LIFE Project Number
LIFE19 ENV/BE/000102

C.1.4 Monitoring Health effects caused by Oak Processionary

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01/09/2020 - 30/08/2025

Report Delivery Due Date – Actual Date
31/01/2026 – 10/12/2025

LIFE PROJECT NAME or Acronym
LIFE Oak Processionary

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1 Context

This report is a result of Action C.1.3, the monitoring of the socio-economic impact on the use of Oak Processionary Caterpillar (OPC) management techniques. This report covers the whole project research period (2020 to 2024).

Currently oak processionary caterpillars (OPC) are managed mostly with biocides (Bt). However, this management approach comes with health and ecological cost. The main objective of the project is a strong reduction of the amount of biocides (Bt) used to control the OPC in favour of more ecological sound techniques.

However, alternative methods that have less negative impact, are considered more expensive.

Also, other measures taken in the context of biodiversity, like ecological roadside management, do help in the management of OPC, as our studies confirmed.

2 Objectives

To estimate the economic feasibility of these techniques, we do need to consider the cost of each of them and the impact their use might have on the environment. Gathering cost data and effectiveness data on management strategies is necessary to guarantee sustainability of OPC management, as well as for communication purposes to a wider audience.

The objective for this action was to collect data on the economic cost for all different management measures used and evaluate and compare cost and benefits for the different methods. The cost included labour cost, material cost, monitoring cost and VAT.

We classified the methods used as preventive (used early in the season before OPC nests appear), or curative (destruction of the nests when they appear). We also considered alternative methods - all other nature management methods used for other objectives, but with known impact on OPC).

Since no quantitative data on health risks and ecological benefits for these methods are available, we evaluated them in a semi-quantitative manner.

To compare the effectiveness (= reduction in number of OPC) between measures, we performed a cost-effectiveness analysis on the methods where the information was available.

2.1 Expected quantitative and semi-quantitative results:

1. Overview of the strategies used, and the preventive, curative and alternative measures taken by the Ambassador communities and the evolution over the lifetime of the project;
2. Calculate the cost of the different strategies and techniques used in a way that they are mutually comparable, i.e. per municipality and per treated tree;
3. Evolution of these cost over the project's lifetime;
4. Average expected cost of the different techniques;
5. A cost-effectiveness analysis of all preventive and curative measures;
6. An evaluation of effectiveness vs. impact on the biodiversity for preventive, curative, and alternative methods.

3 Study setup

To get a good overview of the strategies and different measures used in Belgium and The Netherlands and the associated cost, we wanted to gather information from all our partner regions (the provinces of Antwerpen, Gelderland, Limburg (BE), Limburg (NL) and Noord-Brabant.

To achieve that, we included additional questions in the biocide survey to our Ambassador municipalities that were selected from the entire project region. These ambassadors receive guidance in how sensitization and the application of ecological methods can reduce the need to apply BT, and in return they fill out two questionnaires annually about their preventive and curative measures against the OPM. This allows us not only to monitor their biocide use but also their experiences with alternative treatments.

More specific, we asked the following questions:

1. **For the preventive measures (first yearly questionnaire)**
    - Has your municipality taken preventive measures against oak processionary caterpillars this year?
    - Which product was used?
    - How much product was used?
    - How many trees were treated preventively?
    - What was the cost (including VAT) for the treatment?
    - Do you have any further comments?

7. **For the curative measures (second questionnaire):**
    - Which curative treatment methods did your municipality use in the summer? (multiple answers possible)
    - How many trees were treated curatively?
    - What was the cost (incl. VAT) of the curative treatment?
    - What is your municipality currently doing to attract natural enemies of the OPC? (Multiple answers possible)
    - What is the (estimated) cost (incl. VAT) of this?
    - Is your municipality doing anything else to combat or manage OPC? If so, what?
    - How much disruption has your municipality experienced this year due to the OPC? Please provide a quantifiable account (e.g., number of complaints from citizens, number of trees infected with OPC, etc.).
    - Do you have any further comments?

If answered correctly, the answers would make it possible to gather the economic cost for all the different strategies and measures and compare cost. This cost includes the cost for labour, material, monitoring, for protection against health hazards, for removing the waste and the VAT.

Additional information for evaluating effectiveness, ecological impact and health risks was collected via a literature study.

In the following analysis, the use of these biocides should be related to the abundance of OPC during the same period. When the project started in 2020, OPC abundancy was at a peak level. Since then, the

abundancy has decreased in the whole project area, with a low point in 2023. Since 2024 the abundancy is on the rise again.

Below are the observations of OPC individuals registered in Waarnemingen.be and Waarneming.nl for this period.

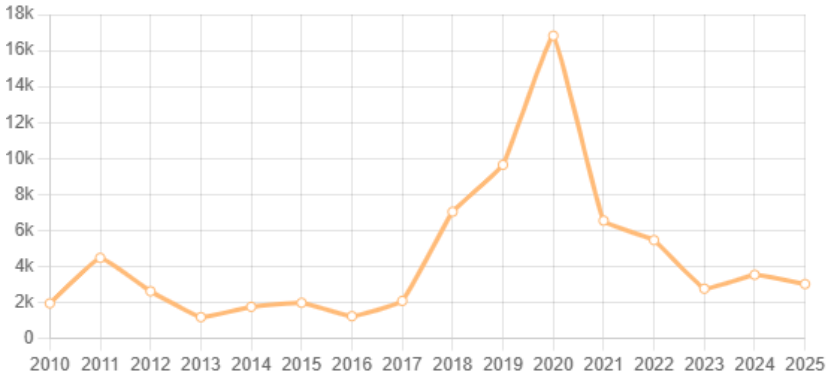

Figure 1: Evolution of OPC individuals observed in Flanders. Source: Waarnemingen.be. Accessed 01/09/2025

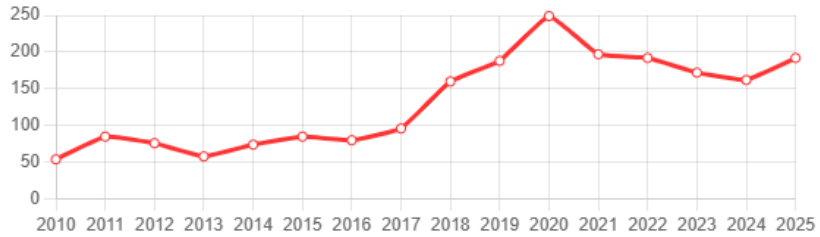

Figure 2: Evolution of municipalities with OPC observations in Flanders. Source: Waarnemingen.be. Accessed 01/09/2025

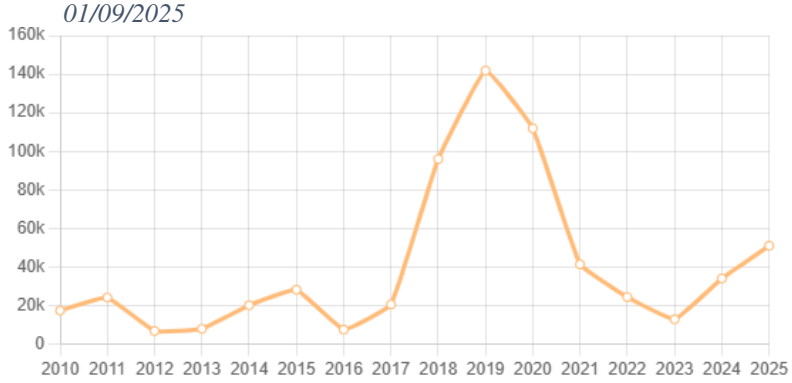

Figure 3: Evolution of OPC individuals observed in the Netherlands. Source: Waarneming.nl. Accessed 01/09/2025

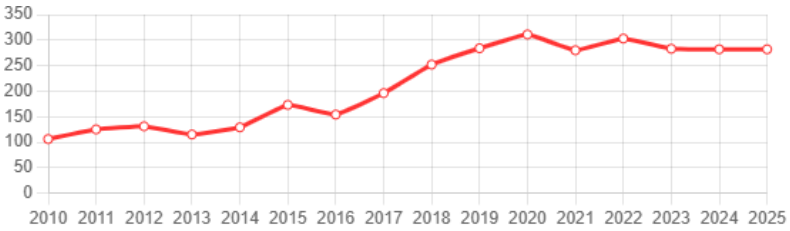

Figure 4: Evolution of municipalities with OPC observations in the Netherlands. Source: Waarnemingen.nl. Accessed 01/09/2025

With these, we expect to see an impact on the use of measures from the start of the measurement period in 2020, so at the peak of the pressure, to 2023, when the pressure was at its lowest point.

4 Results 2021-2024

4.1 Responses

For the background on the use of Ambassador municipalities for this analysis, we want to refer to the report on Action C.1.1 Monitoring the use of biocides (definitive version).

In total, over the four years of questioning we received 97 answers from 31 different municipalities to the questions regarding their strategies and economic cost of their measures, on average 24 each year.

At the start in 2021, 26 municipalities answered, but that number gradually decreased towards the end of the four years, when we got only 22 answers on these specific topics.

4.2 Measures used.

4.2.1 Strategies and measures

Among the ambassador community and from one year to the next, municipalities used a combination of different management measures to manage OPC. We classified these methods as direct – measures specifically intended against the OPC with immediate impact – versus indirect or alternative – nature management methods used for other purposes, but with known impact on OPC, mostly on the longer term.

We divided these direct measures further in preventive measures - used early in the season before OPC nests appear- and curative measures - destruction of the nests when they appear.

At the start of the project and the peak of the OPC pressure, most of the ambassador communities used a combination of both direct and indirect measures. This number decreased systematically towards the end of the project in line with the decreasing pressure. A limited number of municipalities did not report any measure against OPC at all, so almost all our Ambassador municipalities provided at least one measure every year.

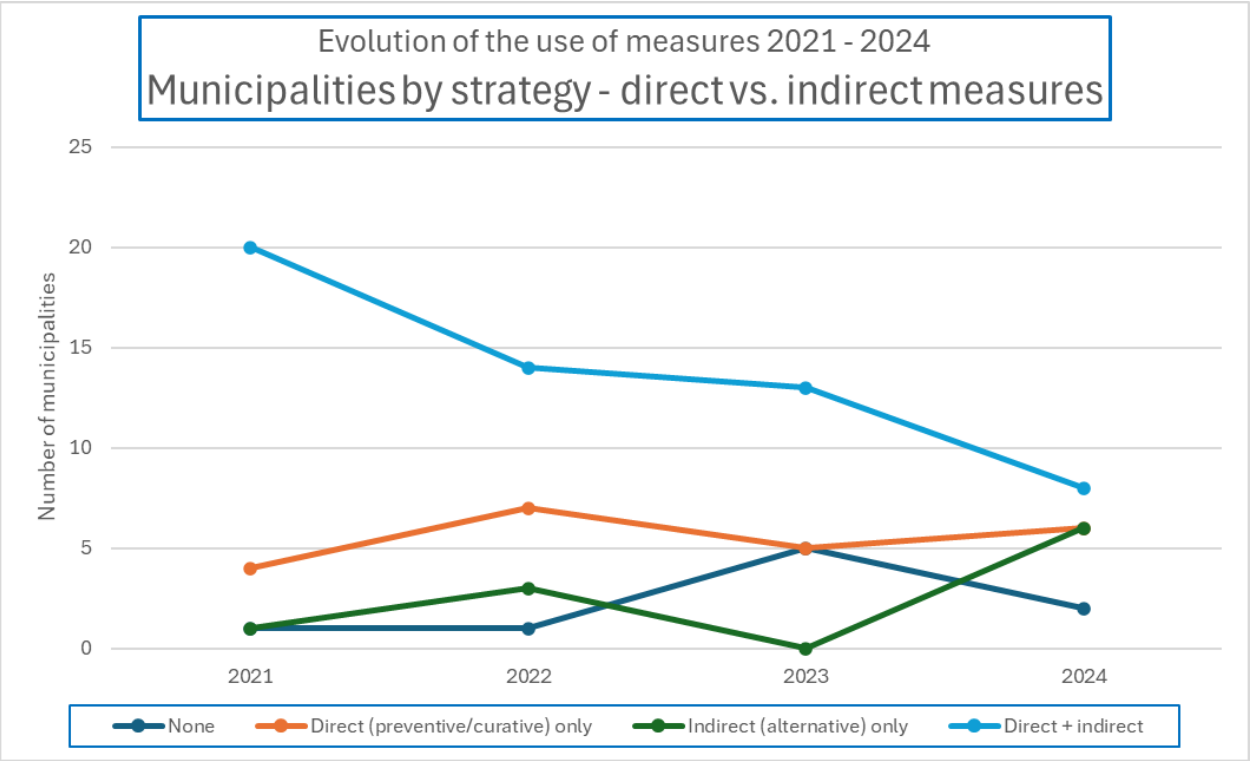

Figure 5: Evolution of the number of municipalities by strategy - direct vs. indirect measures.

When looking at direct measures only, at the start of the project and the peak of the OPC pressure, more than half of the ambassador communities used a combination of both preventive and curative measures. This number decreased systematically towards the end of the project, and in 2024 only two municipalities continued to use both types of measures. In contract to this, the number of municipalities that did not use any direct measure against OPC gradually increased from two at the start towards more than a third at the end. The number of municipalities using only one type of measure was much more stable from one year to the next.

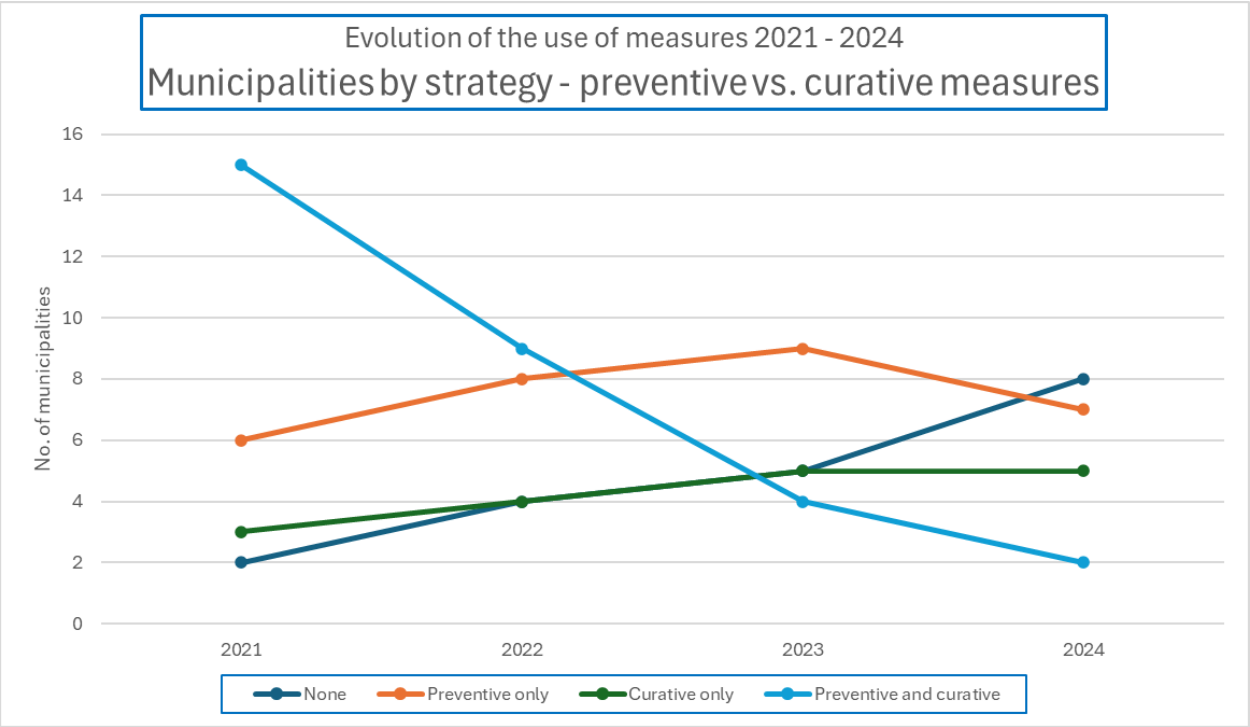

Figure 6: Evolution of the number of municipalities by strategy - preventive vs. curative measures.

Across strategies, the number of trees managed curatively was always much more limited than the number managed preventively. The average number of trees managed by preventive measures per municipality per year was typically between 1.500 and 4.000 trees, while the number managed preventively was between 40 and 240. So, on average around 96% of treated trees were treated preventively.

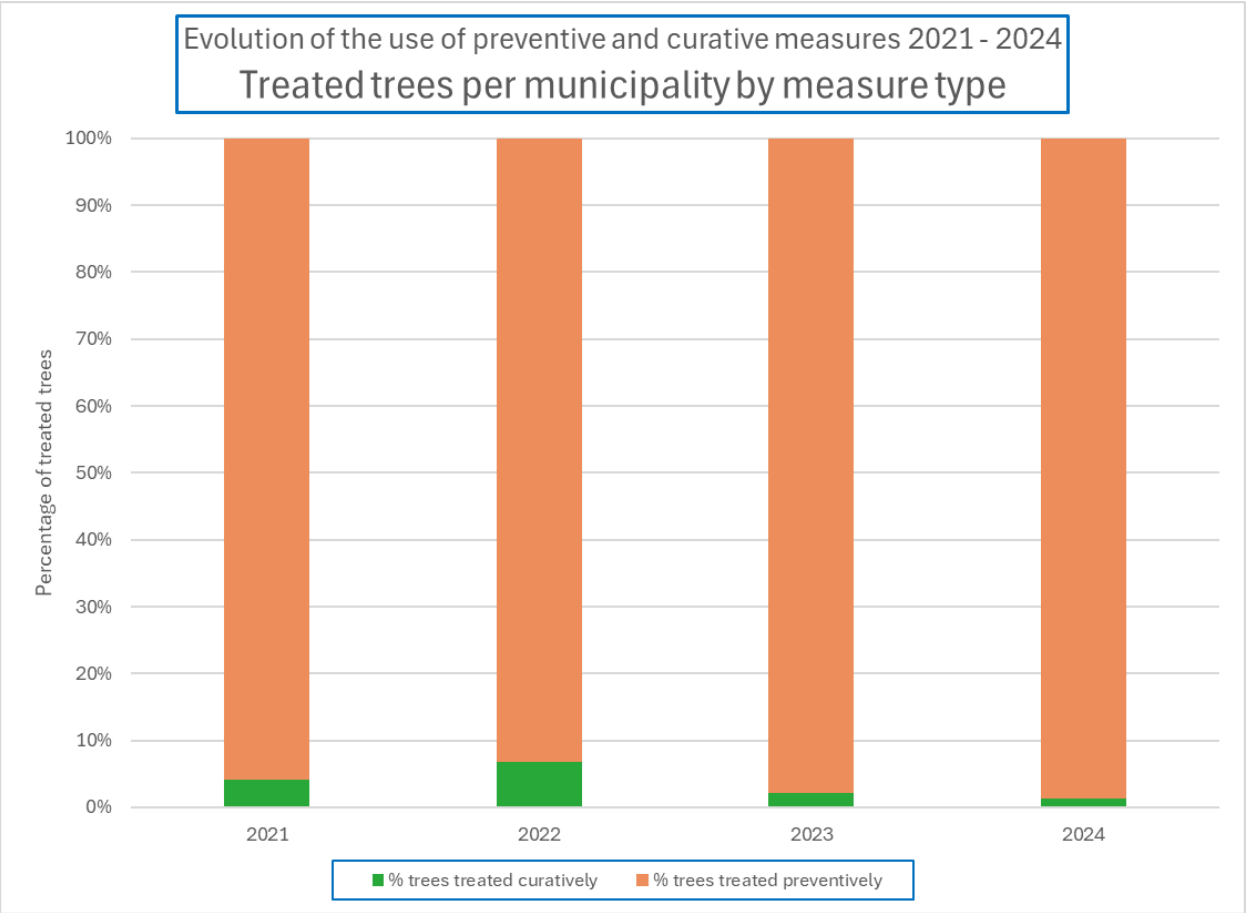

Figure 7: Evolution of the number of treated trees per municipality by direct measure type - preventive vs. curative measures.

4.2.2 Preventive measures

Preventive measures are used before the caterpillars start forming nests. The extent to which they are applied is therefore largely based on monitoring of the previous season(s). This means the accuracy with which these methods can be used to destroy OPC nests is more limited than for the curative methods, which can be used much more targeted. Typically, users spray all trees in a lane or area even when no OPC is present in some of the trees.

Compared to curative measures, these techniques are more automated and can therefore be applied on a much larger scale, which makes them significantly cheaper. Also, if applied at the correct time, the risk of contact with the stinging hairs is much smaller. The main risk for the pest controllers is the biocides themselves, most of which also pose health risks. The biggest problem with these methods is however that they are not selective and, depending on the product, can impact tens to hundreds of organisms in and around the trees.

The Ambassador municipalities used three different preventive products:

- Xentari, a biocide based on the bacterium *Bacillus thuringiensis aizawai* (Bta)
- Foray ES, a biocide based on *Bacillus thuringiensis kurstaki* (Btk)
- Nematodes (e.g. *Steinernema feltiae* and *S. carpocapsae*)

Bt was used in most of the Ambassador municipalities. In the Netherlands only Xentari was used, in Flanders only Foray ES. Nematodes were only used in two instances in one municipality in the Netherlands.

The use of preventive measures decreased gradually during the project runtime. In 2024, most Ambassador communities stopped using biocides.

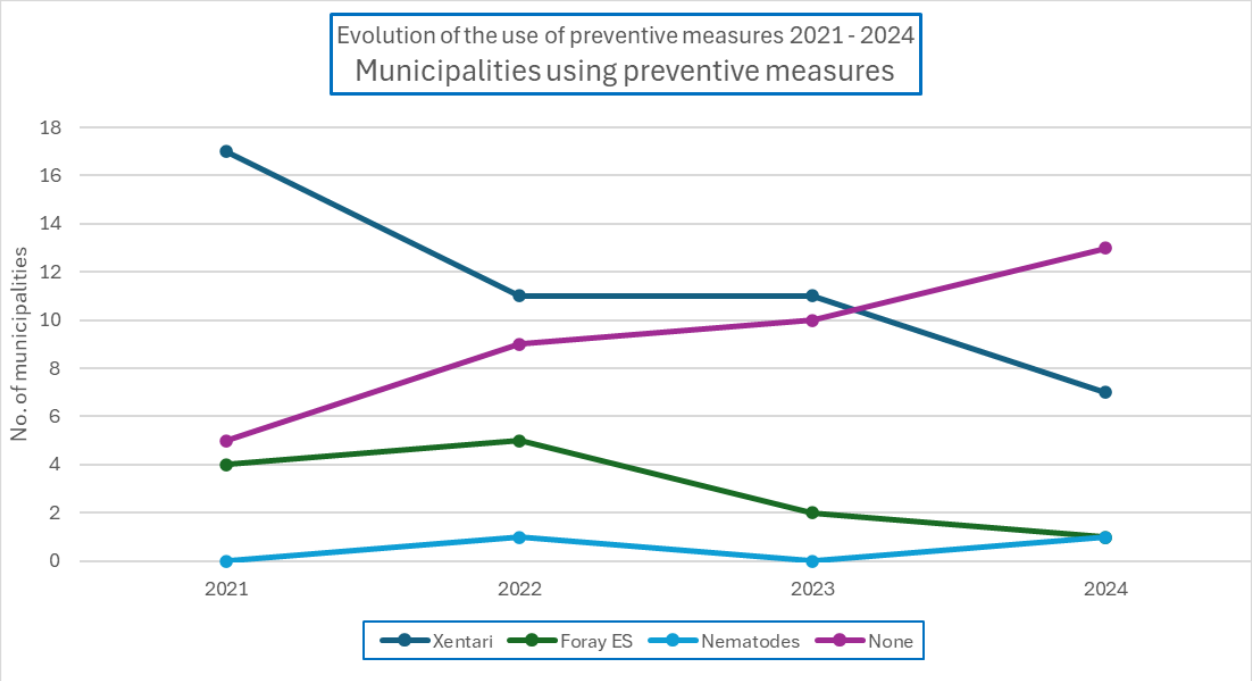

Figure 8: Evolution of the number of municipalities using preventive measures.

In line with the decrease in number of municipalities, also the number of trees treated with biocides decreased during the project runtime, except for 2024 when it rose slightly again in three of the five project areas.

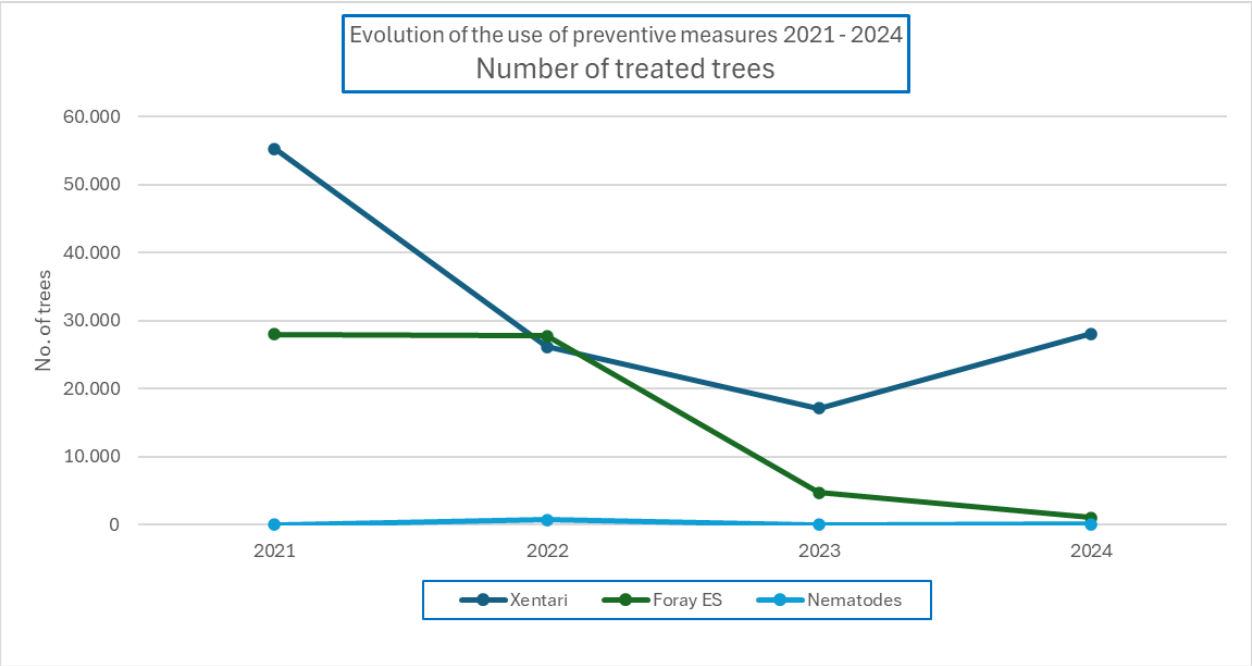

Figure 9:Evolution of the number of treated trees using preventive measures.

4.2.3 Curative measures

Curative measures are typically used once the nests become visible and can therefore be applied much more targeted and on a more limited scale with the same effect. The impact on the environment of these methods is therefore much smaller. Except for burning, these techniques themselves contain no health risk, but since at the moment of application the caterpillars already have developed their urticating hairs, there is a higher risk of health issues for the pest controllers due to contact with the hairs.

For the curative management of OPC nests, the Ambassador municipalities used four different techniques:

- Vacuuming;
- Vacuuming combined with manual removal of large nests;
- Burning;
- Manual removal.

Vacuuming and vacuuming combined with manual removal of large nests were the most popular measures, especially in the early years when OPC was at its peak.

Also, the municipalities using these measures decreased during the project runtime, but at a slower rate than the ones using preventive measures. As from 2023, most municipalities no longer used curative measures.

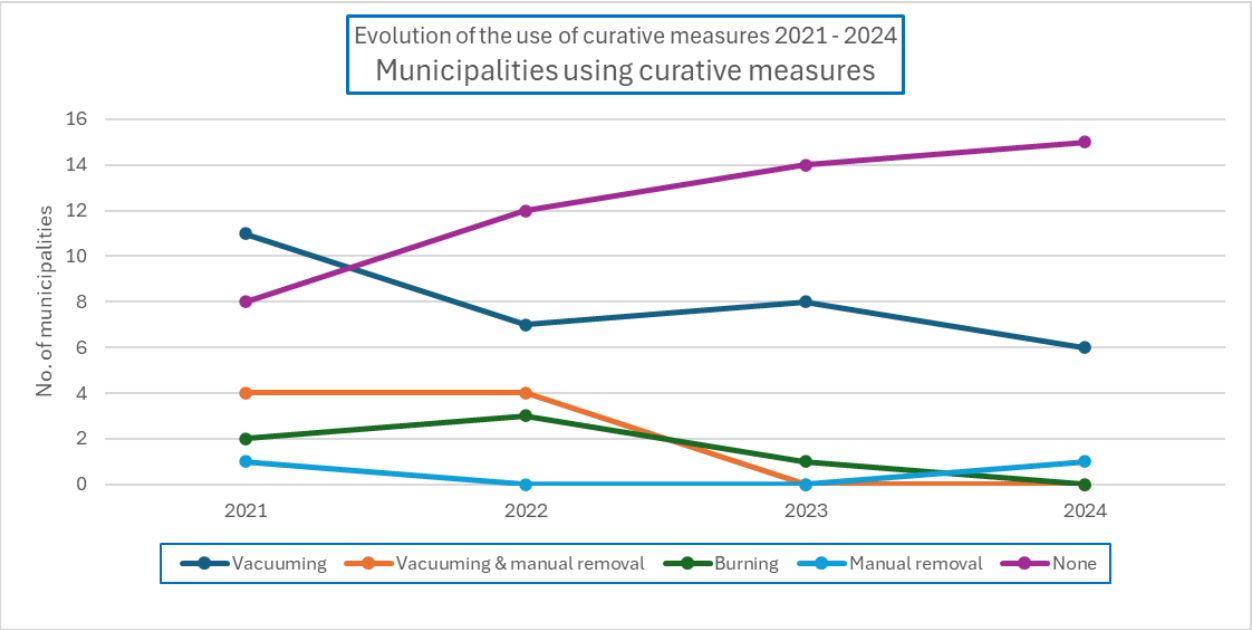

Figure 10: Evolution of the number of municipalities using curative measures.

Contrary to the expectations, the number of trees treated with curative methods in the project area still rose in 2022 compared to 2021, but only in one province (Noord-Brabant). After that, also this indicator decreased the last two years.

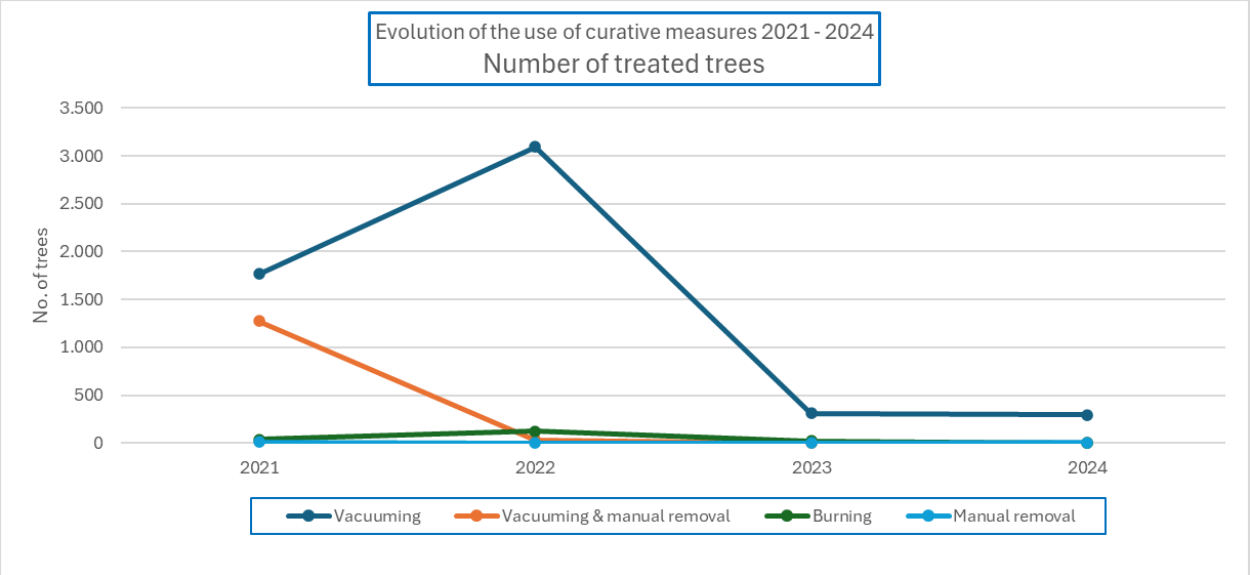

Figure 11: Evolution of the number of treated trees using curative measures.

4.2.4 Alternative measures

Part of the questions in our survey concerned alternative measures used to (or useful) in the management of OPC plagues. These included:

- Ecological roadside mowing techniques, to enhance the habitat for the caterpillar's natural enemies;
- Sowing roadsides with specific flowers species that should attract parasitoids;
- Placing nest boxes for insect eating birds, like great and blue tit;
- Capturing and storing removed OPC nests in parasitoid boxes to allow parasitoids to further develop while not allowing the butterflies to propagate;
- Other measures which might benefit the natural predators of OPC.

The majority of the Ambassador communities had at least one alternative measure in place. The most popular one, used by more than ¾ of the Ambassador communities, were the ecological mowing techniques, followed by using nest boxes.

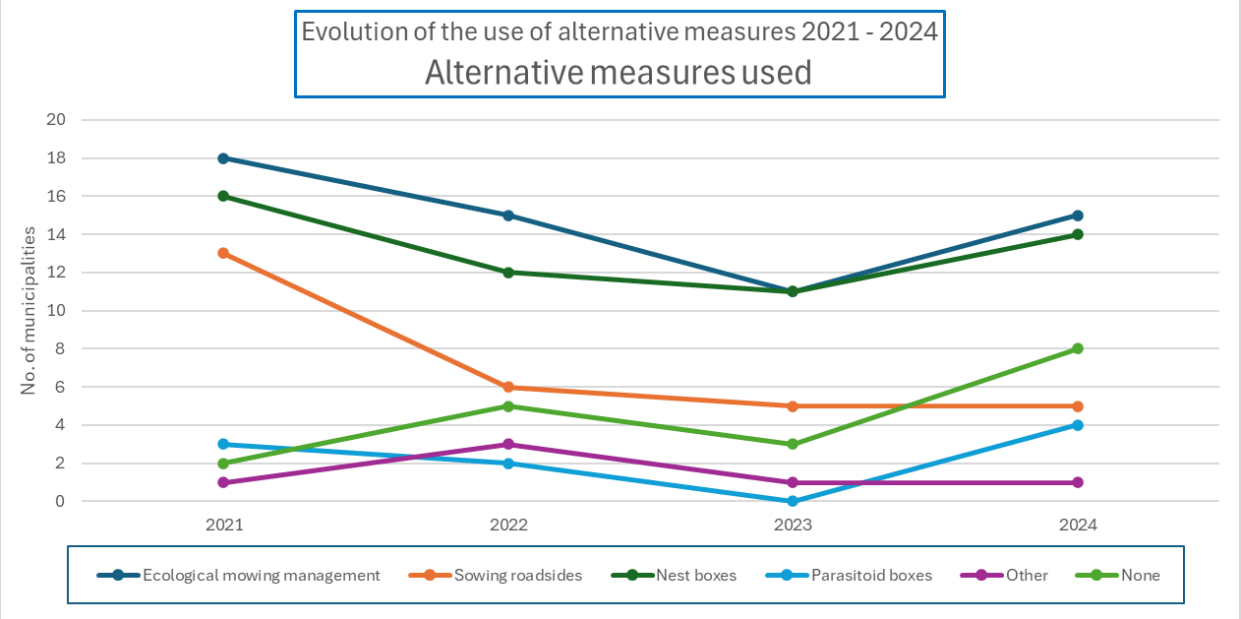

Figure 12: Evolution of the number of municipalities using alternative measures

The number of alternative measures used per municipality fluctuated from year to year, independent of the pressure of OPC. We can even see that the average number of different measures taken per municipality increased slightly over the years. This makes it clear that the reported measures were not only planned for the management of OPC but are part of structural green space management.

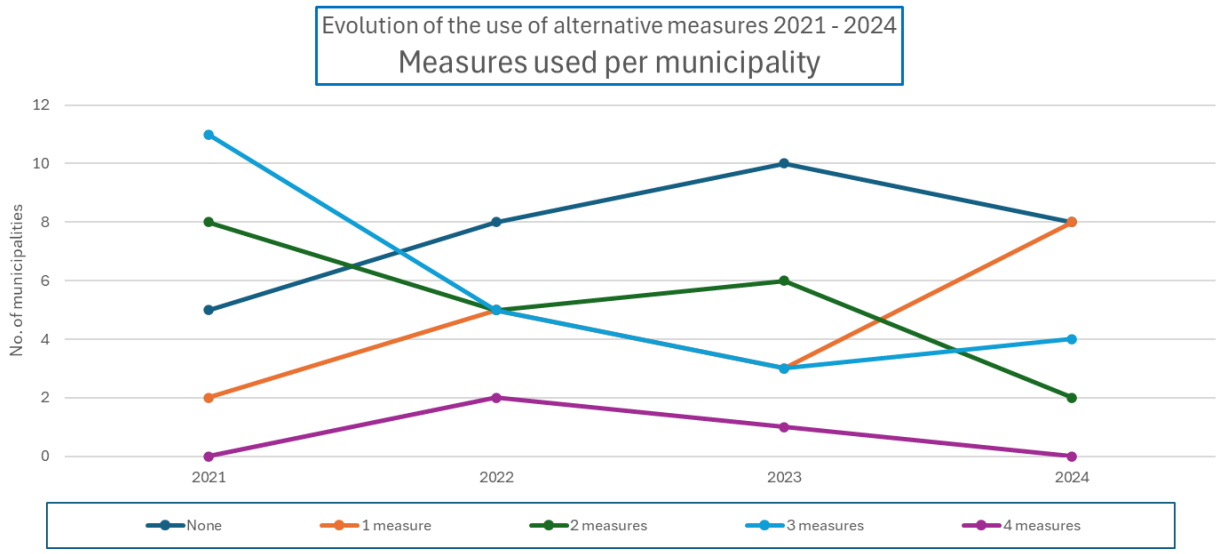

Figure 13: Evolution of the number of alternative measures used per municipality.

4.3 Cost comparison

Based on the reported number of treated trees and total price of the preventive or curative measure, we could calculate the average cost for every technique per municipality and for treating one tree. This cost not only includes the cost of purchase, but also the operational cost for the treatment and VAT.

Because we did not receive detailed information on the cost of alternative measures, we left these out of the comparison.

4.3.1 Preventive measures

Because there were only two cases of the use of nematodes and only one where the cost was reported, we did not include this method in this comparison. In the one case we know the cost for using nematodes, this was around 12,80 €/tree.

As expected, the cost for preventive measures per municipality has decreased significantly during the four years of the project, at least for the Foray ES-users. This, of course, has to do with the decrease in the OPC population, so less trees were treated in the later years. It must be noticed that the cost for municipalities when using Xentari has not decreased even when the number of trees treated with this biocide has decreased significantly.

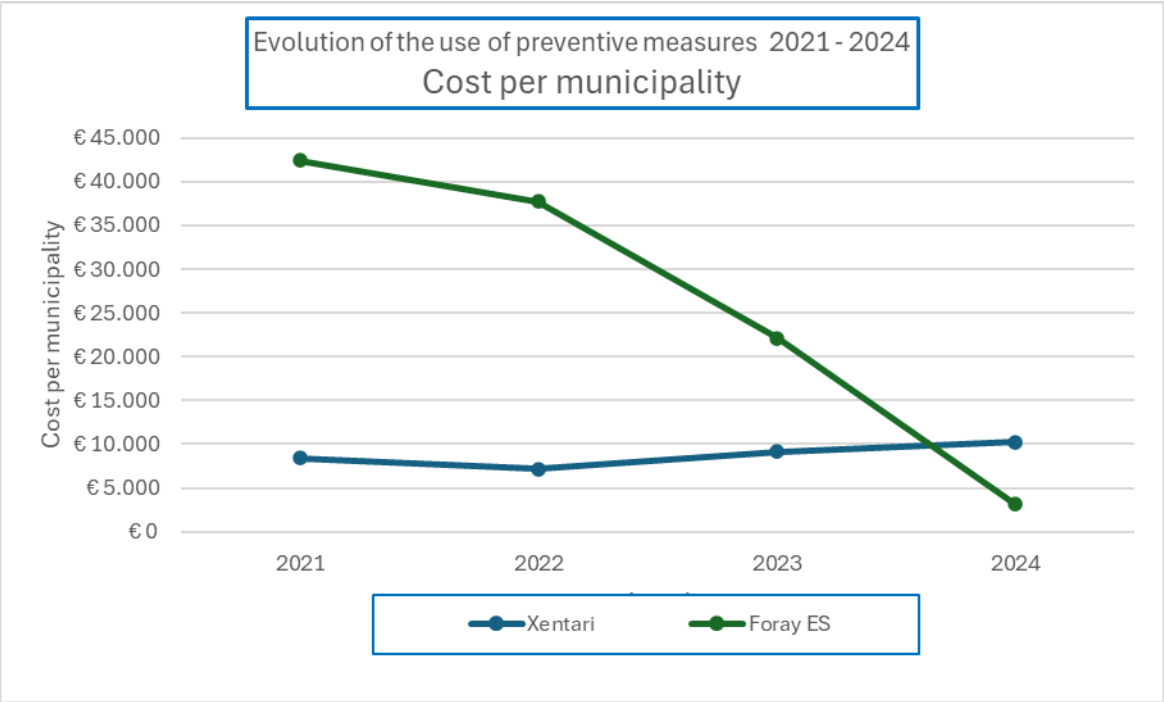

Figure 14: Evolution of the cost per municipality for preventive measures.

Over the years, the average cost of using preventive measures was around 4,30€/tree, with Foray ES (6,60 €/tree) being about twice as expensive to use as Xentari (3,12 €/tree).

	Cost per tree														
Method	**2021**			**2022**			**2023**			**2024**			**Overall**		
	Average	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**
Xentari	€ 2,60	€ 1,88	€ 9,23	€ 3,02	€ 2,05	€ 9,92	€ 5,88	€ 2,73	€ 23,48	€ 2,56	€ 2,08	€ 8,24	**€ 3,12**	€ 1,88	€ 23,48
Foray ES	€ 6,05	€ 3,83	€ 9,58	€ 6,80	€ 3,84	€ 13,45	€ 9,29	€ 8,46	€ 10,28	€ 3,04	€ 3,04	€ 3,04	**€ 6,59**	€ 3,04	€ 13,45
Total	**€ 3,76**			**€ 5,07**			**€ 6,62**			**€ 2,62**			**€ 4,30**		

Table 1: Evolution of the cost per treated tree of preventive measures

The average cost per tree for the preventive measures using Bt (Xentari and Foray ES) has gradually increased since 2021, due to the impact of inflation on both product prices and labour cost. It seems to have dropped in 2024., but that time only one municipality used Foray ES, so this figure is not significant. We cannot explain the decreased cost for using Xentari in 2024 that way, since still six municipalities were using it at that time.

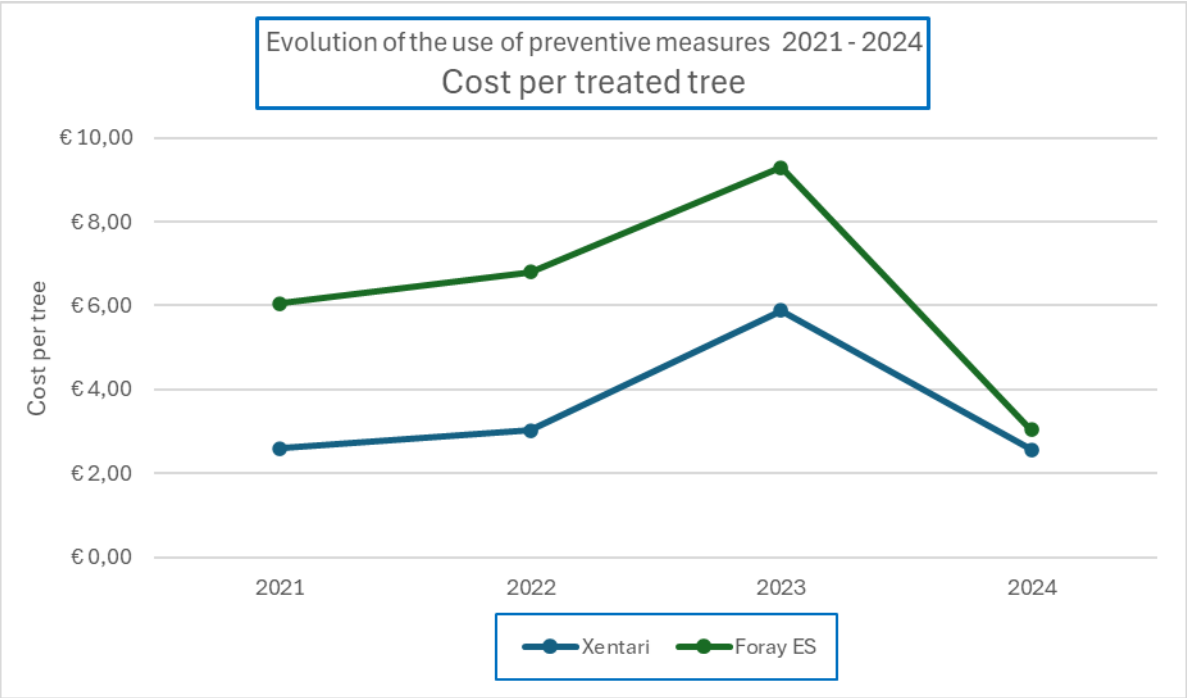

Figure 15: Evolution of the cost per treated tree of preventive measures.

4.3.2 Curative measures

On the curative measures taken, only two cases of manual removal were reported, and only one with the associated cost, so we did not include this method in our comparison. In the one case we know the cost for using only manual removal, this was around 100€/tree.

Compared to the cost for preventive measures, the cost for curative measures per municipality was relative stable during the four years of the project with as exception the expensive vacuuming combined with manual removal.

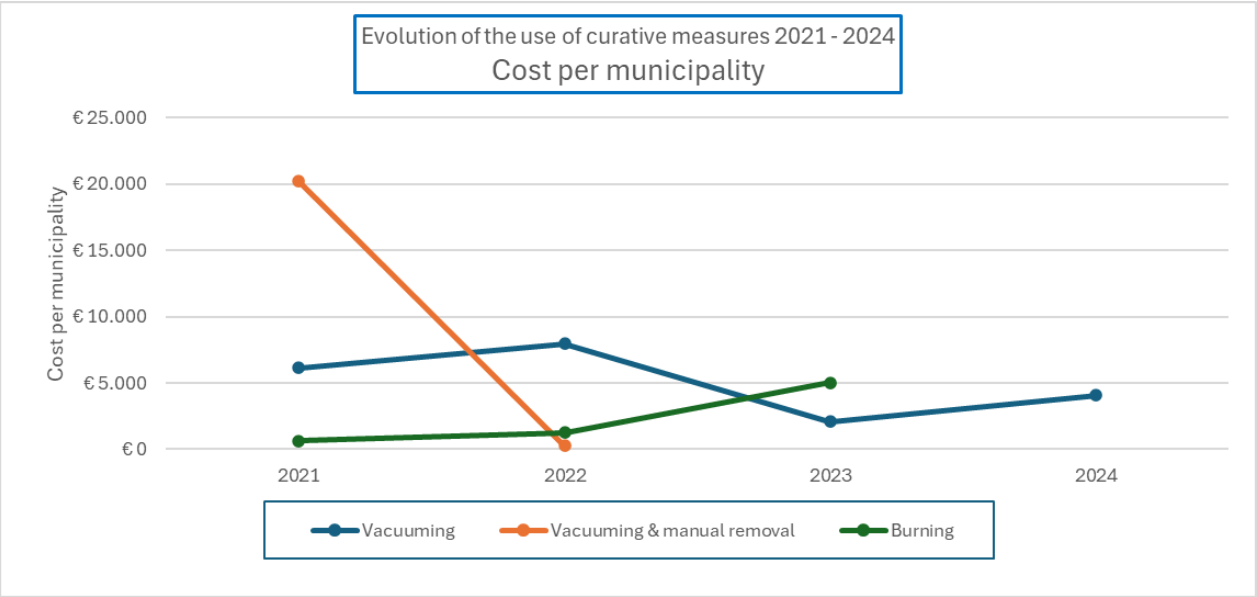

Figure 16: Evolution of the cost per municipality for curative measures.

Over the years, the average cost of using curative measures was around 37 €/tree, but with very high margins. Vacuuming and manual removal of larger nests was most expensive (63 €/tree), twice as expensive as vacuuming only (30 €/tree). The cost of burning was in between.

	Curative measure - cost per tree														
Method	**2021**			**2022**			**2023**			**2024**			**Overall**		
	Average	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**	**Min**	**Max**
Vacuuming	€ 38,28	€ 4,34	€ 162,50	€ 18,00	€ 3,64	€ 95,59	€ 52,59	€ 41,49	€ 68,69	€ 83,25	€ 41,67	€ 333,33	**€ 30,02**	€ 3,64	€ 333,33
Vacuuming & manual removal	€ 63,57	€ 18,00	€ 211,28	€ 33,33	€ 33,33	€ 33,33							**€ 62,83**	€ 18,00	€ 211,28
Burning	€ 31,25	€ 31,25	€ 31,25	€ 31,24	€ 25,00	€ 37,50	€ 250,00	€ 250,00	€ 250,00				**€ 55,55**	€ 25,00	€ 250,00
Total	**€ 48,81**			**€ 18,64**			**€ 64,44**			**€ 83,64**			**€ 36,99**		

Table 2: Evolution of the cost per treated tree of curative measures

Also, for most of the curative measures the average cost increased in the measurement period. The one remaining case where burning was used in 2023 had an exceptional excessive cost of 250 €/tree, probably because only 20 trees were treated.

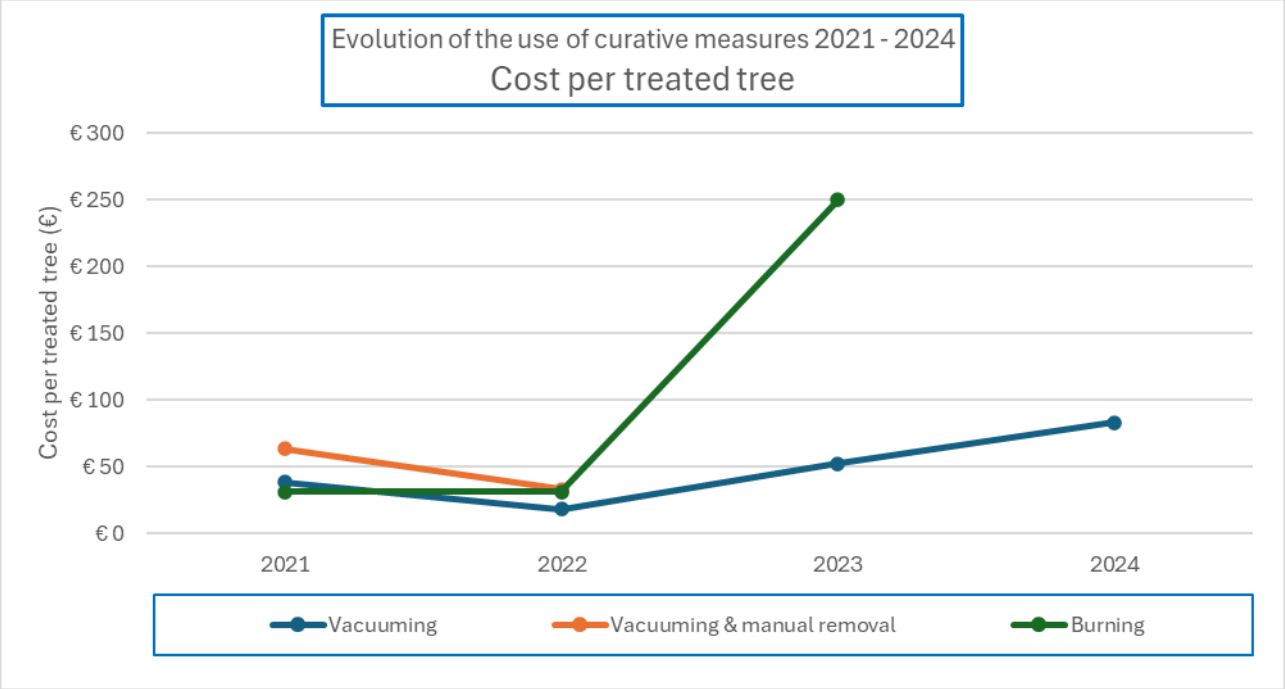

Figure 17: Evolution of the cost per treated tree of curative measures.

4.3.3 Alternative measures

Although we did receive some information on the cost of these alternative measures, they were not split up by measure taken, so we can only provide rough cost estimates. The average cost per municipality per year for all Ambassador communities was around 8.000 €. This is comparable with the average cost for preventive measures (+- 8.400€/municipality) and three times as much as for the curative measures (+- 2.700€).

	Cost of alternative measures					
	2021	**2022**	**2023**	**2024**	**Total**	**Av./year**
Total cost	€ 88.960	€ 95.978	€ 52.260	€ 36.500	**€ 273.698**	**€ 68.424**
Av. per municipality	€ 8.896	€ 10.664	€ 6.533	€ 5.386	**€ 31.478**	**€ 7.870**

Table 3: Evolution of the cost of alternative measures

4.3.4 Cost by strategy

Does the use of cheaper preventive measures early in the season reduce the cost of using more expensive curative techniques later?

In chapter 4.2.1 Strategies and measures, we divided the Ambassador municipalities on a yearly basis according to their strategy, based on the use of only one (preventive vs. curative) or both types of measure.

If using preventive measures would reduce the cost of curative treatment, we expect to see that when we compare the cost of the different strategies.

When looking only at the cost of curative measures, we see that **municipalities using only curative measures spend on average twice as much on these measures as municipalities using both preventive and curative measures**. The difference grows when the OPC pressure diminishes.

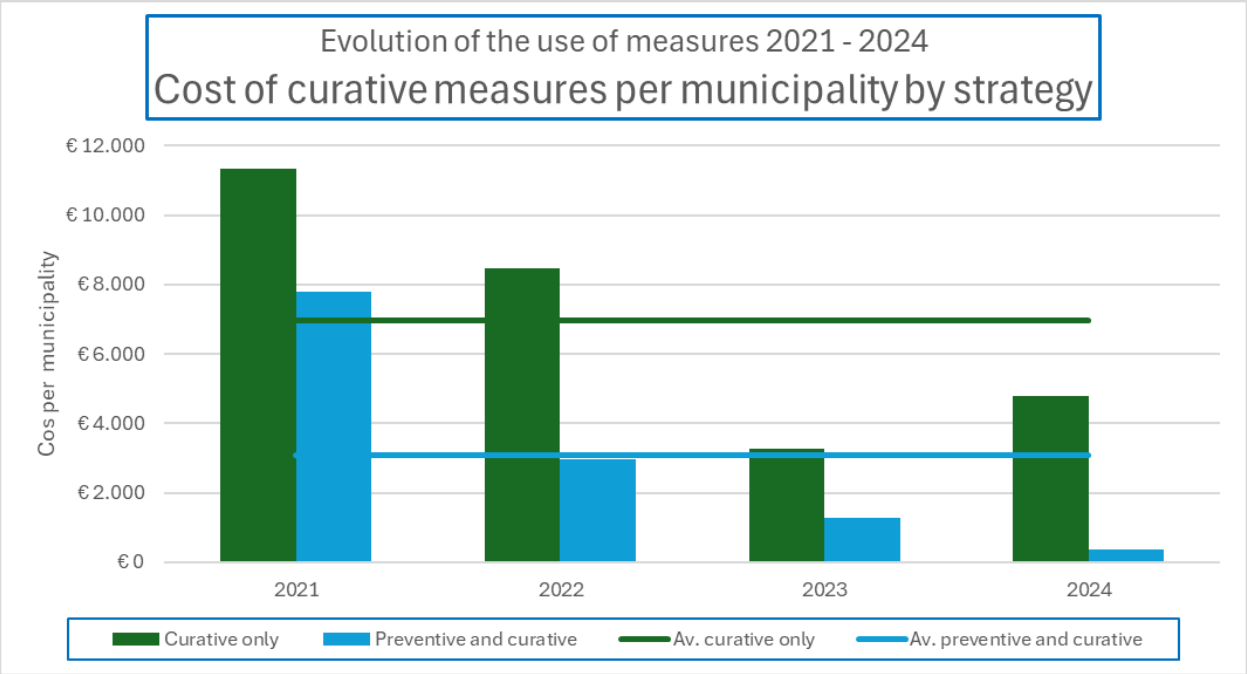

Figure 18: Evolution of the cost of curative measures per municipality by strategy.

So, at first sight using no preventive measures increases the cost for curative measures by around 200%.

However, when looking at the total cost of OPC management per municipality per year, **municipalities using only curative measures report on average only 45% of the total cost of OPC management compared to municipalities that used a combination of measures**. This result is consistent over the time considered, so both on situations with high and low pressure.

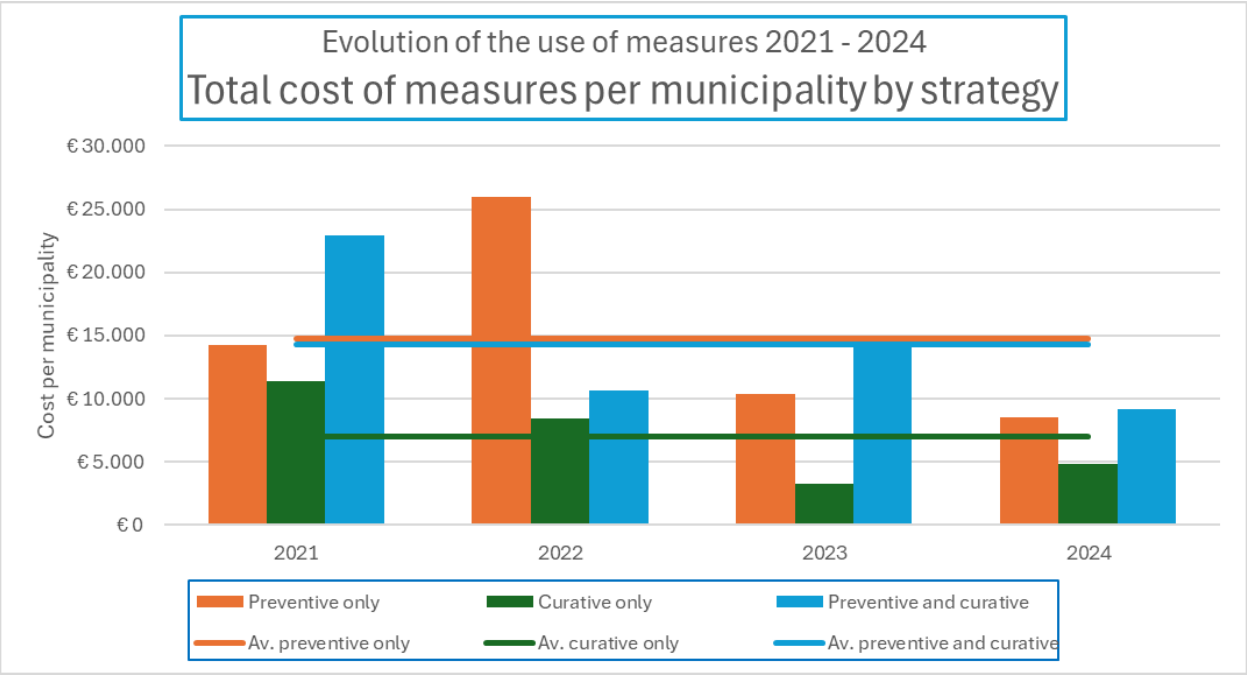

Figure 19: Evolution of the total cost per municipality by strategy.

So, independent of the effectivity of the measures taken, municipalities who only use curative measures on average spent twice as much on their curative measures as municipalities who combine both types of measures, but the total cost of their OPC management is still only 45% of that of the latter.

4.4 Cost-effectiveness analysis

To compare the relative cost and outcomes (effects) of the different techniques used by the Ambassador communities, we performed a cost-effectiveness analysis (CEA).

As an indicator for the cost, we use the average cost per treated tree.

The effectiveness of a technique is harder to estimate. In the end, we opted to use a combination of effectivity (the extent to which the method succeeded in killing OPM under optimal conditions) and usability (the extent to which the method was usable in more typical, non-optimal conditions, taking into consideration the additional risks of the specific method).

To estimate both factors, we used the information available in:

- The product sheets of the various products, where available;
- the 'Nederlandse Leidraad Beheersing Eikenprocessierups' and the information sheets for every technique;
- the page on Oak processionary on Ecopedia, the knowledge sharing website of Inverde, ANB and INBO: Eikenprocessierups | Ecopedia
- the website of the Province of Antwerp for the support of the municipalities: Beheer eikenprocessierups
- the procedure described by the service 'Santé des forêts' of the 'Département de l'étude du milieu naturel et agricole' en Wallonie: Chenille processionnaire du chêne: Comment la détruire?

- The results of our own study

To quantify the estimations, we used for each indicator (effectivity and usability) a scale from 1 to 4, with 1 being the least and 4 the most effective/usable. For the result, we multiplied both factors.

The following table summarizes the findings on the specific methods and the resulting scores:

Method	Effectiveness				
	Effectivity		Usability		Effectiveness score
	Arguments	Score	Arguments	Score	
Preventive measures					
Xentari WG	. Potency 15,000 IU/mg; . 77% less nests after 1 treatment	+2	. Low accuracy . Only usable in for first two stadia . Limited weather conditions . Safety risks . Toxic waste	+2	+4
Foray ES	. Potency 17,600 IU/mg;	+3	. Low accuracy . Only usable in for first two stadia . Limited weather conditions . Safety risks . Toxic waste	+2	+6
Nematodes	. 50-60% less nests after 2 treatments . 80% effective after two treatments	+2	. Low accuracy . Only usable in for first two stadia . Only in ideal weather conditions . Only at night . Two treatments necessary . Limited shelf life	+1	+2
Overall preventive measures		+2		+2	+4
Curative measures					
Vacuuming	. very effective . removes hairs	+4	. Use in limited circumstances (small trees, accessible with a lifting platform, etc.) . Safety risks	+2	+8
Vacuuming & manual removal	. very effective . removes hairs	+4	. Use in limited circumstances (small trees, accessible with a lifting platform, etc.) . Applicable by tree surgeons . Safety risks	+3	+12
Burning	. very effective . removes & destroys hairs	+4	. Use in limited circumstances (small trees, accessible with a lifting platform, etc.) . Safety risks . Additional risks for three damage & fires	+1	+4
Manual removal	. very effective . removes hairs	+4	. Use in limited circumstances (small trees, accessible with a lifting platform, etc.) . Applicable by tree surgeons . Safety risks . More manual work than vacuuming	+2	+8
Overall curative measures		+4		+2	+8
Alternative measures					
Ecological roadside management	. Impact measurable but limited	+1	. Generally applicable	+4	+4
Sowing roadsides	????	0		+1	0
Nest boxes	. Impact measurable but limited	+1	. Generally applicable	+3	+3
Common Ivy	. Impact measurable and significant	+3	. Generally applicable . Safety risks	+2	+6
Parasitoid boxes	. Not yet tested	0	. Not yet tested	+1	0

Table 4: Scoring table for the effectivity and usability of the different measures

We visualized the results of setting out these scores against the calculated cost in Figure 20: Cost-effectiveness analysis of preventive and curative measures.:

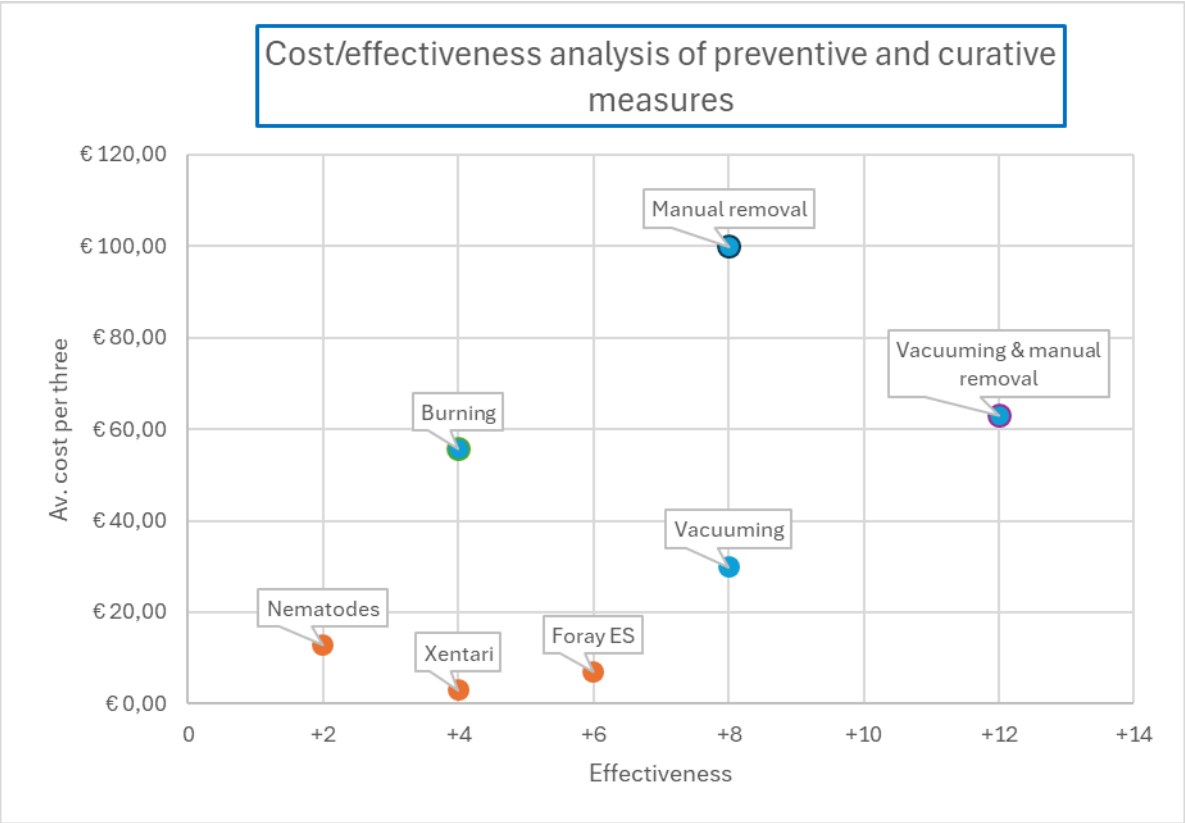

Figure 20: Cost-effectiveness analysis of preventive and curative measures.

The three preventive methods (in orange) are significantly cheaper than the curative methods (blue), but the latter, except for burning, are much more effective.

The least cost-effective solution would be using Nematodes. Most effective would be the combination of vacuuming the nests that are easy to reach and not too large and remove the larger nests manually at the same time. This is also one of the most expensive techniques.

The picture becomes somewhat more complicated when the impact on biodiversity – animal and plant life in and around the oak trees is taken into consideration – see the next chapter.

4.5 Impact on biodiversity

All techniques used in this survey have impact on more than just the OPC. It is a fact that the biocides used to manage OPC will kill other Lepidoptera in the oak and the direct environment at the same rate they kill OPC. Curative techniques, like vacuuming, will have less impact, but will certainly kill all parasitoids present in the nests. **Burning** will not only kill the caterpillars and parasitoids in the nests, but also all insects within the burner's reach.

On the other side, alternative measures like ecological roadside management will not only give predators and parasitoids on OPC more survival opportunities but will do the same for other plants and animals.

For this exercise, we added Common ivy on this list. This method was not mentioned in the survey, but according to our study, allowing common ivy to cover the trunk and lower branches of oak trees significantly reduces the number and size of OPC nests in the tree.

For two methods mentioned in the survey, sowing roadsides and using parasitoid boxes, we do not find conclusive data on the effectiveness, so they are omitted from this exercise.

The indicators we considered:

- OPC parasitoids – parasitic flies and wasps living within the nests;
- OPC predators living in and around the oak trees – mostly birds and bats;
- Other Lepidoptera (butterflies) living in the oak tree, mostly as caterpillars;
- Other invertebrates living in the oak tree;
- Lepidoptera (butterflies) living in the direct environment, especially the roadsides beneath the oak trees;
- Other (indirect) impact on biodiversity.

These impacts and risks are not easy to quantify, but we can evaluate the biodiversity impact the same way we did for effectiveness, using the same information sources. We used for each indicator a scale from -3 to +3, with -3 having the most negative impact on biodiversity and +3 having the most positive impact. For the result, we summarize all indicators to get a final impact score.

We summarized the findings from these sources on the specific methods and the resulting scores in the table below:

	Biodiversity impact												
Method	OPC parasitoids		OPC predators		Other oak Lepidoptera		Other oak insects		Lepidoptera in direct environment		Indirect biodiversity impact		Biodiversity impact score
	Arguments	Score	Arguments	Score	Arguments	Score	Arguments	Score	Arguments	Score	Arguments	Score	
Preventive measures													
Xentari	. Kills all parasitoids in the nest	-3	. Less food for predators	-1	. Kills all Lepidoptera . Indirect impact (feeding)	-2	. Less food for insect predators	-1	. Kills Lepidoptera in roadside	-3	. Impact on food pyramid	-1	**-11**
Foray ES	. Kills all parasitoids in the nest	-3	. Less food for predators	-1	. Kills all Lepidoptera . Indirect impact (feeding)	-2	. Less food for insect predators	-1	. Kills Lepidoptera in roadside	-3	. Impact on food pyramid	-1	**-11**
Nematodes	. Kills all parasitoids in the nest	-3	. Less food for predators	-1	. Kills all Lepidoptera . Two treatments, so more impact . Direct impact (predatory)	-3	. Kills other insects: sciarid flis, beetles, springtails, thrips, ... Less food for insect predators	-2	. Kills Lepidoptera in roadside	-3	. Impact on food pyramid	-1	**-13**
Curative measures													
Vacuuming	. Kills all parasitoids in the nest	-3	. Less food for predators	0		0		0		0		0	**-3**
Vacuuming & manual removal	. Kills all parasitoids in the nest	-3	. Less food for predators	0		0		0		0		0	**-3**
Burning	. Kills all parasitoids in the nest	-3	. Less food for predators	0	. Kills other insects	-1	. Kills other insects	-1		0	. Impact on food pyramid	-1	**-6**
Manual removal	. Kills all parasitoids in the nest unless placed in parasite boxes	-2	. Less food for predators	0		0		0		0		0	**-2**
Alternative measures													
Ecological roadside management	. More food and shelter for parasitoids	+2	. More food and shelter for predators	+1		0		0	. More food and shelter for Lepidoptera	+2	. Large impact on plant and insect biodiversity	+3	**+8**
Sowing roadsides	. More food and shelter for parasitoids	+3	. More food and shelter for predators	+1		0		0	. More food and shelter for Lepidoptera	+2	. Large impact on plant and insect biodiversity	+3	**+9**
Nest boxes		0	. More shelter for predators	+3	. More predation on Lepidoptera	-1		0	. More predation on Lepidoptera	-1	. Impact on bird biodiversity	+1	**+2**
Common ivy		0	. More shelter for predators	+1	. No impact	0	. More shelter and food source for other insects	+2		0	. Food source for insects and birds	+1	**+4**
Parasitoid boxes	. More food and shelter for parasitoids	+2		0		0		0		0		0	**+2**

Table 5: Scoring table for the biodiversity impact of the different measures

Results of setting out these scores against the already quantified effectiveness are visualized in Figure 21: Effectiveness vs. biodiversity impact of preventive, curative, and alternative measures.

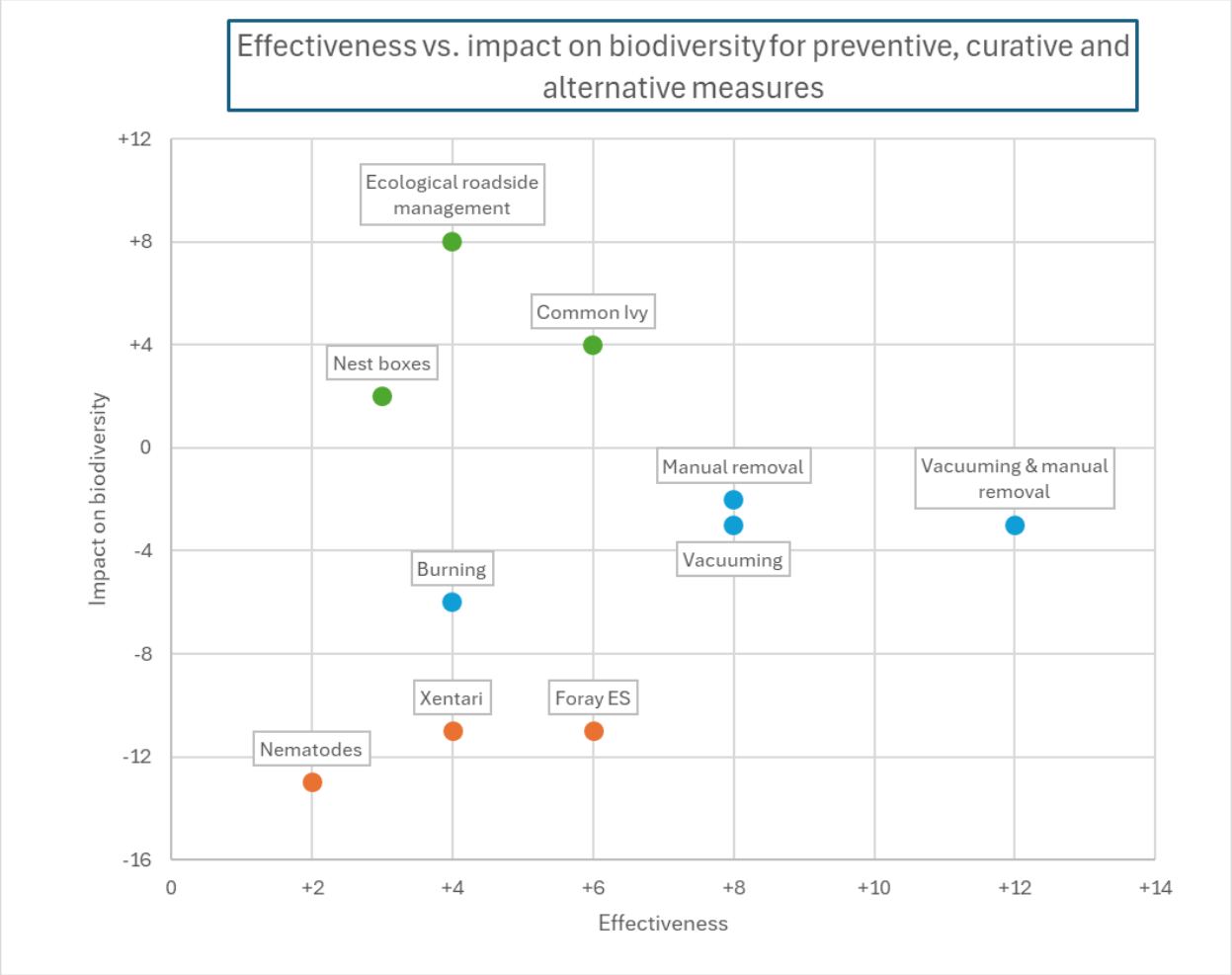

Figure 21: Effectiveness vs. biodiversity impact of preventive, curative, and alternative measures.

The tree preventive methods (in orange) have significantly more negative impact on biodiversity than the curative methods (blue). The tree alternative methods (green) for which the effect was evaluated, scored much more positive on biodiversity impact, even though effectiveness for OPM control was lower.

5 Final conclusions

The following table gives an overview of the main indicators regarding the socio-economic impact of the management of OPC for the Ambassador community.

Measure	Overview					
	Average no. Of municipalities	Average no. of trees treated	Average cost / tree (min - max)	Average cost / municipality (min - max)	Effectiveness score	Biodiversity impact score
Strategies - direct vs. indirect measures						
Direct measures only	6	-	-	-	-	-
indirect measures only	3	-	-	-	-	-
Direct & indirect measures	14	-	-	-	-	-
No measures	2	-	-	-	-	-
Strategies - preventive vs. curative measures						
Preventive measures only	8	21.297	€ 6,70	€ 14.763	+4	-6
Curative measures only	4	403	€ 77,30	€ 6.969	+3	+2
Preventive & curative measures	8	27.128	€ 9,09	€ 14.275	+7	-4
No measures	5	-	-	-	-	-
Preventive measures			**€ 4,30**	**€ 8.462**		
Xentari	12	31.654	€ 3,12 (€ 1,88 - € 23,48)	€ 8.592 (€ 231 - € 45.000)	+4	-11
Foray ES	3	15.400	€ 6,59 (€ 3,04 - € 13,45)	€ 33.820 (€ 3.163 - € 75.042)	+6	-11
Nematodes*	1	439	€ 12,80 (€ 12,80 - € 12,80)	€ 5.617 (€ 1.638 - € 9.597)	+2	-13
None	9	-	-	-	-	-
Curative measures			**€ 37,00**	**€ 2.683**		
Vacuuming	8	1.366	€ 30,02 (€ 3,64 - € 333,33)	€ 5.127 (€ 49 - € 20.120)	+8	-3
Vacuuming & manual removal	1	652	€ 62,83 (€ 18,00 - € 211,28)	€ 10.241 (€ 167 - € 48.594)	+12	-3
Burning	1	59	€ 56,24 (€ 25,00 - € 250,00)	€ 1.980 (€ 100 - € 5.000)	+4	-6
Manual removal*	1	9	€ 100,00 (€ 100,00 - € 100,00)	€ 850 (€ 700 - € 1.000)	+8	-2
None	12	-	-	-	-	-
Alternative measures				**€ 7.870**		
Ecological roadside management	15	-	-	€ 7.870	+8	+8
Sowing roadsides	7				-	+9
Nest boxes	13				+3	+2
Common Ivy	0			(€ 5.386 - € 10.664)	+6	+4
Parasitoid boxes	2				-	+2
None	9				-	-

*Table 6: Overview of the most relevant numerical indicators. *: not included in the CEA due to small number of observations*

At the start of the project, with a high pressure of OPC, most Ambassador municipalities used a combination of both direct (preventive and/or curative) and indirect (alternative) measures to manage OPC. For the direct measures, a large majority used a combination of both preventive and curative techniques.

Both these numbers decreased gradually towards the end of the project with a decreasing OPC pressure.

Most of the Ambassador communities had at least one alternative measure in place, the most popular one being the ecological mowing techniques, followed by using nest boxes.

When comparing the average cost per tree over the years, the cost of using preventive measures was around 4,30€/tree, while for curative measures the cost was around 37 €/tree, both with very high margins. Due to this price difference, the number of trees treated curatively was only a small fraction (around 4%) of those treated preventively.

The average cost per tree for most of the methods used has gradually increased since 2021, probably due to the impact of inflation on both product prices and labour cost.

Comparing the average cost per municipality, an Ambassador municipality spent around 8.500€/year on preventive measures, 2.700€/year on curative measures and 7.900€/year on alternative measures which could impact OPC. For municipalities using Foray ES, the cost decreased significantly during the four years of the project, as would be expected with the decrease in the OPC population. In contrast, the cost for municipalities using Xentari did not decrease, even when the number of trees treated with this biocide did decrease significantly. We can say the same about the cost for curative measures per municipality, which was relative stable during the four years of the project.

When comparing the different strategies used – combinations of preventive, curative and/or alternatives measures, municipalities who only use curative measures on average spent twice as much on their curative measures as municipalities who combine both types of measures, but the total cost of their OPC management is still only 45% of that of the latter. This would mean that using preventive measures early in the season indeed reduces the cost of taking curative measures later, but, regardless of the consequences for health problems and practical objections, it would still be more efficient to invest in curative measures rather dan in the more harmful preventive measures.

The cost-effectiveness analysis shows that preventive methods are significantly cheaper than the curative methods, but the latter are much more effective. Nematodes seem to be the least cost-effective solution, while the combination of vacuuming and manual removal is the most effective technique, but also one of the most expensive ones.

Finally, when we also consider the expected impact on biodiversity, the preventive methods have significantly more negative impact on biodiversity than the curative methods, with Nematodes as the method having the most negative impact. The alternative methods scored much more positive on biodiversity impact, even though effectiveness for OPM control was lower.