UIC SUSTAINABILITY DEPARTMENT

ECOV4R pilot assessment
High speed line between Valladolid and León, Spain

March 2026

ECOV4R
ECOSYSTEM VALUATION FOR RAILWAYS

INTERNATIONAL UNION
OF RAILWAYS

adif

International Union of Railways (UIC), Sustainability, ECOV4R Pilot Assessment – High Speed Line Between Valladolid and León, Spain (Ecosystem Valuation for Railways project), March 2026

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1. Introduction

The Ecosystem Valuation for Railways (ECOV4R) Framework document aims to support the assessment of ecosystem services affected by and/or provided by railway infrastructure. To illustrate the practical use of the ECOV4R Framework, two pilot assessments from two project partners have been undertaken to demonstrate how ecosystem services assessments can be applied to decision-making at project level. The pilot assessment technical reports are intended to be read together with the Framework to help showcase the steps of ECOV4R. The intended audience for these pilot assessment reports is similar to those listed in Section 1.1.3 of the ECOV4R Framework, but the assessments are specifically aimed at guiding and supporting audiences intending to put the Framework into practice.

This document presents a retrospective application of the ECOV4R Framework to the Palencia–León high-speed rail project in Spain, managed by Administrador de Infraestructura Ferroviaria (ADIF). This rail section has already been constructed and upgraded. Developed in collaboration with ADIF and UIC, the assessment demonstrates how each step of the ECOV4R Framework can be integrated into infrastructure planning – even after project completion – using data from the original Environmental Impact Assessment (EIA). The ECOV4R Framework has been applied to assess the impact of the environmental mitigation measures that were implemented (e.g. wetland creation, afforestation). This document provides background information for the pilot project and demonstrates how each step of the ECOV4R Framework can be achieved, as well as providing recommended next steps for the pilot project as a result of the ecosystem services assessment.

By applying steps retrospectively, this case study demonstrates the Framework's flexibility and value in supporting evidence-based decision-making, enhancing the business case for nature-based solutions, and informing future railway infrastructure projects.

2. Project background and context

ADIF is a Spanish state-owned railway infrastructure manager overseeing most of Spain's railway infrastructure. ADIF developed a high-speed railway line between Palencia and León intended to reduce travel times in the north and northeast of the Iberian Peninsula. The total length of the project is 166,141 km. The construction works were carried out in two phases: platform construction from 2008 to 2013, and superstructure works from 2014 to 2016. The railway became operational in 2016.

The current assessment focuses on a 16 km section between Palanquinos and Santas Martas, located in the Autonomous Community of *Castilla y León* (Province of León) within the Duero Valley (see Figure 1). The project site is located approximately 3 km east of the Esla River. The area is of ecological interest due to the presence of steppe fauna species, and serves as habitat for the Iberian wolf. The area is characterised by irrigated and non-irrigated arable land of herbaceous crops (see Figure 2).

Figure 1: Location of the project (Google Earth, 2025)

Figure 2: Agricultural land adjacent to the project (Google Earth, 2025)

During the construction phase, soil from the land adjacent to the project site was utilised to construct the railway embankment (hereafter referred to as fill areas). Restoration measures were then implemented in the affected areas, including the creation of wetlands and broadleaved trees as shown in Figure 3. The embankments and surrounding adjacent areas were covered with grassland, as shown in Figure 4. These areas are currently under the ownership of ADIF.

Figure 3: Wetland created and trees planted as part of the project (ADIF, n.d.)

Figure 4: Embankment covered with grassland (ADIF, n.d.)

Existing environmental documentation was used as input for this study. One key document is the EIA (TIFSA Grupo Renfe, 2002) produced at an early stage. It evaluates four potential railway route options and provides significant baseline data and information for the area. The second document comprises the wildlife monitoring studies (Saintec engineering, 2022) and focuses on the restoration areas developed during the operational phase of the railway project. There are currently no management plans in place for these sites. However, this could be a useful source of information for this assessment, and developing such plans is recommended.[1]

1 Refer to Sections 3.6.2 and 3.6.3 of the ECOV4R Framework for further information on Step E and how the ECOV4R assessment can aid with mitigation, enhancement and monitoring plans.

Table 1 summarises the key project dates, which will inform the assessment, especially to define the scenario and timeframe for the benefits valuation.

Table 1: Project timeframe summary

Key dates for the assessment	Years
Platform construction	2008 to 2013
Superstructure works	2014 to 2016
Habitat restoration implementation (start to finish)	2013
Habitats fully established, one year after implementation (assumption)	2014
Habitat management period	No management plans

2.1. Overview of surrounding area

The EIA of the project was used to provide an overview of the boundary of analysis. The EIA covered a wider area (see Figure 5); therefore, only the sections where the boundary of analysis is located were investigated and marked in the relevant maps. Based on the EIA, the boundary of analysis is located on the Supra-Mediterranean bioclimatic floor covering part of the northern sub-plateau, Iberian moorlands, pre-Pyrenean bases and foothills of the central or southern high mountains of the Iberian Peninsula.

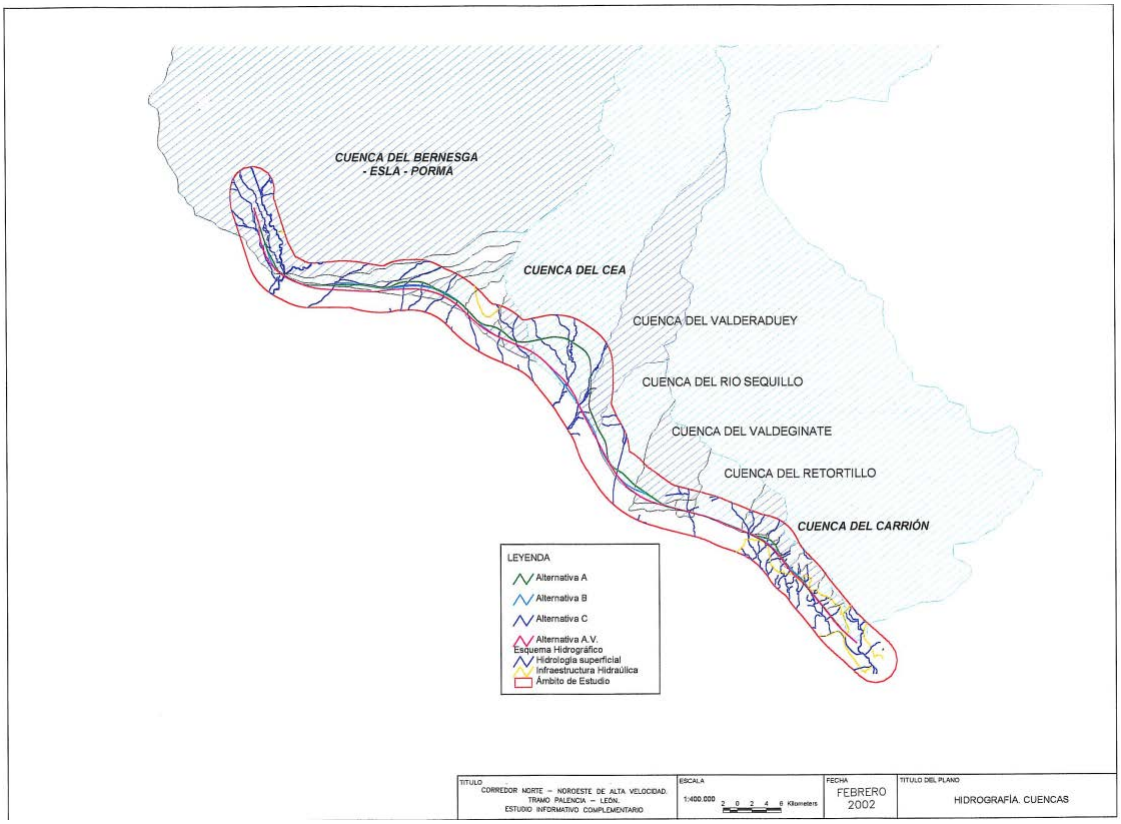


Figure 5: Complete EIA boundary of analysis (Source: TIFSA Grupo Renfe, 2002)

Appendix A.1 highlights the presence of scarce natural vegetation located in unfertile areas and areas next to the rivers, including:

- Mediterranean wet tall grass meadows
- Mediterranean temporary ponds
- Substeppe zones of granaries
- Mediterranean saline steppes

Appendices A.2 and A.3 indicate that most of the land is covered by agricultural land, including dryland crop cultivation (mainly wheat, barley and oats) and irrigated crops (beetroot, alfalfa and corn). Other habitats identified include riparian vegetation, wetlands, shrubland, grassland and poplar groves, as well as small fragmented urban areas (Appendices A.4 and A.5).

The area has important cultural heritage elements such as the *Camino de Santiago* and various sparsely distributed archaeological sites (see Appendix A.6), located close to the railway.

Appendix A.7 shows that the predominant soil type in the area is dystric cambisol. Meanwhile, the level of erosion in the area is mainly low-moderate (5-12 tonnes/ha/year), as shown in Appendix A.8.

3. ECOV4R assessment

This pilot assessment follows the steps set out in the ECOV4R Framework (as shown in Figure 6).

Figure 6: Ecosystem Service Valuation for Railways (ECOV4R) Framework

The following table presents the key parameters considered when developing the assessment. Further detail is provided in the following subsections. In terms of the key analysis parameters listed in the ECOV4R Framework in Section 3.2.1, Table 2 below presents the key analysis parameters decided for the ADIF pilot assessment.

Table 2: Key analysis and contextual parameters for the assessment

Key parameter	Decision for pilot assessment
Boundary of analysis	The boundary of analysis only considers the project's footprint, which includes areas directly impacted by the project, specifically restoration measures such as wetlands, broadleaved woodland and grassland. The total area covered is 339.2 hectares (ha).
Ownership and/or long-term management	ADIF is the owner of the areas in the boundary of analysis. This includes the railway and the parcels where the restoration measures areas were implemented. There are no management plans for the mitigation areas at the moment. For the purposes of this assessment, it is assumed that land will remain under the ownership and management of ADIF.
Timing of actions	The project's construction work started in 2008 and was completed in 2016. The habitat restoration measures were implemented in 2013 and finalised the same year.
Timing of impacts	Some habitats are known to take time to realise their full ecosystem service provision potential. Throughout the assessment it was assumed that the habitats would be established in 2014, one year after their implementation. Habitat losses are assumed to be immediate and take effect from the start of the assessment period. For the purpose of this assessment, all habitats within the construction footprint were assumed to be 'lost' during the construction period and so provided no ecosystem services.
Assessment period	The assessment considers the start of the construction period (2008) as the start of the appraisal. During the construction period (2008 to 2013), it is assumed that the habitats within the footprint were lost during the construction work, and no ecosystem services were provided. The habitat restoration implementation took place in 2013, and ecosystem service provision is assumed to start from 2014 (one year after establishment). This approach will allow us to account for the impacts/benefits across the lifecycle of the project. The full assessment period is 100 years (up until 2107) to capture the long-term benefits of the project.
Price year for monetary values	For the purposes of this pilot assessment, the monetary values presented are in the 2024 price year. All monetary evidence and respective prices used in the calculation of ecosystem service benefits are inflated to the 2024 price year using Spanish inflation indices (IMF, 2025).
Relevant discount rates	Following European Commission guidance, the discount rate of 3% is used (European Commission, 2023).

3.1. Step A: Baseline

3.1.1. Defining the baseline

The boundary of analysis was defined by areas directly impacted by the project (i.e. project footprint). Figure 7 presents the boundary of analysis; the total area covered is 339.2 ha. The boundary of analysis includes the following:

- 16 km of railway
- Fill areas (*préstamos*)/restoration work (wetlands and woodland)
- Embankment/restoration (grassland)
- Other restoration plots (grassland)

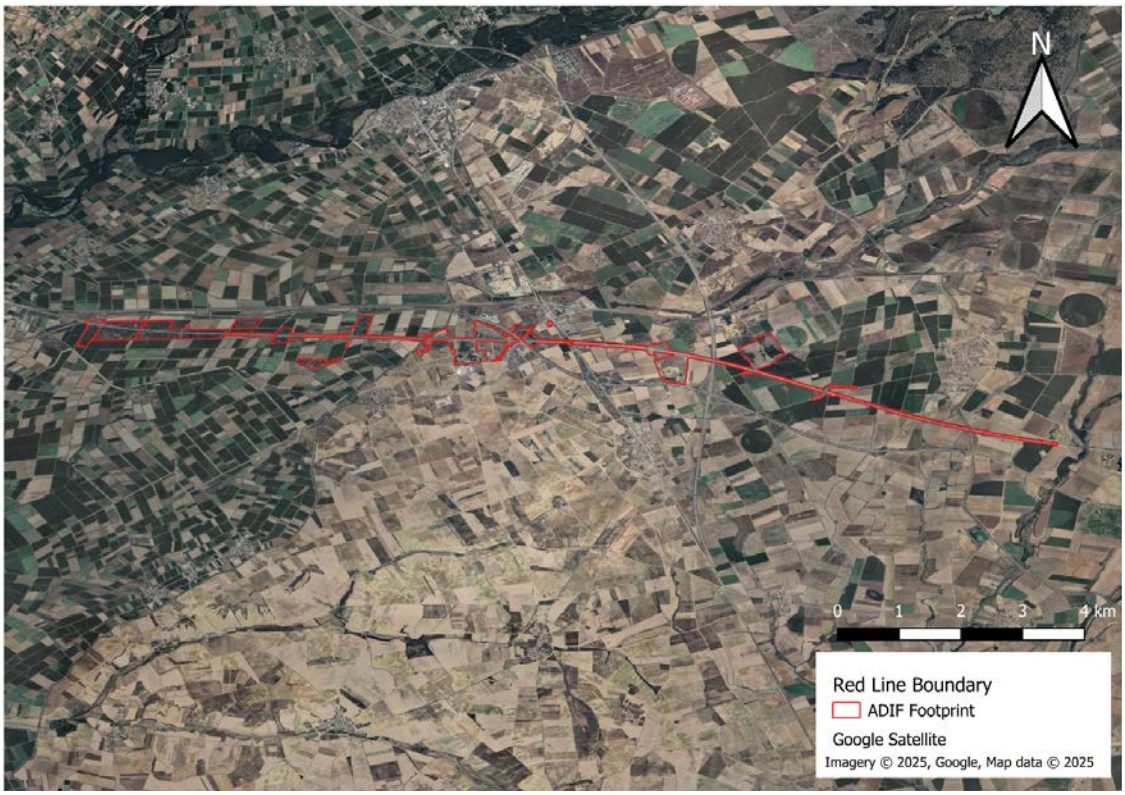


Figure 7: Boundary of analysis

This approach deviates from the recommended 1 km buffer zone around the rail line stated in the ECOV4R Framework as the interventions related to the project were at a shorter distance to the railway and were only applied in specific parcels. This decision to deviate from the 1 km buffer zone to focus on the boundary of analysis was discussed and agreed with project partners. See Appendix B for further information.

3.1.2. Asset register

In Section 3.2.2 of the ECOV4R Framework, it is recommended that the asset register comprises the extent, condition and location of natural capital assets. The asset register was developed by applying the methodology described in Appendix B. In this case, the asset register was developed considering the extent and location of the habitats; however, the condition was not included as there were incomplete records across the boundary of analysis for the baseline and post-intervention scenarios. Without baseline condition assessment, it is not possible to assess the change in quality of habitat and thus assumptions are made on whether the quality of habitats changed as a result of the interventions.

Table 3 presents the habitat areas in the baseline (pre-intervention). The definition of the habitats identified in the asset register are provided in Appendix C. As recommended in Section 2.3.1 of the ECOV4R Framework, the EUNIS Habitat Classification system was mapped to the International Union for Conservation of Nature (IUCN) Global Ecosystem Typology (GET) categories as shown in Table 3.

Appendix D presents the baseline habitat map. The main habitat is 'arable land and market gardens' (324.5 ha); this aligns with the findings in the EIA (see Section 2.1). Other habitats include 'heathland, scrub and tundra' (8.4 ha), 'grassland and lands dominated by forbs, mosses or lichens' (4.3 ha), 'inland unvegetated or sparsely vegetated habitats, transport networks' (1.35 ha), and 'rural industrial and commercial sites still in active use' (0.06 ha).

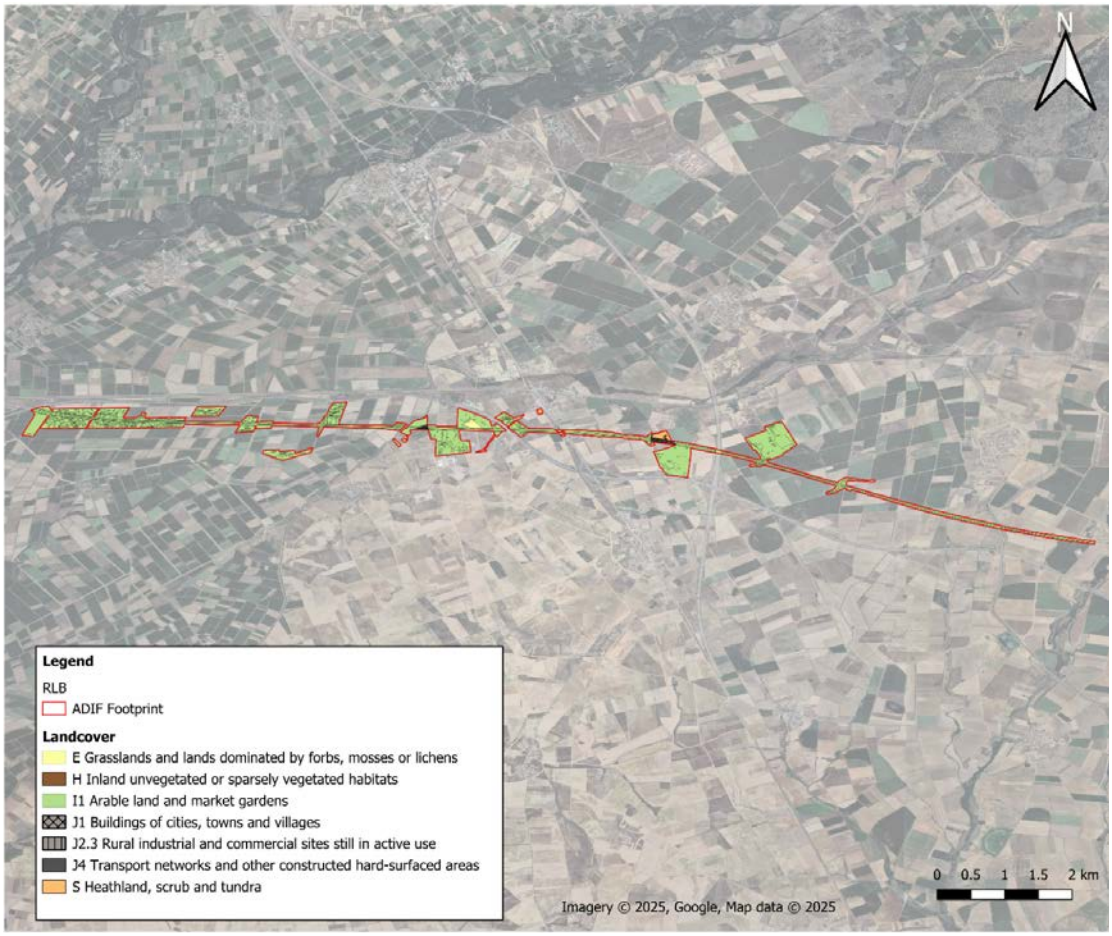


Figure 8: Map of the baseline habitats in the boundary of analysis

Table 3: Baseline asset register

Habitat (EUNIS)	IUCN GET typology	Baseline area (ha)
I1 Arable land and market gardens	T7.1 Annual croplands	324.5
S Heathland, scrub and tundra	T3.2 Seasonally dry temperate heaths and shrublands	8.4
E Grasslands and lands dominated by forbs, mosses or lichens	T4.5 Temperate subhumid grasslands	4.3
H Inland unvegetated or sparsely vegetated habitats	No relevant match found	1.35
J4 Transport networks and other constructed hard-surfaced areas	T7.4 Urban and industrial ecosystems	0.58
J2.3 Rural industrial and commercial sites still in active use	T7.4 Urban and industrial ecosystems	0.06
	Total	**339.19**

3.1.3. Ecosystem services

Quantification and valuation of ecosystem services provided by the baseline is considered concurrently with the impact assessment. See subsequent steps, especially Step D (Section 3.4).

3.2. Step B: Impacts on natural capital assets

3.2.1. Defining the scenario

As detailed in Section 3.3.1 of the ECOV4R Framework, defining the scenario requires a rationale for the intervention, a description of what is likely to occur, and when and where the interventions will take place, as well as who it will affect. See Box 1 below for a description of the project scenario.

Box 1: Definition of the ADIF interventions scenario

Rationale for intervention	The project aims to shorten travel times by introducing a new high-speed rail route. Soil from adjacent land was utilised to construct the embankments. As part of the mitigation efforts, the project restored the impacted areas by creating wetlands, broadleaved woodlands, and grassland zones.
What	The assessment focuses on the project's boundary of analysis, including: ▪ 16 km railway section length and width ▪ Fill areas (*préstamos*)/restoration work (wetlands and woodland) ▪ Embankment/ restoration (grassland) ▪ Other restoration plots (grassland)
Where	16 km section of the high-speed train between *Palanquinos* and *Santas Martas*, located in the Autonomous Community of *Castilla y León* (Province of *León*), Spain.
When	2008 to 2107 (100-year appraisal period).
Who (beneficiaries)	▪ **Railway passengers:** Passenger travel times will be reduced. Moreover, they will be able to take in a landscape with a mix of habitats. ▪ **Railway undertakings/infrastructure managers:** ADIF has benefited from soil extraction for embankment construction, with the mitigation measures being a consequence of this decision. Moreover, potential risks in ADIF's activities will be reduced (e.g. through improved erosion protection). It will also increase its reputation by having delivered different ecosystem services. ▪ **Farmers:** Farmers will be significantly affected by the project. The railway and restored areas have reduced agricultural land and, consequently, the agricultural activity in the area. On the other hand, the environmental mitigation measures would also have a positive impact on the agricultural area nearby, supporting services such as water purification, pollination, and soil and sediment retention. ▪ **Local community:** Small towns are located close to the railway. The immediate community would have a landscape with a mix of habitats. They will benefit from the different ecosystem services that would be provided by the project, such as water purification, pollination, soil and sediment retention, and air filtration. Opportunities for recreation are limited but could be implemented in the future. ▪ **Global community:** The project would have a positive impact in terms of nursery population and habitat maintenance (i.e. biodiversity) as well as improved carbon sequestration potential due to the mitigation measures.

3.2.2. Quantifying the impact of the scenario

The post-intervention asset register followed the same methodology as the baseline asset register (see Appendix B). Figure 9 presents the post-intervention habitat map (Appendix E provides a larger copy of the map for inspection). Table 4 provides the list of habitats and their areas in the post-intervention scenario. This has also been mapped to the IUCN GET categories. The main habitats present in the post-intervention scenario are 'grasslands and lands dominated by forbs, mosses or lichens' (77.33 ha), 'inland unvegetated or sparsely vegetated habitats' (72.38 ha), and 'broadleaved deciduous woodland' (69.47 ha).

Figure 10 presents a comparison of the baseline and post-intervention scenario assets. When comparing the baseline and the post-intervention, the main change is the reduction of arable land and the implementation of two new habitats: 'mires, bog and fens' (referring to the wetlands) and 'broadleaved deciduous woodland'. As expected, there is also a considerable increase in 'transport networks and other constructed hard-surfaced areas'.

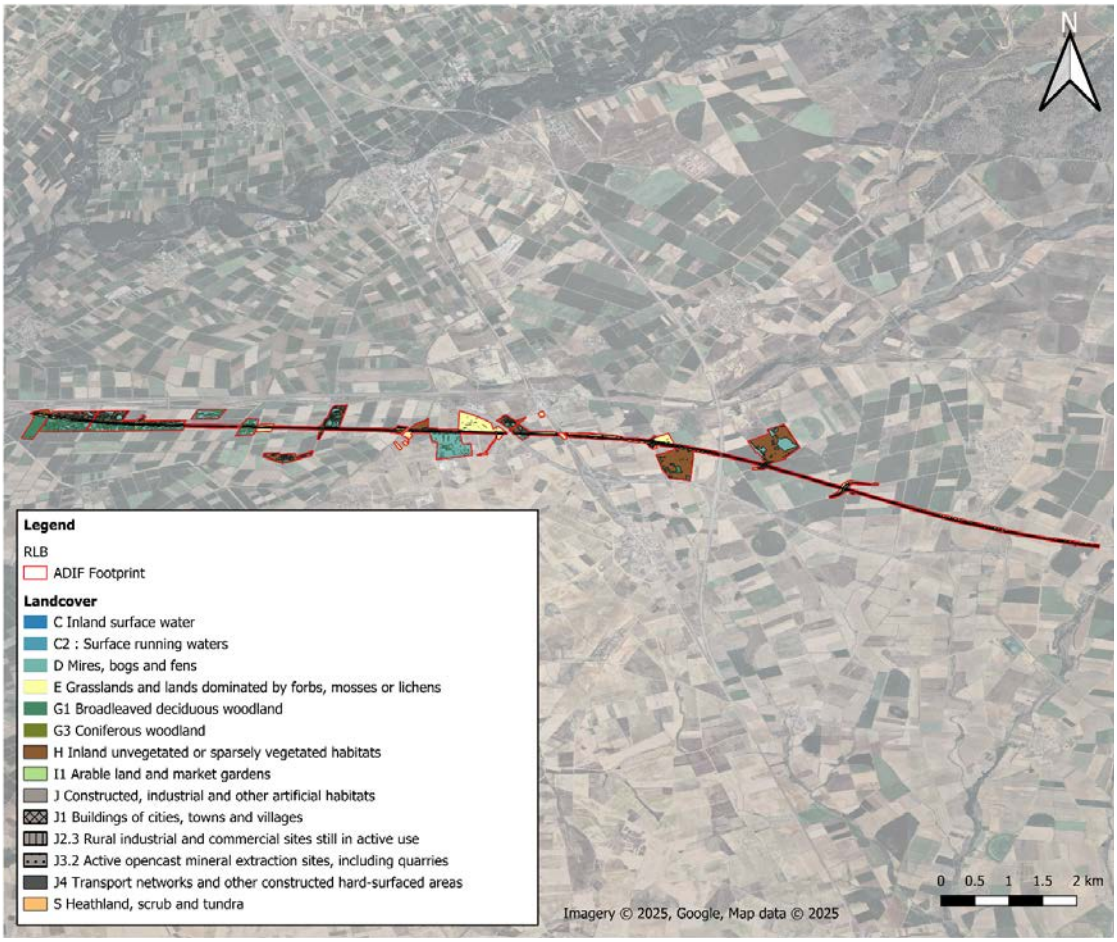


Figure 9: Map of the post-intervention habitats in the boundary of analysis

Table 4: Asset register (post-intervention scenario)

Habitat (EUNIS)	IUCN GET typology	Post-intervention scenario area (ha)	Comparison to baseline area
E Grasslands and lands dominated by forbs, mosses or lichens	T4.5 Temperate subhumid grasslands	77.33	↑
H Inland unvegetated or sparsely vegetated habitats	No relevant match found	72.38	↑
G1 Broadleaved deciduous woodland	T2.2 Deciduous temperate forests	69.47	↑
J4 Transport networks and other constructed hard-surfaced areas	No relevant match found	53.81	↑
D Mires, bogs and fens	TF1 Palustrine wetlands biome	50.57	↑
I1 Arable land and market gardens	T7 Intensive land-use biome	14.86	↓
S Heathland, scrub and tundra	T3 Shrublands and shrubby woodlands biome	0.7	↓
J2.3 Rural industrial and commercial sites still in active use	No relevant match found	0.08	↑
	Total	**339.19**	

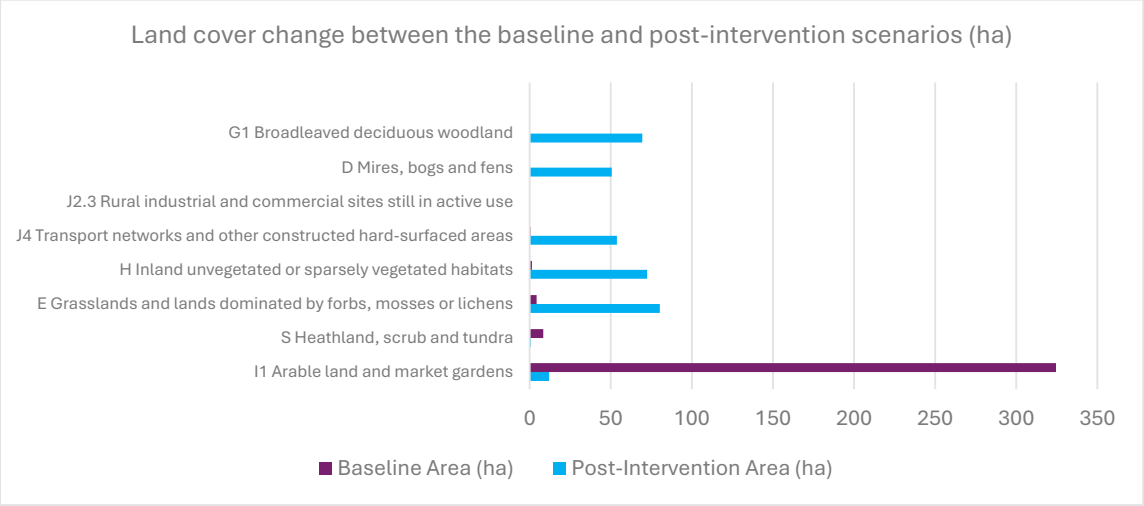


Figure 10: Comparison of the baseline and post-intervention habitats

3.3. Step C: Impacts on ecosystem services

3.3.1. Materiality assessment

Based on the change in habitat area as part of the project, a materiality assessment was conducted against a list of ecosystem services deemed to be relevant to the railway sector. This list was developed collaboratively with UIC members. Please refer to the ECOV4R Appendix Workbook for further information on definitions and the relevance of the ecosystem services to railways. Table 5 provides a summary and rationale of the ecosystem services scoped in or output for the ecosystem services assessment. The table shows the main habitats that were impacted within the boundary of analysis, either positively (creation or habitat increase) or negatively (loss or habitat reduction). Impacts to the quality/condition of the natural assets are also considered, based on planned environmental mitigation measures restoring habitats impacted by the project to a better state.

The materiality assessment was undertaken based on expert opinion and included a quality assurance process. Additionally, as stated in Box 4 within Section 3.4.2 of the ECOV4R Framework, materiality was considered against the five potential criteria stated in the Natural Capital Protocol (Capitals Coalition, 2016). In the context of this pilot assessment, the relevant criteria are namely:

- **Operational:** the extent to which the ecosystem services impact or dependency may significantly affect business operations, such as soil and sediment retention services (e.g. erosion protection).
- **Legal and regulatory:** the extent to which the ecosystem services impact or dependency may influence the project's environmental impact mitigation requirements, achieved through the restoration and implementation of habitats.
- **Reputational and marketing:** the extent to which the ecosystem services impact or dependency may influence customers' and stakeholders' perception of ADIF by providing wider benefits such as global climate regulation services (e.g. carbon sequestration) and nursery population and habitat maintenance services (e.g. biodiversity).
- **Societal:** the extent to which the ecosystem services impact or dependency may generate significant impacts to society, especially to the closest communities and farmers, for example the improvement of services such as pollination, water purification, and soil and sediment retention.

Table 5: Materiality assessment of relevant ecosystem services to railway infrastructure projects

Ecosystem service type	Ecosystem services reference list	Arable land and market gardens	Heathland, scrub and tundra	Grasslands and lands dominated by forbs, mosses or lichens	Broadleaved deciduous woodland	Mires, bogs and fens	Inland unvegetated or sparsely vegetated habitats	Transport networks and other constructed hard-surfaced areas	Comments
Provisioning services	Biomass provisioning services (including crop/grazed biomass/ livestock/wood provisioning)	✓✓							An impact on food production is anticipated due to arable land loss. This service will be assessed quantitively using available sources.
	Genetic material services								Not relevant within the project.
	Water supply								The location and scale of created/ lost habitats are unlikely to influence the water supply. Water supply will not be included in the assessment.
Regulating services	Global climate regulation services (e.g. carbon sequestration)	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		The impact of carbon sequestration through the loss and creation of habitats is anticipated in the project. This service will be assessed quantitively using available sources Embodied carbon and construction emissions would be significant but will be excluded at this stage.
	Rainfall pattern regulation services								The location and scale of created/ lost habitats are unlikely to influence rainfall patterns. This service will not be included in the assessment.
	Local climate regulation services								The location and scale of created/ lost habitats are unlikely to influence local climate regulation. This service will not be included in the assessment.
	Air filtration services	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		Air quality benefits are expected due to created/lost habitats, especially broadleaved woodland and wetlands. This service will be assessed quantitively using available sources.
	Soil quality regulation services	✓	✓	✓	✓	✓	✓		Soil quality improvements are expected – qualitative assessment. This service will be assessed quantitively using available sources.

Ecosystem service type	Ecosystem services reference list	Arable land and market gardens	Heathland, scrub and tundra	Grasslands and lands dominated by forbs, mosses or lichens	Broadleaved deciduous woodland	Mires, bogs and fens	Inland unvegetated or sparsely vegetated habitats	Transport networks and other constructed hard-surfaced areas	Comments
Regulating services	Soil and sediment retention services (e.g. landslide prevention)	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		The area is not prone to landslides, as the topography is mostly flat (see Appendix A.3). However, soil erosion might be improved with the project. This service will be assessed quantitively using available sources.
	Water purification services (e.g. water quality regulation)					✓✓			Wetlands are known for water purification properties. This service will be assessed quantitively using available sources. Note that given the scale of the wetlands, small benefits are expected.
	Water flow regulation services								The location and scale of created/ lost habitats are unlikely to influence the water flow. This service will not be included in the assessment.
	Flood control services								According to Spain's national flooding map (Ministerio para la Transición Ecológica y el Reto Demográfico, n.d), no risk of flooding is present in the area. This service will not be included in the assessment.
	Storm mitigation services								The location and scale of created/ lost habitats are unlikely to influence storm mitigation. This service will not be included in the assessment.
	Noise attenuation services				✓				Woodlands is located next to the train, and when it is mature, it could support this service. Note that only one town is near the railway (0.2 km), but no woodland is located in this section. Other towns are 0.5 km to 2.5 km away. However, it is considered that the railway will have an overall noise impact in the area. This service will be assessed qualitatively.

Ecosystem service type	Ecosystem services reference list	Arable land and market gardens	Heathland, scrub and tundra	Grasslands and lands dominated by forbs, mosses or lichens	Broadleaved deciduous woodland	Mires, bogs and fens	Inland unvegetated or sparsely vegetated habitats	Transport networks and other constructed hard-surfaced areas	Comments
	Pollination services	✓	✓	✓	✓	✓			Habitats could support pollination, which is relevant given the agricultural context of the project. This service will be assessed qualitatively.
	Nursery population and habitat maintenance services (e.g. Biodiversity)	✓	✓	✓	✓	✓			Wetlands qualitative outputs based on biodiversity report. This service will be assessed qualitatively given that there is no suitable metric to value biodiversity for Spain.
Cultural services	Recreation-related services			✓	✓	✓			Unsure, given that areas restored as wetlands are free to access and open to the public but do not have specific signage or walking paths.
	Visual amenity services	✓	✓	✓	✓	✓			Habitat enhancement will be visible from the train. The mix of habitats would provide a more appealing landscape. This service will be assessed qualitatively.
	Spiritual, artistic and symbolic services								Spiritual, artistic and symbolic services are unlikely. This service will not be included in the assessment.
	Ecosystem and species appreciation								Double-counting risk with recreation. This service will not be included in the assessment.

Legend	
✓✓	Quantified and/or valued material impact
✓	Unquantified material impact
	No material impact
	No ecosystem service provision in the boundary of analysis

3.3.2. Qualitative assessment of impacts

The qualitative assessment has been guided by the considerations listed in Section 3.4.1 of the ECOV4R Framework. As not all ecosystem services impacts can be quantified, the qualitative assessment ensures that material impacts are captured, even if they cannot be quantified or monetised.

Table 6 shows the qualitative assessment of the ecosystem services scoped in following the materiality assessment. Significance levels have been assigned based on project information from the EIA, open-source resources and professional judgement. The results were discussed and agreed with ADIF.

Table 6: Qualitative assessment of material ecosystem services to the pilot project

Ecosystem service	Anticipated impact	Reasons/evidence for choosing the scale of the impact	Confidence rating (low, medium, high)
Biomass provisioning services (including crop/grazed biomass/ livestock/wood provisioning)	--	The post-intervention scenario significantly reduced the arable land. Therefore, a significant disbenefit is expected in terms of food production. Moreover, grassland habitats could be useful for livestock; however, a portion of the post-intervention grassland would not be usable for this purpose as it is located on the railway embankment.	High – strong data or consensus of agreeing literature/ evidence.
Global climate regulation services (e.g. carbon sequestration)	++	The implementation of broadleaved woodland in the post-intervention scenario, would favour carbon sequestration. Additionally, arable land, the primary habitat in the baseline, is known for generating carbon emissions. The post-intervention phase significantly reduced the extent of arable land, positively impacting the carbon flux.	High – strong data or consensus of agreeing literature/ evidence.
Air filtration services	+	Implementing woodland and grassland in the post-intervention scenario is expected to benefit the air quality. Trees and grasses absorb pollutants such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter (PM). This natural process helps to reduce the concentration of these substances in the air.	Low – limited data, high uncertainty.
Soil quality regulation services	+	Soil quality improvements are expected with the implementation of habitats such as broadleaved woodland and wetlands, the increase in grassland and the reduction of arable land.	Low – limited data, high uncertainty.
Soil and sediment retention services (e.g. landslide prevention) *	+	The implementation of woodland, shrub and grassland in the post-intervention is expected to benefit soil erosion. The root structure of these habitats reduces the likelihood of soil erosion from wind and rain. Moreover, the vegetation enhances water infiltration into the soil, reducing surface run-off and potential for erosion.	Low – limited data, high uncertainty.
Water purification services (e.g. water quality regulation)	+	The post-intervention scenario presents temporary and permanent wetlands. These are expected to support the water purification service. Wetlands act as natural filters, trapping sediments, pollutants and nutrients from surface run-off before they reach larger water bodies. This process helps to improve water quality by removing contaminants	Medium – moderate evidence, some uncertainty.

Ecosystem service	Anticipated impact	Reasons/evidence for choosing the scale of the impact	Confidence rating (low, medium, high)
Noise attenuation services	--	The post-intervention scenario introduces woodland patches next to the railway; when mature, trees are great elements for noise attenuation. The closest town next to the railway is within 0.2 km, however this section does not have woodland areas. However, it is considered that the railway will have an overall negative noise impact in the area, which will not be able to be attenuated with the proposed habitats. The noise will impact not only the population but will also disturb the habitats and species in the adjacent areas. Hence a significant negative impact is attributed to the project.	Low – limited data, high uncertainty.
Pollination services	+	The post-intervention scenario would incorporate important habitats for pollination, such as woodlands and wetlands, and increase the grassland areas. Pollination would be beneficial to the wider agricultural land in the area.	Low – limited data, high uncertainty.
Nursery population and habitat maintenance services (e.g. biodiversity)	++	Temporary and permanent wetlands were implemented as part of the post-intervention scenario. The monitoring report of the project concludes the following: *'the areas restored as wetlands in the Palencia–León railway may constitute interesting wetlands within the crop matrix of Tierra de Campos, being able to be used temporarily as resting and/or camping areas or in some cases to complete the biological cycle of certain species of birds and amphibians.'*	High – strong data and consensus of agreeing literature/ evidence.
Recreation-related services	+	Arable land does not provide significant recreation opportunities, as opposed to woodlands, wetlands and grasslands. Therefore, it is considered that the post-intervention scenario would provide benefits in this sense. However, while areas restored as wetlands in the post-intervention scenario are free to access and open to the public, they do not have specific signage or walking paths. Hence, benefits would be limited.	Low – limited data, high uncertainty.
Visual amenity services	+	The habitats implemented as part of the post-intervention scenario would provide a visually appealing landscapes with different textures, colours and species throughout the year. Users that could benefit from this are the railway and track/road users, local neighbours and farmers.	Low – limited data, high uncertainty.

Legend	
++	Significant benefit
+	Benefit
0	No benefit
-	Disbenefit
--	Significant disbenefit

Whilst there is good evidence of the impact of certain habitats on air filtration, soil quality regulation, noise attenuation, pollination, recreation and visual amenity services, the magnitude of any impact is highly contextual and depends on the spatial configuration and/or quality of implementation. As we have limited data on these factors, we have assigned a low confidence rating.

3.4. Step D: Benefits valuation – quantify and value

3.4.1. Assessment approach

The purpose of this step is to quantify and (where possible and appropriate) place an economic value on the changes in ecosystem services delivered by the natural assets likely to be caused by the project.

There is no guidance in Spain for undertaking ecosystem services assessments. However, the approach followed in this assessment is aligned with internationally recognised guidance and frameworks such as the United Nations System of Environmental-Economic Accounting – Ecosystem Accounting (UN SEEA-EA) (United Nations, 2012), the *Natural Capital Protocol (Capitals Coalition, 2016), Value Transfer guidelines (eftec, 2010), and* the UK's 'Enabling a Natural Capital Approach' (ENCA) Appraisal Guidance (Defra, 2025).

3.4.2. Quantitative and monetary assessment of impacts

In the following subsections, the approaches taken to quantify and value the impacts of each ecosystem service are explained. Some ecosystem service impacts were not quantified explicitly in biophysical terms but indirectly through the change in area of different habitats. This is due to the valuation approach for these ecosystem services being based on a monetary value per hectare approach.

A literature review was conducted to identify the most suitable valuation for each ecosystem service. Local literature was prioritised to ensure the same currency and economic context. Additionally, local sources offer a comparable geography to the boundary of analysis, with similar habitats. Where local resources were unavailable, literature from other European countries was considered, as these were considered the best available sources and the habitats were aligned with those scoped for the assessment.

All ecosystem service benefits have first been calculated in annual terms and then projected across a 100-year appraisal period. Any monetary values or prices from other studies are presented below in their original currency and price year but were inflated to a 2024 price year before being used and all results are expressed in 2024 euros, using the most recent inflation rate in line with EU policy (European Commission, 2023). Where value transfer has been applied using values from another country, monetary values have first been adjusted for the source country's inflation (IMF, 2025) before converting into 2024 euros using the Spanish purchasing power parity (PPP) conversion factor (World Bank, 2021) to account for differing price levels between countries. (This approach is linked to Section 3.5.3 of the ECOV4R Framework document.) Quantitative and monetary results for all ecosystem services are included in Section 3.5.1.

3.4.2.1. Biomass provisioning services

The average values per hectare from agricultural production from the *Valoración de Activos Naturales en España* (VANE) report (Ministerio de Medio Ambiente y Medio Rural y Marino, 2008) were used to value the impacts on biomass provisioning services. The VANE report was produced by the Spanish government to value Spain's natural assets. The values for the relevant habitats within the boundary of analysis are presented below in Table 7. These values were multiplied by the area of each habitat to estimate the total annual value of biomass provisioning services in the baseline and post-intervention scenarios.

Table 7: Agricultural provisioning values

Landcover relevant to biomass prov. within boundary of analysis	Agricultural provisioning value (€/ha/year, 2005 prices)	Agricultural provisioning value (€/ha/year, 2024 prices)
Pastizal o herbazal **(grassland)**	72.93	100.75
Cultivo herbáceo **(arable land)**	121.39	167.70

Assumptions and limitations

The VANE report uses the 2006 agricultural land prices collected by the *Ministerio de Agricultura, Pesca y Alimentación* (MAPA) as a proxy for the value of agricultural production because an estimate of agricultural yields (e.g. €/tonne/ha or €/livestock/ha) is not available. The chosen valuation method – through land prices – means that the value used for this service does not only include the value of arable, livestock and other food and material production, but may also include other factors that have an impact on price, such as crop subsidies and certain land option values. This may mean that the values used in this report are an overestimate of the biomass provisioning services of the boundary of analysis. Only the price of cropland without irrigation was included in the calculations so as not to double count the value of irrigation water in the land price.

The values used in this study are based on national averages; agricultural productivity and land prices may vary significantly across Spain, potentially limiting the accuracy of these values in this context. The VANE report does, however, apply corrections on a regional scale to account for major metropolitan areas (Madrid and Barcelona) to avoid average prices being skewed upwards.

The post-intervention scenario includes embankments which are classified as grasslands. For safety reasons and due to issues relating to gradient, it was deemed unlikely that the grassland areas on railway embankments could be used for either biomass production (e.g. hay/silage) or grazing, and so these areas were given no value for biomass provisioning services in the post-intervention scenario.

3.4.2.2. Air filtration services

No appropriate biophysical or monetary estimates for air filtration per hectare of the habitat types identified in the boundary of analysis were found for Spain. The quantitative estimates are based on the Office for National Statistics (ONS) (2024) (an update to Jones et al. (2017)) values for air pollution removal by UK vegetation. The tonnes of pollutant capture per hectare was multiplied by the woodland, arable land and grassland habitats in the asset register in the baseline and post-intervention scenarios. The quantitative estimates are based on UK national averages and thus are a useful proxy in the absence of local Spanish data but may not reflect regional differences in climate and emissions sources.

The monetary values for air filtration per hectare produced by ONS (2024) were used as they provided values for three of the scoped habitats. These values are estimates produced by the UK Centre for Ecology and Hydrology (CEH) to update Jones et al. (2017) values for ONS. The monetary values are derived from an 'avoided damage costs' approach which estimates the costs from respiratory and cardiovascular hospital admissions, life years lost and deaths that are avoided due to air pollutant removal by different habitats. This data source is recommended for use in ENCA.

The UK-based source was selected for value transfer as it provides pollutant removal estimates by habitat type using a robust 'avoided cost' methodology. Value transfer criteria (see Section 3.5.3 of the ECOV4R Framework) were considered and met (e.g. relevance of habitat types, assumptions and transparency of valuation methods). Expert judgement supports the transferability of this modelling to the Spanish context, given the similarity in habitat structure and the absence of locally available data.

The value per hectare of each habitat is relative to a bare-soil counterfactual. These values were multiplied by the area of each habitat to estimate the total annual value of air filtration services in the baseline and post-intervention scenarios (Table 8).

Table 8: Air filtration values

Habitat type	Pollutant capture as dry deposition (tonnes/ha/year)2	Air pollutant removal value (£/ha/year, 2023 prices)	Air pollutant removal value (€/ha/year, 2024 prices)
UK woodland	-0.089	399.00	352.85
UK enclosed farmland	-0.056	35.00	30.95
UK semi-natural grassland	-0.049	18.00	15.92

2 These unit values have been generated by dividing the total national UK pollutant capture (tonnes) of PM10, PM2.5, SO_2, NH_3 and NO_2 by the total UK habitat area as reported in the ONS dataset. This is the same way that the £ values were generated. Source: ONS (2024).

Assumptions and limitations

The Jones et al. (2017) study is based on UK air pollutant concentration relative to 'bare soil counterfactual'. The UK is much more densely populated than Spain and so the impact of air pollution is more widely felt as there are more people in close proximity to the sources of air pollutants. For air pollution in relatively sparsely populated areas (such as the boundary of analysis), the health impacts are likely to be lower. Whilst the values have been adjusted for inflation and relative PPP, median income levels differ between the UK and Spain and so willingness-to-pay to avoid loss in life years may also vary. General differences in price levels should be addressed by the PPP conversion factor, but if healthcare is relatively more expensive compared to other goods in one country, then this value would be less accurate.

3.4.2.3. Water purification services

No appropriate biophysical or monetary estimates for water purification filtration per hectare of different habitat types were found for Spain. The quantitative estimates are based on area of change for the wetland habitats in the boundary of analysis (see Section 3.5.1).

The monetary values for water purification per hectare for wetland types produced by Morris and Camino (2011) were used. Inland wetland habitats (the created ponds and wetlands) are the only habitats in the boundary of analysis that provide measurable water purification services. This value was multiplied by the area of wetlands to estimate the total annual value of water purification services in the baseline and post-intervention scenarios (Table 9).

This valuation method draws on UK-based evidence from Morris and Camino (2011), which provides average per-hectare values for inland wetlands based on pollutant removal benefits. This source was selected for value transfer as it offers a transparent, well-documented methodology aligned with value transfer criteria (see Section 3.5.3 of the ECOV4R Framework). The Morris and Camino values are themselves based on a value transfer function derived from evidence from wetland studies across Europe, therefore it is deemed the most suitable proxy for this pilot assessment given the absence of local data.

Table 9: Water purification value for inland wetlands

Habitat type	Water purification value (£/ha/year, 2010 prices)	Water purification value (€/ha/year, 2024 prices)
Average water quality benefits provided by inland wetlands	436.00	533.29

Assumptions and limitations

Morris and Camino (2011) provide estimates for the average and marginal values of water purification benefits by wetlands. In this context, the average value has been used as there were no wetland areas in the baseline scenario and so the project's intervention does not represent the addition of a relatively small amount of wetland habitat to existing wetlands.

Some of the wetland areas created as part of the mitigation measures of the project are temporary and do not remain for the whole year. The proportion of the area of temporary to permanent wetlands is unknown but it is assumed that 50% of the wetland area in the project area is temporary and 50% is permanent. Water purification values were assumed to be equal for both the permanent and temporary wetlands in the boundary of analysis. This may slightly overestimate the total value of water purification services as temporary wetlands may provide water purification services for less of the year.

Whilst the Morris and Camino values have been applied to an average of UK sites, the valuation is based on a value transfer function which draws on evidence from wetlands across Europe. Nevertheless, water purification rates by wetlands may vary by habitat and climate and so the true benefits may vary in a Spanish context.

3.4.2.4. Global climate regulation services (carbon sequestration)

No appropriate quantitative estimates for carbon sequestration rates per hectare of different habitat types were found for Spain and so estimates for UK habitats were used. These are presented in Table 10. Any habitat types not included in the table are assumed to have zero net carbon sequestration. These values were multiplied by the area of each habitat to estimate the total annual tonnes of carbon dioxide equivalent (CO_2e) sequestered in the baseline and post-intervention scenarios.

Table 10: Annual net carbon emissions rates by habitat

Habitat	Net annual emissions (tCO_2e/ha/year) – low estimate	Net annual emissions (tCO_2e/ha/year) – medium estimate	Net annual emissions (tCO_2e/ha/year) – high estimate	Source
Improved grasslands	0.92	-0.36	-1.28	Natural England (Gregg et al, 2021)
Arable land use	0.29	0.29	0.29	Natural England (Gregg et al, 2021)
Hedgerows	-1.67	-1.99	-3.67	Natural England (Gregg et al, 2021)
Broadleaved woodland, light management	-5.70	-5.70	-5.70	Forest Research (Matthews et al, 2022)
Positive values represent net emissions; negative values represent net sequestration.				

To value the carbon sequestered in the baseline and post-intervention scenarios, the carbon sequestration quantities were multiplied by the greenhouse gas (GHG) value factors reported in the International Foundation for Valuing Impact's (IFVI) Greenhouse Gas Emissions Topic Methodology (IFVI, 2024). IFVI provide value factors for the years 2020-2035 whereas our appraisal period runs from 2008-2107. To estimate value factors for the years not covered by the IFVI methodology, the average annual increase across the value factors for 2020-2035 was extrapolated to cover the full appraisal period using an average linear trend (approximately 1.65% increase per year). The full table of carbon values used is presented in Appendix F. These values were multiplied by the quantity of carbon sequestration in each year to estimate the total annual quantity of carbon sequestered in the baseline and post-intervention scenario.

Assumptions and limitations

The IFVI value factors are based on a global social cost of carbon (SCC) approach using the average SCC estimated by two Integrated Assessment Models (IAMs). The SCC represents the net present value of damages from one additional tonne of CO_2e emitted, and the associated climate change (Rogeli et al., 2018). There are other approaches to valuing carbon emissions. One is based on the marginal abatement cost aligned to a particular national emissions pathway. This is the approach used for policy appraisal in the UK where the carbon value is aligned to the marginal abatement cost associated with the UK achieving its climate targets. This approach was not used as no equivalent value for Spain could be found. The other alternative is to use a market price for statutory carbon credits, e.g. those traded under the EU Emissions Trading Scheme (ETS). However, the rail sector is not covered by the EU ETS and so the market price does not represent an internal price of carbon that Adif actually pays.

The habitat classifications in the Natural England and Forest Research papers are not perfect matches for the classification of habitats from CODIIGE[3] in our boundary of analysis. Therefore, some approximations were made based on professional judgement. The '*matorral'* habitat (most closely translated as 'scrub') was assigned the hedgerow carbon sequestration rates which may overestimate the sequestration for this habitat. As elsewhere, the use of UK-based data for carbon sequestration rates will be an imperfect proxy for the sequestration of Spanish habitats.

3 Instituto Geográfico Nacional, n.d.b.

Box 2: Worked example for quantifying and monetising global climate regulation services (carbon sequestration)

Literature review

Some natural assets can remove carbon dioxide from the atmosphere during photosynthesis, releasing oxygen and storing carbon in vegetation and soils. This provides a crucial service in mitigating the effects of anthropogenic climate change. The volume of carbon being sequestered or emitted (a flow) can be quantified using verified average rates or 'carbon factors' for different habitats. The literature review focused on two aspects: firstly, identifying the best available values for carbon fluxes (sequestration and emission rates) for different broad habitat types, taking into consideration the low, medium and high values to use it for the sensitivity analysis; and secondly, identifying the most appropriate monetised value per tCO_2 sequestered.

Quantitative biophysical assessment

The carbon fluxes identified in the literature review were then matched to habitat parcels mapped for the baseline and the post-intervention scenarios based on a best-fit approach. See Table 11 for the quantitative results for the baseline scenario. The same process was repeated for the post-intervention scenario as shown in Table 12.

Table 11: Baseline quantitative carbon sequestration calculations

Existing habitat type	Area (ha)	Source	Carbon flux – net emissions (+) or removals (-) rate tCO_2e/ha/year			Carbon flux – net emissions and removals (sequestration) tCO_2e/year		
			Low	Medium	High	Low	Medium	High
E Grasslands and lands dominated by forbs, mosses or lichens	4.30	Natural England (2021)	0.92	-0.36	-1.28	3.96	-1.55	-5.50
H Inland unvegetated or sparsely vegetated habitats	1.35	N/A	0	0	0	0.00	0.00	0.00
I1 Arable land and market gardens	324.50	Natural England (2021)	0.29	0.29	0.29	94.10	94.10	94.10
J1 Buildings of cities, towns and villages	0.00	N/A	0	0	0	0.00	0.00	0.00
J2.3 Rural industrial and commercial sites still in active use	0.06	N/A	0	0	0	0.00	0.00	0.00
J4 Transport networks and other constructed hard-surfaced areas	0.58	N/A	0	0	0	0.00	0.00	0.00
S Heathland, scrub and tundra	8.40	Natural England (2021)	-1.67	-1.99	-3.67	-14.03	-16.72	-30.83
Total carbon sequestration (tCO_2e/year)						84.03	75.84	57.77

Table 12: Post-intervention quantitative carbon sequestration calculations

Existing habitat type	Area (ha)	Source	Carbon flux – net emissions (+) or removals (-) rate tCO_2e/ha/year			Carbon flux – net emissions and removals (sequestration) tCO_2e/year		
			Low	Medium	High	Low	Medium	High
D Mires, bogs and fens	50.57	No data	0	0	0	0.00	0.00	0.00
E Grasslands and lands dominated by forbs, mosses or lichens	80.23	Natural England (2021)	0.92	-0.36	-1.28	73.81	-28.88	-102.69
G1 Broadleaved deciduous woodland	69.47	Forest Research (2022)	-5.7	-5.7	-5.7	-395.98	-395.98	-395.98
H Inland unvegetated or sparsely vegetated habitats	72.38	N/A	0	0	0	0.00	0.00	0.00
I1 Arable land and market gardens	11.95	Natural England (2021)	0.29	0.29	0.29	3.47	3.47	3.47
J1 Buildings of cities, towns and villages	0	N/A	0	0	0	0.00	0.00	0.00
J2.3 Rural industrial and commercial sites still in active use	0.08	N/A	0	0	0	0.00	0.00	0.00
J4 Transport networks and other constructed hard-surfaced areas	53.81	N/A	0	0	0	0.00	0.00	0.00
S Heathland, scrub and tundra	0.7	Natural England (2021)	-1.67	-1.99	-3.67	-1.17	-1.39	-2.57
		Total carbon sequestration (tCO_2e/year)				-319.87	-422.79	-497.78

Quantitative monetary assessment

Monetisation was undertaken using the IFVI (2024) GHG emissions values, which were extrapolated to the assessment's appraisal period, as explained in Section 3.4.2.4. Given that the IFVI value was in US dollars, the monetary value was adjusted to the source country's inflation, in this case the USA. Then it was converted into 2024 euros using the Spanish purchasing power parity (PPP) conversion factor. Finally, a discount rate was applied, following European Commission (2023) guidance. The following figure summarises the process that was applied to obtain the adjusted 2024 carbon value for Spain for all the years in the appraisal period (2008-2107).

Annual value

The annual value was estimated multiplying the total carbon sequestration (tCO_2e/year) by the average (2008-2107) adjusted 2024 carbon value for Spain. The same process was applied for the baseline and the post-intervention scenario. Table 13 only shows the outputs for the carbon flux central value. To complete the sensitivity assessment, the same process should be applied to the low and high values to obtain the range of values for this ecosystem service.

Table 13: Baseline and post-intervention monetary carbon sequestration calculations

Scenario	Total carbon sequestration (tCO_2e/year) (central value)	Average (2008-2107) adjusted 2024 carbon value for Spain	Annual value
Baseline	75.84	€280.58	-€ 21,279.33
Post-intervention	-422.79	€280.58	€ 115,674.62

The results indicate that the baseline scenario presents carbon emissions, negatively impacting the environment and leading to a negative annual value **(-€21.3k)**. In contrast, the post-intervention scenario presents carbon sequestration, which is beneficial for the environment and would derive in a positive annual value **(€115.7k)**.

3.4.2.5. Soil and sediment retention services

The average values per hectare for erosion protection from the VANE report were used to value the impacts on soil and sediment retention services. The values for the relevant habitats within the boundary of analysis are presented below in Table 14. These values were multiplied by the area of each habitat to estimate the total annual value of soil and sediment retention services in the baseline and post-intervention scenarios.

Table 14: Erosion control values by habitat

Land cover	Erosion control value (€/ha/year, 2005 prices)	Erosion control value (€/ha/year, 2024 prices)
Matorral **(scrub)**	19.98	27.60
Bosque de plantación **(plantation woodland)**	17.21	23.78
Tierras de labor de secano **(dryland arable land)**	2.19	3.03
Herbazal **(grassland)**	8.92	12.32

Assumptions and limitations

The values used in this study are based on national averages, but erosion control by different habitat types may vary significantly across Spain, especially with variation in soil types and climate, potentially limiting the accuracy of these values in this context.

3.4.3. Present value of changes

Annual values and present values (PV) are calculated for all ecosystem services in this study. For this assessment, the discount rate was set at 3% in line with EU policy (European Commission, 2023) and the appraisal period is 100 years. Please refer to Section 3.5.4 of the ECOV4R Framework for further information.

3.5. Step E: Using and interpreting results

3.5.1. Summary of results

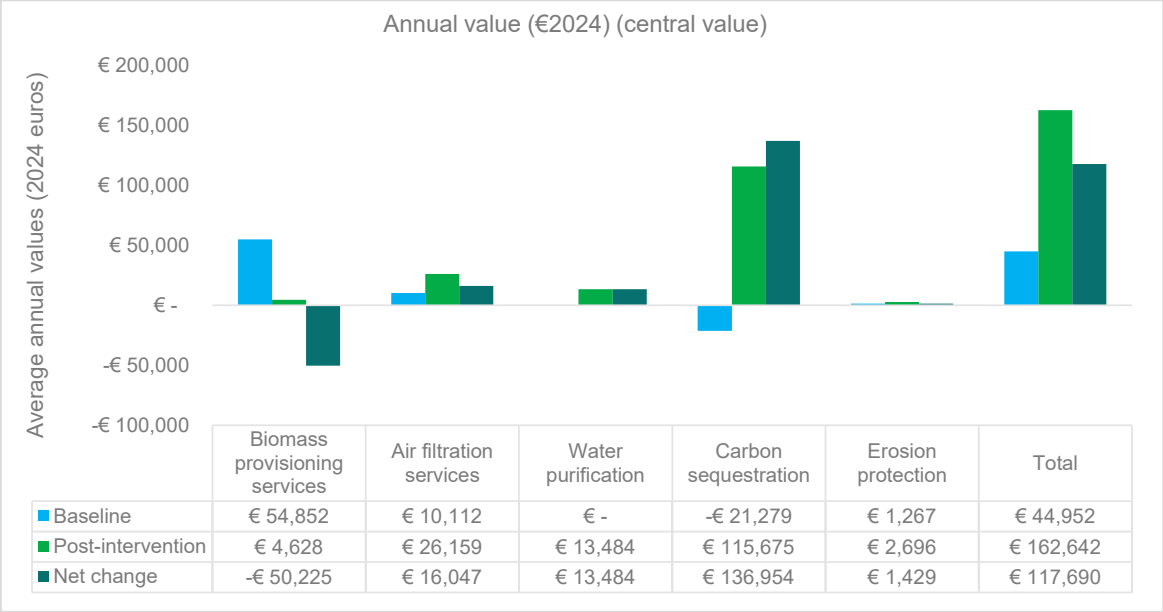
Table 15 and Table 16 present the quantitative (biophysical) estimates of the five ecosystem services scoped for quantitative assessment in the baseline and post-intervention scenarios. The only ecosystem service with an explicit biophysical metric was global climate regulation (e.g. carbon sequestration). The other four ecosystem services were based on assessing the change in quantity of ecosystem service provision based on the area of the relevant habitat. Due to the reduction in net emitting agricultural land and the increase in other habitat cover, such as woodlands, the carbon sequestration rate in the post-intervention scenario is much higher than in the baseline, and the boundary of analysis moves from being a net-emitting area to a net-sequestering area, with 423 tCO_2e sequestered each year in the central estimates.

Table 15: Quantitative estimates by ecosystem service (annual and central values)

Ecosystem service	Unit of measurement	Baseline	Post-intervention	Net change
Biomass provisioning services	Area of relevant habitat (ha)	328.8	38	-290.8
Air filtration services	Pollutant capture (tonnes/ year)	-18.88	-10.84	8.04
Water purification services	Area of relevant habitat (ha)	0	25.3	25.3
Global climate regulation services	tCO_2e/year (central value)	76	-423	-347
Erosion protection services	Area of relevant habitat (ha)	328.8	162.4	-166.4

Table 16: Quantitative estimates of carbon sequestration (annual – sensitivity analysis)

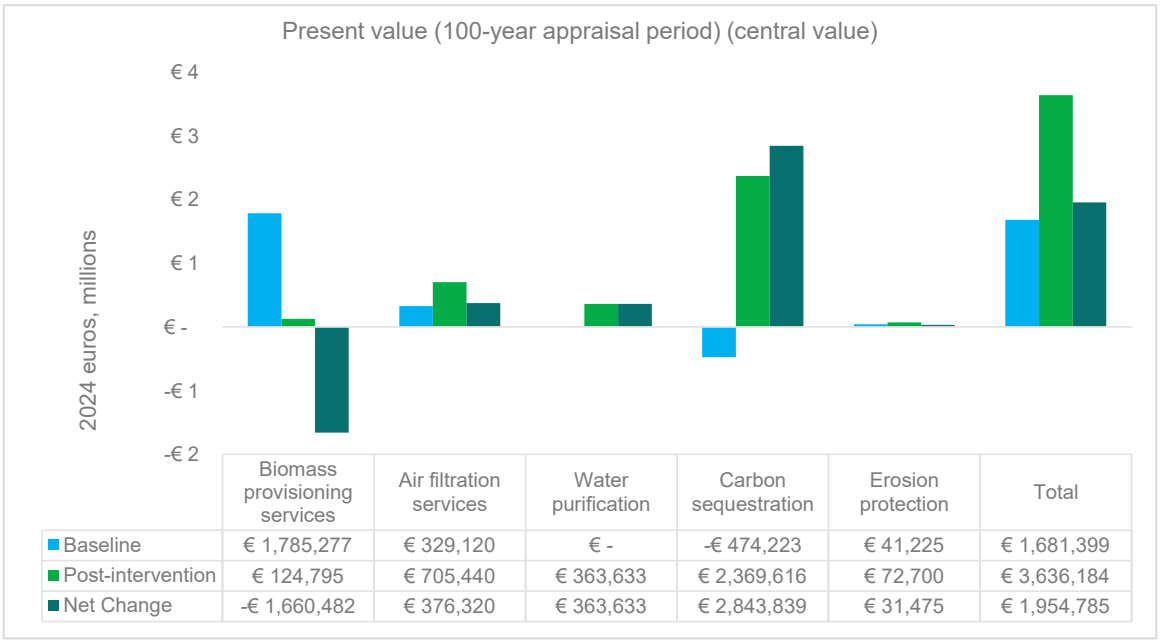
Ecosystem service	Unit	Low baseline	Central baseline	High baseline	Low post-intervention	Central post-intervention	High post-intervention
Global climate regulation services	tCO_2e/ year	84	76	58	-320	-423	-498



	Biomass provisioning services	Air filtration services	Water purification	Carbon sequestration	Erosion protection	Total
Baseline	€ 54,852	€ 10,112	€ -	-€ 21,279	€ 1,267	€ 44,952
Post-intervention	€ 4,628	€ 26,159	€ 13,484	€ 115,675	€ 2,696	€ 162,642
Net change	-€ 50,225	€ 16,047	€ 13,484	€ 136,954	€ 1,429	€ 117,690

Figure 11: Annual monetary value by ecosystem service

Figure 11 presents the annual monetary values for each assessed ecosystem service. The total average increase in annual value resulting from the project is approximately €117,690. The most significant contribution comes from global atmospheric regulation (carbon sequestration), which yields an average annual value of €137,000. This estimate is based on the average carbon price applied over the appraisal period. Other ecosystem services – air filtration, water purification and erosion protection – also show positive annual value changes, albeit on a smaller scale. In contrast, biomass provisioning is the only service exhibiting a decline in value, with an estimated annual loss of €50,000, primarily due to the reduction in agricultural land.



	Biomass provisioning services	Air filtration services	Water purification	Carbon sequestration	Erosion protection	Total
Baseline	€ 1,785,277	€ 329,120	€ -	-€ 474,223	€ 41,225	€ 1,681,399
Post-intervention	€ 124,795	€ 705,440	€ 363,633	€ 2,369,616	€ 72,700	€ 3,636,184
Net Change	-€ 1,660,482	€ 376,320	€ 363,633	€ 2,843,839	€ 31,475	€ 1,954,785

Figure 12: Present value by ecosystem service

Figure 12 illustrates the present value (PV) of each ecosystem service. The total PV of the ecosystem service impacts attributable to the project is just under €2 million. Carbon sequestration again represents the largest positive contribution, with a PV of approximately €2.8 million. The PVs for air filtration, water purification and erosion protection are €376,000, €363,000 and €31,000 respectively. The PV for biomass provisioning reflects a loss of €1.7 million, consistent with the annual value reduction due to the loss of agricultural land.

In terms of the distributional impact of the changes across the beneficiaries, the following list summarises how the beneficiaries may 'gain' or 'lose' from the changes in ecosystem services, assessed qualitatively and quantitatively, delivered as a result of the proposed interventions:

- **Railway passengers**: Indirect gains from reduced travel disruption to train services. Direct benefits from visual amenity services.
- **Railway operators/Infrastructure managers:** Direct gains from reduced erosion risks that could affect their operations, as well as reputational benefits for enhancing the delivery of different ecosystem services.
- **Farmers**: Direct losses for farmers from the reduction of biomass. The boundary of analysis is currently owned by ADIF, however, it used to be agricultural land. In the post-intervention scenario, no agricultural activities are expected in this area, although farmers might be able to use grassland areas for cattle grazing in a limited manner. However, the project would also provide direct and indirect benefits for nearby farmers due to the enhancement of pollination, nursery population and habitat maintenance, air filtration, water purification, erosion protection and carbon sequestration.
- **Local community**: Direct losses from the noise increase of the area due to the implementation of the railway. Direct gains from recreation-related services. Indirect gains from improved nursery population and habitat maintenance, air filtration, water purification, erosion protection, carbon sequestration.
- **Global community**: Indirect gains from improved carbon sequestration.

3.5.2. Uncertainties and limitations

Figure 13 presents the sensitivity analysis of the total PV. The error bars shown are derived exclusively from the variability in carbon sequestration rates, as shown in Table 16. The net change in total PV ranges from €1.4 million to €2.3 million depending on variations in the carbon sequestration rates. This highlights the influence of carbon-related assumptions on the overall valuation and underscores the importance of robust carbon data in ecosystem service assessments.

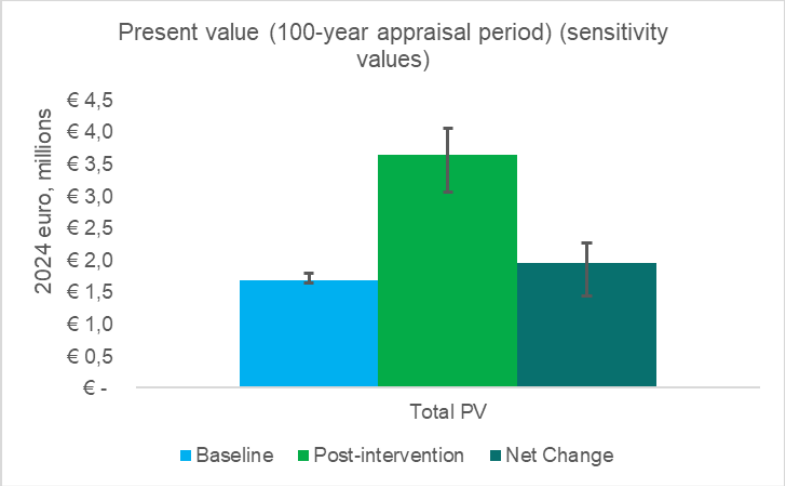


Figure 13: Total present value sensitivity analysis

Assumptions and limitations specific to each ecosystem service methodology are included in Section 3.4.1. More general assumptions and limitations of this study's approach are listed below.

Assumptions:

- All habitats within the construction footprint were assumed to be 'lost' during the construction period and so provided no ecosystem services.

Limitations:

- SIOSE data, for assessing both baseline and post-intervention habitats, lacks detailed granularity.
- This study is not a full analysis of the project and does not consider the potential environmental and wider impacts during the construction phase (e.g. as the carbon emissions associated with soil disturbance or concrete production, temporary land-take to provide facilities, etc.) and so does not account for any impact they have had on ecosystem service provision.
- The geospatial data used does not capture all new access roads that have been constructed adjacent to the railway. The negative impact where there is a loss of habitats due to these roads will not be accounted for and so benefits will be slightly overestimated.
- The ecosystem services provided by this project assume habitats successfully establish and reach maturity. Risk of habitat establishment failure has not been considered.
- Limitations in quantitative and monetary assessment approaches used for each ecosystem service in this study are discussed in their respective subsection in Section 3.4.2.

3.5.2.1. Confidence ratings of quantitative and monetary evidence

As stated in Section 3.6.1 of the ECOV4R Framework, it is important to understand and capture uncertainties in the underlying data and evidence used for the qualitative, quantitative and monetary assessment. One way of acknowledging these uncertainties is through a Red-Amber-Green confidence rating system of the evidence or methods used, as presented in Table 17.

Table 17: Confidence ratings of data and evidence used

Ecosystem service	Assessment type	Anticipated impact / Net change	Confidence
Biomass provisioning services (including crop/ grazed biomass/livestock/wood provisioning)	Qualitative	↓	
	Quantitative (monetary)	↓	
Global climate regulation services (e.g. carbon sequestration)	Qualitative	↑	
	Quantitative (biophysical)	↑	
	Quantitative (monetary)	↑	
Air filtration services	Qualitative	↑	
	Quantitative (biophysical)	↓	
	Quantitative (monetary)	↑	
Soil quality regulation services	Qualitative	↑	

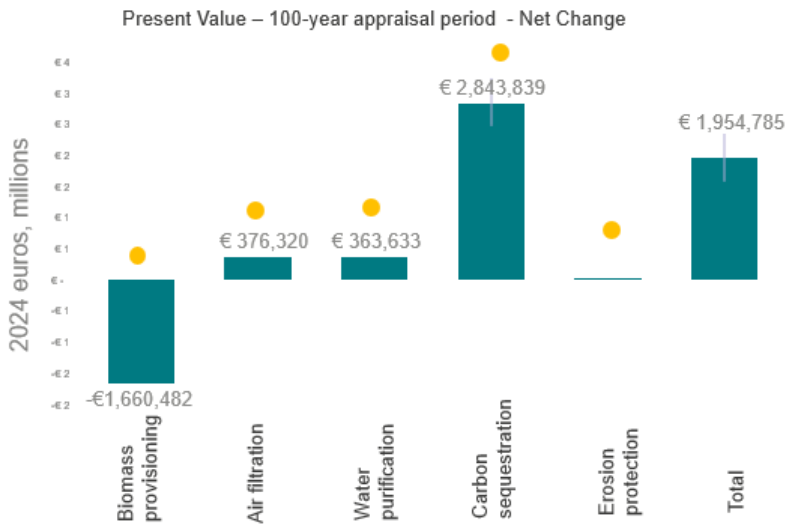
Ecosystem service	Assessment type	Anticipated impact / Net change	Confidence
Soil and sediment retention services (e.g. landslide prevention)	Qualitative	↑	
	Quantitative (monetary)	↑	
Water purification services (e.g. water quality regulation)	Qualitative	↑	
	Quantitative (monetary)	↑	
Noise attenuation services	Qualitative	↓	
Pollination services	Qualitative	↑	
Nursery population and habitat maintenance services (e.g. biodiversity)	Qualitative	↑	
Recreation-related services	Qualitative	↑	
Visual amenity services	Qualitative	↑	

Legend for confidence rating

Green	**Qualitative** – Based on project-specific information (e.g. EIA, monitoring report, etc.) and/or strong consensus of anticipated impact. **Quantitative** – Strong or established evidence with few gaps. Based on local data sources for quantitative methods/values, using data with minimal data limitations. Recommended in guidance.
Amber	**Qualitative** – Based on national/regional data. **Quantitative** – Some evidence, but incomplete or uncertain. Based on international data sources for quantitative methods/values, using data with acceptable data limitations. Recommended in guidance.
Red	**Qualitative** – Based on professional judgement. **Quantitative** – Speculative, major gaps in evidence. Based on international data sources for quantitative methods/values, using data with significant data limitations.

The following infographic summarises the results of this pilot's ecosystem services valuation assessment. The infographic provides a holistic summary of the material impacts on ecosystem services in qualitative, quantitative and monetary terms. The circles in the infographic represent the RAG confidence rating (as explained above). Where applicable, error bars have been used to report ranges in values (carbon sequestration).

Monetary Assessment



Quantitative Assessment

Ecosystem service	Unit of measurement	Net change
Global climate regulation services	tCO_2e/year (central value)	-346.95
Biomass provisioning services	Area of relevant habitat (ha)	-290.8
Air filtration services	Pollutant capture (tonnes/year)	8.04
Water purification services	Area of relevant habitat (ha)	25.3
Erosion protection services	Area of relevant habitat (ha)	-166.4

Qualitative Assessment

Ecosystem Service	Anticipated Impact	Confidence Rating
Biomass provisioning services (including crop/grazed biomass/livestock/wood provisioning)	↓↓	Green
Global climate regulation services (e.g. carbon sequestration)	↑↑	Green
Air filtration services	↑	Red
Soil quality regulation services	↑	Red
Soil and sediment retention services (e.g. landslide prevention) *	↑	Red
Water purification services (e.g. water quality regulation)	↑	Amber
Noise attenuation services	↓↓	Red
Pollination services	↑	Red
Nursery population and habitat maintenance services (e.g. Biodiversity)	↑↑	Green
Recreation-related services	↑	Red
Visual amenity services	↑	Red

Confidence Rating: Red, Amber, Green

Figure 14: Infographic summarising the assessment

4. Conclusions and recommendations

4.1. Conclusions

The ecosystem services assessment shows the overall improvements in the ecosystem services derived from the Palencia–León high-speed rail project, which would have positive outcomes for rail users, farmers, and the local and wider communities. Despite the implementation of a new railway, which would normally generate the loss of habitats, the success of the project relies on the environmental mitigation measures that were applied, such as the implementation of **wetlands, broadleaved woodland and grassland**, which provide positive environmental outcomes.

The qualitative assessment identified multiple benefits, including soil quality regulation, pollination, recreation-related services, visual amenity, air filtration, soil and sediment retention, and water purification. Notably, significant benefits were detected for carbon sequestration and nursery population and habitat maintenance. However, two ecosystem services were identified to have anticipated significant disbenefits: noise attenuation and biomass provisioning.

It was estimated that the project would provide around **€2 m in benefits over 100 years**, based on the **benefits valuation** of five ecosystems (selected based on the available methodologies). Over the 100-year appraisal period, carbon sequestration is the service with the most significant gains (€2.8 m PV), followed by air filtration (€376.6 k PV), water purification (€363.6 k PV), and soil erosion (€31.5 k PV). As expected, biomass provisioning showed losses (-€1.6 k PV).

Moreover, the assessment has successfully showcased the practical application of the ECOV4R Framework. The five-step approach allowed a comprehensive analysis of the project. In *Step A: Baseline*, it was possible to define the boundary of analysis and develop an asset register. In *Step B: Impacts on natural capital assets*, it was possible to define the scenario with which the baseline would be compared, and to develop the post-intervention scenario asset register. Then *Step C: Impacts on ecosystem services* enabled the review of the previous steps to define the materiality assessment to identify the main ecosystem services impacted either positively and negatively by the project and to define which approach would be applied in each case (qualitative or quantitative). In this step, a qualitative assessment was developed based on available evidence and detected habitat changes. *Step D: Benefits valuation* enabled the assessment of the scoped ecosystem services quantitatively, in both a biophysical and monetary context. This step required an exhaustive literature review to define the most appropriate methodologies to be applied within the context of the project and the application of value transfer criteria to select monetary valuation evidence. Finally, *Step E: Using and interpreting results* revisited the project's impacts and defined potential mitigation and enhancement opportunities and wider recommendations.

Overall, the ecosystem services assessment not only highlights the net environmental gains of the Palencia–León high-speed train project, but also demonstrates the value of integrating structured frameworks like ECOV4R into railway infrastructure planning to ensure sustainable and evidence-based decision-making and to support the business and investment case for nature-based solutions.

4.2. Recommended actions

The following recommendations are presented in relation to the delivery of ecosystems services:

- In discussions with ADIF, it was noted that there are currently no management plans for the area of new habitats under ADIF's direct management. Despite the implementation of the new habitats, such as wetlands, woodlands and grasslands, having a positive effect in principle, the associated benefits will only be realised if these habitats are successfully established and well maintained in the long term. This requires appropriate management of the areas to ensure that the habitats are maintained in good condition and reach maturity, enabling them to deliver the anticipated level of ecosystem services now and into the future. For this pilot assessment, we have assumed that long-term management will be undertaken by ADIF.

- It was noted that, despite the new wetlands and woodland being free to access and open to the public, they currently lack dedicated paths, signage or other accessibility features, which limits the number of visitors to these areas and potentially uncontrolled access may cause damage to the natural assets as a result. Therefore, it would be recommended to explore the possibility of improving the accessibility of these particular areas and linking to wider walking networks to enable the delivery of wider ecosystem services, especially cultural services (such as recreation, education, wellbeing, etc.) whilst minimising potential negative impacts on the natural assets. Given the proximity of the railway to these areas, a feasibility assessment should be conducted to ensure public access can be provided safely.

The following recommendations should be considered for future iterations of the ecosystem services assessment:

- Consider refining the assessment using more accurate habitat and road data in future iterations. As mentioned in Appendix B, the asset registers for the baseline and post-intervention scenarios used open-source data as well as data provided by ADIF, but inaccuracies were detected. Moreover, the changes in the adjacent tracks and roads, as a result of the railway project, were not covered by this assessment due to the lack of data. It is recommended that the assessment be updated when more precise data is collected for the project.
- It is recommended that future iterations continue to incorporate the most up-to-date and robust ecosystem services assessment methodologies, acknowledging the dynamic nature of this field and the continual emergence of new approaches.

5. Acknowledgements

Citation:

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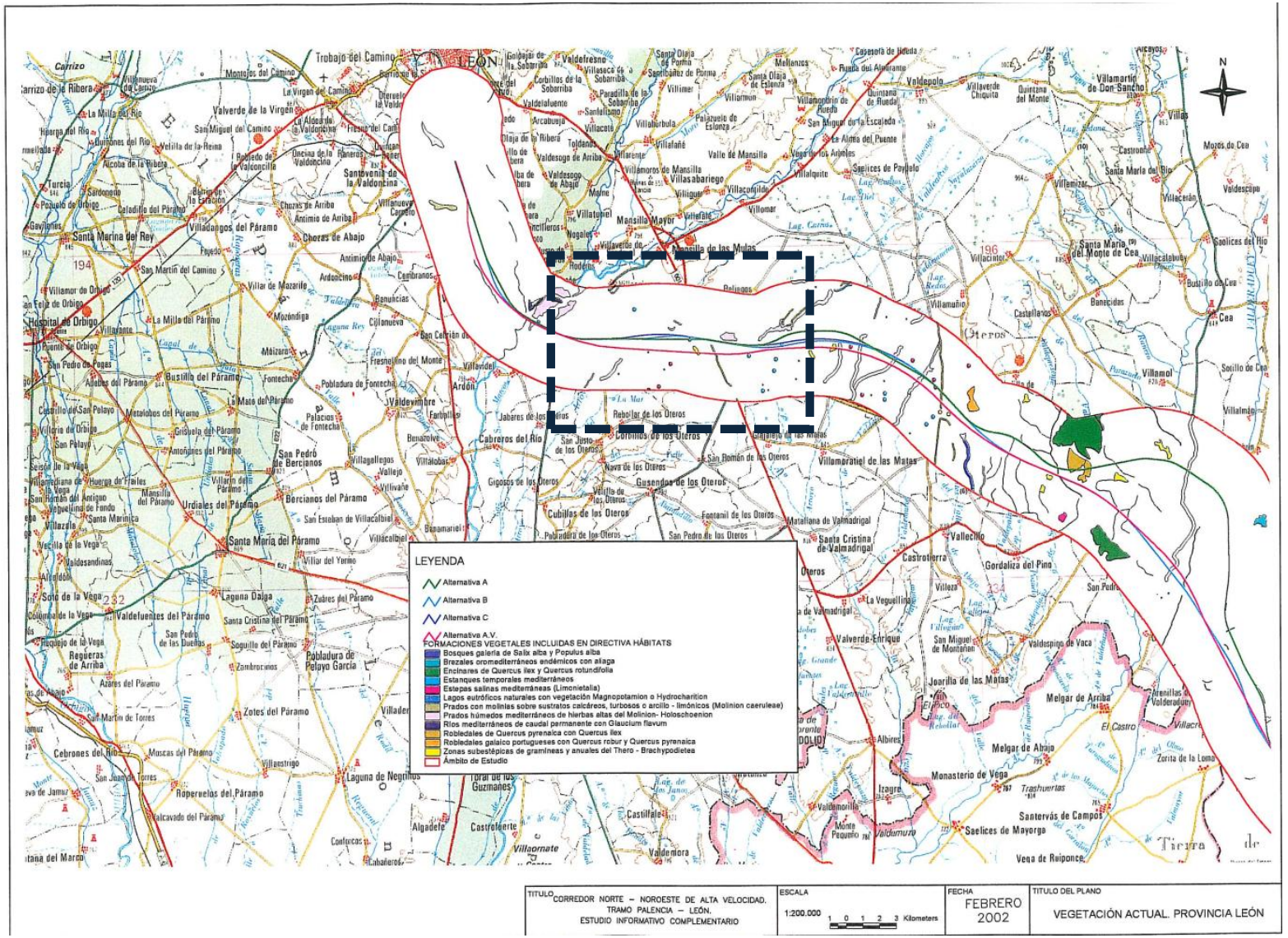
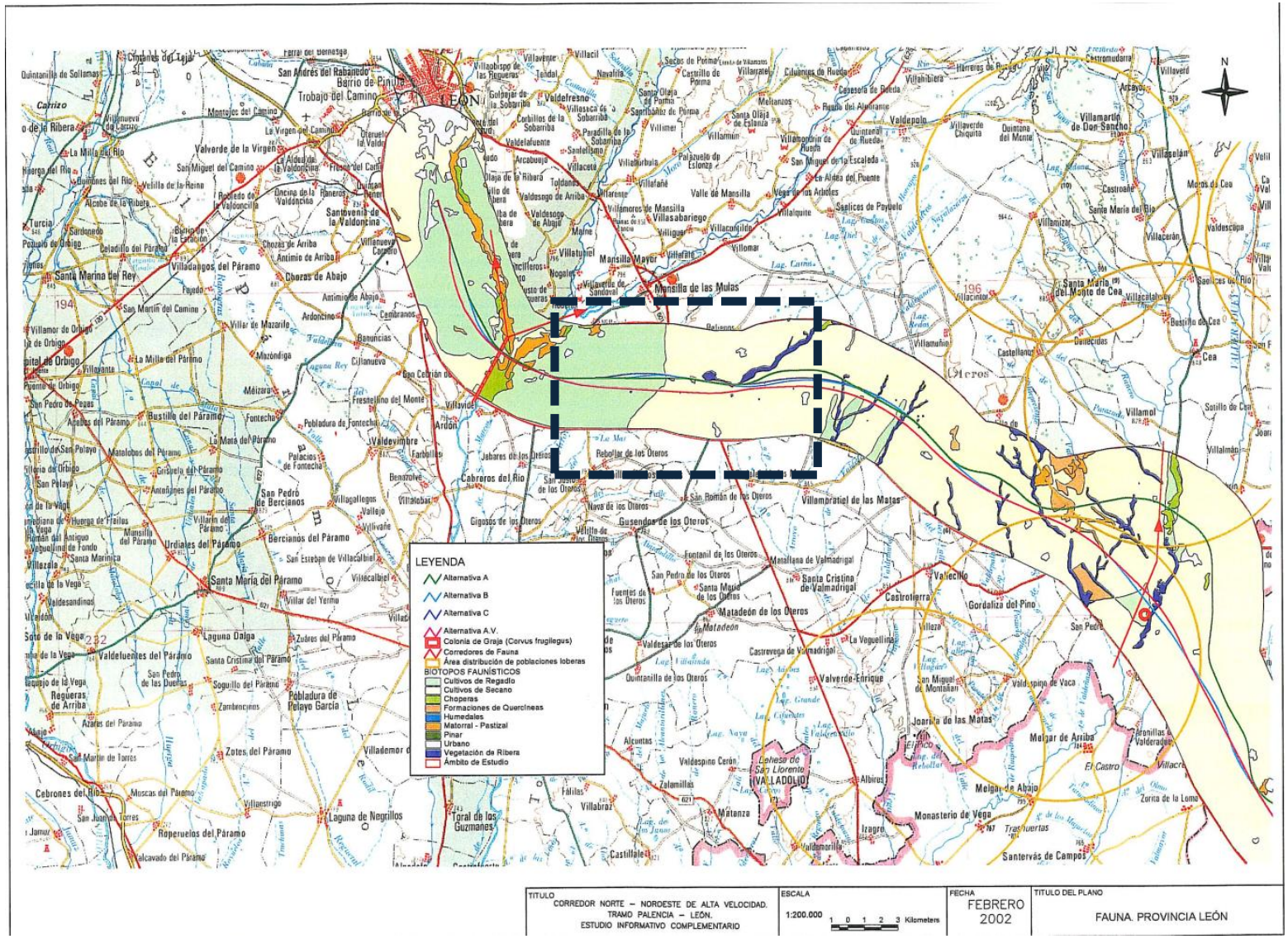
Appendix A. EIA relevant maps

The following maps were extracted from the Palencia–León high-speed train EIA (TIFSA Grupo Renfe, 2002). In the following maps, the 16 km section pertinent to the Ecosystem Valuation assessment is highlighted with a rectangle.

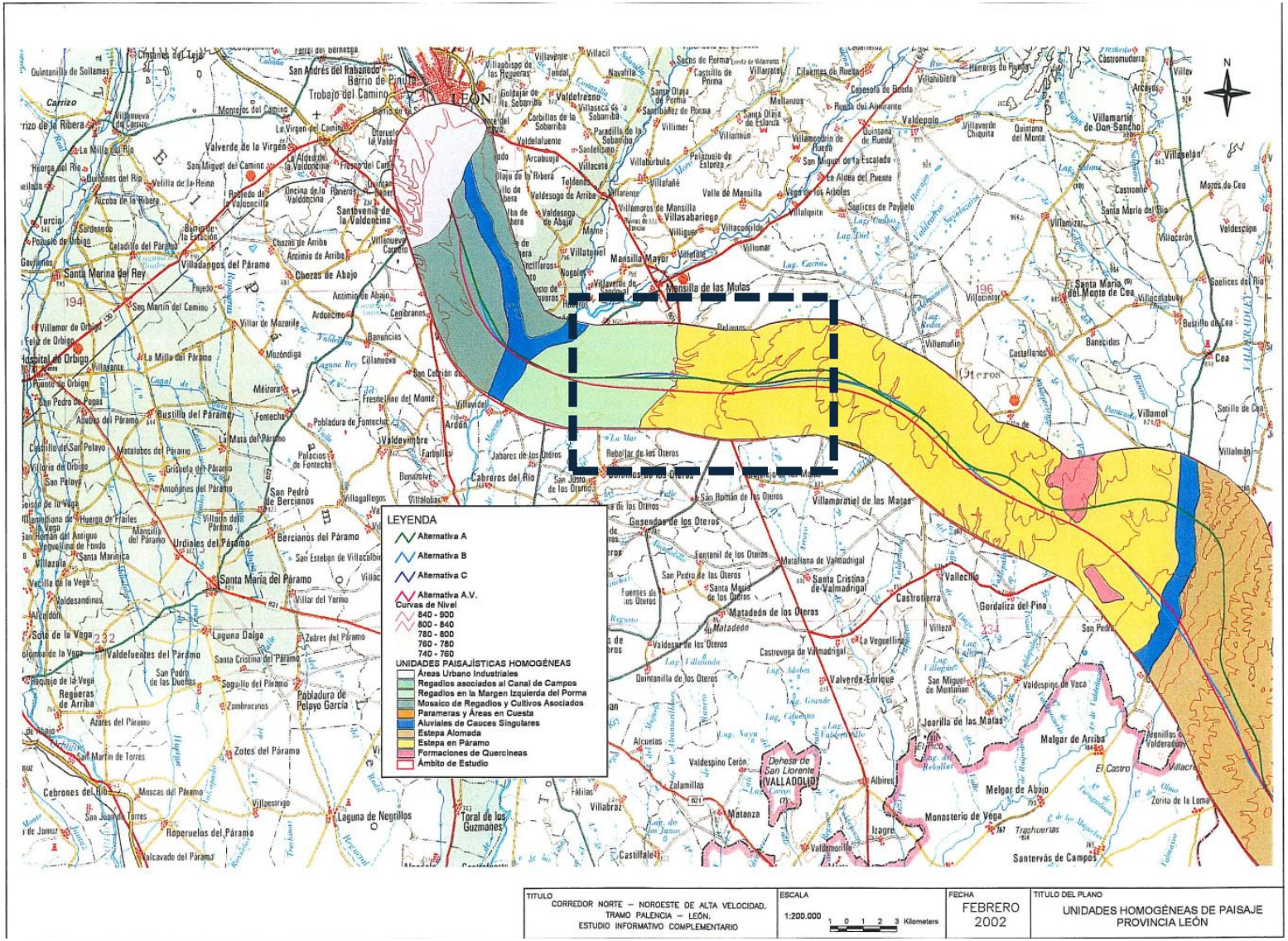
A.1. Vegetation



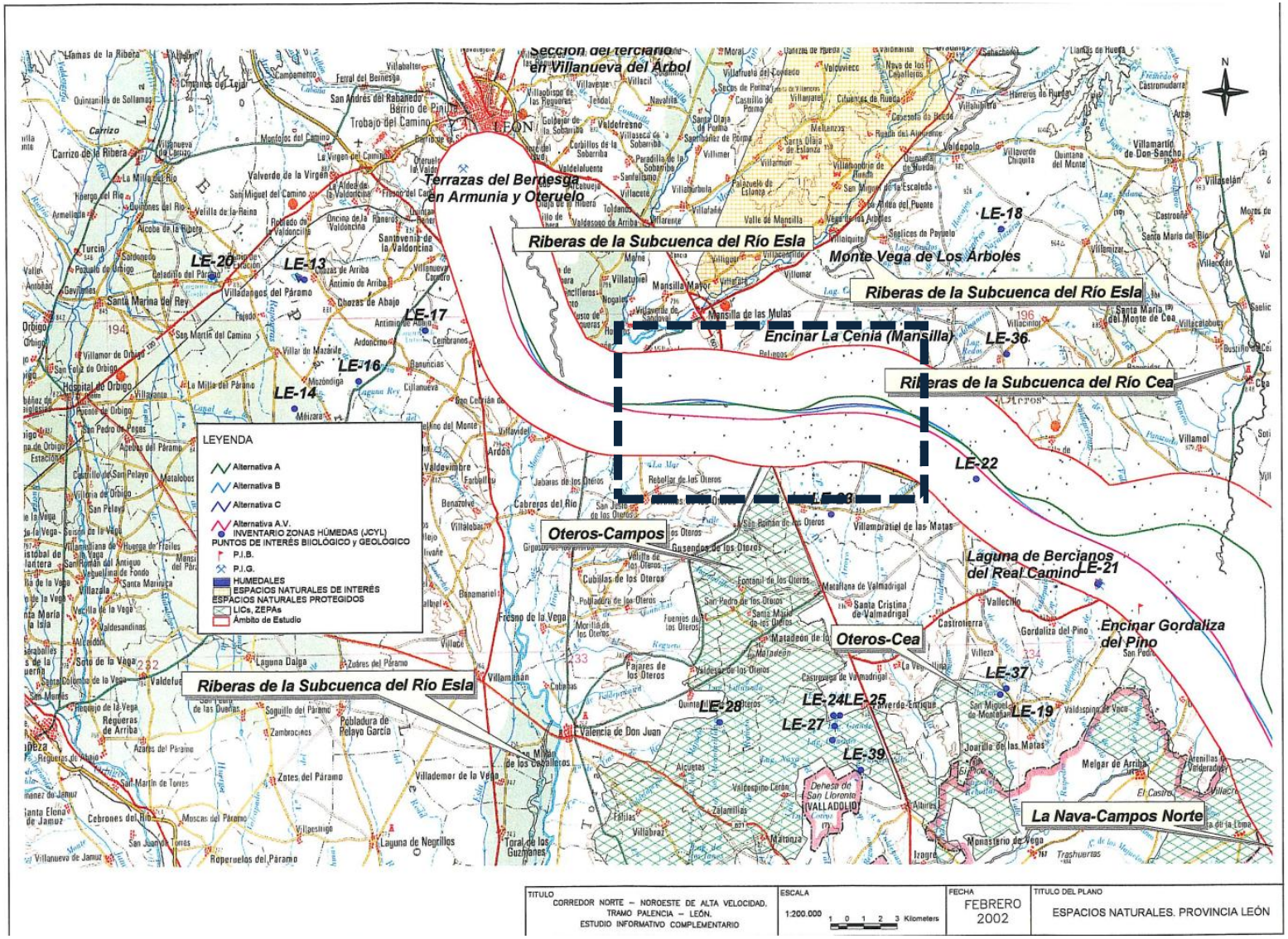
A.2. Fauna


LEYENDA
Alternativa A
Alternativa B
Alternativa C
Alternativa A.V.
Colonia de Graja (Corvus frugilegus)
Corredores de Fauna
Área distribución de poblaciones loberas
BIOTOPOS FAUNÍSTICOS
Cultivos de Regadío
Cultivos de Secano
Choperas
Formaciones de Quercíneas
Humedales
Matorral - Pastizal
Pinar
Urbano
Vegetación de Ribera
Ámbito de Estudio
TITULO
CORREDOR NORTE – NOROESTE DE ALTA VELOCIDAD.
TRAMO PALENCIA – LEÓN.
ESTUDIO INFORMATIVO COMPLEMENTARIO
ESCALA
1:200.000
1 0 1 2 3 Kilometers
FECHA
FEBRERO 2002
TITULO DEL PLANO
FAUNA. PROVINCIA LEÓN

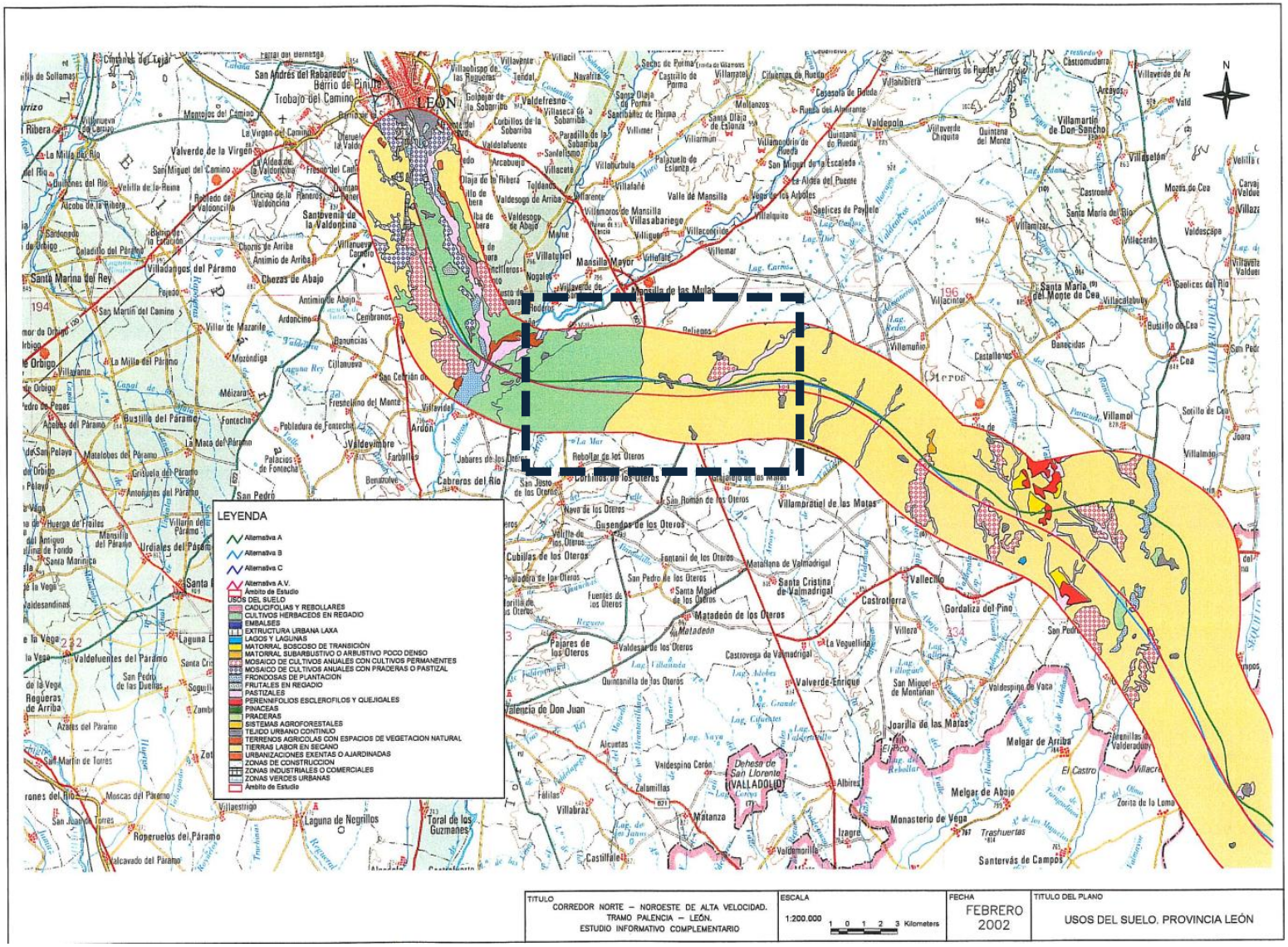
A.3. Homogeneous landscape units



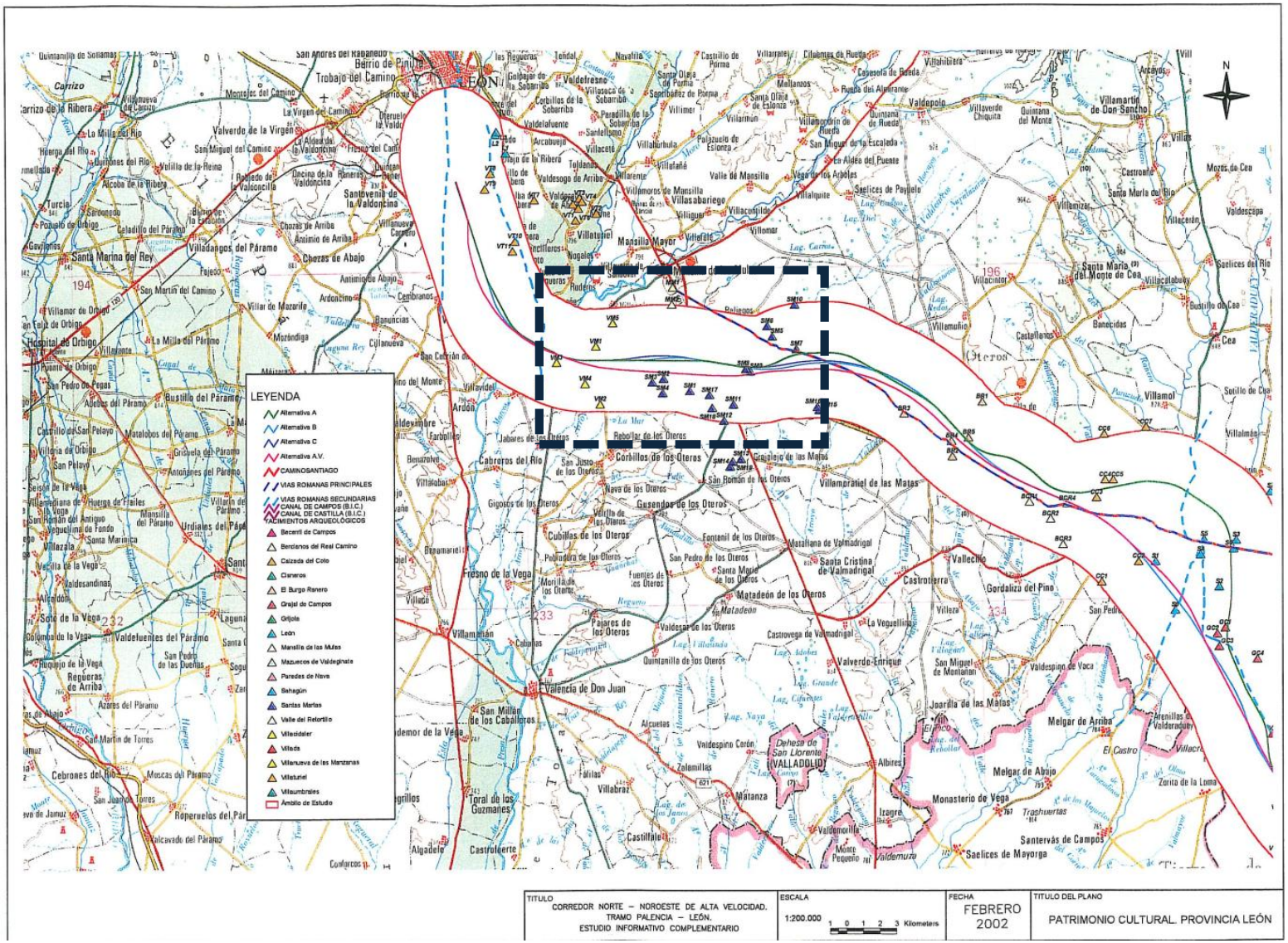
A.4. Natural areas



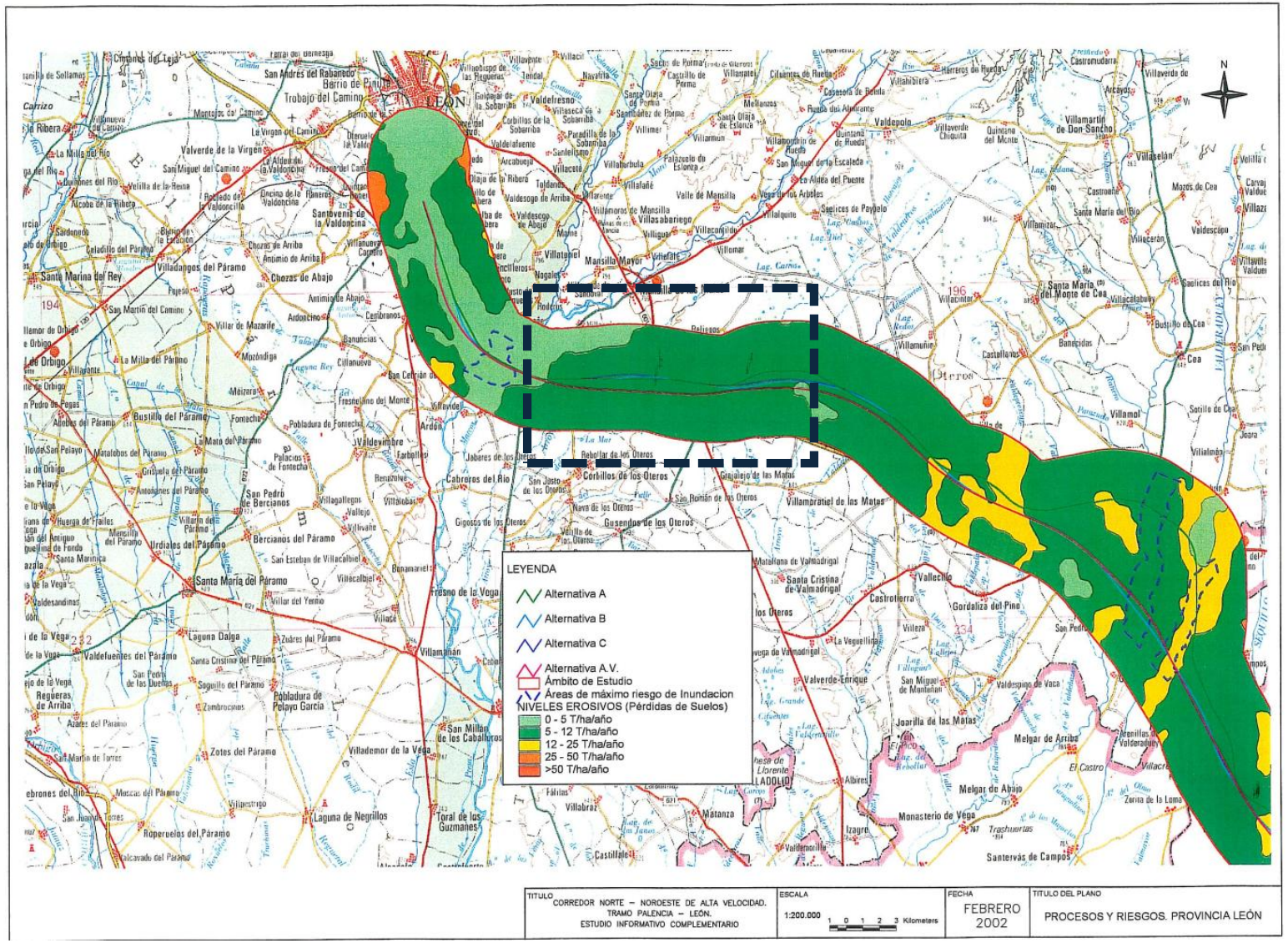
A.5. Land use


LEYENDA
Alternativa A
Alternativa B
Alternativa C
Alternativa A.V.
Ámbito de Estudio
USOS DEL SUELO
CADUCIFOLIAS Y REBOLLARES
CULTIVOS HERBACEOS EN REGADIO
EMBALSES
EXTRUCTURA URBANA LAXA
LAGOS Y LAGUNAS
MATORRAL BOSCOSO DE TRANSICIÓN
MATORRAL SUBARBUSTIVO O ARBUSTIVO POCO DENSO
MOSAICO DE CULTIVOS ANUALES CON CULTIVOS PERMANENTES
MOSAICO DE CULTIVOS ANUALES CON PRADERAS O PASTIZAL
FRONDOSAS DE PLANTACION
FRUTALES EN REGADIO
PASTIZALES
PERENNIFOLIOS ESCLEROFILOS Y QUEJIGALES
PINACEAS
PRADERAS
SISTEMAS AGROFORESTALES
TEJIDO URBANO CONTINUO
TERRENOS AGRICOLAS CON ESPACIOS DE VEGETACION NATURAL
TIERRAS LABOR EN SECANO
URBANIZACIONES EXENTAS O AJARDINADAS
ZONAS DE CONSTRUCCION
ZONAS INDUSTRIALES O COMERCIALES
ZONAS VERDES URBANAS
Ámbito de Estudio
TITULO
CORREDOR NORTE – NOROESTE DE ALTA VELOCIDAD.
TRAMO PALENCIA – LEÓN.
ESTUDIO INFORMATIVO COMPLEMENTARIO
ESCALA
1:200.000
0 1 2 3 Kilometers
FECHA
FEBRERO
2002
TITULO DEL PLANO
USOS DEL SUELO. PROVINCIA LEÓN

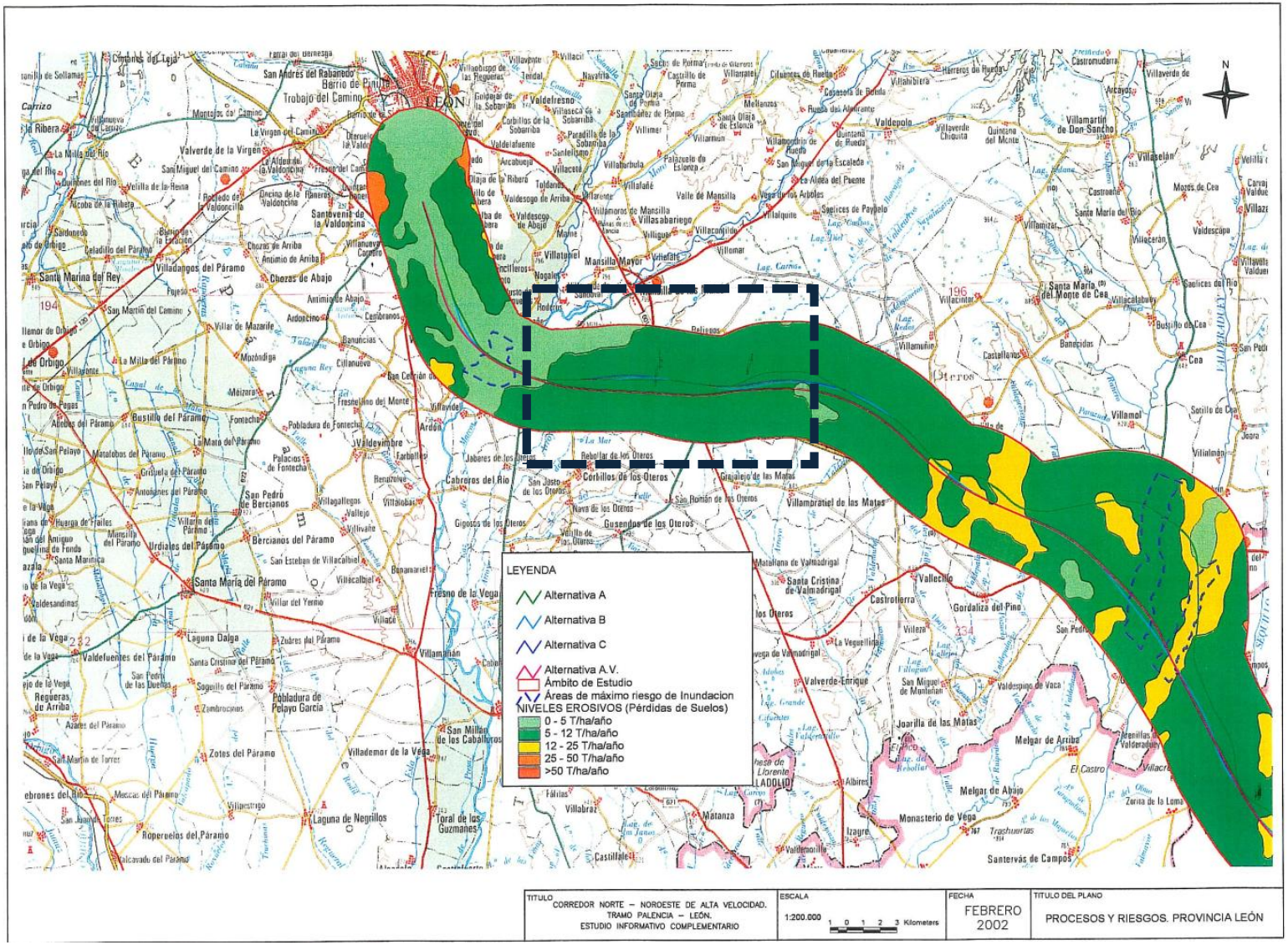
A.6. Cultural heritage



A.7. Soil


LEYENDA
Alternativa A
Alternativa B
Alternativa C
Alternativa A.V.
Ámbito de Estudio
Áreas de máximo riesgo de Inundacion
NIVELES EROSIVOS (Pérdidas de Suelos)
0 - 5 T/ha/año
5 - 12 T/ha/año
12 - 25 T/ha/año
25 - 50 T/ha/año
>50 T/ha/año
TITULO
CORREDOR NORTE – NOROESTE DE ALTA VELOCIDAD.
TRAMO PALENCIA – LEÓN.
ESTUDIO INFORMATIVO COMPLEMENTARIO
ESCALA
1:200.000
1 0 1 2 3 Kilometers
FECHA
FEBRERO
2002
TITULO DEL PLANO
PROCESOS Y RIESGOS. PROVINCIA LEÓN

A.8. Erosion


LEYENDA
Alternativa A
Alternativa B
Alternativa C
Alternativa A.V.
Ámbito de Estudio
Áreas de máximo riesgo de Inundacion
NIVELES EROSIVOS (Pérdidas de Suelos)
0 - 5 T/ha/año
5 - 12 T/ha/año
12 - 25 T/ha/año
25 - 50 T/ha/año
>50 T/ha/año
TITULO
CORREDOR NORTE – NOROESTE DE ALTA VELOCIDAD.
TRAMO PALENCIA – LEÓN.
ESTUDIO INFORMATIVO COMPLEMENTARIO
ESCALA
1:200.000
1 0 1 2 3 Kilometers
FECHA
FEBRERO
2002
TITULO DEL PLANO
PROCESOS Y RIESGOS. PROVINCIA LEÓN

Appendix B. Methodology to develop the asset register

The asset register was developed using QGIS. It combines open-source data and information provided by ADIF to prepare the baseline and post-intervention habitat maps. *Sistema de Información sobre Ocupación del Suelo de España* (SIOSE) (Instituto Geográfico Nacional, n.d.a.) 2005 and 2014 was used to obtain high-level landcover data for the baseline and post-intervention maps respectively. These were the data sets obtained that were closest to the start and finish of the construction period. This data was then adjusted with information shared by ADIF, including wetland areas before the construction of the project, and embankments and restoration areas on the post-intervention scenario.

The SIOSE data uses the CODIIGE (Instituto Geográfico Nacional, n.d.b) (landcover) classification, which is particular for Spain. The landcover data was correlated with the most appropriate habitat using the EUNIS (European Environment Agency, n.d.a) classification. Following the ECOV4R Framework, a further correlation was made with IUCN Global Ecosystem Typology classification (IUCN, n.d.). The following table shows the habitats conversion of these three classifications. The asset register uses the EUNIS classification, as this is the standard classification used in Europe.

Initially, a 3 km buffer zone was intended for analysis, similar to the approach used in the EIA. However, as the available data for the surrounding areas was SIOSE, this presented limitations in precision when compared with satellite images. Moreover, when comparing the baseline and post-intervention area, other land cover changes unrelated to the project were found (e.g. increase of industrial land and waste infrastructure, reduction in grassland areas, etc.), which made impact assessment complex. ADIF provided more precise habitat information on the footprint areas which allowed this data to be combined with the SIOSE data to obtain more accurate results and to capture the land changes derived from the project. Hence, it was decided to evaluate only the project's footprint.

Table 18: Habitat mapping across three classifications

CODIIGE	CODIIGE code	EUNIS	IUCN GET
Aeropuerto	163	J Constructed, industrial and other artificial habitats	n/a
Asentamiento agrícola y huerta	150	I1 Arable land and market gardens	T7 Intensive land-use biome
Bosque de coníferas	312	G3 Coniferous woodland	T2.1 Boreal and temperate high montane forests and woodlands
Bosque de frondosas	311	G1 Broadleaved deciduous woodland	T2.2 Deciduous temperate forests
Casco	111	J1 Buildings of cities, towns and villages	n/a
Combinación de cultivos	250	I1 Arable land and market gardens	T7 Intensive land-use biome
Combinación de cultivos con vegetación	260	I1 Arable land and market gardens	T7 Intensive land-use biome
Combinación de vegetación	340	H Inland unvegetated or sparsely vegetated habitats	n/a
Cultivo herbáceo	210	I1 Arable land and market gardens	T7 Intensive land-use biome

CODIIGE	CODIIGE code	EUNIS	IUCN GET
Curso de agua	511	C2 Surface running waters	F1 Rivers and streams biome
Discontinuo	113	J1 Buildings of cities, towns and villages	n/a
Ensanche	112	J1 Buildings of cities, towns and villages	n/a
Extracción minera	123	J3.2 Active opencast mineral extraction sites, including quarries	n/a
Industrial	130	J2.3 Rural industrial and commercial sites still in active use	n/a
Infraestructura de suministro	171	J2.3 Rural industrial and commercial sites still in active use	n/a
Instalación agrícola y/o ganadera	121	J2.3 Rural industrial and commercial sites still in active use	n/a
Invernadero	220	J2.3 Rural industrial and commercial sites still in active use	n/a
Lago o laguna	512	C Inland surface water	F2 Lakes biome
Lamina de agua artificial	514	D Mires, bogs and fens	TF1 Palustrine wetlands biome
Matorral	330	S Heathland, scrub and tundra	T3 Shrublands and shrubby woodlands biome
Pastizal o herbazal	320	E Grasslands and lands dominated by forbs, mosses or lichens	T4.5 Temperate subhumid grasslands
Red viaria o ferroviaria	161	J4 Transport networks and other constructed hard-surfaced areas	n/a
Suelo desnudo	354	H Inland unvegetated or sparsely vegetated habitats	n/a
Viñedo	233	I1 Arable land and market gardens	T7 Intensive land-use biome
Zona húmeda y pantanosa	411	D Mires, bogs and fens	TF1 Palustrine wetlands biome

Assumptions and limitations

- When comparing SIOSE data with Google satellite images in the corresponding years, discrepancies were noted. Given that SIOSE is a high-level data set, granularity is missing. For example, ADIF shared a data layer of the wetlands that were present before the project, which aligned with the satellite images; however, the SIOSE 2005 data was missing most of these features.
- The SIOSE data does not show the roads and tracks adjacent to the railway either in 2005 or 2014, and instead classifies them as other habitat types. When reviewing the satellite images, it was noted that changes regarding tracks and roads were made given that the new railway would create an obstacle; this includes bridges and tunnels. These changes were not identified in SIOSE. Ideally, the data should show roads in both the baseline and the post-intervention scenario. However, in this case, due to the lack of detail in the data, road and track related changes were not assessed.
- Data provided by ADIF regarding wetlands present before the project's construction, as well as habitats in the post-intervention, such as new wetlands, broadleaved woodland and grassland, were prioritised over SIOSE data.

Appendix C. Habitats description

Table 19: Descriptions of EUNIS habitats

Habitat (EUNIS)	Description (European Environment Agency, n.d.b)
E Grasslands and lands dominated by forbs, mosses or lichens	Non-coastal land which is dry or only seasonally wet (with the water table at or above ground level for less than half of the year) with greater than 30% vegetation cover. The vegetation is dominated by grasses and other non-woody plants, including mosses, macrolichens, ferns, sedges and herbs. Includes semiarid steppes with scattered Artemisia scrub. Includes successional weedy vegetation and managed grasslands such as recreation fields and lawns. Excludes regularly tilled habitats (I1) dominated by cultivated herbaceous vegetation such as arable fields.
H Inland unvegetated or sparsely vegetated habitats	Non-coastal habitats with less than 30% vegetation cover (other than in crevices of rocks, screes or cliffs) which are dry or only seasonally wet (with the water table at or above ground level for less than half of the year). Subterranean non-marine caves and passages including underground waters and disused underground mines. Habitats characterised by the presence of permanent snow and surface ice other than marine ice bodies.
G1 Broadleaved deciduous woodland	Woodland, forest and plantations dominated by summer-green non-coniferous trees that lose their leaves in winter. Includes woodland with mixed evergreen and deciduous broadleaved trees, provided that the deciduous cover exceeds that of evergreens. Excludes mixed forests (G4) where the proportion of conifers exceeds 25%.
J4 Transport networks and other constructed hard-surfaced areas	Includes roads, car parks, railways, paved footpaths and hard-surfaced areas of airports, water ports and recreational areas.
D Mires, bogs and fens	Wetlands, with the water table at or above ground level for at least half of the year, dominated by herbaceous or ericoid vegetation. Includes inland saltmarshes and waterlogged habitats where the groundwater is frozen. Excludes the water body and rock structure of springs (C2.1) and waterlogged habitats dominated by trees or large shrubs (F9.2, G1.4, G1.5, G3.D and G3.E). Note that habitats that intimately combine waterlogged mires and vegetation rafts with pools of open water are considered as complexes.
I1 Arable land and market gardens	Croplands planted for annually or regularly harvested crops other than those that carry trees or shrubs. They include fields of cereals, of sunflowers and other oil seed plants, of beets, legumes, fodder, potatoes and other forbs. Croplands comprise intensively cultivated fields as well as traditionally and extensively cultivated crops with little or no chemical fertilisation or pesticide application. Faunal and floral quality and diversity depend on the intensity of agricultural use and on the presence of borders of natural vegetation between fields.
S Heathland, scrub and tundra	Non-coastal land which is dry or only seasonally inundated (with the water table at or above ground level for less than half of the year) usually with greater than 30% vegetation cover and with the development of soil. Tundra is characterised by the presence of permafrost. Heathland and scrub are defined as vegetation dominated by shrubs or dwarf shrubs of species that typically do not exceed 5 m maximum height. Excludes habitats subject to frequent management such as shrub orchards, vineyards and hedges (which may have occasional tall trees).
J2.3 Rural industrial and commercial sites still in active use	Rural buildings used for industry, offices, warehousing etc. Excludes high concentrations of buildings on sites greater than 1 ha.

Appendix D. Baseline

Appendix E. Post-intervention

Appendix F. Greenhouse gas value factors

Table 20: Value per tonne of carbon dioxide equivalent sequestered

Year	$/tCO$_2$e (2024 USD)	Year	$/tCO$_2$e (2024 USD)	Year	$/tCO$_2$e (2024 USD)
2008	189.11	2047	358.50	2086	679.73
2009	192.24	2048	364.43	2087	690.98
2010	195.42	2049	370.46	2088	702.40
2011	198.65	2050	376.59	2089	714.02
2012	201.94	2051	382.81	2090	725.83
2013	205.28	2052	389.15	2091	737.84
2014	208.67	2053	395.58	2092	750.04
2015	212.12	2054	402.13	2093	762.45
2016	215.63	2055	408.78	2094	775.06
2017	219.20	2056	415.54	2095	787.87
2018	222.82	2057	422.41	2096	800.91
2019	226.51	2058	429.40	2097	814.15
2020	230.25	2059	436.50	2098	827.62
2021	237.33	2060	443.72	2099	841.31
2022	239.06	2061	451.06	2100	855.22
2023	242.97	2062	458.52	2101	869.37
2024	246.05	2063	466.10	2102	883.75
2025	251.20	2064	473.81	2103	898.36
2026	255.32	2065	481.65	2104	913.22
2027	259.44	2066	489.61	2105	928.33
2028	263.56	2067	497.71	2106	943.68
2029	267.67	2068	505.94	2107	959.29
2030	272.82	2069	514.31		
2031	276.94	2070	522.82		
2032	281.06	2071	531.46		
2033	285.18	2072	540.25		
2034	289.29	2073	549.19		
2035	294.44	2074	558.27		
2036	299.31	2075	567.51		
2037	304.26	2076	576.89		
2038	309.29	2077	586.44		
2039	314.41	2078	596.13		
2040	319.61	2079	605.99		
2041	324.90	2080	616.02		
2042	330.27	2081	626.21		
2043	335.73	2082	636.56		
2044	341.29	2083	647.09		
2045	346.93	2084	657.79		
2046	352.67	2085	668.67		

Adapted from IFVI (2024). Highlighted values have been extrapolated using the 2020-2035 average linear trend.

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