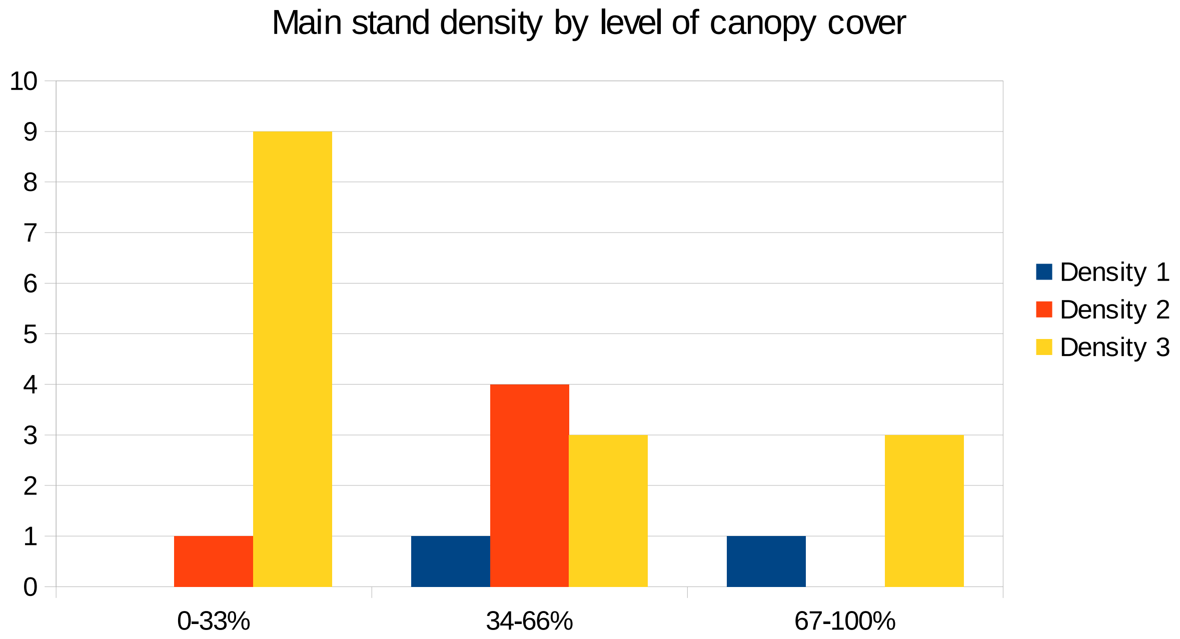

Figure 10. Main stand density by level of canopy cover. Canopy cover categories on the x-axis, number of stands in each density category on the y-axis (N=22).

3.1.5. Correlation between area and density

There was no significant correlation between stand area and stand density: total stand area versus total stand density (Spearman Rank test, p=0.850), total stand area versus main stand density (Spearman Rank test, p=0.687), main stand area versus total stand density (Spearman Rank test, p=0.396), or main stand area versus main stand density (Spearman Rank test, p=0.988). This showed that larger stands did not become less dense.

3.2. Literature study of japanese knotweed impact and management methods

3.2.1. The invasive alien species japanese knotweed

As an invasive alien species, japanese knotweed has a negative impact on native plants (Aguilera *et al*., 2010; Gerber *et al*., 2008). It's early emergence combined with its height allows it to prohibit the regeneration of other plants through shading (Aguilera *et al*., 2010). The out-competing of native plants is likely also facilitated by the species' clonal ability, since it enables the sharing of stored nitrogen and photoassimilates between shoots through its extensive rhizome system (Price *et al*., 2002). This allows nutrients to be transferred to shoots at the peripheral and spreading edges of the stand (Aguilera *et al*., 2010). Rhizomes have been found to function as an assimilate sink from late June onwards, becoming increasingly important as the season progresses and shoot growth and assimilate retention declines (Price *et al*., 2002). Thus, the plant is able to efficiently store energy reserves in the rhizome, which can then be remobilized to new shoots early the following spring. This storing of resources allows japanese knotweed to quickly commence growth at the onset of the new growing season (Price *et al*., 2002). In this way japanese knotweed can come to dominate large areas, though it has been noted that the density of japanese knotweed decreases as the size of the invaded area increases (Gerber *et al*., 2008).

Japanese knotweed can also harm the regeneration of native plants by leaving large amounts of debris, as dead knotweed stems can remain for 2-3 years (CABI, 2019). A study by Aguilera *et al*. (2010) performed in central Massachusetts found that the species could sometimes produce 2-6 times the amount of biomass as the native community (Aguilera *et al*., 2010).

An invasion of japanese knotweed can also have other negative consequences. It can negatively affect ecosystem services (CABI, 2019). Establishment of knotweed can limit possible land usage. Japanese knotweed rhizomes have a strong ability to pierce through matter (Wissman *et al*., 2015), allowing them to grow into buildings and water pipes causing economic damage (Swedish Environmental Protection Agency, 2019g). These rhizomes can also erode soil adjacent to water, thereby increasing risk of flooding (Koutika, 2011).

The ability of japanese knotweed to invade new areas is affected by how the land is used (Chmura *et al*., 2013). The species is mainly found in habitats strongly influenced by human interference (Beerling *et al*., 1994). Both its development and spreading are favored by man-made habitats (Chmura *et al*., 2013). In their study, Chmura *et al*. (2013) found that japanese knotweed occurs most frequently in habitats associated with transport routes, such as roads, railways and waterways (Chmura *et al*., 2013). It can also be found in residential areas, building sites, and similar types of habitat (Beerling *et al*., 1994; Care4Nature, 2020). Chmura *et al*. (2013) also found that knotweed stands were largest in wetlands and along railways, while the smallest stands were found in gardens, followed by forest (Chmura *et al*., 2013).

In Sweden japanese knotweed is particularly problematic in infrastructural environments, especially when these are highly disturbed and with sparse vegetation (Wissman *et al*., 2015). Since highly disturbed environment with sparse vegetation is the most common type of infrastructural environment in Sweden it is also the Swedish environment most vulnerable to IAS (Wissman *et al*., 2015). Therefore, IAS such as japanese knotweed may impede the Swedish Transport Administration's goal to achieve a certain percentage of species rich road verges. Many such road verges have already been invaded by invasive alien plant species (Wissman *et al*., 2015).

Findings of one study (Gerber *et al*., 2008) indicate that the success of japanese knotweed as an IAS can be partially explained by the enemy release hypothesis. This hypothesis states that plant species when introduced to a new habitat experience release from regulation by natural enemies, leading to species distribution and abundance rapidly increasing (Keane and Crawley, 2002). In their study, Gerber et al. (2008) found much fewer insect species on japanese knotweed in Europe than on native species.

3.2.2. Knotweeds and community interactions

Knotweed invasion can have an impact not only on native vegetation, but also on other native taxa, and even soil composition. Japanese knotweed has been found to increase nutrient availability, with the effect being stronger in soils where initial nutrient concentration is lower. This suggests that japanese knotweed may contribute to soil homogenization of the areas it invades (Dassonville *et al.*, 2007).

In regards to soil biodiversity, it has been found that soil fauna structure changes from a plant-based food chain to a detritus-based one when japanese knotweed invades (Koutika, 2011). Knotweed species also seem to favor fungi and amoebae to the detriment of bacteria. The exception seems to be arbuscular mycorrhizal fungi, which are also negatively affected by knotweeds (Lavoie, 2017). These fungi make up the most important and widespread plant symbionts (Zubek *et al*., 2016). They have been found to increase nutrient acquisition, growth and vitality in their host plants, as well as protect them from biotic and abiotic stresses. They have also been found to determine plant community composition and function (Zubek *et al*., 2016). A decrease in arbuscular mycorrhizal fungi abundance and species richness caused by IAS can thus have a negative impact on native plant species, as well as accelerate invasions by IAS plants (Zubek *et al*., 2016).

In riparian habitats knotweeds have been found to have a negative impact on invertebrates (for example herbivores and spiders), with plots invaded by knotweeds having lower abundance, biomass and morphospecies richness (Gerber *et al*., 2008). Gerber *et al*. (2008) observed almost no damage to ”exotic” (”exotic” being the same as ”alien” [IPBES, 2020]) knotweeds by herbivorous invertebrates, whereas the native species growing in control areas were known to host a large number of native invertebrate species. This was taken to indicate that these knotweeds are unpalatable to European invertebrate herbivores (Gerber *et al*., 2008).

The findings of another study (Maerz *et al.*, 2005) suggested that japanese knotweed invasions can also have a negative impact on amphibians, as it found that foraging was less successful for green frogs in areas invaded by japanese knotweed. Maerz *et al*. (2005) theorized that this was caused by a reduction in prey availability, due to the aforementioned negative effect of knotweed invasion on invertebrates (Maerz *et al.*, 2005).

3.2.3. Japanese knotweed in Sweden

Japanese knotweed was introduced to Sweden as an ornamental plant (Swedish Environmental Protection Agency, 2019g), and spread into the wild at some point during the late 1800s to early 1900s (SLU Artdatabanken, 2019b). It has spread throughout the south of Sweden, as far as Dalarna. A small number of sightings have been made along the coast as far north as Umeå (Swedish Environmental Protection Agency, 2019g). Scania has the

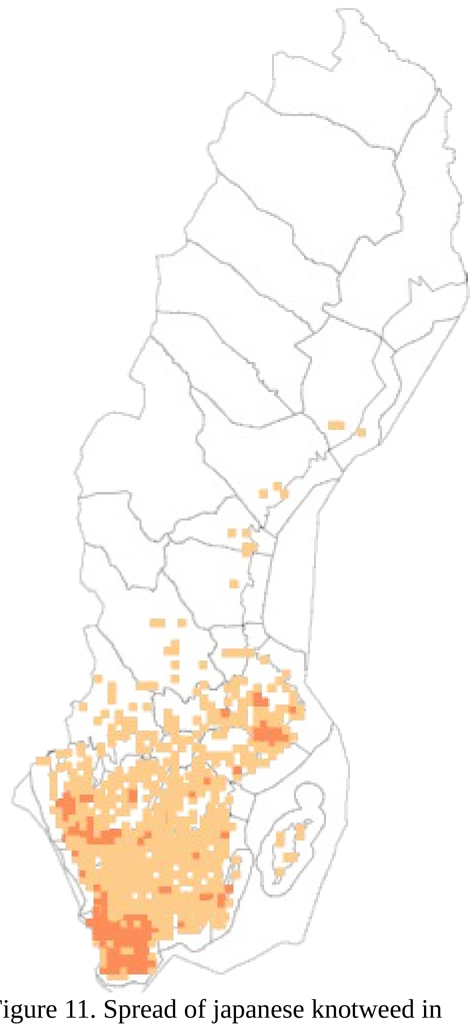

Figure 11. Spread of japanese knotweed in Sweden (SLU Artdatabanken, 2020a).

largest presence of Japanese knotweed in Sweden (Fig. 11) (SLU Artdatabanken, 2019b). It is not currently illegal to either sell or plant Japanese knotweed in Sweden (Wissman *et al*., 2015), though the species is now among the ones proposed to be included on the Swedish national list of IAS which may lead to restrictions in its use (Swedish Environmental Protection Agency, 2020b).

3.2.4. Control methods for japanese knotweed

Several methods are used to attempt to manage or control japanese knotweed. These methods can be mechanical/manual, chemical (Soll, 2004; Delbart *et al*., 2012; Jones *et al*., 2018) or biological (Shaw *et al*., 2011), as well as a combination of methods from more than one of these categories (Soll, 2004). Successful treatment of japanese knotweed will likely take more than one year, let alone one treatment (Soll, 2004). In general, controlling a knotweed stand will need a long-term approach (Jones *et al*., 2018).

3.2.5. Mechanical/manual control methods

Mechanical/manual methods include cutting, mowing, pulling, digging and covering, with the goal of removing or starving the root and rhizome system (Soll, 2004). Manual treatment methods will nearly always require more instances of treatment, as well as more effort, than chemical ones (McHugh, 2006).

Delbart *et al*. (2012) found that cutting combined with transplanting of native trees was the most efficient mechanical control method (Delbart *et al*., 2012). Cutting alone will not eliminate japanese knotweed (but can reduce its overall vigor) (Sieger and Merchant, 1977), unless performed thoroughly for several years (Soll, 2004). Additional cuts during one season leads to additional decrease in rhizome biomass (Sieger and Merchant, 1977). Soll (2004) recommends cutting at least twice a month, from April through August, with additional cuttings once a month until the first frost (Soll, 2004). For newly established plants pulling can be more efficient than cutting, since this also removes the roots. It is then important to not leave the pulled plants where they can take root (Care4Nature, 2020).

There are no reliable reports of covering being completely successful in controlling japanese knotweed. It is likely to be more effective on smaller, isolated patches in open terrain (Soll, 2004). Jones *et al*. (2018) found that covering was the least effective of their tested methods (Jones *et al*., 2018). However, different types of material from cardboard (Soll, 2004) to industrial custom-made cover material (Jones *et al*., 2018) is used, which will likely affect the success rate.

Digging may be successful for very small stands of japanese knotweed (fewer than 50 stems) (Michigan Natural Features Inventory, 2012). It is of vital importance that all plant matter is removed, since digging otherwise increases sprouting of new plants from remaining rhizomes fragments (Michigan Natural Features Inventory, 2012; Care4Nature, 2020), as well as stem fragments (Soll, 2004). Unearthed plant material must be removed, to prevent re-establishment (Care4Nature, 2020). Digging requires monitoring for several years afterwards (Michigan Natural Features Inventory, 2012).

3.2.6. Chemical control methods

Studies comparing different treatment methods found that treatment with glyphosate was the most effective, including when compared to other herbicides (Delbart *et al*., 2012; Jones *et al*., 2018). However, glyphosate and the surfactants it is formulated with have been shown to have a detrimental effect on many non-target organisms (Delbart *et al*., 2012). Delbart *et al*. (2012) found that injecting the herbicide into the stems was more effective than foliar spraying, and required a smaller dose (as well as limiting the risk of pesticide drift [Delbart *et al*., 2012]). Conversely, Jones *et al*. (2018) found that foliar spraying, while equally effective, required a smaller dose of herbicide than stem injection, while also being less labor intensive (Jones *et al*., 2018). Plants may develop resistance if treated improperly or with an incorrect dose (Care4Nature, 2020).

When treating japanese knotweed using herbicides, timing is important. Different types of herbicides are efficient at different times in the growing season, depending on seasonal changes in rhizome source-sink strength (Jones *et al*., 2018). From February through May the rhizomes function primarily as a source of resources, while during June their sink-strength increases, and they come to function primarily as a sink for the rest of the season (Price *et al*., 2002; Jones *et al*., 2018). Therefore, it is appropriate to use herbicide treatments that disrupt growth (and thus directly disrupt resource acquisition) early in the growing season, while late in the growing season one should apply herbicides that are transported to the rhizomes, damaging these and thus preventing resource hoarding for the future (Jones *et al*., 2018). Jones *et al*. (2018) found that while neither increasing herbicide dosage or combining herbicide treatment with other treatment methods improved results, exploiting seasonal changes in rhizome source-sink relationships did (Jones *et al*., 2018).

3.2.7. Biological control methods

Another possible method of managing knotweeds is biological control. Classical biological control, when used as a weed management tool, intends to permanently control the target weed by introducing highly specific coevolved natural enemies from its region of origin (Shaw *et al*., 2011). The psyllid *Aphalara itadori Shinji* has been released in the UK, in an attempt to use classical biological control to manage japanese knotweed (Shaw *et al*., 2011). Grazing by various animals such as sheep and goats has been used for other IAS (Swedish Environmental Protection Agency, 2019h), and small trials appear to have been performed on knotweed (Alakangas, 2019), however I have found no actual data on the success of this method for knotweed control.

3.2.8. Possible effects on non-target species

Control methods can also have impacts on non-target species (McHugh, 2006). Mechanical methods that disturb the soil may create ideal conditions for other IAS to invade. They may also have an impact on the regeneration of other plants (McHugh, 2006). Covering will likely kill any non-target plant growing under the fabric, as well as leave patches of bare soil that require erosion control (McHugh, 2006). It also necessitates leaving black fabric in nature for many years, which may affect wildlife and soil biota (McHugh, 2006). Chemical treatments may lead to herbicide drift onto non-target species and surface waters. This risk is particularly large for foliar spraying (McHugh, 2006). Chemical compounds are also a health hazard for the persons that apply them. Disturbing the roots, through digging, tilling, etc. can lead to increased sprouting, worsening the problem instead of solving it (Michigan Natural Features Inventory, 2012).

3.2.9. Information as a management tool

One of the most important tools for managing IAS is a good system for exchange of information (Tschan, 2018). For a knotweed management program to be successful it is necessary to reach out to landowners who may have japanese knotweed on their land, as well as to educate them on the possible effects of knotweed presence (Soll, 2004). Educating consumers, allowing them to make informed choices when purchasing native or non-native species, is also the best way to help consumers decrease the risk of spreading IAS (Hulme *et al*., 2017).

3.3. Survey regarding japanese knotweed in Scania

From 23 of the 32 municipalities contacted, 24 municipality employees (two from Hässleholm) agreed to participate in this survey (Fig. 12). Seven were interviewed by phone, and twelve by email. Five of the municipalities responded to my initial email where I asked for an interview regarding their knotweed situation with enough information on the topic that I did not think an interview would be necessary. When this was the case I extrapolated the answers to my questions from their response, and did not send the standard questions. Two municipality employees declined to be interviewed, and from six municipalities I received no reply when asking for an interview.

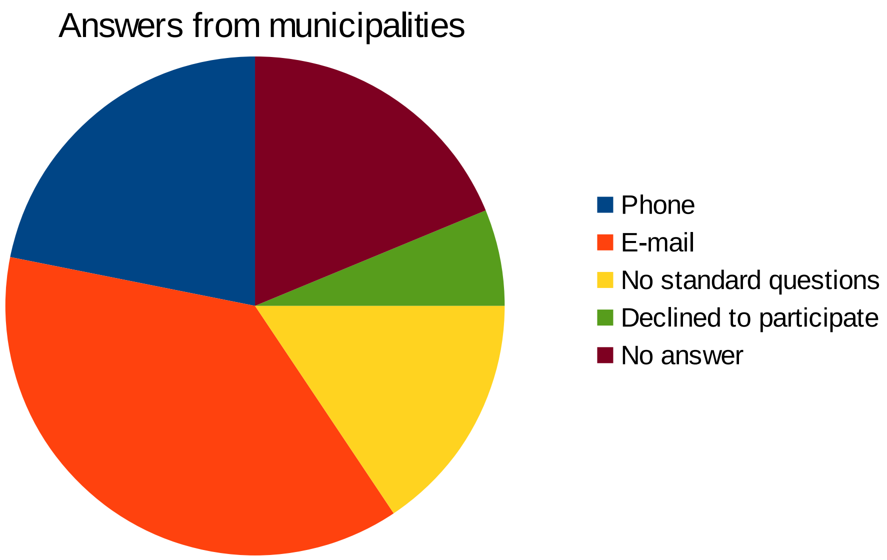

Figure 12. Number of contacted municipalities interviewed, and in what manner (N=32).

3.3.1. Japanese knotweed as a problem

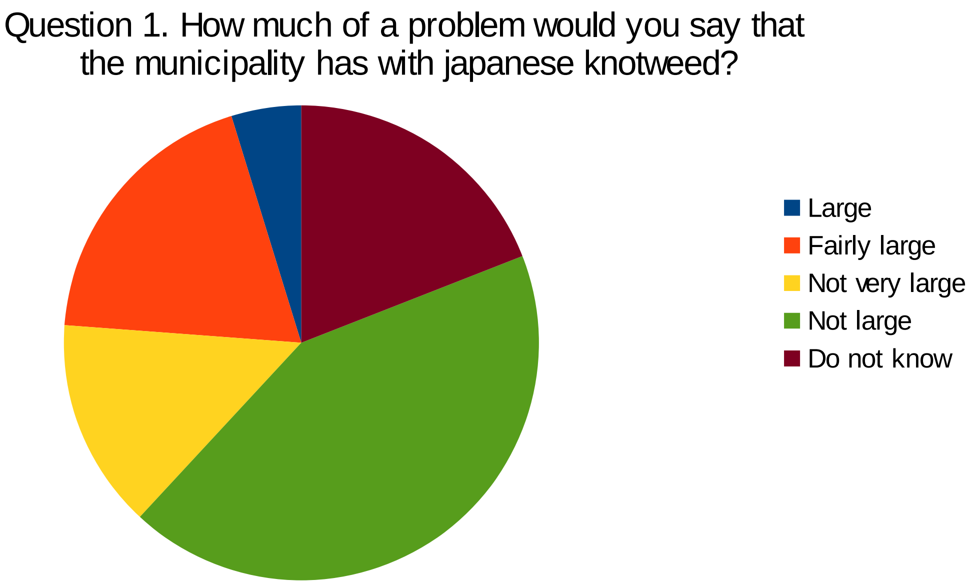

Figure 13. Perceived level of knotweed problem by interviewees (N=21).

When interviewees were asked how much of a problem japanese knotweed was in their municipality, more than half replied that the problem was ”Not very large” (14.3 % n=3) or ”Not large” (42.9 % n=9). Another 19% replied that they did not know if there was a problem. Four municipalities replied that the problem was “Fairly large”, and only one municipality employee gave an answer that fell into the category of ”Large” (4.8%) (Fig. 13).

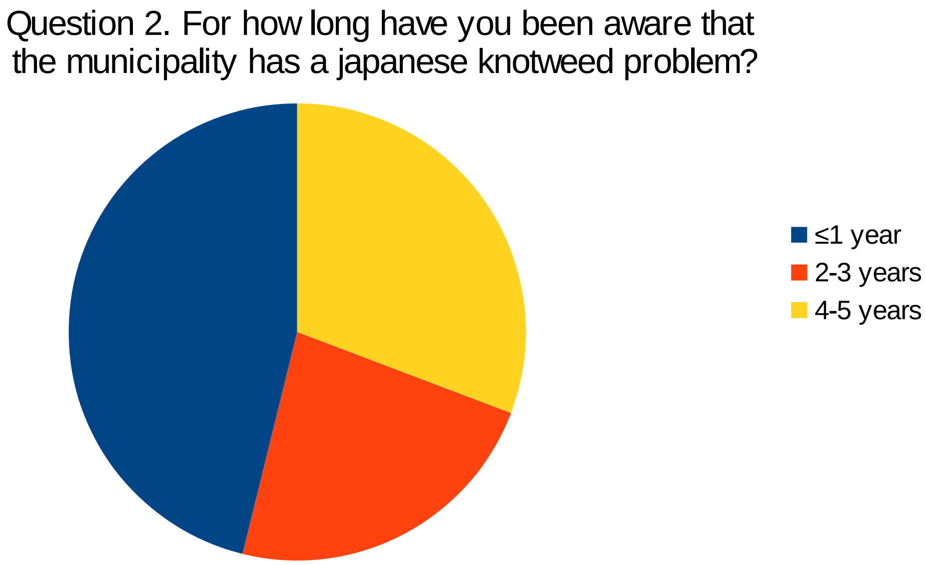

Figure 14. Length of time that interviewees have been aware of a knotweed problem in their municipality (N=13).

Regarding the awareness of the japanese knotweed problem, answers were divided into the categories ”≤1 year”, ”2-3 years” and ”4-5 years”. Of those who answered that their municipality had a knotweed problem, six (46.2%) answered that the municipality had been aware of the problem for less than a year, while three (25%) gave an answer that fell in the category 2-3 years, and four (33%) in the category 4-5 years (Fig. 14). Thirteen municipalities (56.5%) answered Question 2.

3.3.2. Knotweed management

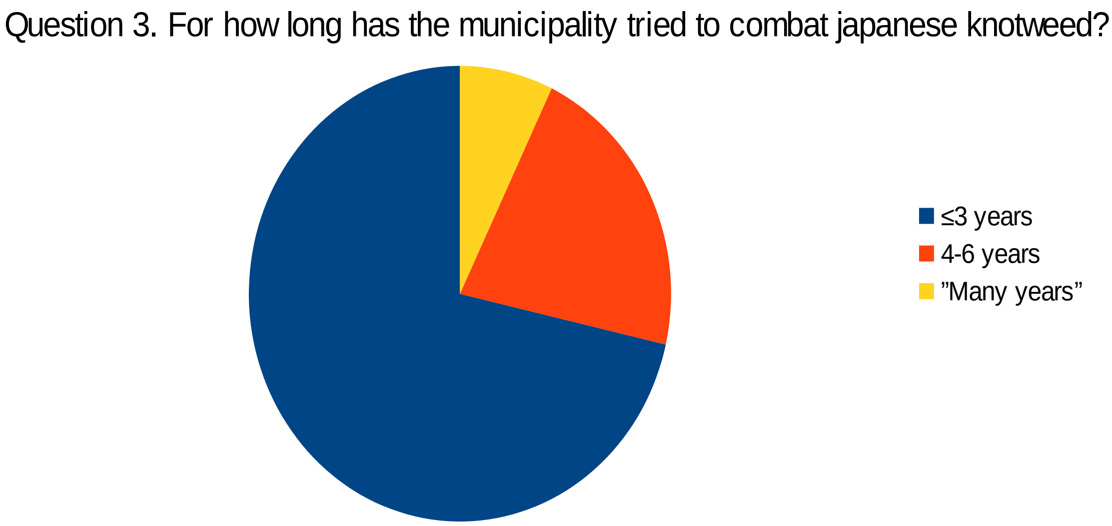

Figure 15. Length of time that municipalities have been attempting to control japanese knotweed (N=14).

When asked for how long the municipality had been trying to combat japanese knotweed a majority (10 municipalities, 71.4%) of those who had answered that their municipality was taking action against knotweed answered that they had been doing so for less than three years. Three (21.4%) gave answers that fell in between 4-6 years, while one (7.1%) answered ”many years” (Fig. 15). Fourteen (60.9%) municipalities answered Question 3.

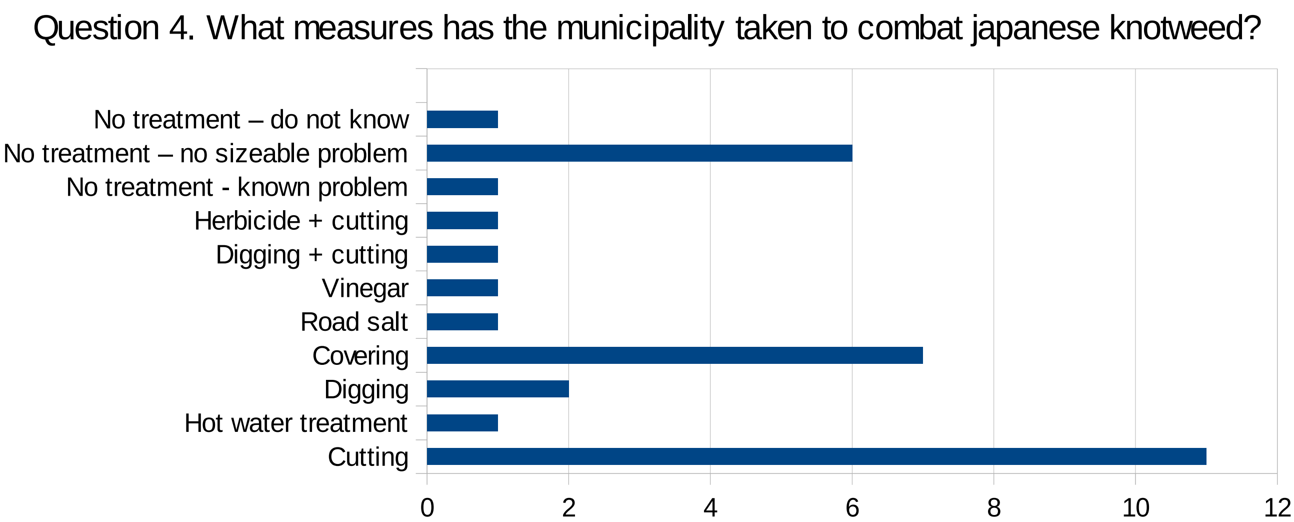

Figure 16. Measures taken by municipalities to control japanese knotweed (N=23).

All 23 municipalities answered Question 4. A total of six different management methods were mentioned as having been tried by the represented municipalities, as well as two different combinations (Fig. 16). Of these methods cutting was the most common, having been tried by 11 municipalities (45.8%). This was followed by covering, which had been tried by seven (25%). One third of municipalities (eight) took no action against japanese knotweed at all. Of these, six (75%) had given answers indicating that their municipality's knotweed problem fell into the ”Not large” category, one person (12.5%) ”Do not know”, and one (12.5%) ”Fairly large”. Several of these (including the person who's municipality had a ”Fairly large” problem) mentioned that plans for knotweed management were underway. Helsingborg municipality had systematically tested and compared different methods, including cutting and covering, in a project that received LONA subsidies.

3.3.3. Method effectiveness

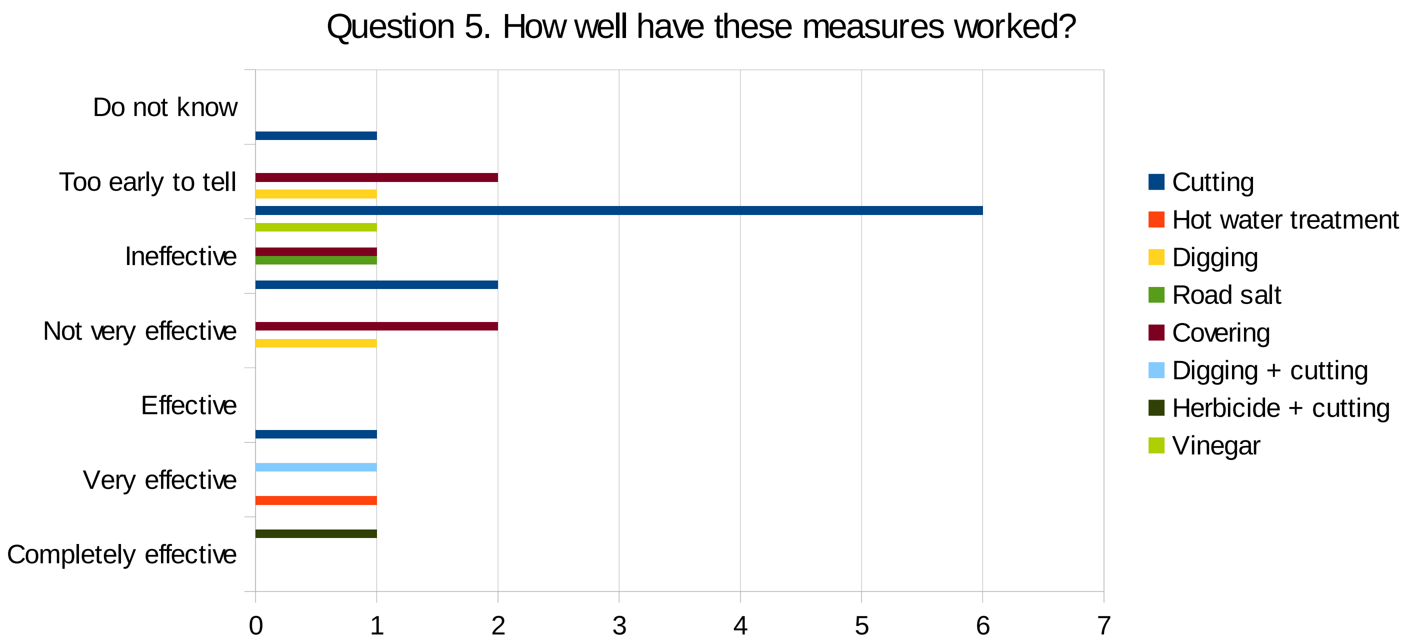

Figure 17. Perceived level of effectiveness of different methods by interviewees, with level of effectiveness on the y-axis, and numbers of answers in each category on the x-axis (N=23).

All 23 municipalities answered Question 5. A chart showing the reported efficiency of different methods is shown in Figure 17, answers having been divided into the categories ”Completely effective”, ”Very effective”, ”Effective”, ”Not very effective”, ”Ineffective”, ”Too early to tell” and ”Do not know”.

The one method reported to have been 100% effective was a combination of cutting and herbicide treatment (cutting once per month from emergence till late July, followed by RoundUp treatments, once in August and once in September, for two years), performed by Höganäs municipality.

Of the municipalities that have tried cutting the japanese knotweed 55.6% answered that it was too early to tell what effect the method had had. 11.1% (one person) answered ”do not know”. 22.2% answered that there had been no change in knotweed presence. These municipalities cut once per year and 2-3 times per year, respectively. Helsingborg municipality found cutting to be the best of their tested methods, being cost effective, lowering the amount of knotweeds by 65% in three growing seasons, and having no risk of causing spreading. They were the only ones to see any actual decrease in japanese knotweed due to cutting, cutting four times per year. The Helsingborg municipality employee I interviewed stressed that it is a method that requires a long term perspective, expressing a belief that continued cutting would likely be necessary for decades.

60% of the municipalities that had tried covering found that it was not effective, having had knotweed emerging through holes in the cover. One also had knotweed emerging to the side. One interviewee expressed concern in regards to potential negative consequences of leaving large amounts of plastic in nature. The remaining 40% answered that it was too soon to tell.

50% of the municipalities that had tried digging found that it was not effective, with Helsingborg municipality seeing an ”explosion” of new plants. The municipality did however see a marked improvement after extensive follow up work digging up these small plants by hand. The remaining 50% answered that it was too early to tell. A combination of digging and cutting had greatly reduced the amount of knotweed for Malmö municipality.

Hot water treatment was found by Helsingborg municipality to be effective (with growth diminished by 80-90%), but very expensive. The exception was a rocky area where the treatment did not manage to reach the roots.

Neither treatment using road salt nor vinegar (each tried by one municipality) had any effect.

3.3.4. Flow of information and cooperation regarding knotweed

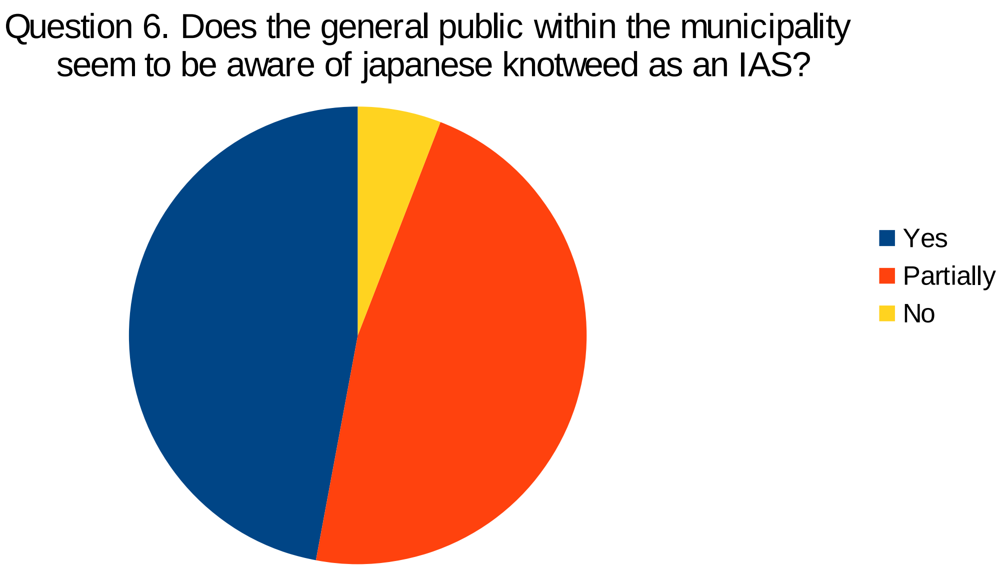

Figure 18. Public knowledge of japanese knotweed as an IAS, as perceived by interviewees (N=17).

17 municipalities answered Question 6 (Fig. 18). Answers were divided into the categories ”Yes”, ”Partially” and ”No”. When asked if the general public of the municipality seemed aware of japanese knotweed as an IAS eight (43.8%) said ”Yes”, and eight (43.8%) said ”Partially”. Only one person (5.9%) said ”No”. Four (23.5%) mentioned that public knowledge has increased due to japanese knotweed being featured in the media.

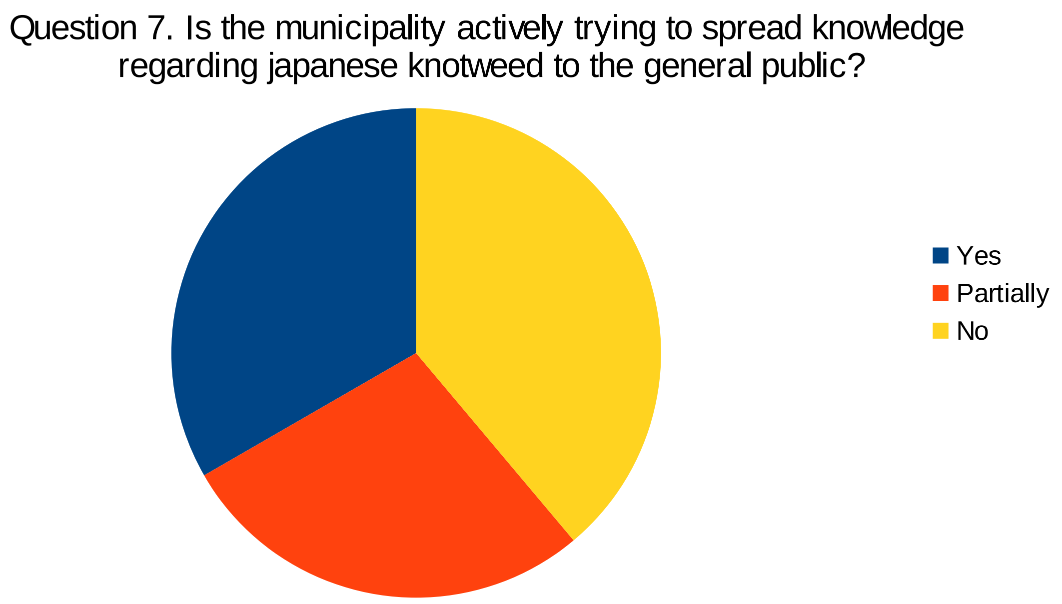

Figure 19. Reported municipality efforts to spread knowledge of IAS (N=18).

18 municipalities answered Question 7 (Fig. 19). Answers were divided into the categories ”Yes”, ”Partially” and ”No”. When asked if the municipality is actively trying to spread information to the public six (33.3%) said ”Yes”, five (27.8%) ”Partially”, and seven (38.9%) said ”No”.

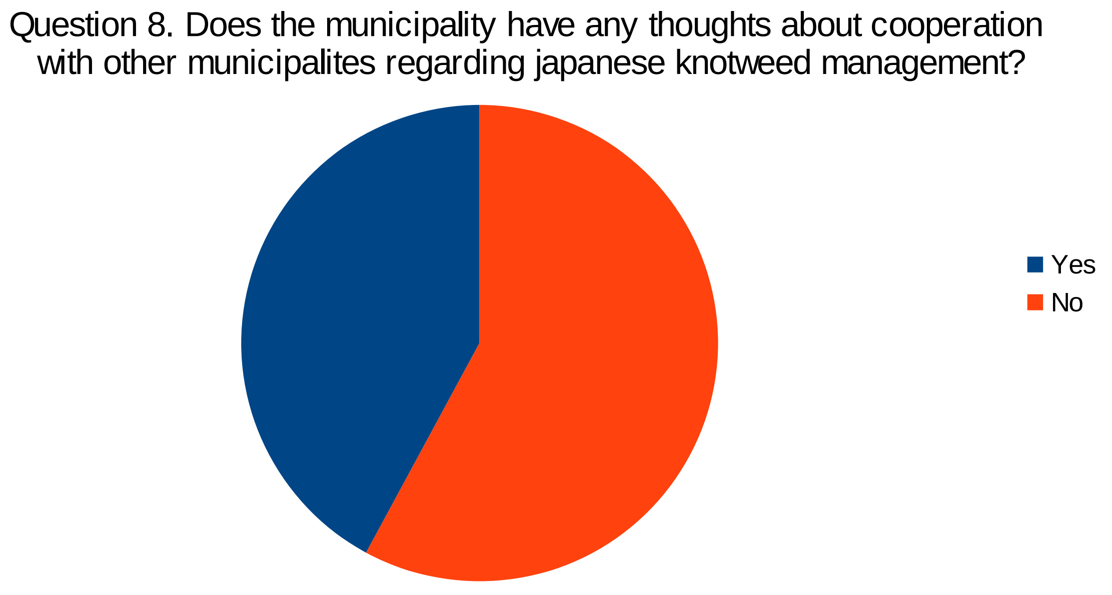

Figure 20. Number of municipalities considering cooperation regarding japanese knotweed management (N=19).

Eight municipalities (42.1%) were engaged in some form of cooperation with other municipalities in regards to knotweed management, though this was often in some informal way (such as exchange of information in networking groups) (Fig. 20). Eleven municipalities (58.1%) were not. Of the ones who answered that they did not cooperate with other municipalities regarding knotweed in some form, three (27.7%) mentioned that they would be open to this kind of cooperation. 19 municipalities answered Question 8.

3.3.5. Other relevant information

The interviews also yielded additional information besides the replies to the questions. One interviewee expressed concern for what would happen if japanese knotweed would be included in a national list of IAS. Their reasoning is that this could lead to more spreading of japanese knotweed, if people are required to remove it from their land without being given proper instructions on how to do so. One interviewee had observed seeding of japanese knotweed, but did not know if the seeds were viable.

3.4. Material for action plan

A compilation of material for an action plan regarding japanese knotweed in Ängelholm municipality can be found in Appendix D (in Swedish).

4. Discussion

4.1. Field survey of knotweeds in Ängelholm municipality

4.1.1. Survey results

The fact that this survey found 77 stands of knotweeds, even though the surveyed area only made up a small part of Ängelholm municipality, shows that there is a substantial knotweed problem within the municipality. This may negatively affect biodiversity (Aguilera *et al*., 2010; CABI, 2019; Gerber *et al*., 2008), as well as cause economic damage (Swedish Environmental Protection Agency, 2019g), for the municipality.

The two nature reserves where we found japanese knotweed were Hålebäckseröd and Magnarps strandängar. Since Hålebäckseröd is located on a narrow strip of land between two roads the fact that we found knotweed there is in line with current observations that spreading is common along infrastructure such as roads (Chmura *et al*., 2013). The other reserve in which we found knotweeds, Magnarps strandängar, is surrounded by residential areas. The nature reserves where we found no knotweeds are all removed from residential areas. This is in concurrence with the findings of Chmura *et al*. (2013) that knotweed is more common in man made habitats. The presence of knotweeds poses a potential threat to the natural values that can be found within these nature reserves (Aguilera *et al*., 2010; CABI, 2019; Gerber *et al*., 2008).

In Havsbaden we found a fairly high number of knotweed stands. Havsbaden is a residential area, and thus a man-made habitat. Therefore the same reasoning applies to Havsbaden as to Magnarps strandängar. Here there is a substantial risk of japanese knotweed causing economic damage, given that its rhizomes are able to pierce through pipes and building foundations (Swedish Environmental Protection Agency, 2019g).

We found 13 stands of knotweed along the surveyed stretch of Rönne stream. This is in line with previous studies that found that japanese knotweed often spreads along waterways (Gerber *et al*., 2008). However, I can see no clear pattern that would indicate that the knotweed has spread along the river from one specific source. The fact that stands can be divided into three groups of stands that are closer together is more of an indication that there either are multiple sources, or the spread does not follow the river. The surveyed stretch of the river was located in the town of Ängelholm, and thus surrounded by man-made habitats. It is therefore possible that the combined factors of man made habitat and dispersal along a waterway result in the amount of knotweed found (Chmura *et al*., 2013). Regardless, the stream is a habitat in which knotweeds are clearly able to thrive, and Ängelholm municipality should keep it under observation to try to prevent further spreading. Apart from potentially negative effects on biodiversity, knotweed rhizomes can erode soil adjacent to water (Koutika, 2011), which may cause problems with the river banks along Rönne stream.

While japanese knotweed on its own is unable to reproduce sexually in most of its introduced range, it is able to do so through hybridization with giant knotweed (CABI, 2019). While most of the stands were either japanese knotweed or Bohemian knotweed, some were giant knotweed. The presence of both giant knotweed and either japanese knotweed or the hybrid shows that there is at least a possibility of the plants reproducing sexually, by seeding. This would create opportunities for knotweeds to spread more easily (CABI, 2019), and thus possibly pose a larger threat to biodiversity. We found both variants together in the centre of town and in Havsbaden. Increasing temperature due to climate change increases the viability of knotweed seeds, and thus the likelihood of successful sexual reproduction of knotweeds, at the northern distribution limits (Groeneveld *et al*., 2014). Thus, the likelihood of knotweeds in Ängelholm reproducing sexually may potentially increase with climate warming.

Stand areas varied from very small to very large. This likely reflects the fact that there are both older established stands and newer ones in the municipality, showing that the knotweed is spreading. (It is important to note that we calculated these areas from the lengths of the longest and widest parts of the stand. They are thus not an accurate representation of stand area, but allow for comparison of relative stand size.)

4.1.2. Impact of environmental factors on findings

When looking at occurrences depending on land use type, the category ”Forest” had a high number of knotweed stands. This seems to go against the findings of Chmura *et al*. (2013), who found less knotweed stands in forests. This shows that knotweeds are able to establish in forests, meaning that forests can not be disregarded when searching for and managing the species. It is worth noting that all forested areas we surveyed were mostly or fully deciduous. The possibility for knotweeds to thrive in a mainly or fully coniferous forest needs to be further investigated.

It is however interesting to note that, while Chmura *et al*. (2013) found forests to have the smallest sized knotweed stands, forest was the category with the second largest average area for this study. This is largely because of one very large knotweed stand found in a forested area. The edge of this stand grows along the forest margin, sticking out into a grass field. It is known that japanese knotweed occurs around forest margins (Beerling *et al*., 1994), much like in this case. Knowing that japanese knotweed stands can share photoassimilates between shoots through its rhizomes (Aguilera *et al*., 2010), it is possible that the fact that part of the stand was growing outside the shade is what allowed it to grow so large. This is in line with studies on the photoassimilate transport by Price *et al*. (2002), and with other clonal plants such as the weed *Aegopodium podagraria*, that could support shaded shoots (Nilsson and D’Hertefeldt, 2008). The other stands found completely in the forest, with no shoots extending into open land, were much smaller.

One stand was found in the category ”Sand”. This stand was found on the sand dunes of the beach in the town of Ängelholm. According to Beerling *et al*. (1994) japanese knotweed growing on sand dunes are ”doubtless the relic of planting” (Beerling *et al*., 1994). However, I think this is unlikely considering its location. If the stand was not planted, this means that sand dunes can also not be disregarded in relation to knotweed invasion.

I had expected to, like Chmura *et al*. (2013), see a significant difference in stand area between different land use types, but found no such difference either for total or main stand area. This can perhaps be explained by the fact that we did not have the same categories of land use types. I divided our findings into the types of land we encountered in Ängelholm municipality, and thus am not able to directly compare my findings with any other study. To investigate this in more detail, a more standardized approach that compares different types of land use should be used.

There was a non-significant trend for difference in total stand density depending on land use type. Interestingly there was a negative correlation between number of stands and higher density for the Parkland category, but a positive one for Gravel. However, it is possible that the trend for Gravel is due to the fact that there were very few data points (six) in this category.

I expected to find a higher number of knotweed stands in areas with a higher level of human interference (Beerling *et al*., 1994; Chmura *et al*., 2013; Tschan, 2018). In my study this trend was not significant. Since the vast majority of the surveyed areas were in densely inhabited areas it can be expected that all of these had some level of human interference. While one can reasonably expect that, for example, a forested area in a residential area has a lower human interference level than a public park, it is possible that they both have a high enough level of interference that it makes little difference.

There was no difference in either area or density of stands of knotweed depending on human interference level. This may be explained by the same reasoning as for the number of stands, expecting more and larger stands with increased human interference. However, if taken at face value, these results indicate that knotweed stands do not have a harder time thriving in areas of lower human interference, but rather are less likely to spread there. This would be in line with current knowledge that human infrastructure and transport are known to be sources for dispersal of IAS (Tschan, 2018).

Percentage of tree canopy cover did not have a significant impact on any measured parameter of knotweeds, though there was a trend of lower main stand density at a higher percentage of canopy cover. I had expected canopy cover to have a negative effect on all categories, seeing how japanese knotweed is known to be negatively affected by even moderate shade (CABI, 2019) (though it does occur in shaded areas [Beerling *et al*., 1994]). This confirms that knotweed has the ability to grow even in the shade. The trend of lower main stand density in stronger shade indicates that shade does in fact have at least some negative effect on knotweed. This pattern could indicate the knotweed stand attempting to spread out, in order to find more sunlight. (It is worth noting that while there was often a distinction between a denser part of the stand and the rest of the stand, knotweed stands varied greatly in appearance, and it was often difficult to determine if and where there could be considered to be a main stand.)

4.1.3. Stand/density correlation

I found no correlation of any kind between stand area and stand density. This goes against the findings of Gerber *et al*. (2008), who found a negative correlation between the area of sites invaded by japanese knotweed and stand shoot density. It is possible that this is due to a difference in measuring methods. Gerber *et al*. (2008) counted shoot density within a stand, while I chose to roughly estimate shoot density by sight, due to time constraints. This is less precise, and may be less accurate. Gerber *et al*. (2008) also looked at area of patches of land infested with japanese knotweed rather than the area of knotweed stands. They also found that larger knotweed patches were less homogenous (i.e. more interspersed with other plant species) than smaller ones (Gerber *et al*., 2008), likely lowering knotweed density. Here the difference between ”stand” and ”patch” might make a significant difference. A patch of land infested with japanese knotweed may be more interspersed with other flora, open space, etc. the larger it is, while a cohesive stand of knotweed may remain as dense regardless of size.

4.1.4. Future studies

When choosing to include searching for knotweed stands reported to Artportalen I wanted to confirm that the knotweed stands reported were still there. I was also hoping to be able to compare the current size of the knotweed stands to the size given when reported to Artportalen, since this would show if and how much the stands had grown since the time that they were reported. Unfortunately, neither of these were entirely feasible. Because location on Artportalen is often not very specific (often reported as, for example, ”+/- 50m”) it was often impossible to say for certain that a reported knotweed stand was no longer present. For that reason I chose not to note when we were unable to find a reported stand. The relatively low resolution for site is unfortunate, as the continued presence of japanese knotweed, from being reported years ago to being surveyed for this project, would be a valuable measure of its persistence. I could also not compare the previously reported stand size to my measured area, since more often than not size was not reported to Artportalen. When size was reported it may very well have been measured in a way different from mine, giving a different estimate of the area.

The intention is that my compiled data for Ängelholm municipality will be possible to function as a baseline, against which future inventories can investigate if there has been a general increase or decrease of knotweeds in surveyed areas, as well as use my provided coordinates to see if individual stands of knotweed are still present. The municipality can also use the measured areas to see if stands have increased or decreased in size. Ängelholm municipality will be able to do this using my GIS files directly, and would not have to rely on Artportalen. A recent BSc-study performed in Hässleholm municipality showed that the municipality used its own detailed records to map control measures of IAS (Lindén, 2020). I would also encourage future studies to use the function “Invasiva arter” on the function “Invasiva arter” on the Artportalen website, where one can report sightings of invasive species (SLU Artdatabanken, 2020b).

4.2. Survey regarding japanese knotweed in Scania

Out of 33 municipalities contacted 24 (72,7%) agreed to participate in this survey. This shows that japanese knotweed is an issue that many municipalities are dealing with, and that there is a general willingness to help spread information about the topic. Most of these interviews were done by email. Generally (but not always) I received more detailed responses when conducting the interviews by phone. Depending on the focus of the study, future studies may want to concentrate on phone interviews, in order to receive detailed information on what methods municipalities are using, and their efficiency.

4.2.1. Japanese knotweed as a problem

While most municipalities were aware of japanese knotweed presence in their municipality only a smaller number felt that there was a large or fairly large problem. What constitutes a large problem may be subjective, but this nevertheless provides a measurement of the awareness and the perceived level of urgency of control of knotweed. Most municipalities became aware of their knotweed problem fairly recently (46,2% answering ”less than a year”), considering that it has been present in the wild in Sweden since the late 1800s to early 1900s. It is difficult to tell whether this is because knotweed has become a larger problem recently, or if it has become more well known in relation to the recent Swedish regulation (2018:1939 [Sveriges Riksdag, 2018]). Both of these alternatives are reasonably likely, considering that global warming is making the Swedish climate increasingly favorable for knotweed (Beerling, 1993), and that nature conservation and biodiversity are issues that have been given more attention in recent years (Swedish Environmental Protection Agency, 2019d).

4.2.2. Knotweed management

Several different methods have been tried by Scanian municipalities (with varying success), reflecting the fact that there is a large variety of methods available whose relative success is debated (Cottet *et al*., 2015). In order to more efficiently control japanese knotweed there would need to be some common consensus on which methods are most efficient and should be used during which circumstances.

Since municipalities have limited funds for knotweed management cost, cost efficiency is likely also taken into consideration when choosing a method. This is reflected in the fact that cutting was the most widely used method as well as the one found to be the most cost effective by Helsingborg municipality. 25% had tried covering, which will hopefully provide a stronger idea of this methods efficiency in the future (seeing how most interviewees thought it too early to tell how effective the treatment had been).

The fact that all municipalities with a significant known knotweed problem are either making management efforts or planning for such efforts shows that japanese knotweed is taken seriously as an invasive species. The municipalities who do not experience that they have any significant knotweed problem have an opportunity to take preventative measures to stop such a problem from arising. The most valuable precaution may be to keep the local public informed, to prevent both intentional and unintentional spreading of knotweed, as well as making it more likely that any present knotweed will be spotted.

4.2.3. Method efficiency

The one method reported to have been 100% efficient was a combination of cutting and herbicide treatment, which had only been tried by one municipality. The use of herbicides is regulated by Swedish law and may require a permit depending on the type of herbicide that is being used (Förordning (2014:425) om bekämpningsmedel, 3 kap. 7§ [Sveriges Riksdag, 2014]). Municipalities may also be reluctant to use herbicides because of the potential negative side effects, both for biodiversity and human health (Swedish Society for Nature Conservation, 2020). When considering whether or not to use herbicides municipalities will have to decide for each case if the expected negative effects of japanese knotweed outweigh the expected negative effects of herbicide treatment.

To maximize the effect of herbicides municipalities should make sure to take into account seasonal changes in rhizome source-sink relationships, and choose herbicides that are most efficient for any given time in the growing season (Jones *et al*., 2018). It is important that stands are treated properly, and with an appropriate dosage, to prevent the knotweed from developing resistance to the herbicide (Care4Nature, 2020).

While many municipalities used cutting as a management method only Helsingborg had observed an actual decrease in japanese knotweed as a result. Cutting is an easy way to temporarily remove knotweed stems, but requires long term efforts to actually reduce the mass of the root system (Soll, 2004). The only municipality that had seen a change in growth, Helsingborg, had cut four times per year for three years. The two that saw no change cut once per year and 2-3 times per year, respectively. This is consistent with the findings of Sieger and Merchant (1977), that additional cuttings lead to more decrease in biomass (Sieger and Merchant, 1977).

All municipalities that had tried covering, with enough time having passed to tell the results, found that it had not been effective. This is consistent with studies comparing different management methods (Soll, 2004; Jones *et al*., 2018). It seems that there is a lot of risk that the cover will tear, and the interview results also confirm that it is possible for the japanese knotweed to emerge on the side of the cover. The Helsingborg municipality employee I interviewed also expressed concern for potential negative effects of leaving plastic (the cover) in nature. This is something that future studies might look into.

All municipalities that had had time to see the effects of digging found that it, on its own, was inefficient. Municipalities had however seen good results when combining digging with either pulling or cutting. Helsingborg municipality saw an increase in new plants after digging. This is consistent with previous reports that digging increases sprouting of new plants from remaining rhizomes fragments (Michigan Natural Features Inventory, 2012; Care4Nature, 2020), and stem fragments (Soll 2004), when these are not removed. Since digging may be successful for very small stands (Michigan Natural Features Inventory, 2012) it could still be part of management efforts, but municipalities must then make sure to remove all knotweed fragments. It is clear that great caution needs to be taken, and the site needs to be monitored after the digging is finished.

Hot water treatment was found to be efficient but expensive by the only municipality that had tried it (Helsingborg). Thus, it may only be an option for municipalities where knotweed is not widespread. Since it did not eradicate knotweed completely for Helsingborg it may need to be combined with other methods.

Road salt and vinegar were both ineffective, and can thus be disregarded as treatment methods in the future.

4.2.4. Flow of information and cooperation regarding knotweed

Most interviewees stated that the local public of their municipality seems to be aware of japanese knotweed to some extent. Several correlate increasing awareness with recent media coverage. Hopefully this will have a positive impact on the situation, by making people more aware that japanese knotweed is an invasive species that should not be spread and, if possible, removed.

However, there is a risk that increased fear of japanese knotweed can lead to people unintentionally spreading it when trying to remove it (for example through insufficient digging or inappropriate transport of remains).

More than half of municipalities were at least partially trying to spread information about japanese knotweed to the public. This is a valuable effort that can help control IAS such as japanese knotweed (Tschan, 2018). It may help prevent people from inadvertently spreading knotweed, as well as incite more people to report knotweed sightings to the municipality.

Most municipalities were engaged in some form of cooperation with other municipalities (though often informal) in regards to knotweed management, and several others would be open to such cooperation. This is positive, since cooperation between agencies is important when combatting IAS (Wissman *et al*., 2015), and since japanese knotweed is a widespread problem in all of Scania (SLU Artdatabanken, 2019a).

4.2.5. Other relevant information

There was some concern that there could be potential negative consequences of a national list of IAS, in that it may cause people to inadvertently spread japanese knotweed when trying to remove it. However, the Swedish EPA has complied and provided information on what precaution needs to be taken when handling japanese knotweed (Swedish Environmental Protection Agency and Swedish Agency for Marine and Water Management, n.d). Once again the spread of information is important. Informing people about how to manage japanese knotweed without risking spreading it can help prevent these potential negative consequences from becoming reality.

Seeding of japanese knotweed has been observed in Scania. It is unclear whether or not these seeds are viable today, but global warming increases the risk that they will be in the future (Groeneveld *et al*., 2014). The ability to spread by seeding would make japanese knotweed able to spread faster, and make it more difficult to monitor and manage.

4.2.6. Future studies

This study provides a general overview of the knotweed situation in Scania, and what is being done to manage it. It can work as a baseline for management efforts in Ängelholm municipality. This kind of information is important, but is often missing when management efforts are planned. Follow up studies performed in a few years time could probably get a better idea of how successful the different methods tried by municipalities have been, since many municipalities answered that it was too early to tell.

5. Conclusion

Management of japanese knotweed in Sweden is a difficult problem that must be seen from a long term perspective. Controlling, not to speak of eradicating, japanese knotweed will require consistent management efforts for many years. Nevertheless it is important that these measures are taken, as (since global warming can be expected to continue to be an issue) the problem will otherwise continue to grow.

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8. Appendices

Appendix A. Maps of surveyed areas

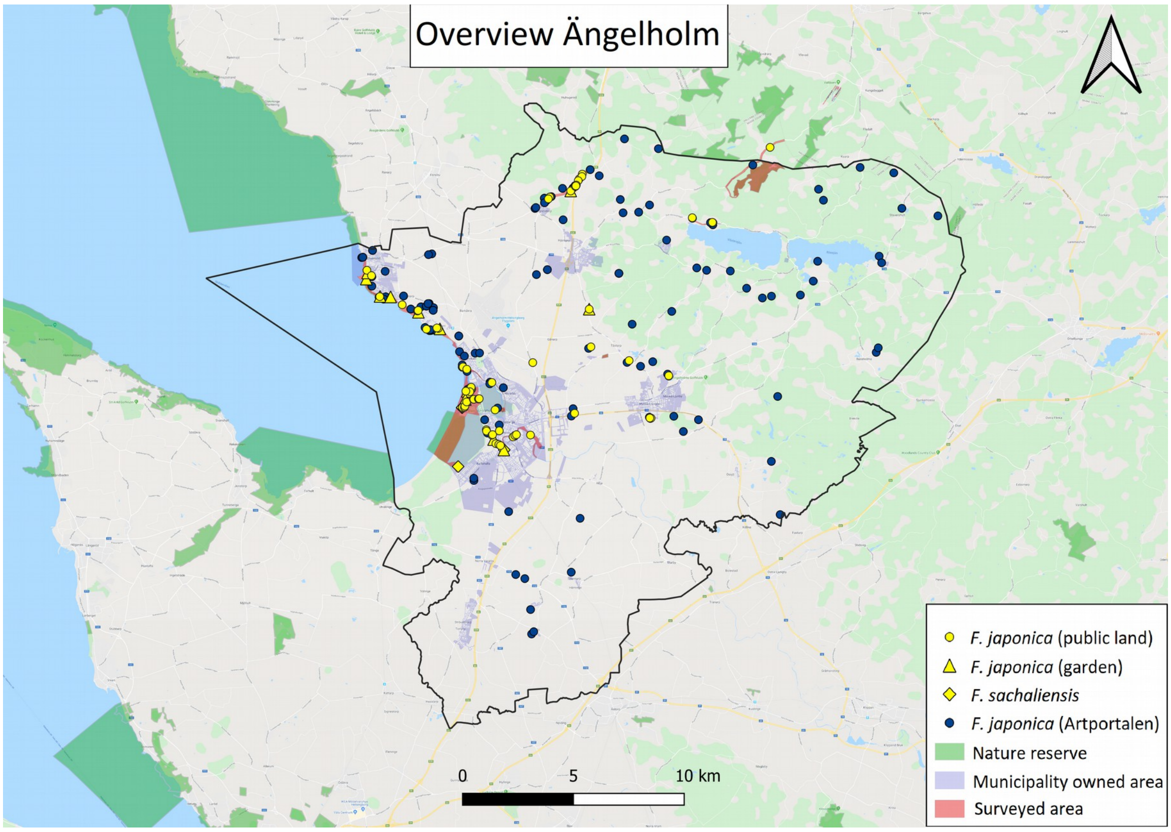


Figure A1. Overview of surveyed areas.

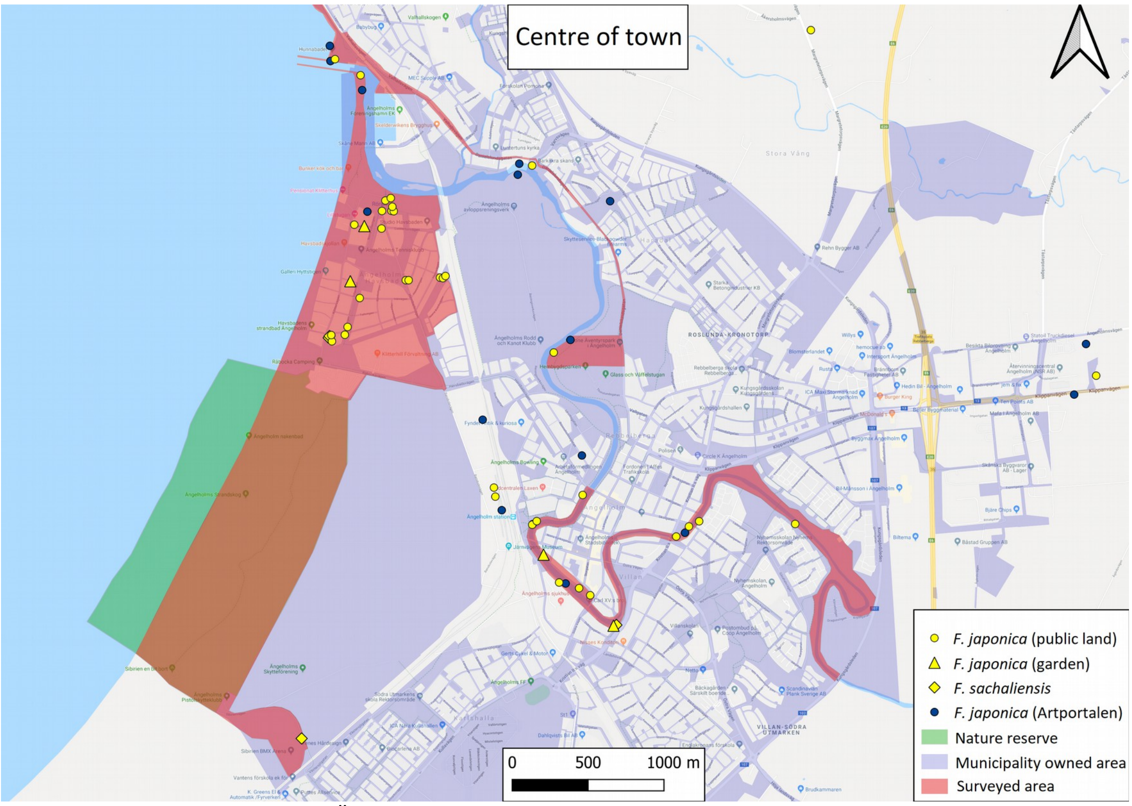


Figure A2. Survey results, central Ängelholm.

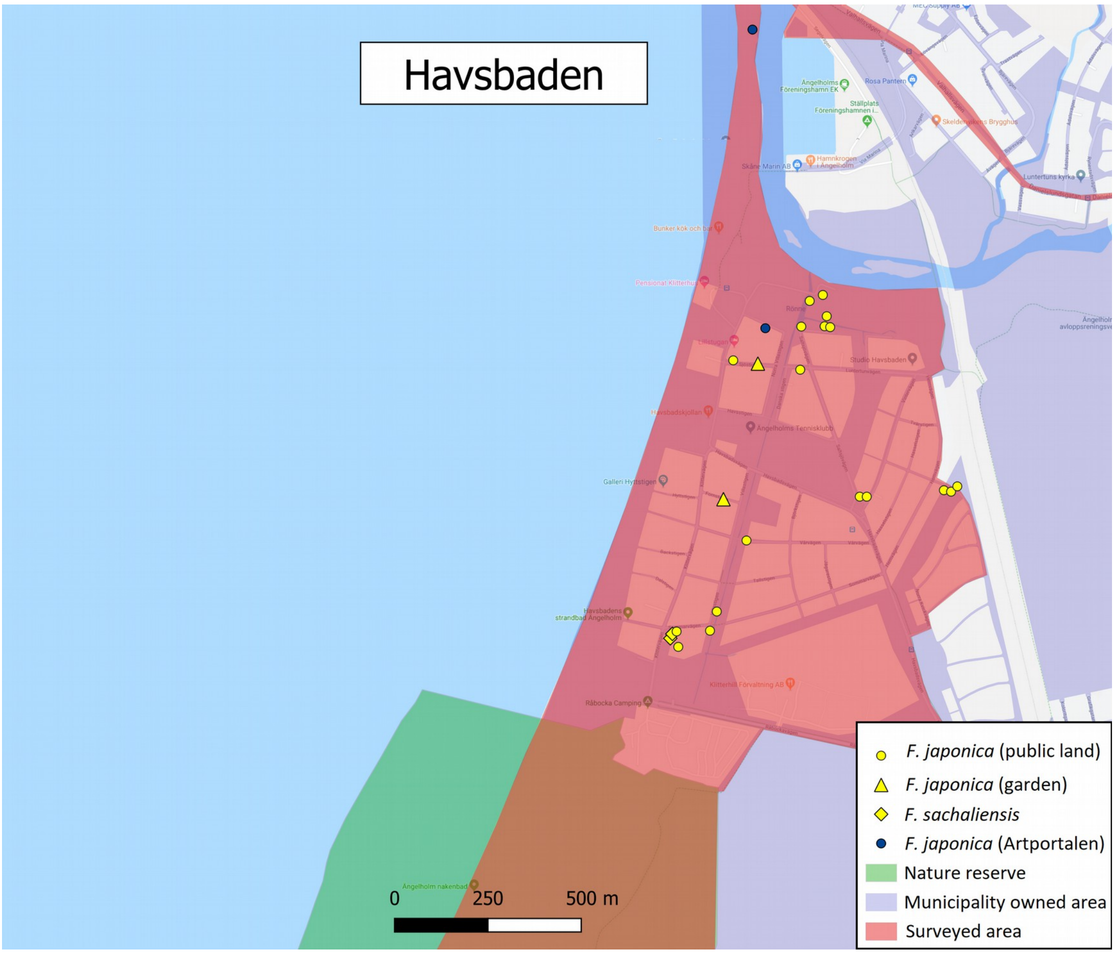


Figure A3. Survey results, areas with known large knotweed presence (Havsbaden).

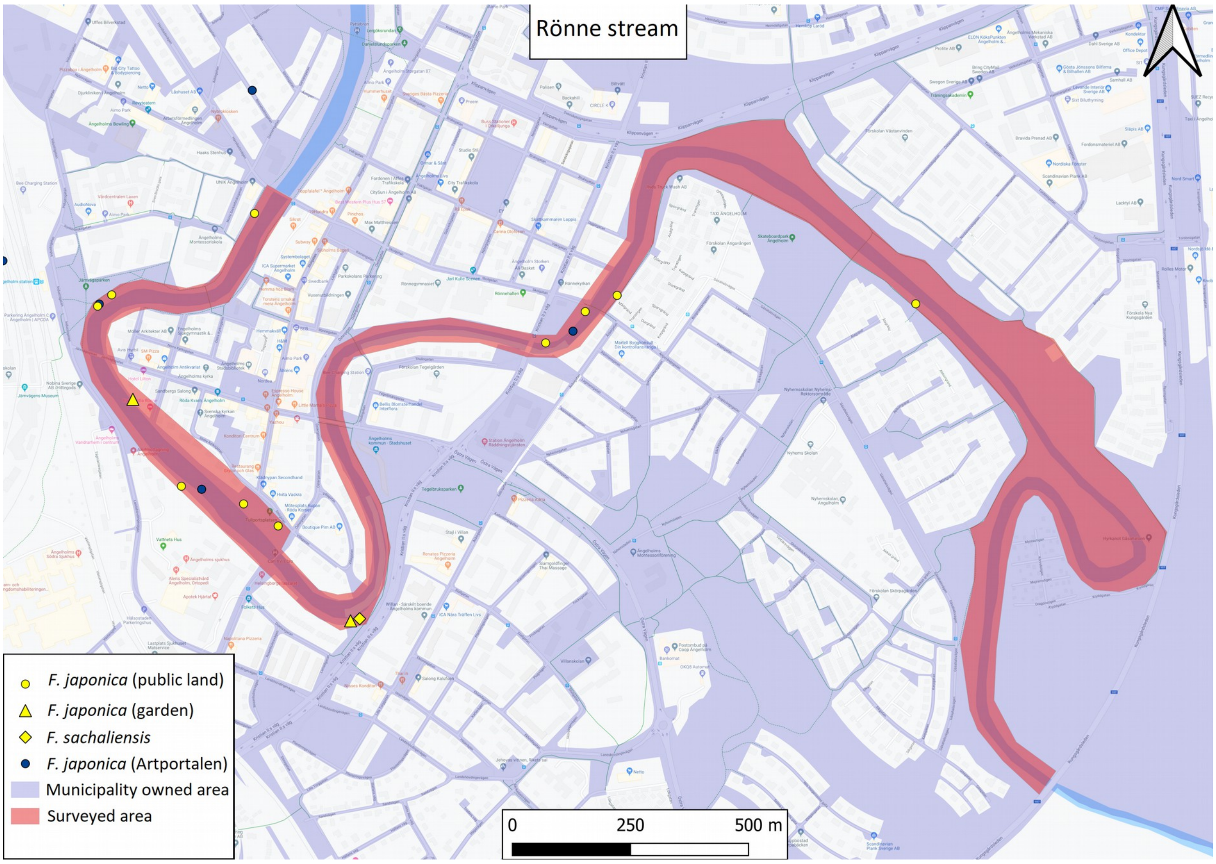


Figure A4. Survey results along part of Rönne stream. The water flows from right to left. The far left part of the stream runs through the center of Ängelholm, while the far right part runs through a residential area.

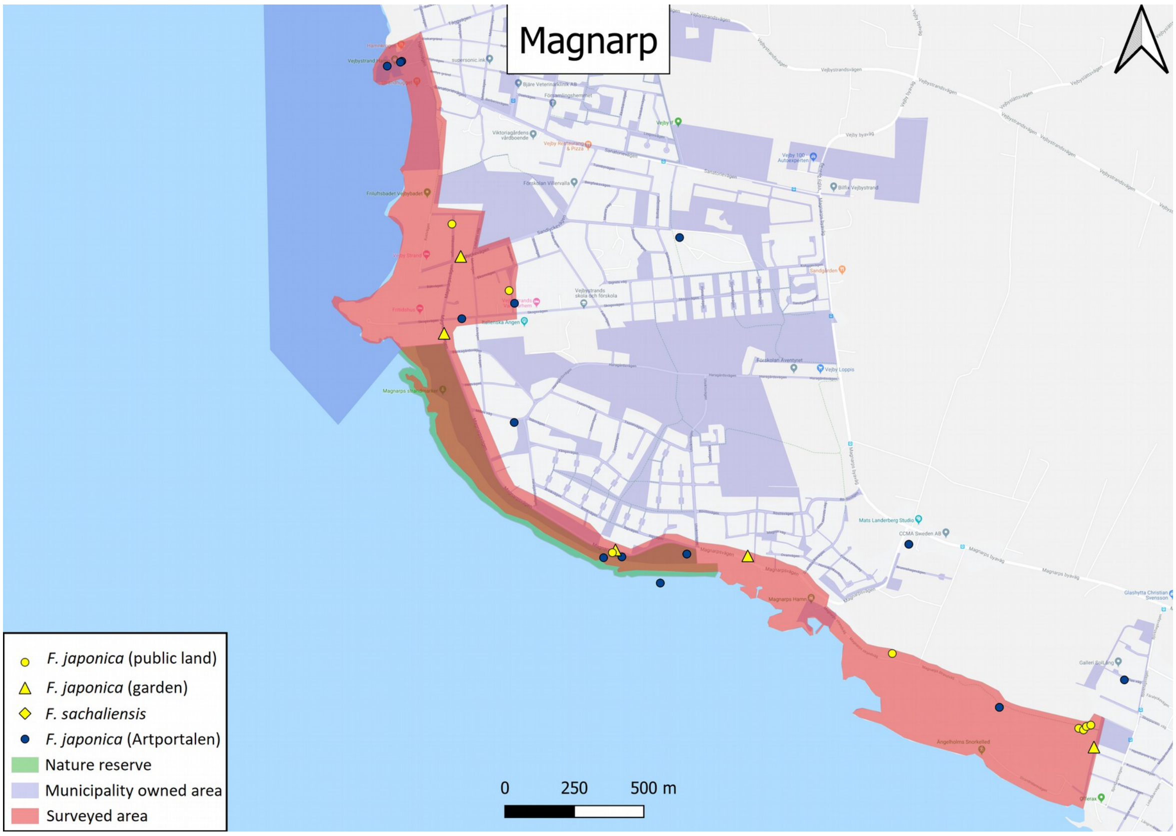


Figure A5. Survey results, Magnarp nature reserve with surroundings.

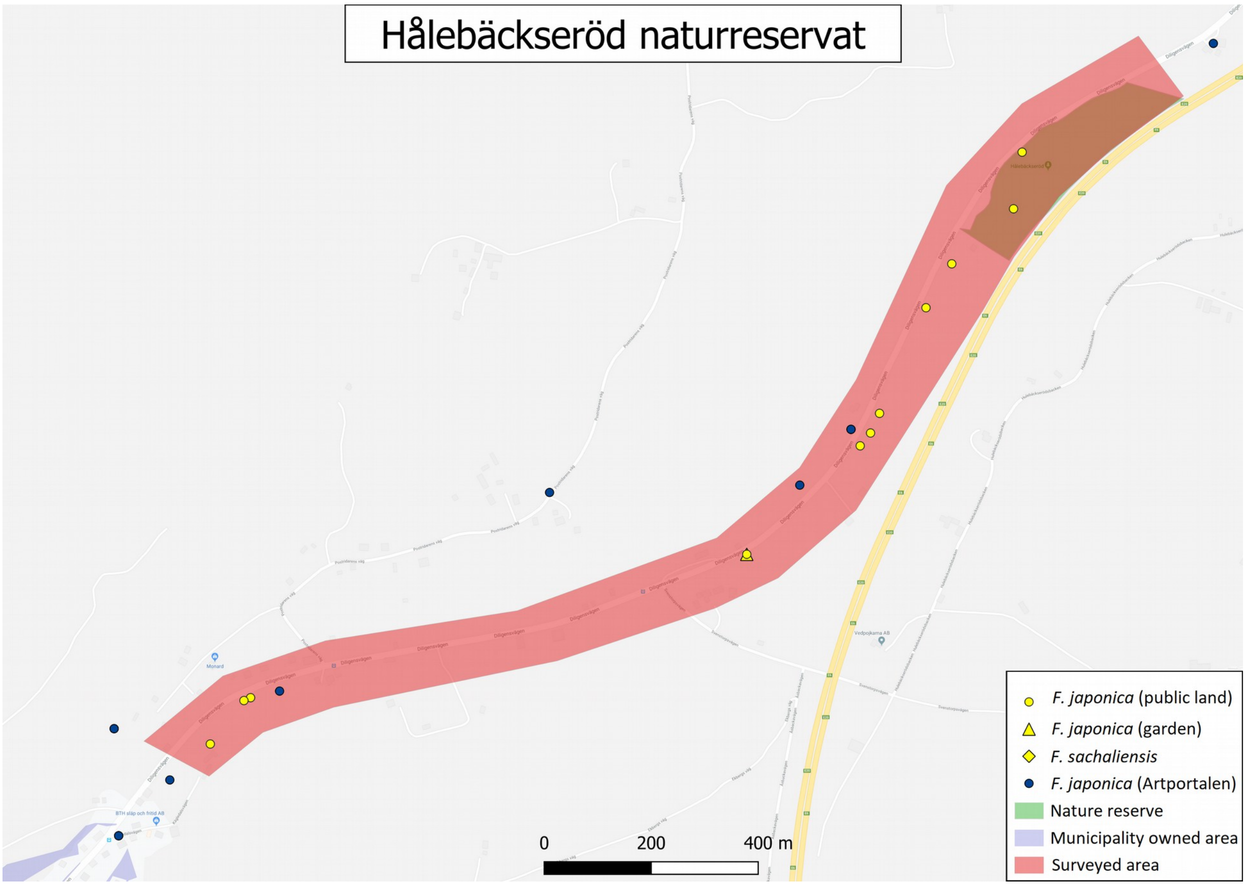


Figure A6. Survey results, Hålebäckseröd nature reserve with surroundings.

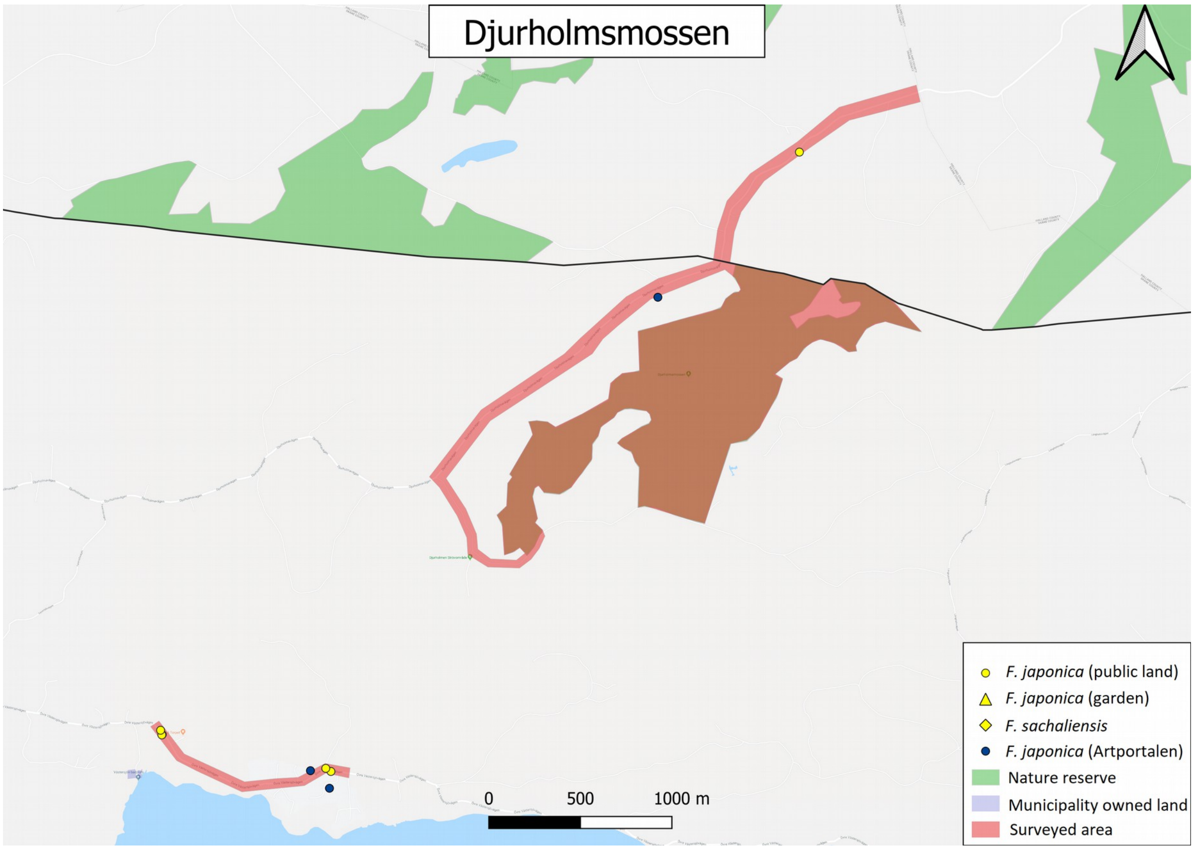


Figure A7. Survey results, Djurholmsmossen nature reserve with surroundings.

Appendix B. Statistical tests

Table B1. Statistical tests performed on knotweed survey data.

Test	Dependent	Factor
Kruskal-Wallis	Total stand area	Land use type
Kruskal-Wallis	Main stand area	Land use type
Kruskal-Wallis	Total stand density	Land use type
Kruskal-Wallis	Main stand density	Land use type
$\chi 2$	Occurrence	Canopy cover
Kruskal-Wallis	Total stand area	Canopy cover
Kruskal-Wallis	Main stand area	Canopy cover
Kruskal-Wallis	Total stand density	Canopy cover
Kruskal-Wallis	Main stand density	Canopy cover
$\chi 2$	Occurrence	Human interference level
Mann-Whitney U-test	Total stand area	Human interference level
Mann-Whitney U-test	Main stand area	Human interference level
Mann-Whitney U-test	Total stand density	Human interference level
Mann-Whitney U-test	Main stand density	Human interference level

Table B2. Statistical tests performed on knotweed survey data.

Test	Factor 1	Factor 2
Spearman Rank	Total stand area	Total stand density
Spearman Rank	Total stand area	Main stand density
Spearman Rank	Main stand area	Main stand density
Spearman Rank	Main stand area	Main stand density

Appendix C. Knotweed stand coordinates

Table C1. Survey results, with coordinates.

ID	Coordinates
1	56.2632652, 12.8402633
2	56.2632729, 12.8412698
3	56.2632513, 12.8415115
4	56.2635144, 12.8413623
5	56.2638812, 12.8406254
6	56.2640248, 12.8411940
7	56.262229, 12.840217
8	-
9	56.255774, 12.834602
10	56.25588,12.83469
11	56.255568,12.834946
12	56.255938, 12.834874
13	56.255957, 12.836317
14	56.256418,12.836611
15	56.258125,12.837895
16	56.262454, 12.837321
17	56.259178, 12.842789
18	56.259178, 12.843092
19	56.259333, 12.846426
20	56.259298, 12.846736
21	56.259426, 12.847007
22	56.254909, 12.858508
23	56.265945, 12.856211
24	56.241323, 12.859080
25	56.240988, 12.861204
26	56.240570, 12.862386
27	56.244040, 12.871519
28	56.244634, 12.872872
29	56.244941, 12.873961
30	56.244781, 12.884158
31	56.246931, 12.852156
32	56.246397, 12.852303

33	56.311073, 12.765607
34	56.308927, 12.768929
35	56.349679, 12.921664
36	56.347808, 12.919538
37	56.348730, 12.921404
38	56.347073, 12.918759
39	56.340541, 12.898347
40	56.340493 12.898146
41	56.339765, 12.897129
42	56.342943, 12.913342
43	56.344760, 12.916770
44	56.345304, 12.917355
45	56.344975, 12.917083
46	56.295444, 12.926720
47	56.280280, 12.927963
48	56.274755, 12.955656
49	56.251599, 12.971574
50	56.251652, 12.970634
51	56.268497, 12.984418
52	56.268667, 12.984381
53	56.253541, 12.916134
54	56.244736, 12.856220
55	56.244951, 12.856701
56	-
57	56.246494, 12.861579
58	56.360461, 13.0578206
59	56.3319821, 13.0015697
60	56.3319648, 13.0015304
61	56.3321922, 13.0014231
62	56.3301762, 13.0164609
63	56.3303290, 13.0160046
64	56.272227, 12.835272
65	56.2739415, 12.8858252
66	56.271278, 12.837985
67	56.287699, 12.817310
68	56.287884, 12.816348

69	56.287395, 12.808755
70	56.3004691, 12.7749341
71	56.296812, 12.793125
72	56.294798, 12.802042
73	56.294745, 12.802316
74	56.294856, 12.802487
75	-
76	56.294901, 12.802744
77	56.297213, 12.791203

Appendix D. Interview questionnaire

Form 1. Questions for municipality employees.

- How much of a problem would you say that the municipality has with japanese knotweed?
- For how long has the municipality been aware that the municipality has a japanese knotweed problem?
- What measures has the municipality taken to combat japanese knotweed?
- For how long has the municipality tried to combat japanese knotweed?
- How well have these measures worked?
- Does the general public within the municipality seem to be aware of japanese knotweed as an IAS?
- Is the municipality actively trying to spread knowledge regarding japanese knotweed to the general public?
- Does the municipality have any thoughts about cooperation with other municipalities regarding japanese knotweed management?

Bakgrund

Parkslide är en storväxt ört som härstammar från östra Asien. Den introducerades till Sverige som trädgårdsväxt (Naturvårdsverket, 2020), och förvildades under någon gång under sena 1800-talet till tidiga 1900-talet (SLU Artdatabanken, 2019). Den är listad av IUCN som en av de 100 mest invasiva arterna (IUCN, 2008). Parkslide påverkar biodiversiteten negativt där den bildar täta bestånd, och är därmed ett hot mot den biologiska mångfalden (SLU Artdatabanken, 2019). Arten kan effektivt konkurrera ut andra växter. Dess tidiga uppkomst under våren och höjd på 2,5 meter, samt det faktum att den lämnar en stor mängd vissnade stjälkar varje höst, gör att den lätt kan skugga andra växter (Aguilera *et al*., 2010).

En annan bidragande faktor till parkslides invasivitet är dess välutvecklade rhizomer, vilka tillåter växten att dela näringsämnen mellan skott (Aguilera *et al*., 2010). Dessa rhizomer kan dessutom tränga sig in i springor i husgrunder och asfalt (SLU Artdatabanken, 2019), och därigenom orsaka ekonomisk skada (Naturvårdsverket, 2020). De kan också erodera jord vid vattendrag, och därmed leda till översvämning (Koutika, 2011).

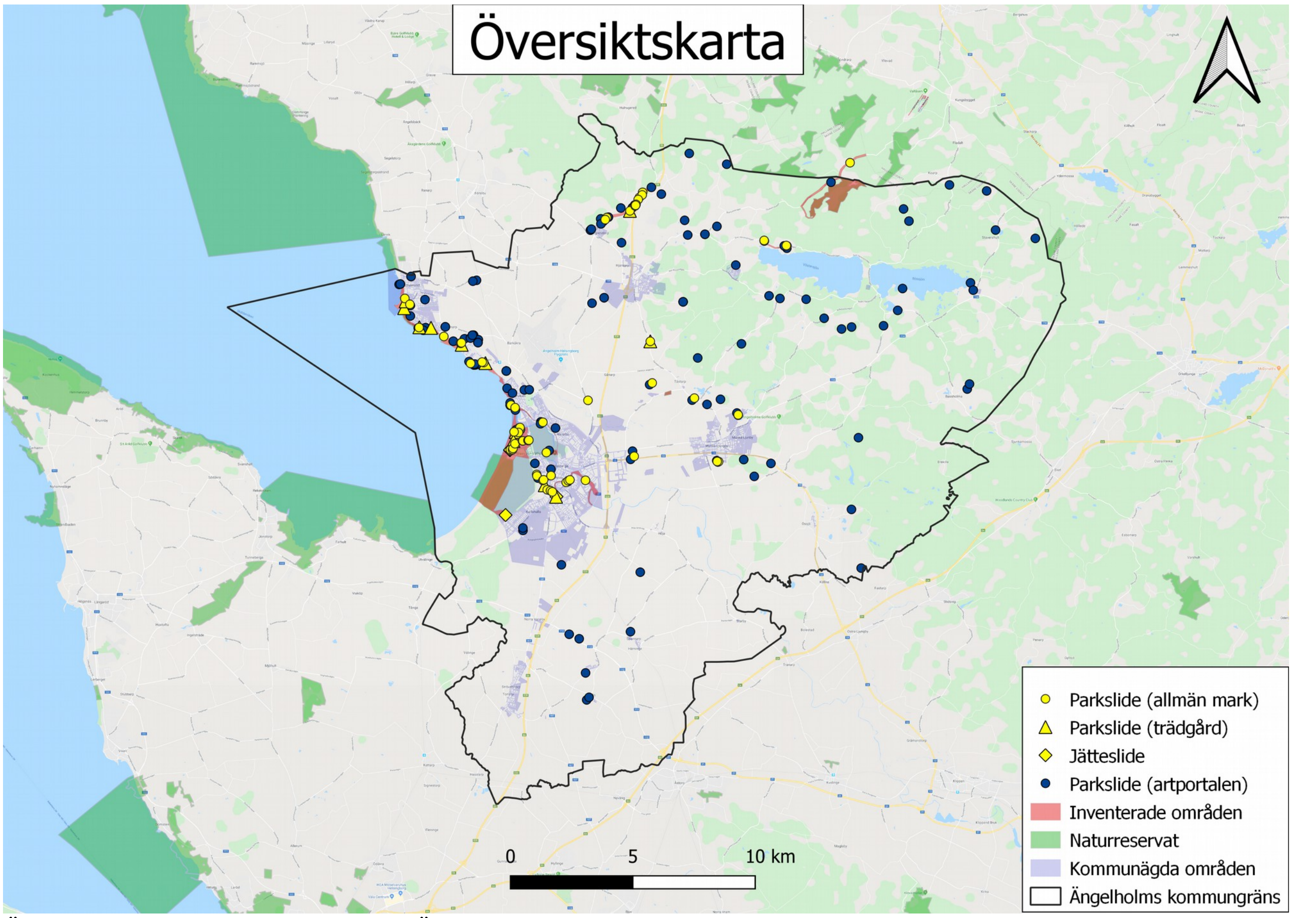
Utbredning

Parkslide trivs i öppna miljöer, särskilt i ruderatmarker (Wissman *et al*. 2015). Den sprids ofta längs med vattendrag (Gerber *et al*., 2008) och vägar (Chmura *et al*., 2013). Parkslide trivs i soliga miljöer, men kan också växa i skugga (CABI, 2019). Felaktig hantering av växtrester kan leda till spridning (Soll, 2004).

Parkslides utbredning i Ängelholms kommun

Parkslide finns på många platser i Ängelholms kommun, både i och utanför tätorter. Den växer bland annat i trädgårdar, längs med vägar, och längs med Rönne å. Kommunen har vidtagit olika åtgärder mot parkslide, såsom klippning och behandling med hetvatten, på flera platser.

Ett kartskikt med förekomster av parkslide i vissa inventerade områden har tillhandahållits till kommunen. Både förekomster på allmän mark och privat mark är angivna, tillsammans med förekomster rapporterade till Artportalen.



Översikt över parkslidets utbredning i Ängelholms kommun.

Bekämpning

Metoder

Det finns flera metoder som används för att bekämpa parkslide. Dessa kan vara mekaniska, kemiska, eller biologiska. Det går också att kombinera olika metoder.

Klippning

Klippning kan användas för att trötta ut rötterna hos parkslide, men detta kräver kontinuerligt arbete under lång tid (troligtvis flera decennier, om målet är att helt bli av med parkslidet). Arbetet bör påbörjas i april, när nya plantor börjar komma upp, och fortsätta fram till den första frosten. Det rekommenderas att klippa minst två gånger i månaden mellan april och augusti, och sedan minst en gång i månaden fram till den första frosten. Ju oftare bestånd slås ner, desto mer kan mängden parkslide förväntas minska. Nya plantor kan även dras upp. Det är viktigt att alla växtrester fraktas bort.

Grävning

Utgrävning kan vara en effektiv metod för mindre bestånd. Det är då mycket viktigt att allt växtmaterial avlägsnas, då det annars är mycket troligt att rotfragment (och möjligtvis också andra delar av växten) så små som 0,7 gram kommer att ge upphov till nya plantor. Det är möjligt att på detta sätt orsaka större förekomst av parkslide. Det är också viktigt att avlägsnad jord hanteras på säkert sätt, för att förhindra spridning av parkslide via växtfragment. Grävning kräver också uppsikt under flera år efteråt, för att säkerställa att parkslidet inte kommer tillbaka.

Täckning
Parkslide kan också täckas med markduk. Om möjligt kan 20 cm jord schaktas bort innan duken läggs ner, annars plattas marken bara till. Duken läggs sedan ned och täcks över med 20 cm jord. Duken ska sedan lämnas i flera decennier, i hopp om att rötterna tröttas ut och dör. Uppföljning krävs för att kontrollera att parkslidet inte kommer upp genom hål i duken, eller på sidorna. Flera studier och aktörer har funnit att täckning har varit oeffektivt, då just detta har hänt.

Hetvatten
Parkslide kan behandlas med hetvatten. Detta görs genom att ett spjut sticks ner i stjälken, genom vilket hetvattnet sprutas ner i skottet. Målet är att nå rötterna och koka sönder dessa. Behandling tar flera år.

Kemisk bekämpning
Av hänsyn till natur och miljö ska kemisk bekämpning undvikas så långt som möjligt och bara ske i undantagsfall då mekanisk bekämpning inte är möjligt. Kemisk bekämpning av parkslide sker, i de fall det är nödvändigt, med preparat baserade på ämnet glyfosat, dvs. roundup och liknande. Bekämpningsmetoden ska ske i enlighet med "Vägledning om tillämpning av Naturvårdsverkets föreskrifter (NFS 2015:2) om spridning och viss övrig hantering av växtskyddsmedel".

Vid behandling med kemiska bekämpningsmedel är det viktigt att ha rotsystemets source/sink-förhållande i åtanke. Mellan februari och maj är rotsystemet en källa till näringsämnen, vilket innebär att det då är lämpligt att använda bekämpningsmedel som skadar tillväxten. Från och med juni tar rötterna istället upp näringsämnen, och det är lämpligt att använda bekämpningsmedel som transporteras till rötterna (så som glyfosat-baserade bekämpningsmedel) (Jones *et al.*, 2018).

Biologisk kontroll
I Stobritannien har rundbladloppan *Aphalara itadori Shinji*, en skadeinsekt som lever på parkslide, släppts ut i ett försök att kontrollera växten.

Pågående arbete

Andra kommuners arbete med parkslide

24 av Skånes kommuner har varit i kontakt angående parkslide. Av dessa uppgav 15 (Höganäs, Ystad, Helsingborg, Lund, Simrishamn, Båstad, Malmö, Höör, Östra Göinge, Kävlinge, Vellinge, Hässleholm, Eslöv, Bromölla och Svalöv) att de arbetade med att bekämpa parkslide på kommunal mark. Vilka metoder som används varierar. Många kommuner klipper parkslidet. Flera (Höganäs, Helsingborg, Lund, Simrishamn, Malmö, Eslöv och Svalöv) har också täckt med markduk eller liknande. Höganäs kommun har besprutat flera bestånd med RoundUp. De flesta kommunerna tillhandahåller information till allmänheten angående parkslide, och flera försöker aktivt att sprida denna information.

Helsingborgs kommun har genomfört ett LONA-finansierat projekt där flera olika bekämpningsmetoder testades på parkslide. Kommunen fann att klippning var mest kostnadseffektivt. Behandling med hetvatten ledde till kraftigt minskad tillväxt, men var mycket dyrt. Grävning ledde till en ”explosion” av nya plantor, men gav ett lyckat slutresultat tack vare uppgrävning för hand av dessa nya plantor. Täckning med markduk misslyckades, då parkslidet kom upp genom hål i duken samt på sidan. Kommunen försökte också behandla parkslidet med vägsalt, vilket inte gav någon effekt.

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