Enhancement and mitigation measures for biodiversity in Environmental Assessment – a catalogue

PRACTICE NOTE

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This report and its contents are an expression of the authors' knowledge and conclusions and do not necessarily represent all BioValue partners.

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1. Technical references

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2. Introduction

Identifying and implementing enhancement and mitigation measures is a core component of the Environmental Assessment (EA) process and allows for addressing and acting upon identified potential environmental impacts. These measures can be categorized according to the mitigation hierarchy – a structured framework originally proposed as a hierarchy of measures for mitigating identified negative impacts (Damiens et al. 2021), but also increasingly recognized for its potential to foster positive impacts through enhancement measures (Larsen et al. 2018). The hierarchy is composed of enhancement, avoidance, minimization, restoration and offsetting measures, each described in their respective sections in chapter 4 of this report.

While both the Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) directives mandate mitigation to address adverse impacts, they do not explicitly require the enhancement of potential positive impacts on biodiversity. This catalogue, therefore, goes beyond these regulatory requirements by including both enhancement and mitigation measures. The objective is to strengthen the proactive integration of biodiversity considerations and goals within EA practice, encouraging these considerations at the early stages of planning and project design.

The purpose of this report is to provide a catalogue of biodiversity-related enhancement and mitigation measures observed in spatial planning-related EAs. The catalogue is intended as an inspiration, not an exhaustive list, reflecting current mitigation practice as a guide for planners and EA practitioners. The measures presented in this report are merely those recommended by EA reports, but it does not delve into whether these measures have been implemented nor whether they have attained the intended consequences.

Through the catalogue, rooted in spatial planning contexts, these measures can be applied broadly to the entirety of the planning process. For instance, they can be considered in planning during initial design phases if wanting a more proactive application and a closer alignment between EA and strategic planning.

For a more detailed exploration of this integration, a complementary report within the BioValue project investigates how SEA and EIA can be embedded in the spatial planning process to enhance biodiversity outcomes through procedural and content-based alignment (Kørnøv, 2024). The report also introduces the Causal Loop Tool, which is linked to three biological principles identified in the project's deliverable D2.2: quality of the area, total area available for habitats, and connectivity between habitats. These leverage points represent critical opportunities where spatial planning can actively enhance biodiversity (see Kørnøv et al., 2024).

This complementary report also guides where and when enhancement and mitigation can be included throughout planning stages – from policy setting to evaluation –to support adaptive, resilient planning cycles that prioritize biodiversity and sustainability.

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3. Applied methodology

The enhancement and mitigation catalogue is created on the basis of an analysis of XX EA reports from Denmark, Portugal, Spain and Germany. These reports were found in relation to other analyses performed in the BioValue project. The catalogue of measures is inspired by a two-step process. Firstly, a general analysis was performed for the four countries as a segment of a causality analysis. Secondly, a more detailed analysis of enhancement and mitigation measures was performed for spatial planning EAs (both SEAs and EIAs) in Denmark.

3.1. General analysis across four countries

The documented mitigation measures were firstly identified as part of a causality analysis, aimed at exploring the causal relations between activities in EA, impacts, significance, mitigation measures and monitoring initiatives. The causality analysis first indicated whether an enhancement or mitigation measure was applied as a result of an identified impact and thereafter categorized the measure according to the mitigation hierarchy (enhancement, avoidance, minimization, restoration, off-setting).

3.2. Detailed analysis of EA reports in Denmark

The more detailed analysis also focused on uncovering the type of enhancement and mitigation measure (whether it was related to design, new technologies, location, etc.), who the recipient of the measure is, the requirement strength of the measure (is it described that the measure "must", "should" or "can" be implemented?), and at what level in the planning process the measure is expected to be implemented. The catalogue presented in this report only draws upon what the enhancement and mitigation measure is and not how it is being applied, described, nor its recipient. The further analysis of these results can be found in Kørnøv et al. (2025, *upcoming*).

3.3. Leverage points for biological principles

The enhancement and mitigation measures have been linked to corresponding biological leverage points, referencing work described in D2.2. In D2.2, three leverage points that enhance biodiversity and can be influenced by spatial planning are identified. These are quality of the area, the total area available for habitat, and the connectivity of these habitats. The linking of measures and leverage points brings with it an assumption that the measures either enhance, avoid, minimize, restore or off-set impacts that to varying degrees have consequences for the biological leverage points. The most relevant one has been linked, but it should be noted that as D2.2 shows, the biological leverage points are interconnected and affecting one has indirect consequences for the other two.

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4. Catalogue

The following sections present the catalogue of enhancement and mitigation measures according to the mitigation hierarchy. Each table consists of the measure, an overall category and the biological leverage point that the measure primarily is targeted.

4.1. Enhancement

Enhancement refers to measures that are implemented to improve the current conditions, meaning that they are not necessarily prompted by the identification of a negative impact, as mitigation measures typically are. As such, they are proactive in their application and have the potential to generate net-gain conditions for biodiversity.

Table 1 Catalogue of potential enhancement measures.

ENHANCEMENT		
Overall category	***Enhancement measure***	***Biological leverage point***
Development of new nature	Developing new ponds, grassy areas, forests, etc. as habitats for species	Area for habitat
Development of new nature	Converting land-use from agricultural land to nature areas	Area for habitat
Development of new nature	Locating projects on areas that used to be agricultural areas, which are not characterized as breeding and resting areas for protected species.	Area for habitat
Development of new nature	Developing new areas designated as either national protected areas and/or as Natura 2000	Area for habitat
Regulation and permissions	Prohibiting hunting in a nature area	Quality of area
Regulation and permissions	Prohibiting the construction of fencing around developments (e.g. PV parks) to allow large animals, such as deer, to pass through the project area	Connectivity

Regulation and permissions	Ceasing drainage of wetlands to increase water levels	Quality of area
Maintenance and tending of vegetation	Allowing the wild growth of unprotected nature areas to create coherency with surrounding protected areas	Area for habitat
Maintenance and tending of vegetation	Planting trees within project area, such as within newly established parking lot	Area for habitat
Maintenance and tending of vegetation	Planting local vegetation beneficial to species	Area for habitat
Maintenance and tending of vegetation	Clearing the protected heath and adjacent area to improve the chances for the adjacent area to become protected heath	Area for habitat
Maintenance and tending of vegetation	Regular cleaning of ponds and lakes that are habitats to species	Quality of area
Maintenance and tending of vegetation	Regular trimming and mowing of vegetation in plan/project area	Quality of area
Maintenance and tending of vegetation	Trimming vegetation around a pond or lake to provide better light conditions for species	Quality of area
Maintenance and tending of vegetation	Using sheep for trimming of nature areas to provide better conditions for resting and foraging areas for amphibians and species-rich vegetation for insects and small animals	Quality of area
Wildlife corridors	Developing new living fences to connect previously unconnected areas	Connectivity
Design/technologies	Using fallen trees and rocks from a removed fence to make a new living fence	Connectivity
Pollution and treatment	Decreasing eutrophication in water bodies, especially those used as habitats for species	Quality of area
Pollution and treatment	Converting land-use to organic farming and replacing the use of fertilizers and pesticides with grazing sheep	Quality of area

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4.2. Avoidance

Unlike enhancement, the remaining mitigation measures are reactive attempts to handle identified negative impacts. Avoidance measures, at the top of the mitigation hierarchy and also the preferred mitigation type of the reactive measures, are meant to prevent a negative impact from happening in the first place.

Table 2 Catalogue of potential avoidance measures.

AVOIDANCE		
Overall category	***Mitigation measure***	***Biological leverage point***
Land-use	Establishing mixed land-use, such as combining renewable energy infrastructure and nature	Area for habitat
Preservation of nature	Securing the land-use designation of an area to nature and prohibiting development on that area	Quality of area
Preservation of nature	Securing the protection of protected lake in converting from recreation to urban purposes	Quality of area
Preservation of nature	Securing that recreative access to the coast does not conflict the function of the ecological corridor	Connectivity
Preservation of nature	Securing the conditions and quality of protected nature when the nature areas border new project development	Quality of area
Preservation of nature	Securing the conditions and quality of protected nature in the decommissioning of projects	Quality of area
Preservation of nature	Preserving existing wildlife corridors and passages	Connectivity
Additional assessment	Securing the assessment of impacts on unprotected nature (e.g. unprotected stone and soil dikes) in future environmental assessments of later plans or projects	N/A
Additional assessment	Determining the likelihood that trees designated for felling are home to bats	N/A
Regulation and permissions	Prohibiting the reduction of nature areas, such as forests, through the local plan	Area for habitat
Regulation and permissions	Prohibiting the construction of infrastructure (e.g. solar panels, fencing, vegetation belts) or other technical facilities within protected areas and protected forest	Area for habitat

Regulation and permissions	Using the local plan to prohibit the construction of infrastructure (e.g. solar panels, fences, vegetation belts) or other technical facilities in areas designated as protected areas or protected forest	Area for habitat
Regulation and permissions	Dispensation from the local plan regarding changes to nature areas (e.g. a new path) to guarantee that hibernation sites are not disturbed	Quality of area
Regulation and permissions	Prohibiting afforestation on low-lying areas with potential for rewetting	Area for habitat
Regulation and permissions	Ensuring that discharged water meets requirements for discharge permits	Quality of area
Regulation and permissions	Securing the protection status of protected nature areas	Quality of area
Regulation and permissions	Avoiding afforestation that can negatively impact protected nature through shadows, falling of large amounts of leaves, changed hydro-morphology, etc.	Quality of area
Regulation and permissions	Prohibiting the felling of trees with hollows with the potential of being breeding and resting areas for species, such as bats	Area for habitat
Regulation and permissions	Prohibiting the construction of buildings or other infrastructure within wildlife corridors	Connectivity
Regulation and permissions	Prohibiting hunting within the plan and project area during operation	Quality of area
Regulation and permissions	Receiving permission from the EPA to decommission a building with regards to potential presence of bats	Area for habitat
Alternative locations	Designating a new location for developments and associated vegetation so that it does not interfere with the river protection line	Area for habitat
Alternative locations	Placing the development such that it does not disrupt the connectivity of the nearby wetlands and forest area	Connectivity
Design/technologies	Raising the wire fence approx. 20cm to ensure that smaller animals can pass under and move through project area, e.g. a PV park and thereby forage between solar panels	Connectivity
Design/technologies	Planting local species for grass areas occupied by a development, e.g., PV parks	Quality of area
Design/technologies	Using local vegetation in vegetation belts to ensure that food availability for species is not worsened	Connectivity

Design/technologies	Establishing a fence around ponds to avoid traffic close to the pond	Quality of area
Design/technologies	Establishing rainwater basins with the option of post-polishing the water	Quality of area
Design/technologies	Adaptation of new forest to the surrounding landscape	Quality of area
Design/technologies	Ensuring the implementation of fences with a large mesh size that allow for the passage of smaller animals	Connectivity
Buffer zone/distance requirements	Establishing a buffer zone (construction-free zone) between protected nature areas (e.g. Natura 2000, water bodies, forests), the development (e.g. PV parks, roads), associated technical facilities (e.g. transformers), fencing and transportation paths (e.g. for construction work)	Quality of area
Buffer zone/distance requirements	Establishing grassy areas or vegetation belt with local species between affected households and the project areas	Quality of area
Buffer zone/distance requirements	Keeping a distance to protected nature while decommissioning buildings	Quality of area
Buffer zone/distance requirements	Establishing a construction-free zone along water bodies to ensure the function of the wildlife corridor and the individual and genetic exchange of species	Quality of area
Pollution and treatment	Conducting the construction phase so that it does not pose a risk for increased emission of harmful substances, fertilizer, etc. that have the potential to spread to protected nature areas	Quality of area
Pollution and treatment	Prohibiting the use of harmful substances in the operation and maintenance of a project (e.g. in cleaning and maintaining solar panels	Quality of area
Pollution and treatment	Implementing criteria to avoid the contamination of water	Quality of area
Pollution and treatment	Equipping infrastructure with technical solutions for preventing pollution, (e.g. transformers for PV parks with measures to prevent emissions of oil, such as hermetically sealing them, mounting a container that can collect oil masses from the transformer or installing a spill tray at the bottom of the transformer)	Quality of area
Pollution and treatment	Placing hay bales between the construction site and nearby bodies of water to prevent washing out of sediments from construction	Quality of area

Pollution and treatment	Establishing precipitation facilities to oxygenate pumped water if it contains more than 0.2mg/l ferrous iron before discharging into streams	Quality of area
Pollution and treatment	Securing that drainage from roads does not end in nature areas to prevent pollution	Quality of area
Requirement for construction	Storing of construction material at a safe distance from bodies of water to avoid erosion and washing out to surface water during heavy rains	Quality of area
Requirement for construction	Placing construction sites, side roofs and displaced soil outside of the protected forest	Quality of area
Requirement for construction	Designing construction that happens nearby protected forest in such a way that prevents the harm of outermost trees (branches, trunks or roots)	Quality of area
Requirement for construction	Establishing a fence around trees if working nearby (fence should be at a distance equalling the width of the tree's crown) to avoid damaging the oak tree's roots and compromising the soil around it	Quality of area
Requirement for construction	Avoiding traffic near the banks of ponds, lakes, streams and rivers to avoid damaging the embankment and spreading sediments into the surface water	Quality of area

4.3. Minimization

Minimization measures refer to those that are applied to reduce a negative impact, when that impact cannot be avoided in the first place. Therefore, implementing minimization measures results in an overall 'net-loss' for biodiversity, but has decreased the severity of that loss.

Table 3 Catalogue of potential minimization measures.

MINIMIZATION		
Overall category	**Mitigation measure**	**Biological leverage point**
Preservation of nature	Protecting trees for nesting	Quality of area
Preservation of nature	Using local plans and future project approval to ensure that future development, such as new housing and urban expansion, does not impose significant impacts to protected nature and nature values	Quality of area
Regulation and permissions	Requiring additional dispensation (e.g. from the EPA) to fell trees that occupy bats	Quality of area
Regulation and permissions	Obtaining additional permission (e.g. from EPA or forest owner) if trees in protected forest need to be trimmed or felled	Quality of area
Regulation and permissions	Obtaining additional permissions according to the Water Framework Directive if rainwater seeps into water bodies	Quality of area
Alternative locations	When rerouting streams, allowing the existing stream to run freely and connecting it with the new stream segment only when the new segment is completed	Connectivity
Design/technologies	Establishing an amphibian fence (temporary or permanent) to keep amphibians away from project area (e.g. a road)	Quality of area
Design/technologies	Establishing a fine-mesh fence that is higher than the current vegetation to keep small mammals (e.g. birch mice) from entering the construction site	Quality of area
Design/technologies	Establishing a fence along both sides of a road to minimize the risk of wild animals colliding with traffic	Quality of area
Design/technologies	Ensuring that small mammals can pass through the established wire fence through, for instance, a larger mesh	Connectivity
Design/technologies	Raising wire fences to ensure that smaller animals can pass under and move through the project area	Connectivity

Design/technologies	Planting a living fence by a newly established wire fence that can act as a wildlife corridor and removing the wire fence when the vegetation has reached its full height	Connectivity
Design/technologies	Designing bridges to match surrounding landscape	Quality of area
Design/technologies	Girdling of trees and boring holes for bats to occupy	Quality of area
Design/technologies	Controlling recreational traffic from parking area by establishing a path system that has the least impact on protected pastures	Quality of area
Design/technologies	Ensuring that bodies of water are designed with embankments	Quality of area
Design/technologies	Implementing smaller and dryer underlay pipes	Connectivity
Design/technologies	Laying out geotextiles on unvegetated slopes to control erosion during project construction (e.g. roads)	Quality of area
Design/technologies	Using solar panels with antireflective surfaces	Quality of area
Design/technologies	Using camera traps prior to construction to determine the presence of species and determine the need for further mitigation measures	N/A
Design/technologies	Installing motion-censored short-term lighting where construction site disturbs species (e.g. bats) and placing or angling them away from the impacted areas and using shadow-casting shades for the lights	Quality of area
Design/technologies	Establishing wildlife corridors to connect nature areas fragmented (by e.g. infrastructure and roads) and to guide wildlife away from development	Connectivity
Wildlife corridors and crossings	Establishing wildlife crossings (such as culverts, tunnels, bridges, underpasses) to ensure the passage of wildlife (e.g. amphibians, small mammals, large mammals)	Connectivity
Wildlife corridors and crossings	Constructing water-based passages so that they have the same conditions as the original bed of the water body	Quality of area
Wildlife corridors and crossings	Establishing an undeveloped strip along bodies of water, fields and roads to allow large animals to navigate in the area	Connectivity
Maintenance and tending of vegetation	Planting broad-crowned oaks every 50-100m along living fence and maintaining a ratio of 1:5 trees and bushes	Quality of area

Maintenance and tending of vegetation	Constructing living fences to be dense and at a minimum breadth of 10m to allow them to function both as a breeding and resting area for species and as a corridor	Quality of area
Maintenance and tending of vegetation	Allowing 1/3 of the living fence to be undisturbed for 7-10 years and thereafter trimming every few years and keeping a minimum height of 3-4m	Quality of area
Maintenance and tending of vegetation	Avoiding trimming the living fence all at once, and instead, trimming in sections and allowing fruit-bearing trees and bushes to be present always	Quality of area
Maintenance and tending of vegetation	Prohibiting the use of machines for trimming living fences	Quality of area
Maintenance and tending of vegetation	Maintaining pastures by scything the pastures twice annually to reduce nutrients in the soil and enhance conditions for a variety of flora and fauna	Quality of area
Maintenance and tending of vegetation	Using local vegetation with a mix of species with characteristics that make them ideal as habitats and foraging areas (long flowering periods, good fruit ripening during the entire summer period, climbing plants, black berry bushes whose tangled structure, thorns and long growth periods are especially good for the protection and foraging opportunities for smaller mammals)	Quality of area
Maintenance and tending of vegetation	Planting trees in areas that are temporarily used for construction of project once the construction period is completed	Quality of area
Maintenance and tending of vegetation	Planting vegetation to shield infrastructure (e.g. PV parks)	Quality of area
Pollution and treatment	Ensuring that initiatives for planting new vegetation do not lead to large emissions of nutrients to ponds, lakes, streams and rivers	Quality of area
Pollution and treatment	Implementing sand traps to remove sand and heavier sediments that sink to the bottom of streams and rivers	Quality of area
Pollution and treatment	Ensuring that crossings over bodies of water, should they be necessary during construction, minimize the risk of erosion and emission of sediment into ponds and lakes	Quality of area
Pollution and treatment	Using local plans and project approval to ensure that rainwater treatment does not significantly impact the nearby streams and rivers	Quality of area
Pollution and treatment	Setting requirements for rainwater treatments, such as the establishment of rainwater basins or seepage of rainwater on own registered land	Quality of area

Pollution and treatment	Purification of harmful substances and particles resulting from diverted road water	Quality of area
Seasonal and/or timed construction	Scheduling construction to happen outside of the breeding and resting/hibernation period for species	Quality of area
Seasonal and/or timed construction	Scheduling the felling of trees to be outside the breeding season for bird and bat species	Quality of area
Seasonal and/or timed construction	Removing ponds for amphibians and draining and lowering groundwater outside of the breeding period for amphibians	Quality of area
Seasonal and/or timed construction	Scheduling the construction of a new road outside of migration seasons	Quality of area
Seasonal and/or timed construction	Reducing construction activity during night hours in which nocturnal species, such as otters and amphibians, are most active	Quality of area
Requirement for construction	Dragging felled trees into nearby forest areas instead of removing them from the site to establish new habitats for insects and fungi	Quality of area
Requirement for construction	Distributing driving plates during construction that can be removed	Quality of area
Requirement for construction	Auditing of environmental conditions (incl. the felling of trees and layout of workplace) during the construction phase on especially valuable locations	N/A
Requirement for construction	Gathering of seeds from pastures prior to construction	N/A
Requirement for construction	Locating construction site that requires safety lighting at a safe distance from areas with bats or other protected species	Quality of area
Requirement for construction	Removing the vegetation and top layer of soil prior to construction (for potential redistribution following construction)	Quality of area
Requirement for construction	Placing soil in protected forests only when strictly necessary and with regard for landscape, nature and recreation in the rest of the forest	Quality of area
Requirement for construction	Filling and levelling holes following the termination of construction work or leaving at least one slanted slope or with a board to allow prevent trapping small species (e.g. birch mice)	Quality of area
Requirement for construction	Locating construction site, associated roads and storage area away from habitats, e.g. in fields that are regularly plowed and do not function as habitats	Quality of area

Requirement for construction	Establishing a temporary fence around construction work that border protected areas	Quality of area
Monitoring	Monitoring species during the operation of infrastructure to determine whether there is a need to continue mitigation measures in the future	N/A
Monitoring	Registering species by the living fence and by wind turbines	N/A

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4.4. Restoration

Restoration measures are applied when negative impacts cannot be avoided nor minimized with the intention of bringing biodiversity conditions back to original conditions in the impacted area or for the impacted species. These measures are often a matter of regeneration of areas following caused damage, but it is not guaranteed that conditions will be the same as before.

Table 4 Catalogue of potential restoration measures.

RESTORATION		
Overall category	***Mitigation measure***	***Biological leverage point***
Regeneration	Regenerating the soil quality in areas that will be occupied temporarily for project construction in order to regenerate nature of the same natural quality as before, by, for instance, removing the topsoil for storing and redistribution following the construction phase	Quality of area
Regeneration	Regenerating pastures using rich subsoils and removing the mulch from the construction area and leaving sandy and gravel materials on the site.	Quality of area
Regeneration	Regenerating nature areas used temporarily during construction to conditions prior to project development	Quality of area
Maintenance and vegetation	Planting the same local species on project area to replicate habitat conditions of the area prior to project development	Quality of area
Requirement for construction	Conducting construction work as carefully as possible to increase chances for restoration of areas	Quality of area

4.5. Offsetting

Impacts can also be offset, in which, e.g., biodiversity is compromised in one area and regenerated in another. It is not guaranteed that conditions will be the same as before the damage was enacted.

Table 5 Catalogue of potential offsetting measures.

OFFSETTING		
Overall category	***Mitigation measure***	***Biological leverage point***
Replacement nature and areas	Replacing compromised habitats (e.g. ponds, lakes, rivers, streams, forests, heaths, wetlands) with new habitats of the same habitat type in a different location and with vegetation that considers the species they accommodate	Area for habitat
Replacement nature and areas	Replacing lost living fences and wildlife corridors with new living fences and wildlife corridors that connects to existing living fences and wildlife corridors	Area for habitat
Replacement nature and areas	Using local soil to establish replacement dikes that is not too compact (no clay unless combined with wood shavings)	Area for habitat
Replacement nature and areas	Identifying and protecting trees in a nearby forest area equal to the number of trees suitable for bats that are felled in construction of the project	Area for habitat
Regulation and permissions	Enforcing a compensation ratio of 1:2	Area for habitat
Regulation and permissions	Prohibiting land-use change of replacement areas in the future	Area for habitat
Regulation and permissions	Prohibiting the use of pesticides and fertilizers on replacement pastures	Quality of area
Regulation and permissions	Strengthening the protection status of the compensated forest	Quality of area

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Location	Locating replacement ponds on both sides of a potential barrier	Area for habitat
Location	Locating compensated nature on agricultural land (potentially rewetted by blocking drains or gutters), preferably on agricultural land that borders protected nature areas to create best conditions for the mobility of species	Area for habitat
Requirement for construction	Removing and relocating amphibians from impacted areas to new habitats by carefully removing piles of rocks and dead vegetation from the project area and placing them in other suitable locations to minimize impacts on amphibians and insects that e.g. hibernate in rocks and vegetation	Area for habitat
Seasonal and/or timed construction	Establishing replacement habitat for species (e.g. amphibians) one year prior to the removal of their current habitat	Area for habitat

5. Conclusion

This catalogue provides a structured overview of enhancement and mitigation measures that can be applied in environmental assessment to support biodiversity within the spatial planning process. By incorporating both traditional mitigation and proactive enhancement measures, the catalogue encourages planners and EA practitioners to address biodiversity considerations early in the planning process. The measures are linked to key biological leverage points – habitat quality, habitat area, and connectivity – emphasizing their interdependencies and reinforcing a systems-based approach to biodiversity resilience.

Through this catalogue, the BioValue project aims to inspire a more holistic use of EA tools, fostering sustainable planning practices that not only mitigate adverse impacts but also create positive environmental outcomes.

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