Rapport **Natuurpunt Studie**

Impact monitoring of the eradication of IAS on pollinators

during the LIFE DUNIAS project

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during the
LIFE DUNIAS project.

Report of the monitoring before IAS eradication.

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Summary

As part of the LIFE DUNIAS project, a monitoring scheme has been established to examine how removing invasive plants from our coastal dunes affects pollinators and other insects. This study aims to investigate the species diversity of various insects before and after the removal of invasive plants. It is also an important objective for this project to observe floral activity on both invasive and non-invasive plants.

During 2022-2023, 11 dune areas were monitored for wild bees and hoverflies and 8 areas for the presence of grasshoppers and butterflies. In 2025-2026, after the removal of the IAS, the same areas will be monitored again.

During the pollinator monitoring scheme, 3610 observations were made: 2867 of wild bees and 743 of hoverflies. A total of 120 species of wild bees and 40 species of hoverflies were identified. The knowledge of the diversity and distribution of pollinators in our coastal dune areas has greatly improved thanks to this scheme.

Through data analysis on all trustworthy observations, we have been able to compile a list of bees that we consider to be typical wild bees for coastal areas. During our observations, we discovered the majority of the typical coastal bees, but not all of them. Only a few species, such as *Osmia spinulosa, Lasioglossum calceatum, Megachile leachella, Andrena florea,* and *Colletes fodiens*, were found in most areas.

From all the investigated nature reserves, both the Doornpanne (71 species) and the provincial domain of Raversyde (70 species) score the best on species richness. The frontal dunes of Mariakerke (43 species) have the lowest number of species. The Doornpanne not only scores well when it comes to overall species variety, it's also home to the largest number (22 species) of typical coastal dune species.

The monitoring scheme for grasshoppers and butterflies was less intensive than with wild bees, and the amount of data was also smaller. Therefore, in this report, we will solely provide a brief overview of the species identified. However, a comprehensive analysis of these species will be conducted after the second round of monitoring when additional data becomes available.

During our monitoring, we observed 11 different species of grasshoppers. Three of these species are regarded as typical coastal species, as they prefer dry areas with low and open vegetation, such as dunes and heathlands. The typical coastal dunes species were found in nearly all investigated locations.

Additionally, 22 distinct species of butterflies were observed. Three of these species are regarded as typical coastal species, as they prefer dunes or open pioneer vegetation, as well as barren, dry, warm grasslands with bare soil as their habitat. Out of the three typical coastal butterflies, only *Aricia agestis* was observed in all locations. The remaining two species were exclusively discovered in the West coast region, with *Issoria lathonia* being found exclusively in Doornpanne.

One of the most important parts of the monitoring was observing wild bees and hoverflies visit flowers. The importance of invasive plant species for pollinators was determined by observing floral visits on them.

Despite the significant threat posed by invasive plant species to our coastal dunes, numerous of the species that pose a concern are fortunately only encountered occasionally or in limited quantities in a few regions. It is subsequently virtually impracticable for pollinators to develop a dependency on them.

We observed 17 species from the red list, and we were able to observe floral visits from all but one species (*Lasioglossum tarsatum*). 15 percent of these floral visits were on invasive plant species. The invasive plant that was visited the most was *Senecio inaequidens*, a plant that won't be removed structurally during the LIFE DUNIAS project.

Several pollinators have visited invasive plant species, especially *Rosa rugosa* and *S. inaequidens*. The pollinators that are most frequently observed foraging on *R. rugosa* include *Bombus terrestris-gr, Apis mellifera,* and *Eristalis tenax*. These are very common and widespread, and all are opportunists who visit a great variety of plants searching for food. During our research, they were observed on native plants more than on invasive plants.

The eradication of *R. rugosa*, especially in the short term, will remove a significant food source for these pollinators. However, numerous alternative sources of nectar and pollen are readily available within the nature reserves and the surrounding gardens. Furthermore, the removal of *R. rugosa* will benefit numerous plants currently visited by these bees, thereby enlarging their area of cultivation.

Our conclusion is that, as the majority of pollinators are found on native plants, it is most likely that the removal of IAS will have a limited impact, particularly on the unique or endangered species found in our coastal dune areas.

1 Project description

A common approach is needed to reverse the negative trend in the decline of pollinators. From the 419 species of wild bees recorded from Belgium, about 12 percent have disappeared, and another third are endangered to different degrees. The rest of the species are considered to be of the least conservation concern or too poorly known to determine their conservation status (Drossart et al. 2019). The decline in the number of hoverflies (Syrphidae, Diptera) in Flanders is accelerating, and more than 50 out of the estimated 320 species are under threat (Van de Meutter et al. 2021). In Flanders, 28% of the macro-moths (Veraghtert et al. 2023) and 52% of the butterflies (Maes et al. 2021) are under threat.

A Belgian national strategy for pollinators (a plan of action for pollinators from 2021 to 2030) was developed (webref 1). Its main objectives are being drawn based on the conclusions from Interreg SAPOLL (Folschweiler et al. 2020) and other related projects. The primary objectives of this initiative are to establish a comprehensive monitoring system that encompasses the changes in the distribution and abundance of all pollinator species throughout the country. Additionally, the objective is to reduce the number of wild pollinator species that exhibit a negative trend in population size and distribution by 50%, while simultaneously enhancing the number of species that exhibit a positive trend by 50% compared to 2019.

LIFE DUNIAS will contribute not only to the Belgian national strategy for pollinators, but also to the European Pollinators Initiative (webref 2), where IAS are mentioned as one of the causes of pollinator decline. As a part of the DUNIAS team, partner Natuurpunt Studie will be able to continue its experience with the monitoring of pollinators and awareness raising campaigns built during the Interreg SAPOLL project.

Partner Natuurpunt Studie vzw possesses extensive expertise in the inventory and monitoring of species and is responsible for monitoring pollinators and red list insects associated with dune habitat types during LIFE DUNIAS. This monitoring will encompass a comprehensive assessment of the locations where nature restoration is being carried out on wild bees, butterflies, and grasshoppers, as well as some locally unique insect species, such as *Bembix rostrata*.

Red list bee species like *Colletes fodiens, Megachile maritima, Coelioxys conoideus, Lasioglossum prasinum* and *Sphecodes scabricollis* could benefit from the proposed works and are expected to be found during the inventories. In a selection of dune areas where IAS will be removed and where there is no knowledge of the occurrence of wild bees, a T0 monitoring before the eradication works has been performed to see which wild bee species occur. At the end of the project, a monitoring will be performed for IAS clusters of at least 400 square meters, as this is the minimum surface used for the evaluation of habitat quality in Flanders according to Article 17 of the Habitats Directive.

The presence of a mosaic of dune habitats is crucial for bees: open dunes (habitat type 2120) to nest for real dune specialists, flowery dune grasslands (habitat type 2130*) and wet dune habitats. We expect a positive effect of the removal of IAS on pollinators and insects dependent on dune habitats.

2 Material and methods

A monitoring scheme has been set up to see how removing invasive plants from our coastal dunes affects pollinators and other insects. This study aims to investigate the species diversity of various insects before and after the removal of invasive plants. It is also an important objective for this project to observe floral activity on both invasive and non-invasive plants.

Figure 1: LIFE DUNIAS project locations (blue), visited locations (pink)

The majority of the time was spent observing wild bees and hoverflies. These important pollinators were monitored in 11 different locations. In order to maximize the chances of observing pollinator activity, each location was visited four times on a day with good weather during the same year.

Wild bees and hoverflies	**April**	**May**	**June**	**July**
2022				
Willemspark x	x	x	x	x
frontal dunes of Wenduine	x	x	x	x
2023				
Fonteintjes x	x	x	x	x
frontal dunes of Bredene	x	x	x	x
frontal dunes of Mariakerke x	x	x	x	x
Raversyde x	x	x	x	x
frontal dunes of Middelkerke x	x	x	x	x
Warandedunes x	x	x	x	x
Simlidunes x	x	x	x	x
Doornpanne x	x	x	x	x
Houtsaegherdunes x	x	x	x	x

Table 1: Locations monitored for wild bees and hoverflies.

Additionally, a surveillance program was established for grasshoppers, butterflies, and other locally uncommon species, such as the digging wasp *Bembix rostrata*. In this case, 8 different locations were monitored in July and August of the same year.

Butterflies, grasshoppers and other insects	**July**	**August**
2022		
frontal dunes of Wenduine	x	x
frontal dunes of De Haan	x	x
2023		
frontal dunes of Bredene	x	x
frontal dunes of Middelkerke	x	x

Butterflies, grasshoppers and other insects	July	August
Warandedunes	x	x
Simlidunes	x	x
Doornpanne	x	x
Houtsaegherdunes	x	x

Table 2: Locations monitored for butterflies, grasshoppers and other insects

During each visit, the field worker walks, in most cases, a similar route. Each visit lasted on average 2.5 hours. However, several of our coastal dunes are too large to be monitored completely within the limited time available. A route was chosen that would pass through the most interesting areas for insects, as well as areas where many invasive plants would grow. The incomplete historical data available for certain locations made it difficult to pinpoint all the hot spots for invasive plants when plotting the route, since the mapping of invasive plants only began later in the year for some locations.

Observation of insects was accomplished through sight or by catching them with a net. It is also possible to recognize grasshoppers by their unique sound. When insects were not able to be identified in the field, they are collected for further investigation.

The ObsMapp app was used to record all observations on-site, with route tracking enabled. Whenever pollinators were observed visiting a flower, the plant they were observed on was also noted in the observation. During the monitoring of pollinators, all wild bees were recorded, as well as most hoverflies. After each day, all observations were uploaded to the www.waarnemingen.be website.

2.1 Study sites

2.1.1 East coast.

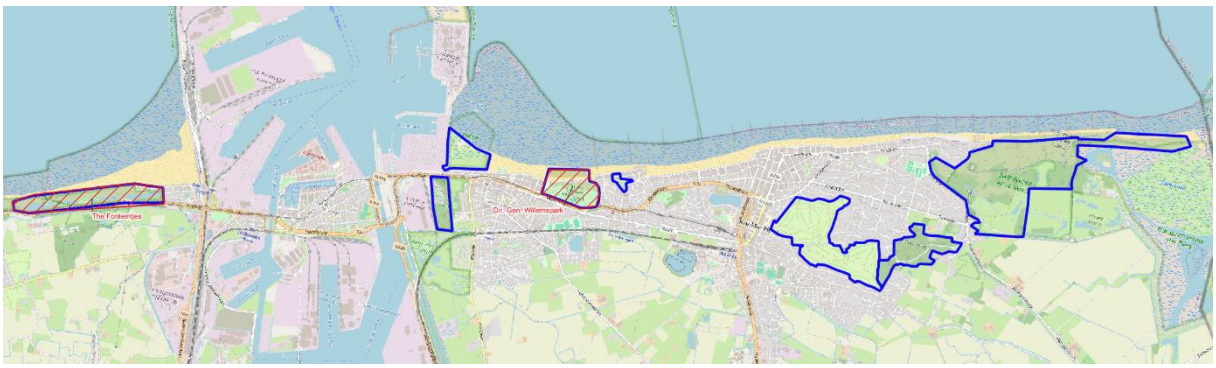

Figure 2: Visited locations in the east coast (pink). From the right to the left: Dir. Gen. Willemspark and the Fonteintjes

2.1.1.1 Dir. Generaal Willemspark

Size: 19ha.

Description: The Dir. Generaal Willemspark is located in the village of Knokke-Heist. The park is surrounded by buildings on all sides, except for the seaside.

In 1909, tennis courts were built here. At that time, trees were planted in this dune strip in order to strengthen the dunes surrounding the tennis court.

During both world wars, the Dir. Generaal Willemspark was used for military purposes, and several gun batteries and bunkers were constructed there. The park was redesigned after the wars ended, and

these facilities were dismantled. In 1980, a public swimming pool was constructed in the park. The pool has been demolished and replaced by a playing field, but the tennis courts with the forest surrounding them remain.

More than half of the park is currently forested, with many of the trees being non-native species. The other part of the park is mostly composed of shifting dunes with *Ammophila arenaria* (H2120) and sea-buckthorn scrub (H2160). Locally small patches of moss dune (H2130) are present.

IAS presence: In the forested areas, few IAS were present. In some locations, *Symphoricarpos albus* was planted in the past. Numerous IAS are present in the open dunes of the park, with *Rosa rugosa* being the dominant species.

Figure 3: Location of IAS (green) in the Dir. Generaal Willemspark and route taken (dotted line) during pollinator observations.

2.1.1.2 Fonteintjes

Size: 40ha
Location: East coast
Description: The Fonteintjes is an elongated dune strip with frontal dunes with marram grass (H2120), dune lakes and humid dune grasslands (H2190) and some sea-buckthorn thicket (H2160). The area is situated within a long, narrow stretch between Blankenberge and Zeebrugge, the sea, and the coastal road.

The Fonteintjes originated when the sea broke through the dunes and was halted by the Graaf Jansdijk. Excavations to strengthen the Graaf Jansdijk led to the formation of deeper ponds. These ponds contain freshwater just 100 meters from the sea. Rainwater is stored beneath the dunes, forming a freshwater lens that displaces the salty seawater. A fishing club is located in the east part of the domain.

IAS prescene: *Rosa rugosa* has a prominent presence within this natural reserve, especially near the various walking paths. But *Elaeagnus angustifolia* can also be found on the slopes near the dune lakes.

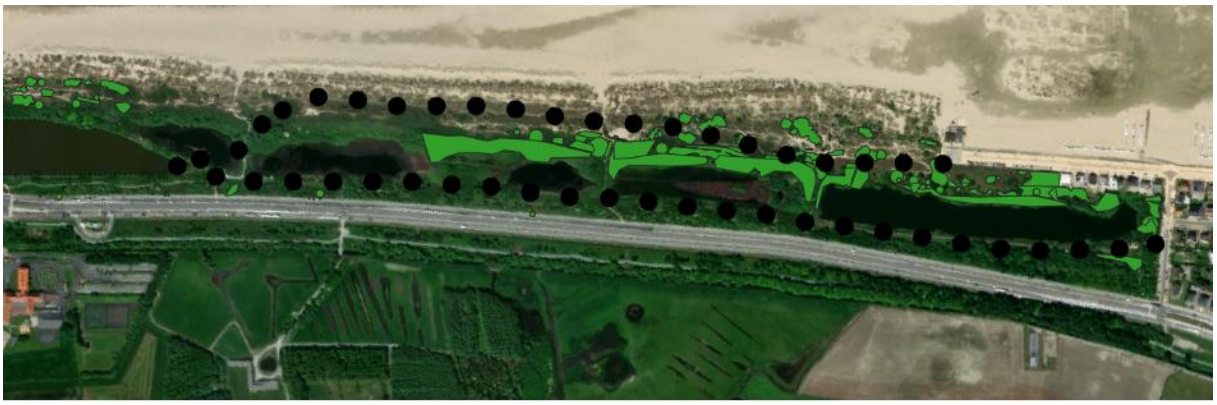

Figure 4: Location of IAS (green) in the Fonteintjes and route taken (dotted line) during pollinator observations.

2.1.2 Midcoast

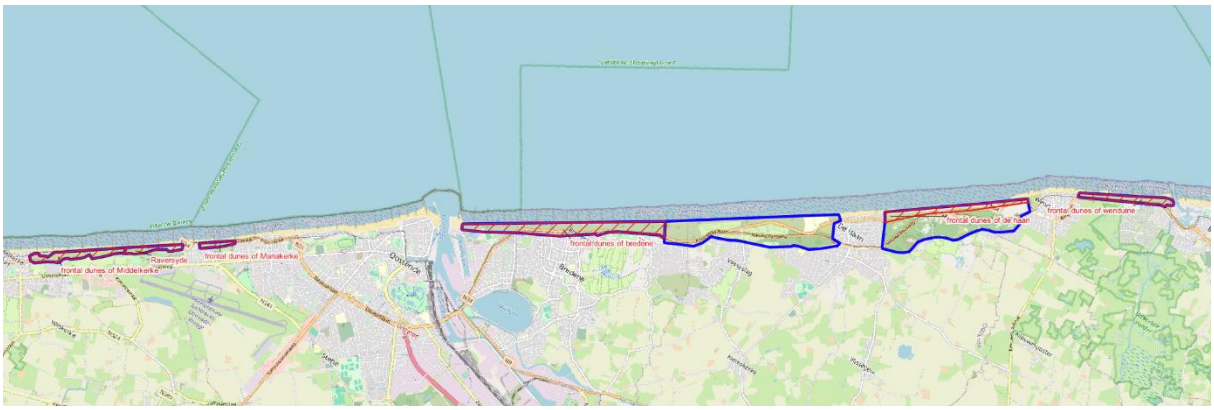

Figure 5: Visited locations in the midcoast (pink). From the right to the left: frontal dunes of Wenduine, frontal dunes of De Haan, frontal dunes of Bredene, frontal dunes of Mariakerke, Raversyde and frontal dunes of Middelkerke.

2.1.2.1 The frontal dunes of Wenduine

Size: 26.5ha
Location: Midcoast
Description: This dune strip is a narrow stretch between Blankenberge and Wenduine, the sea and the coastal road. This frontal dune strip has a length of 2 km. The hinterland of this dune is predominantly comprised of agricultural land and recreational area.

The seaside of this dune strip is composed of shifting dunes with *Ammophila arenaria*. The less exposed land side is dominated by fixed sand dunes and dune bushes. There is a paved walking path in this sheltered area.

IAS presence: On both sides of the walking path, many IAS can be found. The main IAS are *Ligustrum ovalifolium* and *Elaeagnus angustifolia*, but also *Rosa rugosa* and *Tamarix spec*. can be found on the west side.

A limited number of IAS have been observed on the coastline, with the notable exception of the region situated in the east of the dunes. *Rosa rugosa* is found here in several locations, together with *Lycium barbarum*.

Figure 6: Location of IAS (green) in the frontal dunes of Wenduine and route taken (dotted line) during pollinator observations.

2.1.2.2 The dune forests of De Haan

Size: 152ha

Location: Midcoast

Description: The dune forests of De Haan stretch from the lighthouse 'the Vosseslag' to Wenduine. The area consists of three separate parts. The nature reserves of De Zandpanne and De Kijkuit adjoin these, creating a large and diverse dune area with forests, dune scrub, and dune grasslands. The city center of De Haan divides this area into two parts.

After the 11th century, the dunes in De Haan were formed through extensive sand drifting on the beach. The transition from high dunes to the polders, also called the inland dune edge, was already planted with elms in the late 18th to early 19th century. The purpose of these forest plantations was to prevent the disappearance of the rich agricultural land in the polders beneath the inland drifting dune sand.

These dunes have seen numerous forest plantations with varying degrees of success since then. Due to poor maintenance, opposition from local farmers, drought, and World War I, most of these plantations failed. The forest has been replanted after 1922, and this time it has survived.

IAS presence: This natural reserve is home to large patches of *Rosa rugosa*, especially along the roadside. *Ligustrum ovalifolium, Elaeagnus angustifolia, Robinia pseudoacacia*, and *Colutea arborescens* also have a significant presence in the roadside areas.

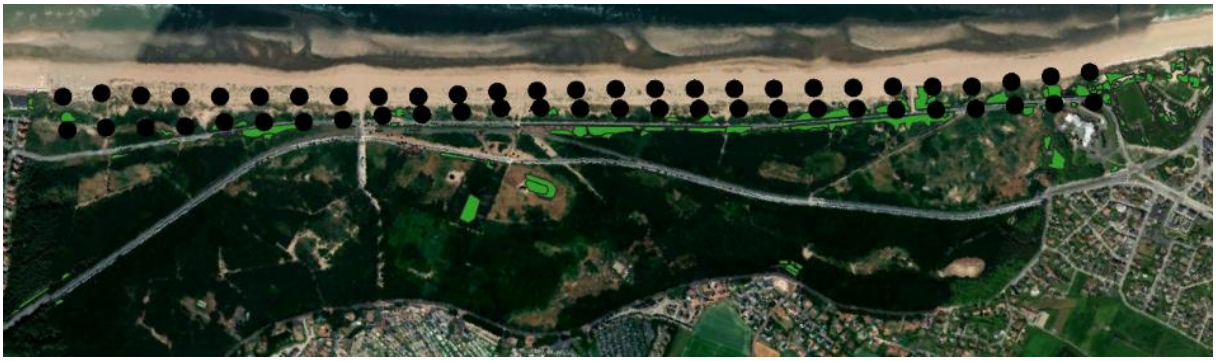

Figure 7: Location of IAS (green) and route taken (dotted line) during pollinator observations.

2.1.2.3 The frontal dunes of Bredene

Size: 101ha

Location: Midcoast

Description: This frontal dune strip is located in Bredene and forms part of the coastal dunes that stretch between De Haan and Oostende. This dune is home to the Spanjaardduin, one of the highest coastal dunes in the country.

The name comes from the Spanish use of it as an observation point during the siege of Oostende. King Leopold II had ambitious plans for this region, which included the establishment of walking paths and a chalet at the summit. However, this didn't happen.

He was successful in creating a golf course in this area. During World War I and World War II, there were many bunkers along the coast. The golf course was destroyed due to intense fighting, and nature reclaimed the land.

Shifting dunes have emerged at the seaside. On the sheltered landside, the dune has become fixed and is now dominated by *Hippophae rhamnoides*, a dune shrub.

IAS presence: *Ligustrum ovalifolium* has been planted along the central pathway. R*osa rugosa* is found in most parts of this area, on the west side, accompanied by several patches of *Lycium barbarum* and *Tamarix* spec.

Figure 8: Location of IAS (green) in the frontal dunes of Bredene and route taken (dotted line) during pollinator observations.

2.1.2.4 The frontal dunes of Mariakerke

Size: 8ha
Location: Midcoast
Description: This frontal dune strip is on the coast of Mariakerke, a sub municipality of Oostende. The dune strip and a small area of polder are surrounded by buildings, as well as the airport of Oostende. Therefore, the nature reserve is somewhat isolated. This reserve contains remnants of various bunkers from both world wars.

Some of the remaining shifting dunes are subject to fixation, and large parts of the dune area have become dune scrub.

IAS presence: The presence of IAS in this dune region is problematic, as large areas are dominated by either *Lycium barbarum* or *Rosa rugosa*.

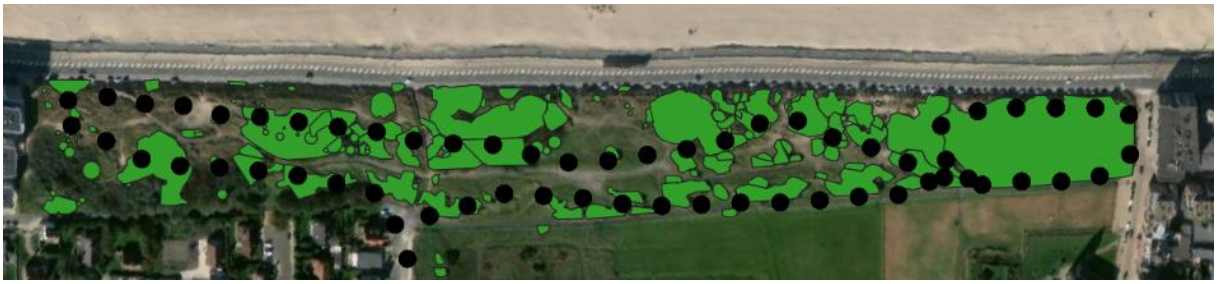

Figure 9: Location of IAS (green) in the frontal dunes of Mariakerke and route taken (dotted line) during pollinator observations.

2.1.2.5 Raversyde

Size: 15ha
Location: Midcoast
Description: The dune strip of Raversyde is part of the provincial domain Atlantikwall Raversyde. This large domain contains various ponds, grasslands, and forested areas, apart from the coastal areas.

The Atlantikwall Raversyde is one of the best-preserved remnants of the German defensive line, featuring over sixty bunkers, open and underground passages, observation posts, and artillery emplacements.

Between the dune strip and the coast is an important road and tram line. On this side, a large retaining wall was constructed to prevent sand from drifting onto the street and to stabilize most of the dunes. The dunes in this area have been fixed and have become dune grasslands.

IAS presence: Large patches of *Lycium barbarum* are present, mostly on the land side of this dune area.

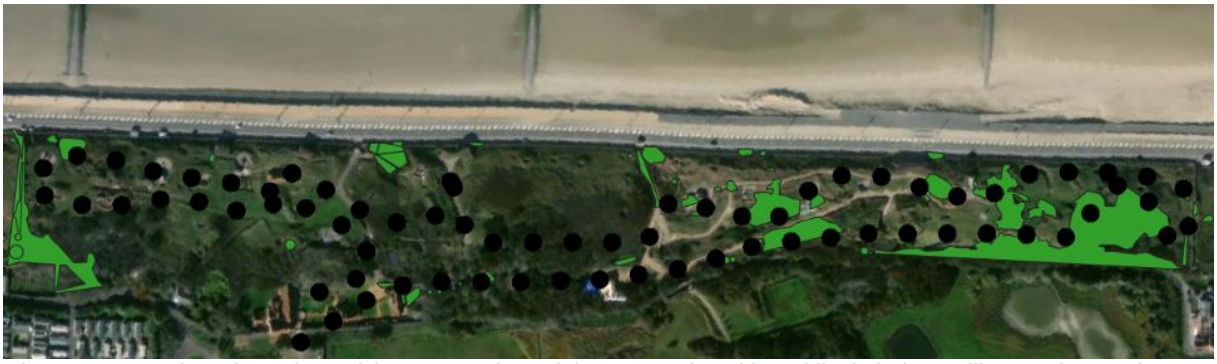

Figure 10: Location of IAS (green) in Raversyde and the route taken (dotted line) during pollinator observations.

2.1.2.6 The frontal dunes of Middelkerke

Size: 32ha
Location: Midcoast
Description: The frontal dunes of Middelkerke are connected to the dunes of Raversyde and form one big coastal dune area. The dunes of Middelkerke are on the landside almost entirely surrounded by recreational and camping facilities.

While the dunes are still separated from the coast strip by a road and tram line, the retaining wall that stabilized most dunes in Raversyde is not present. Despite the fact that the majority of the sand has been fixed by *Ammophila arenaria*, a significant portion of this dune remains a shifting dune.

On the landside, the vegetation primarily comprises shrubs such as *Hippophae rhamnoides* and *Prunus spinosa*. A pond with fresh water is located here as well.

IAS presence: *Rosa rugosa* is abundantly present, especially in the west side close to village of Middelkerke. On this side, *Rosa rugosa* is dominant.

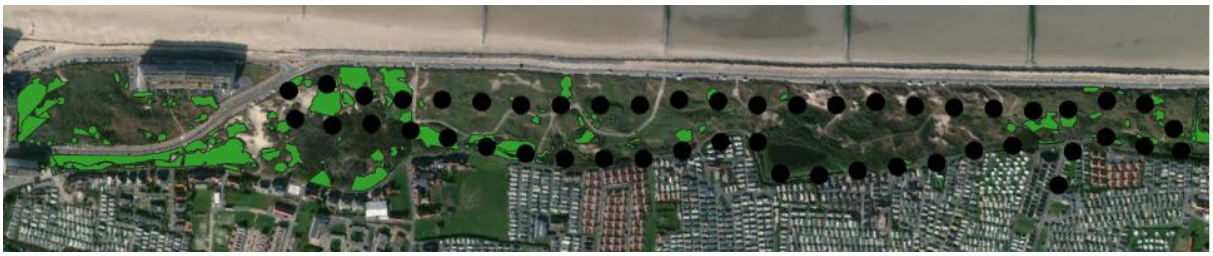

Figure 11: Location of IAS (green) in the frontal dunes of Middelkerke and the route taken (dotted line) during pollinator observations.

2.1.3 Westcoast.

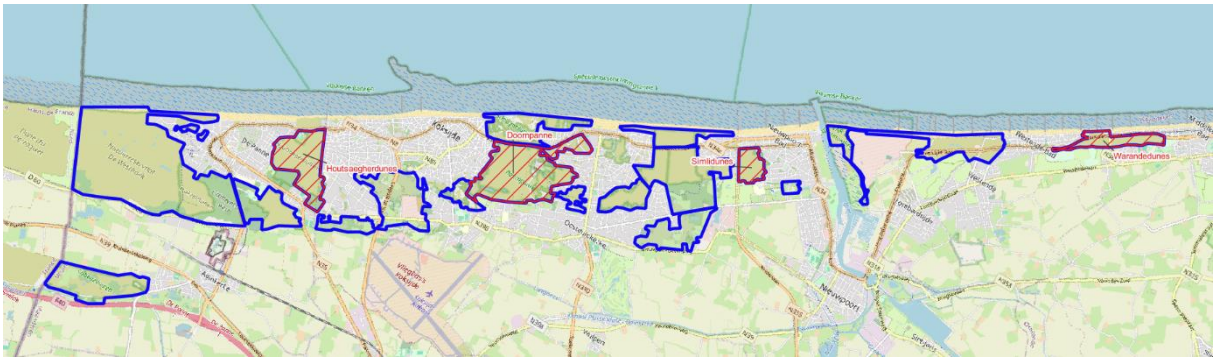

Figure 12: Visited locations in the west coast (pink). From the right to the left: Warandedunes, Simlidunes, Doornpanne and Houtsaegherdunes

2.1.3.1 Warandedunes

Size: 40ha
Location: West coast
Description: The Warandedunes is a limestone-rich dune belt that extends over a length of approximately 2 km between Middelkerke and Westende. The dune area is close to the sea, but it is mostly separated from it by a dike, a road, and apartments. The impact of the sea on the dunes has consequently significantly diminished.

The landscape is variated, consisting of shifting dunes, grey dunes, humid dune slacks, and dune scrub.

IAS presence: Invasive plants can be observed throughout the dunes, although they tend to occur in relatively small quantities. However, in some areas, high concentrations of IAS are found. One of these hotspots is close to the sea and contains several patches of *Rosa rugosa* with a size of 1000m^2 or more.

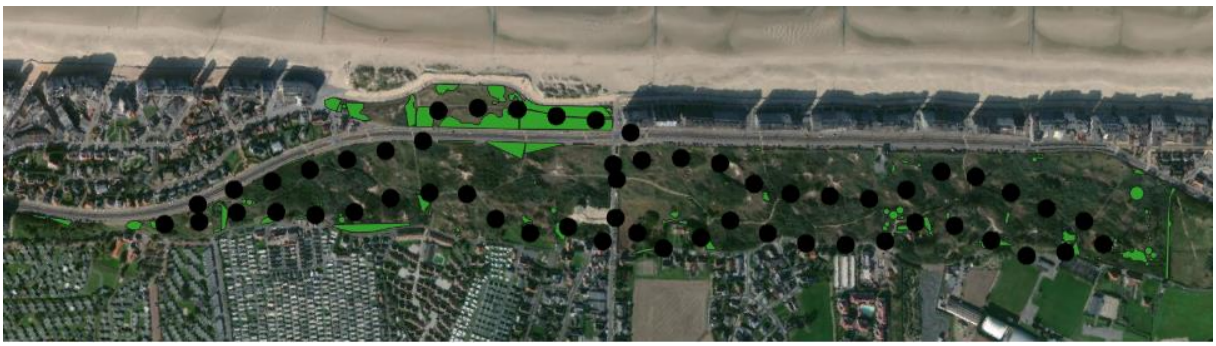

Figure 13: Location of IAS (green) in the Warandedunes and the route taken (dotted line) during pollinator observations.

2.1.3.2 Simlidunes

Size: 30ha
Location: West coast
Description: This fully enclosed dune area, which is separated from the sea, is located in Nieuwpoort. The Simlidunes, which used to be 90 hectares, was a neglected area. The owner, a property developer, was planning to develop this area as an allotment. The government did not approve of this, therefore the remaining undeveloped area was acquired by them and converted into a nature reserve.

The dune area has been restored and extended over the past few years. The restoration project included the demolition of an outdated tennis court and a miniature golf course, along with the construction of a mountain bike trail. In addition, the first steps were taken to remove invasive species and open up the largely overgrown dunes.

Figure 14: Location of IAS (green) in the Simlidunes and the route taken (dotted line) during pollinator observations.

At this point, the restoration project is complete, and the landscape is again more varied, with shifting dunes, humid dune slacks, grey dunes (with locally Cladonia vegetations) and dune scrub.

IAS presence: Despite the actions already taken, there are still several hot spots in this dune area where a variety of invasive plants can be found, including areas where only recently restoration work has been carried out. The most common IAS in the Simlidunes is *Berberis aquifolium*.

2.1.3.3 Doornpanne

Size: 180ha
Location: West coast
Description: The Doornpanne, together with the Hoge Blekker and Schipgatduinen, constitute a 240-hectare dune massif. The area includes various types of dunes, including shifting dunes, dune grasslands, densely vegetated depressions, and stabilized inland dunes. There is a belt of shifting dunes surrounding this area, including the highest dune peak on the Flemish coast, the 'Hoge Blekker'.

For drinking water purposes, freshwater from this area has been extracted from the area since 1947. As a result, the area became dry, and some characteristic plant species disappeared. In order to restore this area, 2.5 million square meters of purified wastewater are annually reintroduced into the ground through infiltration.

Since 2002, sustainable water extraction has been implemented, which has resulted in a reduction in groundwater extractions.

IAS presence: Large concentrations of *Prunus serotina* and *Berberis aquifolium* can be found in this nature reserve. Especially in the East side of this nature reserve.

Figure 15: Location of IAS (green) in the Doornpanne and the route taken (dotted line) during pollinator observations.

2.1.3.4 Houtsaegherdunes

Size: 80ha
Location: West coast
Description: The Houtsaegherdunes, along with the Kerkepanneforest, form a single large natural area, surrounded by the towns of De Panne and Koksijde. The former predominantly open and moist dune area is now significantly dried out and overgrown with natural dune shrubbery. Locally, remnants of the earlier dune grasslands, mossy dunes, and humid dune slacks still exist.

The management focuses on preserving a diverse landscape through grazing with historically present domestic animals, including donkeys. Additionally, old ponds are being restored, humid dune slacks are mowed, and overgrown planted trees are removed. The excavated ponds once again harbor a rich water and shoreline vegetation.

IAS presence: *Berberis aquifolium*, among other invasive species, is found throughout the reserve, but in large concentrations in the North West corner. On the eastern side of the reserve, on both sides of a walking path, significant concentrations of diverse invasive plants, such as *Ailanthus altissima*, can be found.

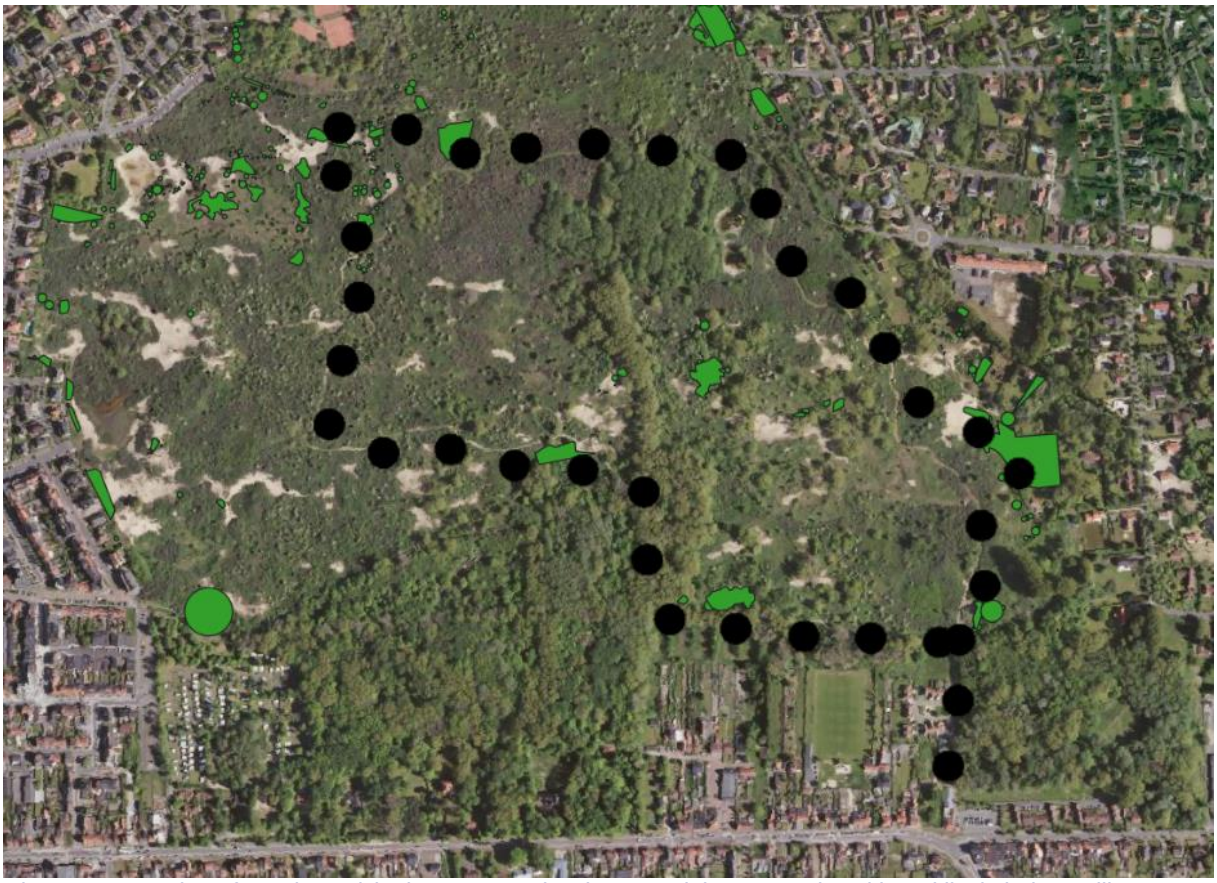

Figure 16: Location of IAS (green) in the Houtsaegherdunes and the route taken (dotted line) during pollinator observations.

3 Species richness

3.1 Wild bees and hoverflies

During the pollinator monitoring scheme of LIFE DUNIAS in 11 different locations, 3610 observations were made, 2867 of wild bees and 743 of hoverflies. **A total of 120 species of wild bees and 40 species of hoverflies were identified.**

The knowledge of the diversity and distribution of pollinators in our coastal dune areas has greatly improved thanks to this scheme. Since the start of www.waarnemingen.be in 2007, more than 8400 observations have been inserted in this citizen science portal which could either be verified by a validator or are from an experienced observer. These observations are not only from the locations monitored during our scheme, but from all the dune areas where LIFE DUNIAS will remove invasive plants. This figure includes observations made during LIFE DUNIAS, so we can state that this project added more than a third of all trustworthy observations from all coastal dunes to this public database.

Thanks to the data from this citizen science website, we know that our coastal dune area harbors more species than the 120 we have found. **178 species of wild bees have been found in all coastal dunes areas in Flanders since 2007.** However, many of these observations are from areas that were not monitored during LIFE DUNIAS, such as large nature reserves like Het Zwin or De Westhoek. We can say that this figure demonstrates the full potential of species that could be found in our dune areas. Furthermore, it is noteworthy to mention that **10 of the 178 species found in all coastal dune areas were first discovered during the LIFE DUNIAS monitoring scheme**.

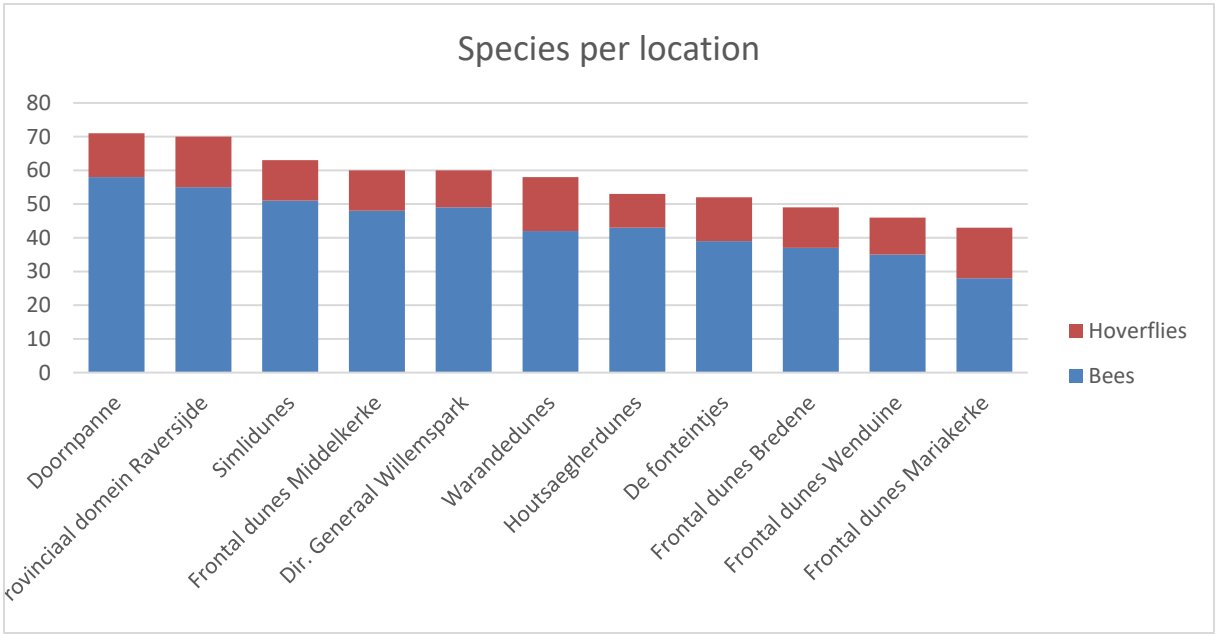

Table 3: Species found per location.

From all the investigated nature reserves, both the Doornpanne (71 species) and the provincial domain of Raversijde (70 species) score the best on species richness. The frontal dunes of Mariakerke (43 species) have the lowest amount of species.

As a point of reference, in 2019, as a part of the Interreg-project SAPOLL, a comprehensive monitoring of wild bees was conducted in De Westhoek, the largest coastal dune nature reserve in Belgium (Proesmans 2019a). In total, 77 distinct species of bees were identified, which is significantly higher

than the number of bees observed during our observations. The Westhoek is widely recognized as the most intact coastal dune reserve in Belgium.
It is noteworthy that the monitoring scheme was more extensive, with De Westhoek being monitored five times throughout the year for nearly a full day. This has to be considered when comparing the results with the LIFE DUNIAS monitoring.

The greater variety of bees observed in De Westhoek provides a valuable clue as to the potential outcomes that can be achieved through the rehabilitation and extension of our coastal sand dunes. But the observed significantly lower bee diversity during LIFE DUNIAS monitoring in certain locations also indicates that the quality of these coastal dunes is significantly lower compared to De Westhoek.

3.1.1 Typical wild bees for coastal areas.

Through data analysis on all trustworthy observations, we have been able to compile a list of bees that we consider to be typical wild bees for coastal areas. These are bees that are predominantly found in our coastal region. This data analysis has led to the classification of **38 bee species as typical coastal bee species.**

Name	**Dir.-Generaal Willemspark**	**Frontal dunes Wenduine**	**Fonteintjes**	**Frontal dunes Bredene**	**Frontal dunes Mariakerke**	**Raversyde**	**Frontal dunes Middelkerke**	**Warandedunes**	**Simlidunes**	**Doornpanne**	**Houtsaegherdunes**
Andrena barbilabris	x			x	x				x	x	x
Andrena florea	x	x	x		x	x	x		x	x	x
Andrena pilipes							x		x		
Bombus campestris				x		x	x	x		x	x
Bombus ruderarius		x									
Coelioxys conoideus				x			x			x	
Coelioxys mandibularis	x	x	x	x			x		x	x	
Colletes cunicularius	x	x	x		x		x	x		x	x
Colletes fodiens	x	x	x			x	x	x	x	x	x
Colletes halophilus											
Colletes marginatus										x	
Epeolus tarsalis											
Epeolus variegatus	x	x		x			x	x		x	x
Halictus confusus	x				x			x	x		
Hoplitis adunca											
Hoplitis claviventris											
Hoplitis leucomelana			x					x	x	x	x
Hylaeus confusus		x					x		x	x	x
Lasioglossum albipes											
Lasioglossum brevicorne									x	x	
Lasioglossum calceatum	x	x	x	x		x	x	x	x	x	x

Name	Dir.-Generaal Willemspark	Frontal dunes Wenduine	Fonteintjes	Frontal dunes Bredene	Frontal dunes Mariakerke	Raversyde	Frontal dunes Middelkerke	Warandedunes	Simlidunes	Doornpanne	Houtsaegherdunes
Lasioglossum leucozonium	x	x			x	x	x			x	x
Lasioglossum prasinum											
Lasioglossum punctatissimum								x	x		x
Lasioglossum sexstrigatum	x								x		
Lasioglossum tarsatum	x										
Lasioglossum zonulus											x
Megachile leachella	x	x	x	x	x	x	x		x	x	
Megachile maritima			x	x			x	x		x	
Megachile versicolor									x	x	x
Osmia aurulenta											
Osmia leaiana										x	
Osmia spinulosa	x	x	x	x	x	x	x	x	x	x	x
Sphecodes albilabris	x		x				x	x	x	x	
Sphecodes scabricollis											
Stelis breviuscula										x	
Stelis odontopyga		x	x				x			x	
Stelis ornatula											
Total	**14**	**12**	**11**	**9**	**7**	**7**	**16**	**11**	**16**	**22**	**14**

Table 4: Overview of typical wild bees for coastal areas.

During our observations, we discovered the majority of the typical coastal bees but not all of them. Only a few species, such as *Osmia spinulosa, Lasioglossum calceatum, Megachile leachella, Andrena florea* and *Colletes fodiens*, were found in most areas.

The Doornpanne not only scores well when it comes to overall species variety, it's also home to the largest number (22 species) of typical coastal dune species. The frontal dunes of Mariakerke didn't do well when it came to overall species richness, and consequently also did poorly when it came to the typical species (7 species). More surprising is the low number of typical coastal bee species for the provincial domain of Raversyde, which scored well in overall species richness. The lack of shifting dunes in this location, which are the required habitat for many of our typical coastal bees, is probably an important reason for the absence of many of those bees.

Location	Other bee species	Typical coastal species	%
Doornpanne	36	22	38%
Frontal dunes Wenduine	23	12	34%
Frontal dunes Middelkerke	32	16	33%
Houtsaegherdunes	29	14	33%
Simlidunes	35	16	31%
Dir. Generaal Willemspark	35	14	29%
De fonteintjes	28	11	28%

Location	Other bee species	Typical coastal species	%
Warandedunes	31	11	26%
Frontal dunes Mariakerke	21	7	25%
Frontal dunes Bredene	28	9	24%
Provinciaal domein Raversyde	48	7	13%

Table 5: Overview of wild bee species found per location, split up by other bee species and typical coastal species including share of typical coastal species.

With an exception of the domain of Raversyde, the total bee diversity of all investigated locations consisted for nearly a quarter or more out of typical coastal bee species.

3.1.2 Notable finds

3.1.2.1 Lasioglossum tarsatum

The sweat bee *Lasioglossum tarsatum* is very rare in Belgium. For the last 100 years, it has only been seen along the coast, except for one sighting in Genk in 1977. In Europe, this particular bee is predominantly found in the Netherlands, Germany, Poland and the Alps. However, sightings are also limited in these countries.

Jens D'Haeseleer, who found a female in the nature reserve Het Zwin in Knokke-Heist in 2018, rediscovered this bee in Belgium. Prior to this discovery, the most recent observation was made in Nieuwpoort in 1977. This particular bee was also observed during our observations in the Dir. Generaal Willemspark in Knokke-Heist. Currently, these locations remain the sole locations where this particular bee has been discovered in recent times in Belgium.

Females are observed from April, and males from June. It is regarded as a polylectic bee, lacking a specific flower reference. In Belgium, this bee has not been observed foraging on flowers; however, in Germany and the Netherlands, it has been observed foraging on brambles and various plants belonging to the Asteraceae family, including *Taraxacum officinale, Hypochoeris radicata*, and *Leontodon autumnalis*.

We wrote a 'natuurbericht' on the important rediscovery of this species:
https://www.natuurpunt.be/nieuws/de-duingroefbij-herontdekt-aan-de-belgische-kust-20221027

3.1.2.2 Lasioglossum bluethgeni

In 2019, Fons Verheyde sighted this sweat bee on an old pathway north of the village of Nieuwkerke (cfr. https://waarnemingen.be/observation/177449641/). This observation of *Lasioglossum bluethgeni* is regarded as the first observation of this bee in Belgium (Verheyde & De Blanck 2022).

The highest densities of this bee can be found in Austria, Hungary and Switzerland, but it's also present in other countries, mostly in central or southern countries of Europe. The sighting in Belgium is the most northern location to date.

The bee has also been discovered during our observations in The Doornpanne, situated on the roadside of a hiking trail in an area dominated by shrubs and trees. The first time this bee was seen in Belgium was also on a hiking trail in a sheltered area where shrubs and trees were present.

It is considered a polylectic bee, and it has been seen foraging on various plants from different families. This bee has been observed in The Doornpanne on *Chaerophyllum temulum*, a flower from the Apiaceae family.

Females can be observed from May and males as from August.

3.1.2.3 Andrena lagopus

Olivier Foubert observed this mining bee in the village of Gesves in the Namur province in 2020. This observation of *Andrena lagopus* is considered the first observation of this bee in Belgium. At that time, we wrote a 'natuurbericht' on the discovery of this species: https://www.natuurpunt.be/nieuws/de-tweecellige-zandbij-een-nieuwe-bijensoort-voor-belgi%C3%AB-20200519.

During our observations in the Simlidunes, several male individuals were observed, indicating a local population.

This is a remarkable discovery, considering that this bee has only been found in inland areas like the Walloon Region and the Limburg province. This bee's main range is in Europe's southern parts and Switzerland, but it's been moving further north in recent years. Until now, it has primarily used the valleys of the river Meuse for its rapid northward distribution.

Figure 17: Andrena lagopus (female) – photographer Hectonichus (CC BY-SA 4.0)

However, with this sighting on our coastline, we can also conclude that it is advancing via the coastline of France. Thomas J. Wood, an expert on mining bees in Europe, believes that this bee will find its way to the U.K. in the very near future.

Andrena lagopus is an oligolectic bee that is specialized in the collection of pollen from flowers belonging to the Brassicaceae family. The males observed in the Simlidunes were patrolling the flower *Sinapis arvensis*. This dune area also has an abundance of *Alliaria petiolate* flowers, especially in areas that have recently been cleared of shrubs and invasive plants. With the presence of both plants, a large number of suitable plants are present.

This bee is active as from April until June.

3.1.2.4 *Andrena pilipes*

Andrena pilipes is part of the *Andrena nigrospina complex* that has confused taxonomists for years. Several taxonomists regarded *Andrea pilipes* and *Andrena nigrospina* as distinct species, while others regarded them as a single species. The genus *Andrena* in Belgium was revised in 2023 by Thomas J. Wood, who utilized DNA analysis to establish that they are distinct species. The southern species *Andrena pilipes* dominates the Mediterranean basin, while the more widespread *Andrena nigrospina* is found throughout Europe, with its strongest presence in Central and North-Europe.

Figure 18: Andrena pilipes (female) - photographer Henk Wallays

Both species can be seen in Belgium, but *Andrena pilipes* distribution is restricted to the West coast. *Andrena nigrospina* can be found in the central and northern regions of Belgium.

Prior to the start of the LIFE DUNIAS project, this bee was only found in the nature reserve De Westhoek, on the border with France. During LIFE DUNIAS, the bee has been found in additional locations due to intensive monitoring. Volunteers from the Natuurpunt workgroup Aculea, who are primarily concerned with studying aculeates (wasps, ants, and bees), have made supplementary observations. These observations have allowed us to confirm that this bee is present throughout the entire West coast and also in Middelkerke.

Andrena pilipes is a bivoltine species that has two generations per year, with its primary flight periods occurring during the months of March-April and July-August. It is considered a polylectic bee, and it has been seen foraging on various plants from different families. However, the spring generation is found mostly on flowers from the Brassicaceae family.

3.1.2.5 *Stelis odontopyga*

During a bee inventory in the dune reserve De Westhoek in De Panne in June 2019, a specimen of the tube bee *Stelis odontopyga* was found (Proesmans 2019a). It is only the second time that this species has been observed in Belgium. The previous observation dates back to 1954 when the species was discovered in Koksijde. The species was also discovered in the province of Hainaut on an old mine slag heap in July of the same year.

At that time, we wrote a 'natuurbericht' on the discovery of this species: https://www.natuurpunt.be/nieuws/slakkenhuistubebij-duikt-voor-het-eerst-65-jaar-weer-op-20190802.

Except for an additional finding in Antwerp, all recent observations of this bee have been made in coastal dune areas. As a result of the extensive bee monitoring conducted during LIFE DUNIAS and the supplementary findings obtained from Aculea volunteers, it can be concluded that the bee is prevalent in a majority of the Belgian coastline.

Tube bees are parasitic bees. The females of this species infiltrate the nests of other bee species and lay their eggs there. Due to this parasitic egg-laying behavior, these bees are also known as 'cuckoo bees.'

Stelis odontopyga is a bee that has specialized in parasitizing nests of *Osmia spinulosa*, a bee that utilizes empty snail shells as nesting material. *Osmia spinulosa* is abundantly found in our coastal dunes, as well as in various inland locations.

3.1.2.6 *Megachile maritima* and *Coelioxys conoideus*

In the past, *Megachile maritima*, a leafcutter bee, was found in both coastal and inland dunes, as well as areas with sandy soil all over the country. In the past few decades, populations have been declining, and now this bee is only found in our coastal dune areas.

Figure 19: Megachile maritima (male) - photographer Kurt Geeraerts

Prior to the year 2020, sightings were restricted to the West Coast region and Oostende. In recent years, either due to natural migration or increased monitoring, this bee has been spotted in nearly all coastal dunes on our Belgian coast.

This bee is more frequently seen in the Netherlands, probably due to the higher quality of the dune areas. The majority of sightings are observed in coastal dune regions, however, recent observations have also been made in inland locations. One of these sightings occurred near Roermond, less than 10 km away from the Belgian border. There is a high probability that this bee will be observed again in the province of Limburg, Belgium, in the near future.

The same thing can be said about *Coelioxys conoideus*, a sharp-tail bee that parasitizes *Megachile maritima*. Until 2020, sightings were limited to the West Coast region, with one sighting in 2019

occurring in Zedelgem, a village 20km off the coast. The cuckoo bee has since been observed in more locations, but it has not yet been found on the east coast. It is likely that this will only be a matter of time.

Both bee species can be observed from the middle of June until the end of August. *Megachile maritima* is a polylectic bee with no flower preference. During the LIFE DUNIAS monitoring, this bee was mostly observed on *Eryngium maritimum* and *Ononis spinosa*, respectively. Males were frequently observed patrolling around *Lathyrus latifolius*, in search of a female.

Figure 20: Coelioxys conoideus (female) - photographer Kurt Geeraerts

Cuckoo bees, like *Coelioxys conoideus*, are always polylectic, as they do not collect pollen. Although this bee does not have a specific preference, it has only been observed on flowers from the Asteraceae family and mainly on *Eryngium maritimum* in Belgium.

3.1.3 Factors influencing wild bee diversity

Although we observed both wild bees, hoverflies and other insects during our surveys, we mainly focus on wild bees for the in-depth analysis of the results. We consider the data from the wild bees as most complete and thus more substantiated conclusions can be drawn from them at this stage of the LIFE project.

In order to understand the results of our observations, we have to consider the different factors that influence species richness. The reason why one dune area has a higher species richness cannot be reduced to one single factor.

3.1.3.1 Size and location

One could contribute the difference between the results of the Doornpanne and dunes of Mariakerke to their obvious difference in size. The Doorpanne is the largest reserve that was investigated and the dunes of Mariakerke the smallest. While the limited size of the dunes in Mariakerke will have its impact on the diversity that can be found there, it is not the most dominant factor. Other small areas like the provincial domain of Raversyde did score well on overall species richness.

Name	**Bees (typical coastal bees)**	**Hoverflies**	**Total**	**Size**	**Location**
Doornpanne	58 (22)	13	71	180 ha	West coast
Provinciaal domein Raversijde	55 (7)	15	70	15 ha	Midcoast
Simlidunes	51 (16)	12	63	30 ha	West coast
Frontal dunes Middelkerke	48 (16)	12	60	32 ha	Midcoast
Dir.-Generaal Willemspark	49 (14)	11	60	19 ha	East coast
Warandedunes	42 (11)	16	58	40 ha	West coast
Houtsaegherdunes	43 (14)	10	53	80 ha	West coast
De fonteintjes	39 (11)	13	52	40 ha	East coast
Frontal dunes Bredene	37 (9)	12	49	101 ha	Midcoast
Frontal dunes Wenduine	35 (12)	11	46	26,5 ha	Midcoast
Frontal dunes Mariakerke	28 (7)	15	43	8 ha	Midcoast

Table 6: Detailed overview of species found, including size of each location and coastal region.

The presence of additional nature reserves or green spaces within the immediate vicinity of the investigated dune area will have an impact on the diversity of species. The frontal dunes in Mariakerke are not only small, but also isolated. Bees and other insects have fewer options for migration, and there is a limited supply of food or suitable habitat in the greater region. Gardens from the surrounding residences can be a source of food and can be a compensating factor. However, most gardens are not a suitable habitat for our dune specialists.

Raversyde, the seconds smallest investigated dune area, is surrounded by other dune areas and a large natural park, which makes the situation totally different. Although the investigated area is relatively small, it is part of a larger network.

Dune areas located on the West Coast have a higher abundance of bee species. The investigated areas in this region boast the highest overall bee variety, as well as the most typical coastal dune species. It appears that the presence of multiple dune areas in close proximity to each other has a favourable effect on the diversity of species.

Figure 21: the Doornpanne is not only one of the biggest investigated dune areas, it's also surrounded by multiple other nature reserves.

The Belgian West Coast region, which stretches from the French border to the Yser's estuary, is home to numerous protected areas. Furthermore, on the French side of the border, there are also a number of protected dunes. The dune regions located on the West Coast of the Belgian coast are therefore a part of a broader network of protected nature reserves.

3.1.3.2 Habitat variation

The limited variation in habitats is a common characteristic of the locations where we observed the fewest bee species. In most cases, these areas only have two different dune habitats. Semi-fixed dunes can be found on the seaside, while dune shrubs or forests can be found on the land side.

The absence or limited presence of dune slacks, dune hollows, or creeping willow thickets in certain locations is a significant constraining factor in terms of bee diversity. The low diversity of habitats is also a significant reason for the limited number of typical coastal dune specialists observed within the domain of Raversyde.

Figure 22: the domain of Raversyde has many buildings, trenches and bunkers fixating the dunes. Flowers are abundant but habitat variation is limited, and particularly, the typical open dunes with bare sand are missing.

Raversyde is an open-air museum where visitors can observe preserved fortifications of the Atlantic Wall that date back to the First and Second World Wars. You can find more than 60 bunkers and three kilometers of trenches here. A retaining wall and fences have been built around the premise to keep

people out and keep sand from drifting on the important road in front of the domain. Consequently, this dune area has been completely fixed.

Our typical coastal bee species favour semi-fixed dunes for nesting, and the absence of these in Raversyde is a key reason for the lack of these in this area. The numerous constructions make the domain more sheltered than other frontal dune strips. This, coupled with a greater variety and abundance of flowers, has resulted in a significant number of non-typical coastal bees finding their way to the domain.

3.1.3.3 Natural succession and human interference

The term "natural succession" refers to the gradual and predictable process of ecological transformation and development over a specific period in a particular region. It involves the establishment, growth, and replacement of plant and animal species in an ecosystem. Plant succession, specifically, focuses on the changes in plant communities.

The process begins with pioneer species, typically lichens and mosses. These organisms are capable of breaking down rocks and minerals to form a basic soil. Over time, as the pioneer species die and decompose, they contribute organic matter to the soil. This process, along with weathering of the substrate, leads to the formation of more developed soil.

As the soil becomes more enriched and stabilized, other plant species, such as grasses and herbaceous plants, can establish themselves. Over many years, shrubs and eventually trees may dominate the landscape, completing the succession.

Numerous factors exert an influence on natural succession, resulting in either a rapid or a slowed-down process. Natural disturbances like floods or wind, human activities like deforestation, agriculture, urbanization or nitrogen deposition, invasive species, and climate change have their impact on the speed of the natural succession process.

Figure 23: the Houtsaegherdunes, an inland dune area, consists mostly out of fixed dunes.

The transition from embryonic dunes to semi-fixed dunes and ultimately fixed dunes is a result of natural succession. Further succession to the phase where shrubs and trees dominate is halted by the drying effect of strong gusts of wind, combined with salt spray. In coastal areas where the wind has free rein, natural succession is largely stopped. Furthermore, the grazing practiced by rabbits and other livestock also slow down the rate of transition from open dunes to dune forest.

This is advantageous for habitats such as dune slacks, dune grasslands, or creeping willow thickets as it prevents them from being overgrown by large shrubs and trees. Many of the bees found in our coastal areas have a strong preference for open habitats, so wind is an important (indirect) ally for them.

In recent years, the impact of human influence has significantly impacted the natural succession process. The 20th century saw the rise of tourism, and once-small fishing towns have now grown into bustling tourist destinations. There has been a huge increase in urbanization in our coastal area. Since the year 1960, the emergence of extensive apartment complexes along our coastline has accelerated urbanization. Since then, many of our dune areas have disappeared along with their unique wildlife.

The remaining dune areas are also impacted by this urbanization, not only because they have greatly diminished in size and are becoming more fragmented, but also because the positive effect of the wind on various dune habitats has been diminished by the numerous structures constructed around and in front of them. Buildings mitigate the impact of wind, resulting in more sheltered environments. Natural succession, which is frozen in time by the effects of wind, can again transform crucial habitats for many unique plants and insects into shrubberies and forests.

Our coastal dunes, which are already fragmented and degenerated, are presently experiencing an alarming increase in overgrowth by shrubs and trees, particularly in the inland dunes. This transformation is most evident in the vicinity of buildings. Twenty or more years ago, the dune area situated adjacent to a residence or apartment would have been characterized by an open vegetation with a distinct presence of sandy soil. Today, the vegetation is becoming denser. At best, these building are now surrounded by shrubs, but often trees are already taking over. This growth is rendering suitable nesting locations for wild bees unsuitable and also resulting in the disappearance of numerous herbaceous plants that are essential for wild bees.

The process of nitrogen deposition is accelerating natural succession by fertilizing the soil. Grass, shrubs, and trees benefit from a more fertile soil. The result is that our dunes are becoming greener, have less open spaces, and are less suitable for many herbaceous flowers. As a result, diversity is declining.

Furthermore, the significant decrease in rabbits in our coastal dunes since the middle of the 20th century is also contributing to the dunes being overgrown. Rabbits are important for our dunes systems, by their constant grazing and digging they influence the vegetation. In the Netherlands, in order to prevent a further decline in rabbit populations, rabbits from inland areas are being relocated to dune areas (Dekker et al, 2022).

3.1.3.4 Shelter

The influence of wind on our coastal environment is significant, as it is a primary driver for dune formations and contributes to the creation of various habitats. For plants and animals, areas exposed to a lot of wind are harsh environments. Coastal areas are generally considered windy areas and plants can quickly dry out when exposed to constant wind.

However, insect diversity is also influenced by wind. Wind affects insect dispersal and, as a result, the presence of windbreaks affects insect dispersal. Flying insects prefer to settle in areas with lower or slower winds, where they have greater control over their flight.

Figure 24: a sheltered area on the land side in Raversyde. The meadow is protect from gusts of wind by a dune ridge overgrown by shrubs.

The locations where we observed the smallest number of bee species are also those where wind plays a predominant role. The nature reserves like De fonteintjes and the frontal dunes of Bredene, Mariakerke and Wenduine are narrow dune strips located next to the sea and feature a limited number of dune ridges. These ridges typically create sheltered areas, which are preferred by bees, and are less prevalent in comparison to larger dune areas such as the Doornpanne, which has a depth of 1km.

Wind can have different effects on our coastal dunes. Many insects avoid windy places and prefer to forage in places that are sheltered. However, wind is a significant factor in the formation of habitats. The wind our coastal area is subjected to, creates the habitats our wild bees depend on.

3.1.3.5 Invasive plants

The presence of invasive plants is also a significant constraining factor for the diversity of bees. These invasive plants are known for their rapid growth and can quickly take over natural areas, leading to further degeneration and fragmentation. When habitats become excessively small and fragmented, they are unable to support the substantial number of plants and insects that are dependent upon them.
Dune slacks and grasslands serve as important habitats for a significant number of our coastal insects. However, these habitats are particularly susceptible to the overgrowth of *Rosa rugosa*, the most widespread invasive plant in our coastal region. This plant is rapidly deteriorating habitats, thereby putting additional strain on our pollinators, who are already declining.

Figure 25: the frontal dunes of Mariakerke have high abundance of invasive plants. Rosa rugosa and Lycium barbarum dominate the landscape.

In terms of coverage percentagewise, the frontal dune strip of Mariakerke possesses the highest concentration of invasive plants among all the locations examined. However, De Fonteintjes and the frontal dune strip of Wenduine, where also few wild bees were observed, have also significant areas infested by invasive plants, accounting for over 5% of the total surface area.

3.1.4 Conclusion

We have created an overview showing the factors that have an impact on bee diversity. For each factor we have tried to estimate the impact it has on the location.

Scorecard	Size	Location	Shelter	Habitat variation	Human interference	Invasive plants
Doornpanne	++	++	++	++	-	-
Provinciaal domein Raversyde	--	+	+	-	--	--
Simlidunes	-	++	++	++	--	-
Frontal dunes Middelkerke	-	+	--	+	-	--
Dir. Generaal Willemspark	--	--	+	+	--	--
Warandedunes	+	--	+	+	--	-
Houtsaegherdunes	++	++	++	++	-	-
De fonteintjes	+	--	-	+	-	--
Frontal dunes Bredene	++	-	--	--	-	-
Frontal dunes Wenduine	--	--	--	--	-	-
Frontal dunes Mariakerke	--	--	--	--	-	--

Table 7: Detailed scorecard with factors influencing species richness.

Explanation on the score system.
Size: smaller than 30 ha (--), between 30 and 40 ha (-), between 40 and 70 ha (+), larger then 70ha (++).
Location: location in a region with high amount of dunes areas (++), surrounded by some dune areas (+), adjacent to one other dune area (-), isolated and/or surrounded by buildings (--).
Shelter: sheltered inland location or large location with varied terrain (++), smaller location but with sufficient variation in terrain or presence of natural or manmade windbreaks (+), narrow frontal dune with some windbreaks (-), narrow frontal dune with few windbreaks or terrain variation (--)
Habitat variation: high variation in habitats, water present (++) fewer but sufficient variation, water present (+), some variation but no water present (+), few variation and no water present (--).
Human interference: nitrogen deposition (-), nitrogen deposition and influence of wind largely negated by constructions (--).
Invasive plants: IAS presence limited, without large areas dominated by invasive plants (-), large areas dominated by invasive plants (--)

3.1.4.1 The frontal dunes of Mariakerke, Wenduine and Bredene

With this comprehensive overview, it is evident why the frontal dunes of Mariakerke, as well as those in Wenduine and Bredene, exhibit a low level of diversity. These locations score bad or very badly on most factors. The limited variation in habitat in combination with limited size and isolated location make these locations less suitable for many bee species. However, in the case of the frontal dune of Wenduine, a good number of typical coastal bees have been found, despite the low overall bee diversity. Many of the typical coastal bees dependent on shifting dunes are present in this location.

3.1.4.2 The Doornpanne

The Doornpanne, however, scores excellent on most factors, which is probably why we have observed most pollinator species in this dune area. Being surrounded by other dune reserves and having a larger area than other investigated spots is a huge added value. There are still large areas with shifting dunes, but there are also dune forests and dune scrub in combination with more moist areas.

Furthermore, a visitor center is situated within the premises, offering an educational garden equipped with a bee hotel and bee-friendly plants. A few houses with typical ornamental gardens can be found in the center of the reserve. One particular garden featured a significant number of lavender plants in its front yard, attracting numerous species of the *Megachile* family, including several extremely rare *Megachile maritima*.

3.1.4.3 Raversyde.

The second highest number of pollinator species has been observed in the domain of Raversyde, however, it exhibits a low score in several aspects, including size and human interference. These negative influences are likely the reason why few typical coastal bees were found. The bee diversity in Raversyde is positively influenced by the presence of a large park located directly behind the domain. Several of the more typical inland bee species found in the park also visit the domain. However, the dunes within the domain are too fixed and there are insufficient habitat variations to sustain numerous typical coastal bee species.

3.1.4.4 The Simlidunes.

Despite its size and extensive human interference, the Simlidunes exhibit a wide array of bee species. This dune area derives significant advantages from its geographical proximity to several other dune areas, as well as its extensive habitat diversity. It is encouraging to note that over the past few years, significant efforts have been made to restore this previously neglected dune. Important initiatives, such as the removal of invasive plants and dune scrub, have been undertaken, thereby facilitating the growth of herbaceous plants.

Especially *Alliaria petiolata*, a plant belonging to the Brassicaceae family, benefited from this and is currently thriving in abundance, attracting numerous insects. Consequently, two extremely rare bees, which are specialized or have preference in collecting pollen from plants belonging to the Brassicaceae family, have been observed in this area. If the planned removal of invasive plants coupled with habitat restoration has an equally beneficial impact on all locations, then the bee diversity in our coastal region will receive a significant boost in the forthcoming years.

3.1.4.5 The frontal dunes of Middelkerke.

The frontal dunes of Middelkerke are adjacent to the domain of Raversyde. In contrast to Raversyde, a lower number of bee species were observed in this dune region. The absence of a retaining wall at the seaside, intended to prevent sand drifting, makes this dunes area more natural to us.. Furthermore, there are no bunkers, trenches, or other man-made constructions.

The dunes in this area are still considered to be shifting dunes. Consequently, in comparison to the adjacent domain of Raversyde, a greater proportion of typical coastal dune species can be observed in this particular area. The harsher environment created by the wind in this dunes area makes it more suitable for the typical coastal bee species that have adapted to it.

3.1.4.6 The Dir. Generaal Willemspark.

The Dir. Generaal Willemspark is a combination of a park and a dune area. A significant number of bee species have been discovered in this region, despite its modest size and isolated location. This has been accomplished by attracting a significant number of typical coastal bee species with its shifting dunes, as well as more typical inland bee species, owing to the presence of the park.

The central portion of the dune region is characterized by a substantial, sheltered vale, which serves as a suitable habitat for numerous bees. In this valley, a limited number of shrubs and trees are found, however, a significant number of invasive plants are prevalent. Restoring this vale will probably have a significant positive impact, possibly creating more opportunities for *Lasioglossum tarsatum*, a very rare coastal bee. This particular bee has been mostly seen in Het Zwin, a large natural reserve, as well as within the boundaries of this park.

3.1.4.7 The Warandedunes.

The Warandedunes are nearly entirely isolated from the sea by extensive apartment complexes, resulting in a significant level of human interference. A significant portion of the area is being occupied by shrubs, primarily *Prunus spinosa* and *Hippophae rhamnoides*, rendering it less suitable for numerous typical dune species.

3.1.4.8 The Houtsaegherdunes.

The Houtsaegherdunes is a large, sheltered dune area that scores well on many factors, but has a rather low bee diversity. In this dune area, few shifting dunes are present, which is the preferred habitat for many of our coastal species. Rather, a significant portion of this location is either occupied by forests or has been overtaken by shrubs such as *Prunus spinosa* and *Hippophae rhamnoides*, rendering it less suitable for numerous typical dune species. Consequently, species such as *Megachile leachella* and *Megachile maritima*, as well as their parasites, have not been observed during our investigations.

The more open parts of this dune are grazed intensively by sheep in order to prevent them from being overgrown by shrubs as well. The grazing technique employed is mob grazing, a technique of ultra-high-density grazing that involves a large number of animals grazing a specific, limited area for a brief period of time. In the spring, these dune grasslands are covered with dandelions, which bloom abundantly. Later in the year, when intensive grazing has begun, there are far fewer flowers and thus less food for bees.

Despite the efficiency of mob grazing in preventing the overgrowth of shrubs on dunes, a study examining the impact of grazing on the breeding density of *Bembix rostrata* has concluded that grazing has a negative effect (Batsleer et al, 2021). The breeding density of this typical dune wasp was significantly lower in areas with intensive grazing than in areas without any or minimal grazing.

It's not certain if soil compaction is the reason for the absence of certain typical coastal bees, but it would be worth investigating.

3.2 Grasshoppers and butterflies

In addition to the surveillance of wild bees and hoverflies, a separate program was established for grasshoppers, butterflies, and other locally uncommon species, such as the digging wasp *Bembix rostrata*.

Several of the locations monitored for butterflies and grasshoppers were also monitored for wild bees. However, some areas, like the frontal dunes in De Haan, have only been checked for grasshoppers and butterflies. The investigated areas were all situated in either the midcoast or West coast, no locations on the East coast where monitored.

During our analysis of the species richness for wild bees, we have identified several factors that exert an impact on the species. While many of these factors will have an impact on both grasshoppers and butterflies, we must acknowledge that the ecology is different and that more or other factors might influence the species richness of butterflies and grasshoppers.

The monitoring scheme was less intensive than with wild bees, and therefore the amount of data was also smaller. Therefore, in this report, we will solely provide a brief overview of the species identified. However, a comprehensive analysis of these species will be conducted subsequent to the second round of monitoring, when additional data becomes available.

In the final report, the focus will be on comparing the results of the two monitoring rounds, specifically to see if grasshoppers and butterflies are now showing up in areas previously dominated by invasive plants.

Number of species	***Region***	***Butterflies***	***Grasshoppers***
frontal dunes of Wenduine	Midcoast	12	4
frontal dunes of De Haan	Midcoast	10	3
frontal dunes of Bredene	Midcoast	12	7
frontal dunes of Middelkerke	Midcoast	13	8
Warandedunes	West coast	15	6
Simlidunes	West coast	13	5
Doornpanne	West coast	16	7
Houtsaegherdunes	West coast	12	7

Table 8: Overview of number of species found per location.

3.2.1 Grasshoppers and diggerwasp *Bembix rostrata*

11 different species of grasshoppers were observed during our monitoring. Three of these species are regarded as typical coastal species, as they prefer dry areas with low and open vegetation, such as dunes and heathlands.

English name	*Latin name*	Red list category	Typical coastal species
Lesser marsh grasshopper	*Chorthippus albomarginatus*	Least concern	
Bow-winged grasshopper	*Chorthippus biguttulus*	Least concern	
Long-winged conehead	*Conocephalus fuscus*	Least concern	
Mottled grasshopper	*Myrmeleotettix maculatus*	Least concern	Yes
Blue-winged grasshopper	*Oedipoda caerulescens*	Least concern	Yes
Sickle-bearing bush-cricket	*Phaneroptera falcata*	Least concern	
Dark bush-cricket	*Pholidoptera griseoaptera*	Least concern	
European bush cricket	*Platycleis albopunctata*	Least concern	Yes
Roesel's bush-cricket	*Roeseliana roeselii*	Least concern	
Cepero's groundhopper	*Tetrix ceperoi*	Least concern	
Great green bush-cricket	*Tettigonia viridissima*	Least concern	

Table 9: List of all the grasshopper species found during survey with additional information.

Figure 26: Myrmeleotettix maculatus - photographer Flip Hermans

The typical coastal dunes species were found in nearly all investigated locations, with the exception of one species, *Myrmeleotettix maculatus*, which was not observed in the frontal dunes of Wenduine. Non-typical species are the primary reason for the disparity in species observed across diverse locations.

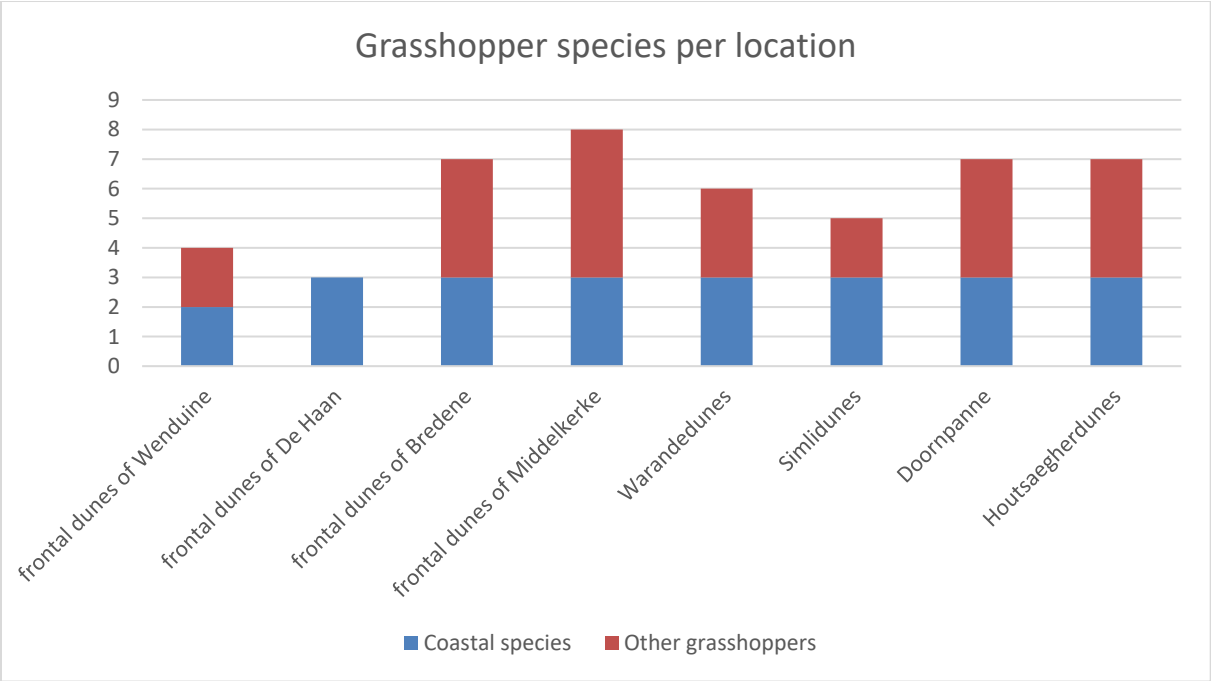

Table 10: Grasshopper species per location, split up by typical coastal species and other species

The frontal dunes of Middelkerke had the highest number of grasshoppers species, but other dune areas also had high levels of diversity. Except for the frontal dunes of De Haan and Wenduine, both scoring significantly lower than the other investigated areas.

Grasshoppers and Grand digger wasp	***frontal dunes of Wenduine***	***frontal dunes of De Haan***	***frontal dunes of Bredene***	***frontal dunes of Middelkerke***	***Warandedunes***	***Simlidunes***	***Doornpanne***	***Houtsaegherdunes***
Bembix rostrata	x		x	x	x	x	x	x
Chorthippus albomarginatus							x	
Chorthippus biguttulus			x	x			x	x
Conocephalus fuscus	x		x	x	x		x	x
Conocephalus spec.			x	x	x			
Gomphocerinae indet.	x							
Myrmeleotettix maculatus		x	x	x	x	x	x	x
Oedipoda caerulescens	x	x	x	x	x	x	x	x
Phaneroptera falcata						x		
Pholidoptera griseoaptera						x		
Platycleis albopunctata	x	x	x	x	x	x	x	x
Roeseliana roeselii				x				
Tetrix ceperoi								x
Tettigonia viridissima			x	x	x		x	x
Totaal	**5**	**3**	**8**	**9**	**7**	**6**	**8**	**8**

Table 11: Overview of where each grasshopper species and the digger wasp Bembix rostrata was found.

Five of the species observed were exclusively observed in a single location, and only two species, both characterized as typical coastal species, were observed in all locations.

The digger wasp *Bembix rostrata*, which inhabits open-sand surfaces in warm regions, was found in all locations, with the exception of the frontal dunes of De Haan. Prior to the year 2018, this wasp was primarily found in coastal areas and certain locations in the province of Antwerp. However, since then, it has been rapidly expanding throughout the country, colonizing various inland locations with sandy soils.

3.2.2 Butterflies

During our monitoring, we observed 22 species of butterflies. Three of these species are regarded as typical coastal species, as they prefer dunes or open pioneer vegetation, as well as barren, dry, warm grasslands with bare soil as their habitat. The most common of the three typical species is *Aricia agestis*, which can also be found along roads and in fields across the country, provided the soil isn't too nutrient rich.

English name	Latin name	Red list category	Typical coastal species
Peacock butterfly	*Aglais io*	Least concern	
Small tortoiseshell	*Aglais urticae*	**Endangered**	
Ringlet	*Aphantopus hyperantus*	Least concern	
Brown argus	*Aricia agestis*	Least concern	Yes
Mallow skipper	*Carcharodus alceae*	Least concern	
Holly blue	*Celastrina argiolus*	Least concern	
Small heath	*Coenonympha pamphilus*	Least concern	
Common brimstone	*Gonepteryx rhamni*	Least concern	
Grayling	*Hipparchia semele*	**Endangered**	Yes
Queen of Spain fritillary	*Issoria lathonia*	Least concern	Yes
Small Copper	*Lycaena phlaeas*	Least concern	
Meadow brown	*Maniola jurtina*	Least concern	
Speckled wood	*Pararge aegeria*	Least concern	
Large white	*Pieris brassicae*	Least concern	
Green-veined white	*Pieris napi*	Least concern	
Small white	*Pieris rapae*	Least concern	
Comma	*Polygonia c-album*	Least concern	
Common blue	*Polyommatus icarus*	Least concern	
Gatekeeper	*Pyronia tithonus*	Least concern	
Essex skipper	*Thymelicus lineola*	**Vulnerable**	
Red admiral	*Vanessa atalanta*	Least concern	
Painted lady	*Vanessa cardui*	Least concern	

Table 12: list of all butterfly species found during the survey with additional information.

Out of the three typical coastal butterflies, only *Aricia agestis* was observed in all locations. The remaining two species were exclusively discovered in the West coast region, with *Issoria lathonia* being found exclusively in Doornpanne.

Figure 27: Hipparchia semele - photographer Toon Verbruggen

In the majority of locations, 12 to 13 species of butterflies were observed, with the exception of three locations. The Warandedunes and especially the Doornpanne have a higher diversity of butterfly species than the other locations. And in De Haan's frontal dunes, there was less variety.

It's probably not a coincidence that the most bees and butterflies are found in The Doornpanne during our monitoring program. Furthermore, the diversity of grasshoppers in this particular location was substantial.

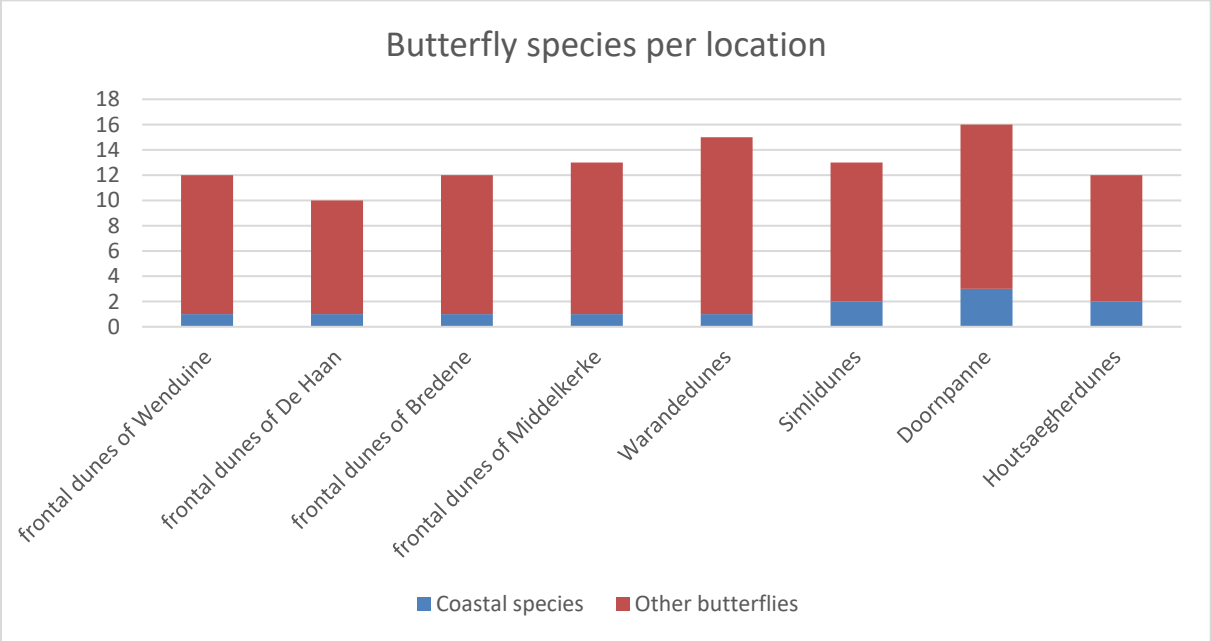

Table 13: Butterfly species per location.

Four species of butterflies were observed solely in a single location, whereas six species have been identified in every location. We have detected two endangered species and one vulnerable species during our monitoring. The endangered species were restricted to a few locations, whereas *Thymelicus lineola* was widespread.

Butterflies	***frontal dunes of Wenduine***	***frontal dunes of De Haan***	***frontal dunes of Bredene***	***frontal dunes of Middelkerke***	***Warandedunes***	***Simlidunes***	***Doornpanne***	***Houtsaegherdunes***
Aglais io	x	x	x	x	x	x		
Aglais urticae			x	x				x
Aphantopus hyperantus				x				
Aricia agestis	x	x	x	x	x	x	x	x
Carcharodus alceae	x				x		x	
Celastrina argiolus					x			x
Coenonympha pamphilus	x	x	x	x	x	x	x	x
Gonepteryx rhamni						x	x	x
Hipparchia semele						x	x	x
Issoria lathonia							x	
Lycaena phlaeas		x					x	
Maniola jurtina	x	x	x	x	x	x	x	x
Pararge aegeria			x		x	x	x	x
Pieris brassicae	x		x	x	x		x	
Pieris napi	x							
Pieris rapae	x	x	x	x	x	x	x	x
Pieris spec.						x	x	
Polygonia c-album				x	x			
Polyommatus icarus	x	x	x	x	x	x	x	x
Pyronia tithonus	x	x	x	x	x	x	x	x
Thymelicus lineola	x	x	x	x	x		x	
Vanessa atalanta			x	x	x	x	x	x
Vanessa cardui	x	x			x	x		
Totaal	**12**	**10**	**12**	**13**	**15**	**13**	**16**	**12**

Table 14: Overview of where each butterfly species was found.

4 Analysis of floral visits

An important part of the monitoring was observing wild bees and hoverflies visit flowers. The importance of invasive plant species for pollinators was determined by observing floral visits.

We can obtain a good overview of the plants that are popular among wild bees and hoverflies by combining the data from the 11 visited nature reserves. We have observed 3.813 interactions between pollinators and flowers. Social bees, such as honeybees and bumblebees, were observed the most frequently (1.969 individuals). We also observed a total of 923 floral visits from solitary bees and 921 from hoverflies.

4.1 Most visited plants (by species)

The number of species that each plant attracts, indicates that native plants are more important than invasive plant species. An exception is *S. inaequidens*, which attracts a large number of solitary bee species and hoverflies. Even though there are many individuals foraging on *R. rugosa*, it is clear that these individuals belong to a select group of species. There are numerous wild bees and hoverflies that prefer *Rubus*.

All plant species	Social bees	Solitary bees	Hoverflies	Total
Rubus spec.	9	28	9	**46**
Senecio inaequidens	5	22	13	**40**
Taraxacum spec.	8	16	13	**36**
Crepis capillaris	4	20	9	**33**
Hypochaeris spec.	3	18	10	**32**
Jacobaea vulgaris	5	15	6	**26**
Hieracium umbellatum	9	10	2	**21**
Alliaria petiolata	4	9	5	**18**
Rosa rugosa	6	5	5	**16**
Diplotaxis tenuifolia	4	8	3	**15**

Table 15: The top 10 most visited plants, ranked by the number of species seen. IAS are marked in red.

Invasive species	Social bees	Solitary bees	Hoverflies	Total
Senecio inaequidens	5	22	13	**40**
Rosa rugosa	6	5	5	**16**
Lycium barbarum	3	3		**6**
Tamarix spec.	1	1	4	**6**
Ligustrum ovalifolium	3		2	**5**
Gaillardia spec.	4		1	**5**
Symphoricarpos albus	3		1	**4**
Berberis aquifolium	3			**3**
Cotoneaster spec.	1			**1**
Colutea arborescens		1		**1**

Table 16: The number of species observed on invasive plant species.

4.2 Floral visits from red list species

A total of 193 floral interactions were observed from individuals belonging to a red list species, including 192 interactions from bees and one from a hoverfly.

The status of a species is considered a red list species if it has one of the following statuses: near threatened (NT), vulnerable (VU), endangered (EN), or critical (CR).

4.2.1 Bees

During our observations, 17 red list species were found, and from all but one species (*Lasioglossum tarsatum*) we were able to observe floral visits. 15 percent of these floral visits were on invasive plant species.

Family	***Name***	**Flower family preference**	**Red list status**
Halictidae	*L. tarsatum*		CR
Megachilidae	*C. conoideus*		CR
Megachilidae	*M. maritima*		CR
Apidae	*B. ruderarius*	polylectic with preference for Fabaceae and Lamiaceae	EN
Halictidae	*L. brevicorne*	oligolectic on yellow coloured Asteraceae	EN
Andrenidae	*A. helvola*		VU
Apidae	*B. campestris*		VU
Apidae	*B. jonellus*		VU
Halictidae	*H. confusus*		VU
Megachilidae	*C. mandibularis*		VU
Megachilidae	*M. leachella*	polylectic with preference for Loteae	VU
Andrenidae	*A. wilkella*	oligolectic on Fabaceae	NT
Apidae	*B. hortorum*		NT
Apidae	*B. lucorum*		NT
Apidae	*B. vestalis*		NT
Apidae	*E. cruciger*		NT
Megachilidae	*O. spinulosa*	oligolectic on Asteraceae	NT

Table 17: An overview of the species that have been identified as being on the red list (endangered species).

Osmia spinulosa, a solitary bee with red list status near threatened, was seen the most when visiting flowers. It was observed 14 times foraging on *S. inaequidens*, which is also the plant that attracted the most red list bees among the invasive species.

The other invasive plants are not or only rarely visited by endangered species. This is primarily due to the fact that these plants are generally not preferred by wild bees. But also because several of the red list species are specialized (oligolectic) or have a strong preference for a certain plant family when it comes to pollen collection. *Coelioxys conoideus* was the only species found foraging on an invasive plant among the most endangered species. This bee is a parasitic bee and does not collect pollen. It only visits flowers for nectar. Therefore, it is not very selective when looking for nectar.

Species name	*S. inaequidens*	*L. barbarum*	*Gaillardia spec.*	*R. rugosa*	On other plants
Andrena helvola				1	0
Andrena wilkella					1
Bombus campestris					12
Bombus hortorum					7
Bombus jonellus					1
Bombus lucorum			1		11
Bombus ruderarius					1
Bombus vestalis			6		14
Coelioxys conoideus	1				1
Coelioxys mandibularis	1				3
Epeolus cruciger	1				0
Halictus confusus perkinsi				1	2
Lasioglossum brevicorne					3
Megachile leachella	1	1			26
Megachile maritima					6
Osmia spinulosa	14				104
Total	**18**	**1**	**7**	**2**	**192**

Table 18: The observed endangered species and the IAS species they were observed on.

Plant species	NT	VU	EN	CR
Rosa rugosa		2		
Gaillardia spec.	2			
Senecio inaequidens	2	2		1
Lycium barbarum		1		

Table 19: The invasive plant species and the quantity of observed endangered species, arranged by red list status.

The most important plants for endangered species are native plants, only the non-native plants *S. inaequidens* and *Lavandula* attracted three or more species. The lavender plant was not discovered within a nature reserve, but it was planted in the ornamental garden of the domain Raversyde and in the front yard of a house situated in the middle of the nature reserve Doornpanne.

Plant species	Social bees	Solitary bees	Total
Hieracium umbellatum	4	2	6
Rubus spec.	2	4	6
Jacobaea vulgaris	2	4	6
Senecio inaequidens	0	5	5
Lavandula spec.	2	1	3
Hypochaeris spec.	0	3	3

Table 20: Plant species and the number of endangered species observed foraging on them. Non native species are marked in red.

4.2.2 Hoverflies

We only observed one foraging individual of an endangered species during our surveys, so it is impossible to provide any analysis on the dependence of hoverflies on invasive plant species. The individual we observed was a *Cheilosia illustrata*, a species that has been designated as vulnerable, and was observed foraging on *Heracleum sphondylium*.

4.3 Dependency of pollinators on invasive plant species.

We have observed numerous visits by diverse pollinators on invasive plant species, particularly on *R. rugosa* and *S. inaequidens*. As all of these invasive plants, with the exception of *S. inaequidens*, will be eradicated during LIFE DUNIAS, it is imperative to evaluate the significance of these plants for pollinators. We have attempted to determine the correlation between the species observed foraging on these plants and the degree of dependence.

During the LIFE DUNIAS invasive plant inventory, more than 30 species of plants were mapped and designated for elimination in coastal dunes. Pollinators were only observed foraging on a total of 10 invasive plant species. On *B. aquifolium*, Cotoneaster sp., and *C. arborescens,* however, there were less than five pollinators observed. This quantity is insufficient to derive any significant inferences; therefore, these plants have been excluded from our analysis of dependency. Moreover, *S. inaequidens* is also excluded, as this plant will not be removed on a large scale during LIFE DUNIAS.

Bee species	***L. barbarum***	***L. ovalifolium***	***Gaillardia spec.***	***S. albus***	***R. rugosa***	***Tamarix spec.***	**Total IAS**	**Grand total**	**Ratio**
Bombus terrestris-gr	12	5	6	8	171	17	221	494	45%
Bombus lapidarius	2		2		9		14	332	4%
Eristalis tenax		34	1		20	1	56	293	19%
Bombus pascuorum	6	2		4	3		17	228	7%
Apis mellifera		1			29		30	101	30%
Episyrphus balteatus		1			4		5	62	8%
Bombus pratorum				1	4		5	46	11%
Lasioglossum leucozonium					1		1	36	3%
Andrena helvola					1		1	30	3%
Bombus lucorum			1				1	27	4%
Eupeodes corollae					7	1	8	24	33%
Bombus hypnorum					2		2	24	8%
Halictus confusus perkinsi					1		1	19	5%
Bombus vestalis			6				6	15	40%
Andrena dorsata						3	3	15	20%

Table 21: The observed visits of endangered bee species on invasive plants (IAS), as well as the total visits from all plants.

From the total number of pollinator species surveyed, only 15 species that visited an invasive plant were observed more than 15 times on any plant species. The majority of these species had a limited number of visits on invasive plant species. Only 5 species had more than 10 individuals on any plant that was invasive.

When comparing the visits of these five species on invasive plants with the total monitored visits on any plant, it is evident that pollinators visit other plants more frequently than invasive species. The ratio between visits on invasive plants and total plants is significant only for three species.

During the course of our research, a significant amount of time was devoted to monitoring invasive plant species, indicating that a greater than usual amount of time was devoted to monitoring floral visits on these plants. Despite our thorough and extensive research, it is impossible to draw conclusive conclusions regarding the dependence of pollinators on invasive plant species.

The large amount of information we gathered suggests a low risk of dependence, given the small number of visits tracked from the majority of pollinator species on invasive plants. We will conduct a comprehensive analysis of the floral visits of *B. terrestris-gr*, *E. tenax*, and *A. mellifera*, which were observed to have a significant number of visits on invasive plants. This will enable us to verify the impact of the removal of the invasive plants they frequented the most.

4.3.1 *Bombus terrestris*-gr

It is not possible to determine to species level with certainty the workers of the following bumblebee species: *B. terrestris, B. lucorum, B. magnus*, and *B. cryptarum*. They are therefore grouped into the *Bombus terrestris-gr*. In some cases, males from this group can be recognized in the field, and in that case, the species name is recorded. The queens of these species can be identified with a high degree of certainty when observed through microscope. However, in order to minimize ecological harm, the queens are not collected, and consequently, observed individuals are added to the group.
B. terrestris and *B. lucorum* are common bee species in Europe. Together with *B. pascuorum*, they are the most common wild bee species in Belgium.

Members of this group exhibit social behaviour, with nests comprising between 400 and 600 individuals during their peak period (May-June). The species in this group are not considered to be specialized in the collection of pollen. They are regarded as opportunistic bees that are not confined to a specific plant or plant families.

With a total of 1.150 observations, 951 of which were recorded while foraging on flowers, this group of bees was the most frequently observed during our investigation.

Plants species	**# individuals**
Rosa rugosa	171
Rubus spec.	117
Lavandula spec.	104
Eryngium maritimum	71
Eupatorium cannabinum	71
Ligustrum vulgare	39
Lamium purpureum	38
Hieracium umbellatum	27
Rhinanthus angustifolius	23
Taraxacum spec.	21
Jacobaea vulgaris	18
Centaurea jacea	17
Tamarix spec.	17
Thymus pulegioides	15

Rosa spinosissima	14

Table 22: The top 15 plants where B. terrestris-gr was observed on, ranked by number of individuals. Non-native species are marked in red.

The extensive variety of diverse plants on which they were observed exemplifies the opportunistic nature of this group of bees. They were observed on a total of 65 distinct plant species. Certain species, such as *R. rugosa*, *Rubus* sp. and lavender, are attracting them in a significant quantity.

Individual bees belonging to this group were observed most frequently on *R. rugosa*. This invasive plant is prevalent in certain coastal regions on a significant scale, and possesses the capacity to dominate areas exceeding several thousand square meters. On these occasions, *R. rugosa* is capable of attracting a significant number of *B. terrestris-gr* bees.

The main flowering period for *R. rugosa* is between May and June, but it continues to produce flowers during the summer. During this primary flowering period, the majority of bumblebee species nests reach their maximum extent and the demand for pollen and nectar reaches its highest level.

During these peak months, 157 bees belonging to this group were observed foraging on *R. rugosa*. During this period, plants such as *Rubus* and lavender also experience their primary flowering period, along with several other plants that are frequently visited by *B. terrestis-gr* bees. There were a total of 390 individuals observed on other plants. While *R. rugosa* is a significant source of food during this period, a far greater number of sightings were made to other, largely non-invasive, plants.

Figure 28: Bombus terristris-gr (queen) - photographer Kris Devos

At the Flemish coast, numerous dunes and nature reserves are relatively small and surrounded by homes and public facilities. Despite their preference for foraging within close proximity to their nest, *B. terrestris-gr* members are capable of searching for food at distances exceeding several kilometres from their nest. The plants found in the ornamental gardens surrounding the coastal dunes have the potential to provide significant sources of food for these bees. The high number of visits recorded on lavender plants at two locations within our search area suggests that they will visit common garden plants like lavender when planted in gardens around nature reserves.

With the eradication of *R. rugosa*, particularly in the short term, a significant food source for *B. terrestris-gr* bees will be eliminated. However, numerous alternative sources of sustenance are readily accessible within the natural preserves and the surrounding gardens.

Furthermore, the removal of *R. rugosa* will aid numerous plants currently visited by these bees, thereby enlarging their area of cultivation. The second most popular plant for these bees, *Rubus*, is one of those plants that can rapidly expand its acreage and colonize areas that have become vacant following the removal of *R. rugosa*. Several perennial plants will self-seed themselves even faster and compensate for some of the loss as a food source by removing *R. rugosa*. Several indigenous plant species were visited very often by *B. terrestris-gr ,* particularly relatively to their being scarce to rare, e.g. *Eryngium maritimum.*

While *B. terrestris-gr* species use *R. rugosa* as an important food source, we do not consider them dependent on the plant. Although the removal may have a brief-term localized impact, it is most likely that numerous plants, which are frequently visited by this group, will increase in abundance and compensate for the loss. Further investigation regarding this topic will be carried out during LIFE DUNIAS to support our thesis.

4.3.2 Eristalis tenax

E. tenax is the most widespread hoverfly species worldwide and in Belgium also one of the most common hoverfly species.

The larva of *E. tenax* is a rat-tailed maggot that inhabits areas where water is polluted with organic matter, such as drainage ditches, manure piles, and sewage. It is an aquatic organism that thrives on dead or decaying organic matter.

Figure 29: Eristalix tenax - photographer Henk Wallays

The adult fly measures approximately 15 millimetres in length and, in this form, it visits flowers to obtain nectar, which it utilizes as a source of energy. The adult form of the species was observed during our research period.

With a total of 305 observations, of which 238 were recorded while foraging on flowers, this species was the most frequently observed hoverfly during our investigation.

Plants species	# individuals
Diplotaxis tenuifolia	93
Jacobaea vulgaris	84
Senecio inaequidens	77
Hieracium umbellatum	56
Cakile maritima	44
Ligustrum ovalifolium	34
Hypochaeris spec.	27
Sinapis arvensis	25
Rubus spec.	24
Brassica napus + Brassica rapa	20
Rosa rugosa	20
Sonchus arvensis var. maritimus	20
Ligustrum vulgare	19
Eupatorium cannabinum	17
Eryngium maritimum	15

Table 23: The top 15 plants where E. tenax was observed on, ranked by number of individuals. IAS species are marked in red.

Adults of *E. tenax* frequently visit a diverse range of flowers and exhibit no distinct preference. The extensive variety of diverse plants on which they were observed exemplifies the opportunistic nature of this hoverfly. They were observed on a total of 36 distinct plant species. This hoverfly was most frequently observed on native plants, predominantly belonging to the *Asteraceae* and *Brassicaceae* families.

The invasive perennial *S. inaequidens* attracted a significant number of individuals. As this plant will not be eradicated on a large scale during LIFE DUNIAS, the eradication process of invasive plant species within this project will not have an impact on this hoverfly.

Other invasive plant species, such as *L. ovalifolium* and *R. rugosa*, have also attracted a significant number of individuals, although not as significantly as the native plants that can be found in our coastal dunes.

Furthermore, *E. tenax* utilizes flowers as an energy source, rather than for reproduction, as this occurs exclusively in aquatic environments. The elimination of invasive plant species will not have any impact on these environments as only a limited number of aquatic invasive plants were detected.

The removal of these invasive plants will most probably not affect the population of *E. tenax* because most of its flower visits are on native plants. Further investigation regarding this topic will be carried out during LIFE DUNIAS to support our thesis.

4.3.3 *Apis mellifera*

The western honey bee, also known as the European honey bee, is the most prevalent of the various honey bee species found worldwide. As with all honey bee species, the western honey bee exhibits eusocial behavior, resulting in the formation of colonies capable of accommodating tens of thousands of bees.

Despite the fact that *A. mellifera* is a native species of Europe and was once regarded as a wild species, there are currently a limited number of wild colonies in Europe. Honeybees that we observe today are domesticated and cared for by beekeepers. Beekeepers often use a breed of honey bee, which is a cross of many subspecies and their strains.

Honeybees are opportunistic bees, with no preference for specific plants or plant families. They do, however, prefer to forage for plants that are abundantly available.

We have observed a total of 152 individuals, of which 149 were recorded while foraging on flowers.

Plants species	**# individuals**
Taraxacum spec.	38
Rubus spec.	32
Rosa rugosa	29
Ligustrum vulgare	7
Crepis capillaris	6
Salix spec.	5
Senecio inaequidens	4
Bryonia dioica	3
Brassica napus + Brassica rapa	3
Crataegus spec.	3

Table 24: The top 10 plants where A. mellifera was observed on, ranked by the number of individuals. IAS species are marked in red.

Honeybees were observed on 24 distinct species of plants, a significant diversity when compared to the limited number of observations. The majority of observations were conducted on native plants, with the exception of *R. rugosa*, which attracted a significant number of honeybees.

Beekeepers consider *B. aquifolium* an important source of nectar in the spring and this IAS is abundant in our coastal area. Many honeybees will indeed forage on this plant in most parts of our country, but we did not observe this during our monitoring. During the blooming period of this plant, between March and April, the weather conditions in our coastal dune areas are still harsh. Our dunes are then subject to strong winds and temperatures are lower than the more sheltered inland areas. Honeybees need better weather conditions and are not benefiting from the blooms of *B. aquifolium* in our dunes areas.

Figure 30: Apis mellifera (female) - photographer Rachel Poppe - Delmelle

Honeybees, similar to bumblebees, have a tendency to forage within close proximity to their nest. However they are capable of searching for food at distances exceeding several kilometres from their nest. The plants found in the ornamental gardens surrounding our coastal dunes have the potential to provide significant sources of food for these bees.

While honeybees use *R. rugosa* as an important food source, we do not consider them dependent on the plant. Although the removal may have a brief-term localized impact, it is likely that numerous plants, which are frequently visited by this group, will increase in abundance and compensate for the loss.

Furthermore, beekeepers frequently relocate colonies of honeybees to alternative locations. When honey production begins to decline, beekeepers have the option of moving the hive to a better location.

Further investigation regarding this topic will be carried out during LIFE DUNIAS to support our thesis.

4.4 Discussion

Our extensive monitoring of 11 coastal dune areas enabled us to investigate the diverse habitats present within these areas. During the course of 132 hours of monitoring, we have observed 5.139 bees and hoverflies, and 3.813 of them were found foraging on various flowers.

Our monitoring included a significant task of observing pollinator interactions with invasive plant species. Despite conducting a thorough investigation and focusing on invasive plants, pollinators were not observed in the majority of the invasive species that will be eradicated as a part of the coastal restoration program from LIFE DUNIAS.

Despite the significant threat posed by invasive plant species to our coastal dunes, a large number of the species that pose a concern are fortunately only encountered occasionally or in limited quantities in a few regions. It is subsequently virtually impracticable for pollinators to develop a dependency on them.

Certain plant characteristics, such as the blooming period, also limit the usefulness of these plants for pollinators like bees and hoverflies. For example, *B. aquifolium* displays a particularly early blooming period during the months of March and April. During this period, a multitude of bee species are present; however, the majority of them exhibit specialized or strong preferences for pollen from diverse willow species or other indigenous plants. Furthermore, many early wild bee species construct their nests underground and are not well-suited to nesting in sandy soils found in coastal dunes. Numerous wild bee species that are typically active during the spring season are presently absent from our coastal dune habitats, with the exception of specialized sandy soil species such as *Colletes cunicularius* and *Andrena barbilabris*.

Two invasive plant species, *R. rugosa* and *S. inaequidens*, attract a large number of pollinators. The examination of the collected data reveals, however, that *R. rugosa* draws numerous individuals, but mainly those belonging to a select group of social bee species. The plant is an important food source for bees and hoverflies, but only for a select group.

Figure 31: Osmia spinulosa (female) on Senecio inaequidens - photographer Kurt Geeraerts

The pollinators that are most frequently observed foraging on *R. rugosa* include *B. terrestris-gr, A. mellifera*, and *E. tenax*. These are very common and widespread, and all are opportunists who visit a great variety of plants in search of food. During our research, they were observed on native plants more than on invasive plants. They are more dependent on native plants then on invasive plants.

The eradication of *R. rugosa*, especially in the short term, will remove a significant food source for these very limited group of common and opportunistic pollinators. However, numerous alternative sources of nectar and pollen are readily available within the natural preserves and the surrounding gardens.

Furthermore, the removal of *R. rugosa* will benefit numerous plants currently visited by these bees, thereby enlarging their area of cultivation. *Rubus*, a popular plant for these bees, is one of those plants that can rapidly expand its acreage and colonize areas that have become vacant following the removal of *R. rugosa*. Several perennial plants will self-seed themselves even faster and compensate for some of the loss as a food source by removing *R. rugosa*.

Figure 32: Megachile leachella (female) on Rubus spec. - photographer Kurt Geeraerts

Numerous pollinators, primarily solitary bees, forage on *S. inaequidens*. This widespread invasive plant appears to be important to a large group of bees and hoverflies. We found 40 different kinds of bee species foraging on this plant, only the native *Rubus* attracted more species (46). Although this plant is considered an invasive species, it will not be eradicated during LIFE DUNIAS. This important food source for pollinators will continue to be present on a large scale in our coastal dune areas.

During our monitoring, we observed very few endangered species or typical coastal dune species on invasive plants that will be eradicated in the coming years. The removal of these plants is unlikely to pose a threat to these pollinators, but it is more likely to provide space for the indigenous plants they rely on.

In the Simlidunes, one of the investigated project areas, removal of IAS species has already occurred in combination with habitat restoration. It is likely that this had a positive effect on the amount of pollinators, as the 3th highest amount of species was observed here.

One of the native plants that benefitted greatly from the removal of IAS and shrubs was *A. petiolate*, a flower from the Brassicaceae family. During our monitoring we have found 2 rare bees (*A. pilipes* and *A. lagopus*) who are greatly dependent on flowers of the Brassicaceae family. Without the removal of IAS plants, combined with habitat restoration, there wouldn't be such abundance of the flower *A. petiolate* and probably both rare bee species wouldn't have been found.

In 2025-2026, after eradication of the mapped invasive plant species, follow-up monitoring will be conducted. The objective of this monitoring is to ascertain the impact of the removal of these plants on pollinators. As the majority of pollinators are found on native plants, it is probable that the removal will have a positive impact, particularly on the unique or endangered species found in our coastal dune areas as we observed already in the Simlidunes

4.4.1 Honeybees

Honeybees, along with wild bees and hoverflies, serve as pollinators, visiting a diverse range of flowers to retrieve pollen and nectar. In their pursuit of food, they are in direct competition with the other pollinators. In recent years, a growing number of studies have been published, demonstrating that the presence of honeybees has a direct impact on wild bees and other pollinators. The high density of

honeybees, for instance, results in a reduction in reproduction rates and alterations in foraging behavior for wild bees (Webref 3).

Figure 33: A large amount of honey bee hives has a negative effect on wild bee populations.- photographer Olivier Foubert

It is always a good practice to reduce the number of honeybee colonies in or near nature reserves, as their primary function is to protect local biodiversity. Even though we did not observe a significant number of honeybees during our research, it may prove beneficial to take measures to address the presence of honeybees in our coastal dunes areas, especially after the removal of invasive species.

The removal of significant quantities of *R. rugosa* will undoubtedly have an impact on both *B. terrestris*-gr and honeybees, as both species frequently use this plant for food. New plants will appear to make up for the loss, but it will take some time. In order to mitigate the threat of competition between honeybees and wild pollinators, it would be prudent to restrict the presence of honeybee colonies in close proximity to our coastal dunes. It is imperative to prevent an increase in honeybee colonies at the bare minimum. A situation where there will be a reduction in food and an additional increase in competition by adding more honeybees should be avoided at all costs.

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6 Tables

Tabel 25: The list of plant species and the quantity of pollinator species observed foraging on them. The species are divided into social, solitary, and hoverfly groups. IAS are marked in red.

Plant name	Socials bee species	Solitary bee species	Hoverflies species	Total species
Rubus spec.	9	28	9	46
Senecio inaequidens	5	22	13	40
Taraxacum officinale	8	16	13	36
Crepis capillaris	4	20	9	33
Hypochaeris radicata	3	18	10	32
Jacobaea vulgaris	5	15	6	26
Hieracium canadense	9	10	2	21
Alliaria petiolata	4	9	5	18
Rosa rugosa	6	5	5	16
Diplotaxis tenuifolia	4	8	3	15
Prunus spinosa	4	8	2	14
Salix spec.	5	6	2	13
Eupatorium cannabinum	5	5	2	12
Cirsium arvense	5	4	2	11
Lavendula spec.	6	5		11
Rosa spinosissima	5	2	3	10
Heracleum sphondylium	1	3	6	10
Eryngium maritimum	2	6	1	9
Acer pseudoplatanus	3	6		9
Lamium purpureum	6	2	1	9
Sonchus arvensis var. maritimus	3	1	5	9
Anthriscus sylvestris	2	3	3	8
Malva spec.	5	3		8
Brassica spec.	3	3	2	8
Sedum acre	2	2	4	8
Lamium album	6	2		8
Ranunculus spec.	1	4	2	7
Calystegia sepium	3	3	1	7
Bryonia dioica	4	3		7
Centaurea jacea	4	1	2	7
Crataegus spec.	3	2	2	7
Lycium barbarum	3	3		6
Erodium cicutarium subsp. dunense	1	4	1	6
Achillea millefolium	1	3	2	6
Thymus pulegioides	5		1	6
Ononis spinosa subsp. procurrens	3	3		6
Sinapis alba	6			6
Geranium spec.	4	2		6

Plant name	Socials bee species	Solitary bee species	Hoverflies species	Total species
Tamarix spec.	1	1	4	6
Potentilla reptans	6			6
Ligustrum vulgare	4		2	6
Chamaenerion angustifolium	5	1		6
Helminthotheca echioides		4	1	5
Anchusa officinalis	5			5
Ligustrum ovalifolium	3		2	5
Pulicaria dysenterica	1	2	2	5
Sinapis arvensis		3	2	5
Gaillardia spec.	4		1	5
Galium verum	1		3	4
Sonchus oleraceus	3		1	4
Symphoricarpos albus	3		1	4
Rhinanthus angustifolius	4			4
Lotus corniculatus	3	1		4
Ranunculus acris	1	2	1	4
Ballota nigra	2	2		4
Carduus tenuiflorus	2	1	1	4
Lathyrus pratensis	4			4
Vinca spec.	4			4
Trifolium repens	3	1		4
Tanacetum vulgare	2		1	3
Medicago x varia	2	1		3
Chaerophyllum temulum		1	2	3
Veronica chamaedrys	1	1	1	3
Papaver rhoeas	1	2		3
Senecio spec.	1		2	3
Berberis aquifolium	3			3
Cirsium vulgare	2	1		3
Lonicera Maackii	3			3
Daucus carota	2		1	3
Anthyllis vulneraria	3			3
Prunus avium	2	1		3
Silene latifolia	2			2
Pastinaca sativa		1	1	2
Lythrum salicaria	2			2
Glechoma hederacea	2			2
Ribes uva-crispa	2			2
Bellis perennis		2		2
Raphanus spec.		1	1	2
Erodium cicutarium	2			2
Rosa spec.	1		1	2
Chelidonium majus	2			2
Cynoglossum officinale	2			2
Cakile maritima			2	2

Plant name	Socials bee species	Solitary bee species	Hoverflies species	Total species
Asparagus officinalis			1	1
Stachys sylvatica	1			1
Cytisus scoparius	1			1
Fumaria spec.			1	1
Cotoneaster spec.	1			1
Colutea arborescens			1	1
Cerastium fontanum				1 1
Arctium minus	1			1
Hyacinthus spec.	1			1
Matricaria spec.			1	1
Papaver spec.	1			1
Arctium spec.	1			1
Cerastium glomeratum			1	1
Medicago sativa	1			1
Tragopogon spec.			1	1
Lepidium draba			1	1
Geranium robertianum	1			1
Medicago falcata	1			1
Hypericum perforatum	1			1
Spiraea spec.	1			1
Claytonia perfoliata			1	1
Convolvulus soldanella	1			1

Natuurpunt is de grootste natuurvereniging in Vlaanderen. Duizenden vrijwilligers en 400 professionele medewerkers werken voor de bescherming van belangrijke leefgebieden, soorten en landschappen. Om dit doel te bereiken beschermt de vereniging de resterende natuur in Vlaanderen door gebieden aan te kopen en beheren, door soorten en leefgebieden te bestuderen en monitoren, door mensen kennis te laten maken met de natuur en door beleidsbeïnvloeding op lokaal, regio-naal en Europees niveau. Natuurpunt beheert meer dan 28.000 ha natuur verspreid over 500 natuurgebieden. 130.000 families zijn lid van Natuurpunt.