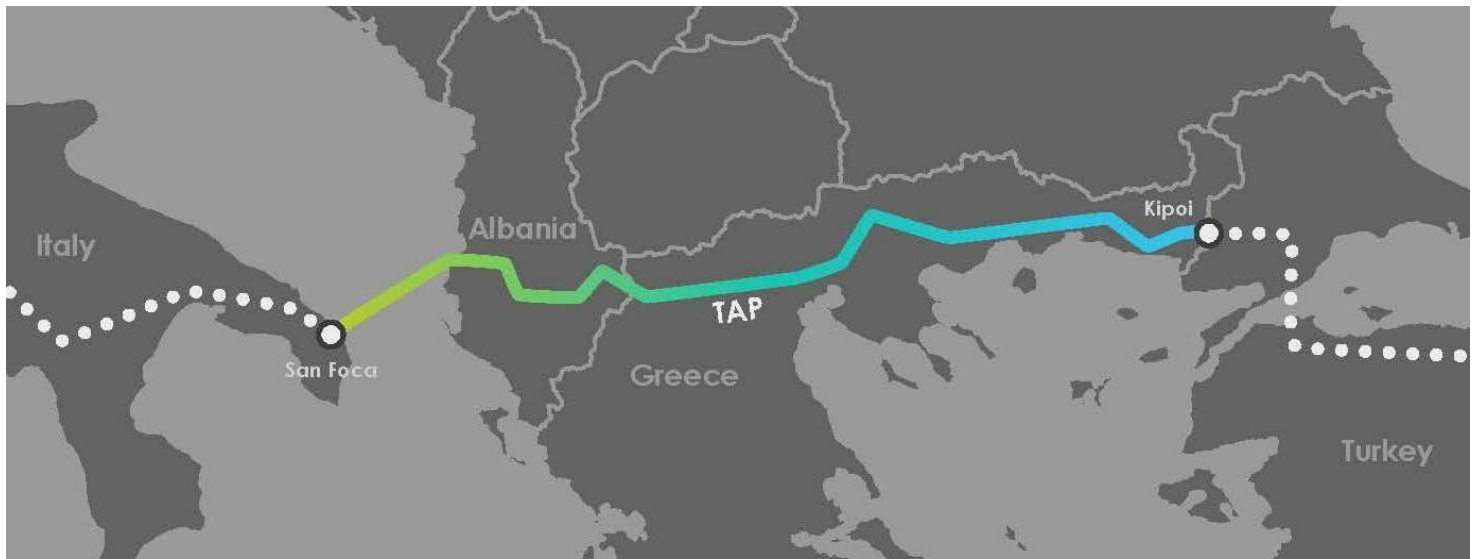





Trans Adriatic
Pipeline



Biorestoration Management Plan

Appendix 7 – TAP Habitat Monitoring Philosophy and Key Performance Indicators

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Appendix 7 – TAP Habitat Monitoring Philosophy and Key Performance Indicators

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1. STANDARD KEY PERFORMANCE INDICATORS AND DATA COLLECTION

1.1 Introduction

The Biorestitution Monitoring Plan has been developed to guide the re-establishment of vegetation cover and species diversity to pre-disturbed conditions or better. Biorestitution is defined as restoration of flora and fauna and the establishment vegetation cover and species diversity to pre-construction conditions.

Key Performance Indicators (KPIs) are measurable variables that demonstrate how effectively an objective is dealt with. Key Performance Indicators should be applied to objectively indicate that post-construction processes work towards No Net Loss (NNL) for any PBF habitat and Net Gain (NG) in any Critical Habitat. In this framework, good performance would be eventually interpreted either as NNL or NG status for the corresponding habitat. Therefore, the indicators should clearly act as the means to achieve this interpretation.

Following the methodological framework presented in Bull *et al* (2013)¹ and Kiesecker *et al* (2010)², TAP is committed to achieving No Net Loss (NNL) of Priority Biodiversity Features (PBFs) and Net Gain (NG) of Critical Habitats.

The objectives of the biorestitution monitoring plan are to ensure NNL of PBFs and Net Gain of CH and are further streamlined with the guidelines suggested by Richardson *et al* (2017)³ summarized in Table 1-1.

Table 1-1 – Application of Richardson *et al* Guidelines


Considerations for discussing indications of pipeline disturbance/recovery (Richardson & al 2017) ⁴	Application in the TAP biorestitution monitoring plan
Emphasis on data-driven biodiversity priorities in diverse ecosystems along the linear infrastructure	Species/habitats that are of conservation interest have been set as priority since the ESIA commencement. Data-driven information collection focuses on categorical (i.e. habitat types), binary (i.e. presence/absence of breeding sites) or continuous (i.e. % plant cover at the Braun - Blanquet scale) variables. There is data input from almost all non-agricultural areas along the TAP route.
Determine the levels of impact (population, community)	Local populations are considered for species, community types are considered for habitats.

¹ Bull *et al* (2013) Conservation when nothing stands still: moving targets and biodiversity offsets Front Ecol Environ 2013; doi:10.1890/120020

² Kiesecker *et al* (2010) Development by design: blending landscape level planning with the mitigation hierarchy Front Ecological Environment 2010 8(5): 261–266

³ Richardson *et al* (2017) A review of the impact of pipelines and power lines on biodiversity and strategies for mitigation Biodiversity Conservation 26: 1801 - 1815

⁴ Richardson *et al* (2017) as above.

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Considerations for discussing indications of pipeline disturbance/recovery (Richardson & al 2017) ⁴	Application in the TAP biorestoration monitoring plan
Adjust for the geographic scale of the bioremediation plan	The potentially impacted area comprises habitat “parcels” (of relatively small size) at approximately the same latitude but different longitude along the TAP ROW. This forms the geographic basis of the sampling scheme.
Cost, safety, access and the time needed to collect useful data should be taken into account	Health and Safety Plans are compiled for every field survey. Taxa of ambiguous/little known taxonomy (i.e. lichens) or taxa which are not readily distinguished in the field (e.g. several insect groups) have been considered as “inadequate” to provide useful data and thus are not assessed for the TAP bioremediation plan.
Reevaluate indications of disturbance and recovery after a continuous input of appropriate data	TAP has compiled an extensive ecological data set since 2011 and this allows for continuous screening of information.

The general objectives of all TAP biorestoration monitoring activities are:

- VEGETATION 1) enable the establishment of the preconstruction natural communities along the impacted ROW after taking into account the pre-construction status, natural dynamics and in-situ landscape characteristics 2) perform forest reinstatement work in accordance with the Project commitments and national laws.
- FLORA - ensure that sensitive flora species along the ROW return to pre-construction distribution.
- LARGE CARNIVORES *Canis aureus*, *Canis lupus*, *Ursus arctos* and *Felis silvestris* - collect information on whether their breeding and foraging patterns of movement in the area have been disturbed by project-related activities; establish breeding success of animals whose ranges are bisected by the TAP alignment.
- BIRDS - assess the status of recorded taxa of conservation interest within the TAP corridor at a post-construction stage, eliminate any remaining disturbing factor and preserve or even enhance presence of these species in the vicinity of the ROW
- REPTILES AND AMPHIBIANS - provide evidence whether at a post-construction stage patterns of fine-grained distribution in areas along the ROW resemble those at similar control sites elsewhere in the vicinity of the project area; otherwise consider offset measures.
- FRESHWATER FISH AND MACRO INVERTEBRATES - ensure that presence/absence data and relative proportions of catches in crossing points are the same to the ones recorded by means of similar tools in the pre-construction period or in scientific literature, otherwise consider offset measures.

1.2 KPIs

To assess the status of habitat types and animal/flora species that comprise Critical Habitats (CH) and Priority Biodiversity Features (PBFs), Key Performance Indicators (KPI) have been

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developed to monitor the success of biorestoration. These are presented in Tables 1-2 through to Table 1-17.



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Table 1-2 - Riparian habitat monitoring plan

RIPARIAN HABITATS: annual achievement criteria All pre-construction locations Habitat codes: 32B0, 91E0, 92A0, 92C0, 92D0			Monitoring	
Post-construction Year 1 achievement criteria	Post-construction Year 2 achievement criteria	Post-construction Year achievement criteria	Period	Frequency
At least QBR factors 3 and 4 should be the same as in the year before construction (i.e. native species should be recorded as seedlings). If not, reinstate with dominant riparian tree species of the preconstruction habitat.	As in Year 1. In addition, QBR factor 2 should be increasing with respect to Year 1 or projected to converge with the pre-construction status. If not, implement reinstatement as in Year 1.	The QBR should be the same or better than that of the preconstruction status. If no full data are available, compare with satellite/aerial photos for factors 1 and 4 at a preconstruction level.	Annually once, any time between May and July.	Annually up to Year 5, frequency to be determined following Year 3 indicators for DMU.
<p>THE PRINCIPAL KPI: QBR</p> <p>TAP has adopted the Spanish index of riparian quality (QBR) as the principal Key Performance Indicator (KPI) to assess the status of riparian habitats (either forested or non-forested) at crossing points and the potential need for restoration. Developed⁵ in Spain, the index has been tested in Greece⁶ and shown to provide an efficient and objective concise assessment of the status of a riparian site, irrespective of regional differences in plant communities, basin characteristics or observer experience. Other major advantages of this index are:</p> <ul style="list-style-type: none"> • Focused on riparian vegetation, thus is not prone to day-to-day changes in the stream channel. • Quantitative data are easy to measure in the field. • Ideal for collective use. <p>The index is based on four components of riparian habitat:</p> <ul style="list-style-type: none"> • FACTOR 1 - total riparian vegetation cover; the % of cover of any kind of plant except annuals is measured and connectivity also considered. • FACTOR 2 - cover structure: the % of cover due to forest or shrubs or low lying vegetation. • FACTOR 3 - cover quality: the geomorphological type of stream is established and number of native tree species counted. • FACTOR 4 - channel alterations: the presence of fluvial terraces or other man-made structures is taken into account. 				

⁵ Munné *et al* (2003) A simple field method for assessing the ecological quality of riparian habitat in rivers and streams: QBR index Aquatic Conservation March. Freshwater Ecosystems 13: 147ic Conservation

⁶ Chatzinikolaou *et al* (2011) River riparian zone assessment using a rapid site-based index in Greece Fresenius Environmental Bulletin 20: 296 – 302

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RIPARIAN HABITATS: annual achievement criteria All pre-construction locations Habitat codes: 32B0, 91E0, 92A0, 92C0, 92D0	Monitoring
The index ranges from 0 to 100: the higher the number, the better the quality of the riparian habitat.	


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Table 1-3 - Grassland monitoring plan

GRASSLAND – annual achievement criteria All preconstruction locations Habitat codes 62A0, 6290, 6420, 6510, 6250			Monitoring	
Post-construction Year 1 achievement criteria	Post-construction Year 2 achievement criteria	Post-construction Year 5 achievement criteria	Period	Frequency
No statistical difference between quadrats sampled next to the RoW (outside reinstated areas) compared to quadrat sites of the same habitat type at control sites. If there is a statistical difference, implement remediation practices (e.g. allow/inhibit sheep grazing) next to the RoW. The practices should be defined in agreement with the vegetation profile of the quadrats at the time of the survey.	As in Year 1.	No statistical difference between quadrats sampled next to the RoW / reinstated areas compared to quadrat site of the same habitat type at control sites.	Annually once, any time between May and July.	Annually up to Year 5, frequency to be determined following Year 3 indicators for DMU.
<p>The KPI is the statistical distance (difference) between:</p> <ul style="list-style-type: none"> Vegetation quadrats at random points but next to the RoW. Vegetation quadrats at control sites randomly selected at adjacent habitat strips not impacted by the project (control habitat type). <p>The null hypothesis is that the TAP project has raised no impact outside the working strip, so quadrats outside the working strip should cluster together with quadrats at control sites i.e. that between-quadrats variability should show no statistical difference with within-quadrats variability.</p> <p>This statistical distance will be calculated by multivariate statistics techniques (e.g. MANOVA)⁷, the exact type to be determined in accordance with the site-specific monitoring plan.</p> <p>METHODOLOGICAL ISSUES: please refer to Table 1-4.</p>				

⁷ Gotelli and Ellison (2004) A primer of ecological statistics, Sinauer



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Table 1-4 - Forest and Scrubland monitoring plan

FOREST AND SCRUBLAND – annual achievement criteria All pre-construction locations Habitat codes: 91MO, 92D0, 5160, 9110, 9130, 9170, 9340, 9530, 9540, 2260, 5110, 5130, 5210, 5340, 5350.			Monitoring	
Post-construction Year 1 achievement criteria	Post-construction Year 2 achievement criteria	Post-construction Year 5 achievement criteria	Period	Frequency
No statistical difference between quadrats sampled next to the RoW/ (outside reinstated areas) compared to quadrat sites of the same habitat type at control locations. If there is difference, implement remediation practices (e.g. afforestation) next to the RoW. The practices should be defined in agreement with the vegetation profile of the quadrats at the time of the survey.	As in Year 1.	No statistical difference between quadrats sampled next to the ROW (outside reinstated areas) compared to quadrat sites of the same habitat type at control locations.	Annually once, any time between May and July.	Annually up to Year 5, frequency to be determined following Year 3 indicators for DMU.
<p>The KPI is the statistical distance (difference) between:</p> <ul style="list-style-type: none"> Vegetation quadrats at random points but next to the RoW. Vegetation quadrats at control sites randomly selected at adjacent habitat strips not impacted by the project. <p>The null hypothesis is that the TAP project has raised no impact outside the working strip so quadrats there should cluster together with quadrats at control sites i.e. that between-quadrats variability should show no statistical difference with within-quadrats variability. This statistical distance will be calculated by means of multivariate statistics techniques (e.g. MANOVA)⁸, the exact type of which will be decided in accordance with the field survey plan.</p> <p>METHODOLOGICAL ISSUES: This indicator is based on setting a ‘next-to-the-RoW’ zone versus a ‘control’ zone, both approximately in parallel to the RoW and both comprising the same habitat type with no other confounding factors. In theory, the principal difference between the two zones is only distance from the impacted RoW but in practice there may be other factors that influence the results: for example, the ‘control’ zone might be further away from the RoW yet closer to a mountain road that may also have an effect on several vegetation parameters. Alternatively, the topography of either zone might affect the micro-habitat</p>				

⁸ Gotelli and Ellison (2004) A primer of ecological statistics, Sinauer

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FOREST AND SCRUBLAND – annual achievement criteria	Monitoring
All pre-construction locations	
Habitat codes: 91MO, 92D0, 5160, 9110, 9130, 9170, 9340, 9530, 9540, 2260, 5110, 5130, 5210, 5340, 5350.	
<p>irrespective of whether the RoW stands close to the sampling point or further away: i.e. sites that stand on a ridge are likely to have different floristic composition than sites within depressions. It is anticipated that candidate sites where such confounding variables prevail may be identified by desktop tools before the initiation of the field surveys. Within the rest of the areas, it is expected that using as guidelines the results of similar published studies on road effects would be helpful. Thus, setting a 'next-to-the-ROW' zone at approx. 20-30m from the edge of the RoW and a 'control' zone at approx. 50-200m from the RoW would probably be a realistic option: a study⁹ on the effect of a road on Mediterranean forests of <i>Quercus cerris</i>, <i>Quercus pubescens</i> and <i>Fagus sylvatica</i> showed that the distance from the road edge that has the maximum difference in species richness is 0-20m. From then up to the 200m threshold the species richness changes only slightly; species evenness even after taking into account rare species is not really affected by distance from the road. Similar results are also reported¹⁰ from pine and laurel forests in the Canary Islands which were almost free from alien species within 50m from the asphalt though alien species seemed to penetrate more in scrublands.</p> <p>In addition to this data, it is anticipated that field surveys will be repeated at exactly the same sampling points outside the RoW where pre-construction vegetation data from 2015 had been collected; there it is of interest to explore by 'repeated-measures' tools whether vegetation has actually changed after construction or not with emphasis on the effect of distance from the RoW.</p> <p>The number of quadrats to employ per km of pipeline is currently an open issue; it is anticipated that this will be calculated as soon as the first field data are available. Then, margins of errors may be considered and used as a guideline to gauge the appropriate sample size. Nevertheless, it is envisaged that for several habitat types the optimal sample size (i.e. the optimal minimum number of quadrats per zone to comply with certain margin of errors) will not be achievable. Either because these habitats within the corridor are of very small size (e.g. habitat types 5210, 5160) or are prone to being affected by confounding factors (i.e. stand next to roads and/or cultivations), such habitats are likely to be excluded from considerations of optimal sample size and be assessed in rough.</p> <p>The recommended variable to sample per quadrat is Braun-Blanquet abundance / % cover. This data can serve as a baseline to estimate species richness as well as other composite variables such as species evenness and the taxonomic distinctness index which may be used for more detailed analysis¹¹.</p>	

⁹ Marcantonio *et al* (2013) Biodiversity, roads and landscape fragmentation: two Mediterranean cases *Appl. Geogr.* 42: 63-72

¹⁰ Otto *et al* (2014) Road Edge Effect and Elevation Patterns of Native and Alien Plants on an Oceanic Island (Tenerife, Canary Islands) *Folia Geobot.* 49:65–82

¹¹ Marcantonio *et al* (2013) as above


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Table 1-5 - Rocky outcrops monitoring plan

Rocky outcrops habitats – annual achievement criteria All pre-construction locations 8210, 8220			Monitoring	
Post-construction Year 1 achievement criteria	Post-construction Year 2 achievement criteria	Post-construction Year 5 achievement criteria	Period	Frequency
% similarity of habitat area at a post-construction level with its status at a pre-construction level as assessed by satellite photos (% to be defined in site-specific KPIs).	As in Year 1.	% similarity of habitat area at a post-construction level with its status at a pre-construction level as assessed by satellite photos. The post-construction areas (within the corridor) should be at least of the same coverage as at the pre-construction level.	Annually once, any time between May and July.	Annually up to Year 5, frequency to be determined following Year 3 indicators for DMU.
The KPI is % similarity of habitat area at a post-construction level with its status at a pre-construction level as assessed by satellite photos. Methodology: please refer to Table 1-4.				


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Table 1-6 - Beaches, dunes and saltmarshes monitoring plan

Beaches, dunes and saltmarshes – annual achievement criteria All pre-construction locations Habitat codes: 2110, 2270, 1420			Monitoring	
Post-construction Year 1 achievement criteria	Post-construction Year 2 achievement criteria	Post-construction Year 5 achievement criteria	Period	Frequency
No statistical difference between quadrats sampled next to the ROW/ (outside reinstated areas) compared to quadrat sites of the same habitat type at control locations. If there is difference, implement remediation practices (e.g. afforestation) next to the RoW. The practices should be defined in agreement with the vegetation profile of the quadrats at the time of the survey.	As in Year 1.	No statistical difference between quadrats sampled next to the RoW (outside reinstated areas) compared to quadrat sites of the same habitat type at control locations.	Annually once, any time between May and July.	Annually up to Year 5, frequency to be determined following Year 3 indicators for DMU.
<p>The KPI is the statistical distance (difference) between:</p> <ul style="list-style-type: none"> Vegetation quadrats at random points but next to the RoW. Vegetation quadrats at control sites randomly selected at adjacent habitat strips not impacted by the project. <p>The null hypothesis is that the TAP project has raised no impact outside the working strip so quadrats there should cluster together with quadrats at control sites, i.e. that between-quadrats variability should show no statistical difference the same with within-quadrats variability. This statistical distance will be calculated using multivariate statistics techniques (e.g. MANOVA)¹²; the exact type to be decided in accordance with the field survey plan. METHODOLOGICAL ISSUES: Please refer to Table 1-4.</p>				

¹² Gotelli N.J. & A.M. Ellison (2004): A primer of ecological statistics, Sinauer


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Table 1-7 - Reed beds monitoring plan

Reed beds – annual achievement criteria All pre-construction locations Habitat codes: 72A0			Monitoring	
Post-construction Year 1 achievement criteria	Post-construction Year 2 achievement criteria	Post-construction Year 5 achievement criteria	Period	Frequency
1.5m annual re-colonisation rate.	As in Year 1.	No statistical difference between quadrats sampled next to the RoW (outside reinstated areas) compared to quadrat sites of the same habitat type at control locations.	Annually once, any time between May and July.	Annually up to Year 5, frequency to be determined following Year 3 indicators for DMU.
<p>The KPI is the statistical distance (difference) between:</p> <ul style="list-style-type: none"> • Vegetation quadrats at random points but next to the RoW. • Vegetation quadrats at control sites randomly selected at adjacent habitat strips not impacted by the project. <p>The null hypothesis is that the TAP project has raised no impact outside the working strip so quadrats there should cluster together with quadrats at control sites, i.e. that between-quadrats variability should be the same with within-quadrats variability.</p> <p>This statistical distance will be calculated by using multivariate statistics techniques (e.g. MANOVA)¹³, the exact type to be decided in accordance with the field survey plan.</p> <p>METHODOLOGICAL ISSUES: please refer to Table 1-4.</p>				

¹³ Gotelli N.J. & A.M. Ellison (2004): A primer of ecological statistics, Sinauer


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Table 1-8 - Rare and endemic vascular plants monitoring plan

Rare and endemic vascular plants – Annual Achievement Criteria All DMUs as per appendix 5			Monitoring	
Post-construction Year 1 Achievement criteria	Post-construction Year 2 Achievement criteria	Post-construction Year 5 Achievement criteria	Period	Frequency
No significant difference between pre and post construction plant numbers or densities at pre-recorded sites in DMU.	No significant difference between pre and post construction plant numbers or densities at pre-recorded sites in DMU. The following years achievement criteria dependent on results of year 2	No significant difference between pre and post construction plant numbers or densities at pre-recorded sites in DMU.	Any time between May - July	Annually up to Year 5, frequency to be determined following year 3 indicators for DMU.
CONCISE PRESENTATION OF THE INDICATOR: The KPI is % similarity of species distribution at a post-construction level with its status at a pre-construction level.				


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Table 1-9 - Brown Bear monitoring plan

Brown Bear – Annual Achievement Criteria All DMUs as per appendix 2			Monitoring	
Post-construction Year 1 Achievement criteria	Post-construction Year 2 Achievement criteria	Post-construction Year 5 Achievement criteria	Period	Frequency
Post-construction data should have the same spatial configuration within the TAP corridor as reported in the pre-construction level. If not, consider biodiversity offset strategy or restore sites previously known as suitable for bears	As in year 1	No significant difference between pre and post construction habitat suitability for the wolf in the context of the DMU.	TBC - dependent on DMU characteristics. i.e. foraging, commuting, denning	2 visits annually up to Year 5, frequency to be determined following year 3 indicators for DMU.
Method: Comparison of the habitat suitability data at the preconstruction level with those at the post-construction level.				


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Table 1-10 - Wolf monitoring plan

Wolf (Canis lupus) – Annual Achievement Criteria All DMUs as per appendix 2			Monitoring	
Post-construction Year 1 Achievement criteria	Post-construction Year 2 Achievement criteria	Post-construction Year 5 Achievement criteria	Period	Frequency
Post-construction data should have the same spatial configuration within the TAP corridor as reported in the pre-construction level. If not, consider biodiversity offset strategy or restore sites previously known as suitable for wolves.	As in year 1	No significant difference between pre and post construction habitat suitability for the wolf in the context of the DMU.	TBC - dependent on DMU characteristics. i.e. foraging, commuting, denning	2 visits annually up to Year 5, frequency to be determined following year 3 indicators for DMU.
Method: Comparison of the habitat suitability data at the preconstruction level with those at the post-construction level				


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Table 1-11 - Large carnivores (*Canis lupus*, *Ursus arctos*) monitoring methodology

Field method and/or analysis	Description and enforcement period	Scope & Benefits
Survey Point evaluation	<p>Field-sample areas over and close to TAP alignment to assess attributes related to LC habitat suitability.</p> <p>Fast method, facilitated by an extended forest road network</p>	<ul style="list-style-type: none"> • On-site evaluation of habitat suitability models. • Expert judgment on habitat characterization (homesite area, foraging area, rendezvous site area, resting area, movement corridor) especially when adequate field data are lacking • Identification of LC critical areas according to landscape and vegetation attributes • Evaluate –identify important foraging area/area with important trophic value for bears/ wolves (e.g orchards, fruit plantations, wild ungulate habitat suitability).
Interviews with local people (shepherds, hunters)	<p>Asking people of recent LC activity, trends, consistence /frequency of LC reproduction in specific areas close to ROW.</p>	<ul style="list-style-type: none"> • Record presence-absence, reproduction and denning areas. • Compensates well with short timed field trips and limitations on field methods for direct LC spotting (e.g lack of suitable substrate to record tracks/scats) given also the spontaneous movement pattern of LC's.
Transects for recording LC signs	<p>Searching by feet on paths and dirt roads for tracks and signs of LC (scats, food remains, territorial markings)</p> <p>2016 surveys included also searching for bear dens at rocky formations</p>	<ul style="list-style-type: none"> • Confirm LC presence, evaluate validity of interview data. • Evaluate importance of specific areas and frequency of LC occurrence on site • Identify TAP crossing areas • Evaluate presence and relative abundance of wild ungulates (approximations only) useful to access wolf habitat.


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Table 1-12 - Jackal monitoring plan

Jackal (<i>Canis aureus</i>) – Annual Achievement Criteria All DMUs as per appendix 5			Monitoring	
Post-construction Year 1 Achievement criteria	Post-construction Year 2 Achievement criteria	Post-construction Year 5 Achievement criteria	Period	Frequency
Post-construction data should indicate at least the same number of territorial groups within the TAP corridor as reported in the pre-construction level. If not, consider biodiversity offset strategy or restore sites previously known as suitable for jackals	As in year 1	No significant difference between pre and post construction number of territorial groups in the DMUs.	TBC - dependent on DMU characteristics. i.e. foraging, commuting, denning	2 visits annually up to Year 5, frequency to be determined following year 3 indicators for DMU.
Method: Comparison of the habitat suitability data at the preconstruction level with those at the post-construction level. The acoustic method will be employed and the calling stations will comprise at least the same ones as in the preconstruction period				


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Table 1-13 - Otter monitoring plan

Otter (<i>Lutra Lutra</i>) – Annual Achievement Criteria All DMUs as per WCMP			Monitoring	
Post-construction Year 1 Achievement criteria	Post-construction Year 2 Achievement criteria	Post-construction Year 5 Achievement criteria	Period	Frequency
Post-construction data should indicate that pre-construction suitable sites preserve this feature. If not, consider construction of artificial otter holts after official guidelines	As in year 1	No significant difference between pre and post construction habitat suitability for otter holts	During seasonal flow of watercourse.	Annually up to Year 5, frequency to be determined following year 3 indicators for DMU.
Method: Comparison of the habitat suitability data at the preconstruction level with those at the post-construction level.				


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Table 1-14 - Avifauna monitoring plan

Avifauna – Annual Achievement Criteria			Monitoring	
All species and DMUs in Appendix 7.				
Post-construction Year 1 Achievement criteria	Post-construction Year 2 Achievement criteria	Post-construction Year 5 Achievement criteria	Period	Frequency
No significant difference between the pre-and post-construction status	As in year 1	As in year 1	Between April – July.	3 visits annually up to Year 5, frequency to be determined following year 3 indicators for DMU.
<p>Method: As per Appendix 7</p> <p><u>For territorial species</u> comparison of the locality and number of territories next to the ROW as recorded at a preconstruction level with those of the same species at the post-construction level</p> <p><u>For non-territorial species</u>, population census at the wider area and comparison with the preconstruction status</p>				


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Table 1-15 - Amphibian and reptile monitoring plan

Amphibian and reptile – Annual Achievement Criteria			Monitoring	
All DMUs for: Macedonian Crested Newt <i>Triturus macedanicus</i> Albanian Pool Frog <i>Pelophylax shqipericus</i> Four lined Snake <i>Elaphe quatuorlineata</i>				
Post-construction Year 1 Achievement criteria	Post-construction Year 2 Achievement criteria	Post-construction Year 5 Achievement criteria	Period	Frequency
No significant difference between pre and post status in DMU.	As in year 1	As in year 1	As per Appendix 4 of EMP	As per appendix 4, annually up to Year 5, frequency to be determined following year 3 indicators for DMU.
Method: As per survey species survey methods in appendix 4				


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Table 1-16 - Bat monitoring plan

Amphibian and reptile – Annual Achievement Criteria All DMUs and Species in Appendix 6			Monitoring	
Post-construction Year 1 Achievement criteria	Post-construction Year 2 Achievement criteria	Post-construction Year 5 Achievement criteria	Period	Frequency
No significant difference between pre and post construction status in DMU.	As in year 1	As in year 1	Monitoring of bat populations will need to cover both hibernation and Maternity seasons (June/ July and December / January).	One visit per season annually up to Year 5, frequency to be determined following year 3 indicators for DMU.



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Table 1-17 - Freshwater fish and invertebrate monitoring plan

Amphibian and reptile – Annual Achievement Criteria All DMUs and Species WCMP.			Monitoring	
Post-construction Year 1 Achievement criteria	Post-construction Year 2 Achievement criteria	Post-construction Year 5 Achievement criteria	Period	Frequency
% population proportions per sample assessed at a post-construction level should be similar to the ones at a pre-construction level	As in year 1	% population proportions per sample assessed at a post-construction level should be similar to the ones at a pre-construction level	spring – early summer	Annually up to Year 5, frequency to be determined following year 3 indicators for DMU.
Method: Electrofishing				

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2. TECHNICAL COMPONENTS OF FLORA KPIS AND DATA COLLECTION


2.1 Flora restoration monitoring

Regarding vegetation, there are four (4) different KPIS recommended to use to assess biorestoration success:

- **KPI 1 is based on the concept of community similarity indices** as applied in spatial ecology. The main idea on which the KPI is built originates from Tobler’s 1st Law of Geography: “Everything is related to everything else, but near things are more related than distant things”¹⁴. It is envisaged that from year-1 at the post-construction level, flora species will start recolonizing the ROW and those in shorter distance from the ROW will tend to be readily reestablished, therefore rendering the ROW patches more similar to unaffected sites next to them than those further away. Depending on the recolonization success rate, the ROW vegetation will start resembling the adjacent intact habitat from year 1 and this resemblance will fluctuate but show an increasing trend in time leading to gradual recovery (No Net Loss) of the original habitat.
- **KPI 2 is the QBR “Index of Riparian Quality”** applied during the ESIA at several crossing points along the Greek ROW and applied again during TAP verification surveys in 2017 and 2018 at crossing points in both Greece and Albania
- **KPI 3 comprises the annual rate of increase of a certain habitat type** as estimated along the ROW area. It is only used for monotypic habitats such as the reeds (“72A0”) for which there are more or less standardised rates of growth known for the dominant plant species and few species. Therefore, habitat recovery on the ROW can be compared to literature values.
- **KPI4 is a binary index comprising presence/absence data:** it is only used for point habitats such as 5160 which are widespread in regional terms but only located on spots or along linear landscape features in a fine -grained scale.

Further details are provided in the following sections.

¹⁴ https://en.wikipedia.org/wiki/Tobler%27s_first_law_of_geography, access 19th July 2018

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2.1.1 Key Performance Indicator 1: % degree of similarity in vegetation parameters as assessed on the ROW and adjacent intact habitat

The framework of this idea is that the vegetation establishing on the operation strip resembles more and more of the vegetation of the adjacent unaffected habitats as the time goes by, thus one should expect that quadrat counts tend to be similar for quadrats that are close in space. For two (2) sets of vegetation quadrats, one allocated on the ROW and the other allocated on the neighboring habitats along the ROW, the degree of similarity between pairs of quadrats within the two sets will be positively correlated with the reciprocal distance between the quadrats. In other words, it is assumed that in certain vegetation parameters there is similarity between values that are close together, so these parameters are spatially correlated.

Three (3) methodological frameworks are considered:

- Calculation of the average Euclidean distance (or other dissimilarity /similarity metrics¹⁵) in quadrats on the ROW and quadrats in adjacent intact habitat and comparison of them either by means of a non-parametric test or by randomization methods. The null hypothesis is that when there is no difference in the metrics as assessed on the ROW quadrats and the intact habitat next to the ROW then the habitat has recovered.
- Cluster analysis to check how quadrats group together. The working hypothesis is that in year 1, quadrats on the ROW will tend to group together irrespective of the type of intact habitat observed next to the construction zone but as time passes quadrats will tend to resemble to the control quadrats located in the intact habitat.
- Testing for spatial autocorrelation¹⁶ between the counts in quadrats on the ROW and quadrats in adjacent habitats via Mantel (semi-parametric) or Moran (parametric) test. Moran's¹⁷ I is a parametric test while Mantel's test is semi-parametric. Both tests indicate if there is spatial autocorrelation either positive or negative and provide a p-value for the level of autocorrelation. Both test against the null that there is no spatial autocorrelation. Moran's I does this with a correlation that is weighted by inverse distances; the Mantel test¹⁸ examines the correlation between two distance matrices and generating a null distribution for this correlation by randomly permuting one of the matrices.

Testing for spatial autocorrelation¹⁹ between the counts in quadrats on the ROW and quadrats in adjacent habitats via Mantel (semi-parametric) or Moran (parametric) test. Moran's²⁰ I is a parametric test while Mantel's test is semi-parametric. Both tests indicate if there is spatial autocorrelation either positive or negative and provide a p-value for the level of autocorrelation. Both test against the null that there is no spatial autocorrelation. Moran's I does this with a correlation that is weighted by inverse distances; the Mantel test²¹ examines the

¹⁵ Morisita Index, Canberra Index etc., Krebs (1989) Ecological Methodology, 2nd Edition, HarperCollins

¹⁶ <https://stats.idre.ucla.edu/other/mult-pkg/faq/general/faq-how-can-i-detectaddress-spatial-autocorrelation-in-my-data/>, 20 December 2018


¹⁷ Hammer, Harper, D.A.T. and Ryan (2001) PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4(1): 9pp.

¹⁸ Manly (2001) Statistics for environmental science and management, Chapman & Hall

¹⁹ <https://stats.idre.ucla.edu/other/mult-pkg/faq/general/faq-how-can-i-detectaddress-spatial-autocorrelation-in-my-data/>, 20 December 2018

²⁰ Hammer, Harper, D.A.T. and Ryan (2001) PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4(1): 9pp.

²¹ Manly (2001): Statistics for environmental science and management, Chapman and Hall

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correlation between two distance matrices and generating a null distribution for this correlation by randomly permuting one of the matrices.

Applicability and data collection: KPI 1 is to be assessed at several sites in both Greece and Albania (see Table 2-1). The baseline raw data comprise of matrices²² with species names and abundance per species and quadrat. As a result, appropriate species identification and estimation of number of individuals per quadrat is the starting point for all three (3) methodological frameworks described above. Preliminary results should be collected in year 2019 to use as guidance on what similarity indices should be used, which cluster method to apply to analyse the data set and whether parametric or semi-parametric spatial autocorrelation analysis should be considered. Some metrics for example, do not behave well in cases of high local species richness and should be rejected in favour of others, more appropriate ones. The sampling effort is initially set as ten (10) quadrats per km of intact habitat crossed (five quadrats on the ROW and five in adjacent habitat) but this may change according to findings from the preliminary surveys: it has been recommended²³ that the appropriate value for multivariate ecology techniques is a minimum median value of 58 individuals per sample.

Control sites and interpretation: Control sites are a prerequisite for the application of KPI 1 because they set the natural framework within which the ROW estimates are interpreted. The sampling design is simplistically shown below: squares are quadrats randomly allocated on the ROW and the adjacent intact habitats, each quadrat with a unique code name. Species and species' abundance are estimated per quadrat. As an example, average Euclidean distance will be calculated from flora abundance data for all ROW quadrats and compared to average Euclidean distance calculated for quadrats in oak and meadow habitats. Cluster analysis will give rise to clusters taking all quadrats into account; Spatial autocorrelation will be calculated after all quadrat data.

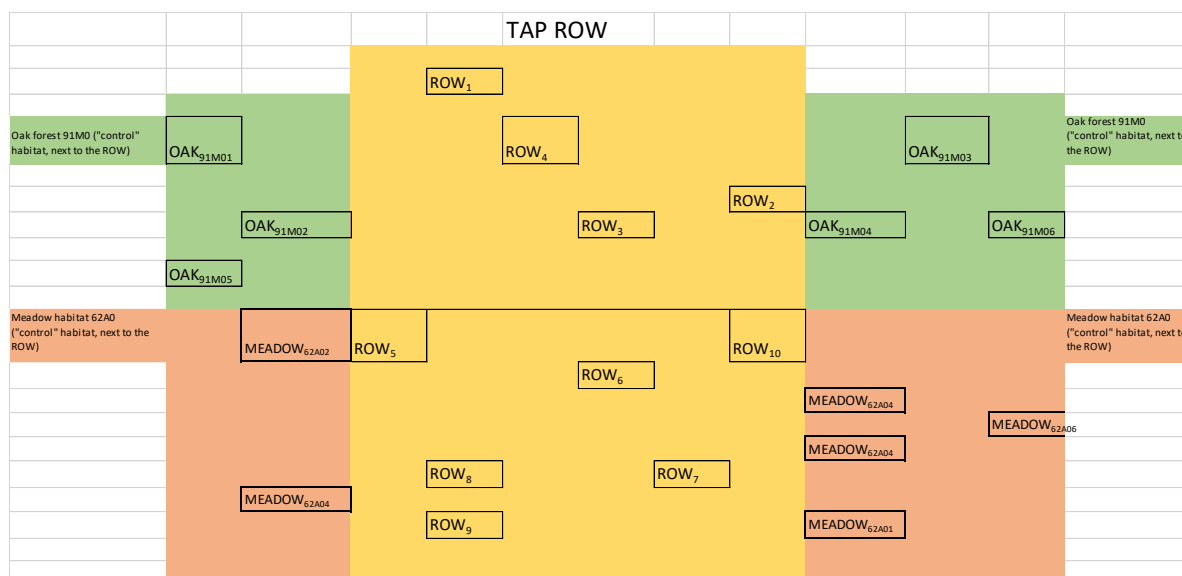



Figure 2-1 – Right of Way Quadrants

²² One (1) matrix per quadrat

²³ Forcino F *et al* (2015) Re-examining Sample Size Requirements for Multivariate, Abundance-Based Community Research: When Resources are Limited, the Research Does Not Have to Be. PLoS ONE 10(6): e0128379. doi:10.1371/journal.pone.0128379

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Use in the TAP Biorestitution framework: in all cases, similarity is either shown by statistical means or shows an increasing trend in time. If similarity between the ROW and intact habitat does not increase in 3-4 years, then offset mechanisms should be considered for the respective PBF habitat.



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Table 2-1 - Key Performance Indicator 1: Similarity Indices/cluster methods/Mantel or Moran’s test

Key Performance Indicator 1: Similarity Indices/cluster methods/Mantel or Moran’s test Summary of properties for the Biorestoration Plan								
Sites to apply	Habitat to assess	Prerequisite	Control sites	Site visits per year	Duration of monitoring	Value for acceptance as «successful biorestoration» – End point	Value that triggers action «biorestoration failed»	Intervention
As marked in Annex 1	As marked in Annex 1	<p>Control sites in each habitat type – Surveys in 2019 should provide evidence on required sampling size.</p> <p>Confounding variables due to vegetation reinstatement should be taken into account from the start.</p>		1 or 2 (May or June and July) per site annually	Minimum 3-4 years	<ul style="list-style-type: none"> • Statistical evidence of spatial autocorrelation between quadrats on the ROW and adjacent habitat • ROW quadrats cluster together with quadrats from adjacent habitats • average Euclidean distance among ROW quadrats similar comparable to Euclidean measured between ROW quadrats and adjacent habitats. 	As time passes, ROW quadrats keep showing higher autocorrelation /similarity among themselves than adjacent habitat.	Offset mechanism if the PBF habitat seems not to be on track to recover.
Drawbacks:								
Advantages:								

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2.1.2 Key Performance Indicator 2: the QBR index or riparian quality

The QBR index²⁴ is a more or less humanized concept of what may be considered as a “healthy” or “well-performing” riparian vegetation site. It encompasses several ecological factors which indicate low human intervention (e.g. channel alteration). It serves well to standardize status across variable riparian systems in a large geographical area and it provides an excellent comparative framework to assess recovery or change.

Applicability and data collection: The QBR index can be estimated anywhere where there is riparian vegetation but for comparative reasons it is recommended to use at all crossing points from which there have been reference (pre-construction/during-construction) values collected: nine (9) sites from ESIA Greece and several²⁵ from TAP verification surveys in both Greece and Albania (year 2018). The properties to visually assess or measure are shown in Annex III: all of them can be assessed in a single site visit which can take place any time during the year. For safety issues the index is usually assessed outside of high flow periods so that access to the bank can be secured.

Control sites and interpretation: this being an advantage and disadvantage at the same time, the QBR does not need control sites. As already mentioned, this index was developed as a result of the humanized perception of what is “high” or “low” ecological status in riparian sites so there are set standards to which the values are compared: for example a site with more than 85% of riparian cover would be considered of high ecological status with regards to this factor even if this value is in practice unattainable (e.g. in locations where riparian species do not develop in such an extend or where hydrological factors constrain plant growth). A site whose QBR is estimated in lower absolute values compared to another site is by definition considered of lower conservation status in the QBR framework.

Use in the TAP Biorestoration framework: any increase (or no change if there is an ESIA measurement) of the QBR index compared to the reference conditions is considered as «success». If this is recorded in two (2) consecutive years (2019 and 2020) then biorestoration is thought of as “complete”. A lower than the reference condition QBR value is thought of as an “alarm trigger”: if it can be readily interpreted as a result of events exogenous to TAP (e.g. buildings constructed next to the bank) then the site is actively monitored for one more year. If the lower QBR is objectively related to TAP actions (e.g. failure in riparian vegetation establishment along the crossing point) then this indicates a biorestoration issue: active reinstatement procedures should be considered either through enhanced erosion prevention measures or planting.

²⁴ Munné *et al* (1998) QBR: Un índice rápido para la evaluación de la calidad de los ecosistemas de ribera. Tecnología del Agua, 175: 20-37 and Chatzinikolaou G. *et al* (2011): River riparian zone assessment using a rapid site-based index in Greece Fresenius Environmental Bulletin 20: 296 - 302

²⁵ 10 – 20 additional sites, data set in preparation



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Table 2-2 - Key Performance Indicator 2: the QBR index of riparian quality

Key Performance Indicator 2: the QBR index of riparian quality								
Summary of properties for the biorestoration plan								
Sites to apply	Habitat to assess	Prerequisite	Control sites	Site visits per year	Duration of monitoring	Value for acceptance as «successful biorestoration» – End point	Value that triggers action «biorestoration failed»	Intervention
~20 in both Greece and Albania	Riparian crossing points	Reference data from the same location	Not necessary	One (1) per location	Two (2) years (2019 and 2020)	Any increase or no change of the QBR value with regards to reference conditions	Drop in QBR value that can be related to TAP procedures	Depending on the parameter that is linked to the drop, erosion prevention measures or planting
<p>Drawbacks:</p> <ul style="list-style-type: none"> • Scale of «good» or «bad» ecological status may not always link to natural dynamics • May be influenced by stochastic events or observation bias • May be influenced by exogenous to the site factors <p>Advantages</p> <ul style="list-style-type: none"> • Can be used to assess local trends in a variety of riparian site properties • Links ecological and landscape features in the same context • Excellent for comparative purposes • Simple to apply 								

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2.1.3 Key Performance Indicator 3: % recovery of monotypic habitat (reeds)

Applicability and data collection: On reed (72A0) habitats in Greece.

Control sites and interpretation: No need of control sites. The annual increase can be readily measured in the field and compared to the preconstruction status from TAP construction data and satellite photos. Threshold values will be used after literature data.

Use in the TAP Biorestoration framework: The field range changes at a post-construction level will be compared to the literature data. Where no success is seen, the species will be reinstated by artificial planting.

2.1.4 Key Performance Indicator 4: presence/absence of dominant (diagnostic) species

Applicability and data collection: On all habitats that are of point range within the TAP ROW (mainly habitat type 5160)

Control sites and interpretation: No need of control sites. If the diagnostic species known from preconstruction/verification surveys is seen to colonise the area as seedling, this is taken as success. Where no success is seen, the species will be reinstated by artificial planting.

Use in the TAP Biorestoration framework: Diagnostic (dominant) species are recorded for all 5160 sites in Greece²⁶. These data can be directly used for comparative purposes.

²⁶ This habitat was not recorded in Albania



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Table 2-3 – Recommended KPIs and threshold values

Objective: No Net Loss of Habitat at PBFs along the ROW							
Recommended KPIs and threshold values							
92/43 EE Habitat type (ALBANIA/GREECE)	KPI 1	KPI 2	KPI 3	KPI 4	Comments ²⁷	Sampling Scheme	Threshold value and intervention
92A0 <i>Salix alba</i> and <i>Populus alba</i> galleries	Not applicable	Applicable (at some sites)	Not applicable	Applicable	KP 0 - KP 535 in Greece: 29 REIRS with point distribution along the ROW	Year 1 (2019): one (1) survey per point Year 2 (2020): one (1) survey per point	QBR decreasing because of lower values at locally measured variables No recovery is discernible. Dominant species not observed. INTERVENTION: plant dominant riparian species

²⁷ Following surveys in years 2017 and 2018, updates in REIR status or identity are presented in Annex I


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Objective: No Net Loss of Habitat at PBFs along the ROW

Recommended KPIs and threshold values

92/43 EE Habitat type (ALBANIA/GREECE)	KPI 1 Spatial similarity/autocorrelation indices (Annex III for details)	KPI 2 QBR index (Annex III for details)	KPI 3 % recovery (or no change) compared to preconstruction spatial data	KPI 4 Recovery of dominant species	Comments ²⁷	Sampling Scheme	Threshold value and intervention
72A0 reedbeds	Not applicable	Not applicable	Applicable	Applicable	KP 140- KP152 in Greece: point distribution along the ROW	Year 1 (2019): one (1) survey per point Year 2 (2020): one (1) survey per point	No recovery discernible Dominant species not observed. INTERVENTION: plant dominant riparian species
92D0 Southern riparian galleries and thickets	Not applicable	Not applicable	Applicable with restrictions ²⁸	Applicable	GREECE KP 375 (mostly outside the ROW)	Year 1 (2019): one (1) survey per point Year 2 (2020): one (1) survey per point	No recovery discernible Dominant species not observed. INTERVENTION: plant dominant riparian species


²⁸ This habitat type is prone to changes from year to year in cases of high flood events in Axios. Recovery may not be observed because of reasons exogenous to TAP.

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Objective: No Net Loss of Habitat at PBFs along the ROW

Recommended KPIs and threshold values

92/43 EE Habitat type (ALBANIA/GREECE)	KPI 1 Spatial similarity/autocorrelation indices (Annex III for details)	KPI 2 QBR index (Annex III for details)	KPI 3 % recovery (or no change) compared to preconstruction spatial data	KPI 4 Recovery of dominant species	Comments ²⁷	Sampling Scheme	Threshold value and intervention
92C0 <i>Platanus orientalis</i> and <i>Liquidambar orientalis</i> galleries (<i>Platanion orientalis</i>)	Not applicable	Applicable (at some sites)	Not applicable	Applicable	GREECE KP 27, KP 239-241 and KP 449	Year 1 (2019): one (1) survey per point Year 2 (2020): one (1) survey per point	QBR decreasing because of lower values at locally measured variables No recovery is discernible Dominant species not observed. INTERVENTION: plant dominant riparian species
5160 South-eastern sub-Mediterranean deciduous thickets	Not applicable	Not applicable	Not applicable	Applicable	Several along KP 0 - 320 in Greece	Year 1 (2019): one (1) survey per point Year 2 (2020): one (1) survey per point	Dominant species not observed. INTERVENTION: plant dominant species

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Objective: No Net Loss of Habitat at PBFs along the ROW

Recommended KPIs and threshold values

92/43 EE Habitat type (ALBANIA/GREECE)	KPI 1 Spatial similarity/autocorrelation indices (Annex III for details)	KPI 2 QBR index (Annex III for details)	KPI 3 % recovery (or no change) compared to preconstruction spatial data	KPI 4 Recovery of dominant species	Comments ²⁷	Sampling Scheme	Threshold value and intervention
924A (now 91M0) Thermophilous oak woods of E Mediterranean and Balkans	spatial correlation index (e.g. Mantel test) or correlogram or multivariate similarity/dissimilarity indices	Not applicable	Not applicable	Applicable with restrictions ²⁹	GREECE KP 16-18, 48-58, 430-437, KP 443, 545 – 550 ALBANIA KP 93-97 in patches	Year 1 (2019): two (2) surveys per sampling area Year 2 (2020): two (2) surveys per sampling area Year 3 (2021): two (2) surveys per sampling area	Low ³⁰ similarity/separate clustering calculated between quadrats on the ROW and quadrats in adjacent «control» habitat INTERVENTION: offset

²⁹ Growth of the actual oak trees takes years to assess although oak seedlings may appear from year 1. In addition, the PP zone will be cleared from tree seedlings.


³⁰ Compared to similarity/clustering degree observed between quadrats in adjacent «control» habitat

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Objective: No Net Loss of Habitat at PBFs along the ROW

Recommended KPIs and threshold values


92/43 EE Habitat type (ALBANIA/GREECE)	KPI 1 Spatial similarity/autocorrelation indices (Annex III for details)	KPI 2 QBR index (Annex III for details)	KPI 3 % recovery (or no change) compared to preconstruction spatial data	KPI 4 Recovery of dominant species	Comments ²⁷	Sampling Scheme	Threshold value and intervention
5210 Arborescent matorral with <i>Juniperus</i> spp	As for habitat 91M0				GREECE KP 540 (patchy distribution, see Annex I)	As for habitat 91M0	
5340 Garrigues of Eastern Mediterranean,	As for habitat 91M0				GREECE KP 43-48 KP 183-187 (as mosaic)	As for habitat 91M0	
5350 Pseudomaquis	As for habitat 91M0				GREECE KP 50-56 (as mosaic), 183 – 194 (as mosaic)	As for habitat 91M0	
62A0 Dry meadows	As for habitat 91M0				GREECE KP85 – 493 several sites, often as mosaic	As for habitat 91M0	
9540 Mediteranean Pine forests	As for habitat 91M0				GREECE KP 27-33, 50-56 (as mosaic)	As for habitat 91M0	

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Objective: No Net Loss of Habitat at PBFs along the ROW

Recommended KPIs and threshold values

92/43 EE Habitat type (ALBANIA/GREECE)	KPI 1 Spatial similarity/autocorrelation indices (Annex III for details)	KPI 2 QBR index (Annex III for details)	KPI 3 % recovery (or no change) compared to preconstruction spatial data	KPI 4 Recovery of dominant species	Comments ²⁷	Sampling Scheme	Threshold value and intervention
9130 Asperulo–Fagetum beech forests	As for habitat 91M0				GREECE KP 438 - 441	As for habitat 91M0	
6420 Mediterranean tall humid grasslands of the Molinio-Holoschoenion	As for habitat 91M0				GREECE KP 441-443	As for habitat 91M0	
9340 <i>Quercus ilex</i> and <i>Quercus rotundifolia</i> forests	As for habitat 91M0				ALBANIA KP 102 – 130 (in patches)	As for habitat 91M0	
Beech forest	As for habitat 91M0				KP 89	As for habitat 91M0	
6520 Hay meadows	As for habitat 91M0				ALBANIA KP 54, KP 69-73 (patches)	As for habitat 91M0	

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Objective: No Net Loss of Habitat at PBFs along the ROW

Recommended KPIs and threshold values

92/43 EE Habitat type (ALBANIA/GREECE)	KPI 1 Spatial similarity/autocorrelation indices (Annex III for details)	KPI 2 QBR index (Annex III for details)	KPI 3 % recovery (or no change) compared to preconstruction spatial data	KPI 4 Recovery of dominant species	Comments ²⁷	Sampling Scheme	Threshold value and intervention
KP 210-215 Coastal habitats	As for habitat 91M0						

METHODOLOGICAL ISSUES:

For all habitat types assessed by means of KPI 1, ten (10) quadrats will be used for 1km of ROW, five on the ROW and five in control sites. Surveys will take place in April to July. Analysis of the preliminary data set will indicate whether the number of the quadrats should increase to allow for higher statistical power.

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2.2 Natural variability in ecological data and how natural dynamics may influence habitat recovery along the ROW in Greece and Albania

Although measurable attributes comprise a significant entity in objective assessment of environmental performance, the biodiversity KPIs are infrequently used in general environmental guidelines due to their ambiguity and technical difficulties in assessment. DEFRA³¹ for example avoids setting for UK business any KPI for variables directly related to biodiversity; instead, it provides a list of abiotic factors (such as emissions to land/water/air) as well as evidence of resource use as appropriate indicators of sustainability. Indicators on biodiversity issues are generally preferred in larger scales such as an entire country³², a continent³³ or on a planetary scale³⁴ where large data sets are available and coarse trends may be discerned.

The fundamental reason that setting performance indicators on narrow-scale biodiversity issues is frequently thought of as impractical is that the concept of ecological performance is currently not adequately operational³⁵. In single-species (or single-habitat) case studies such as marine stocks or targeted conservation efforts one may set performance indicators because the threshold values of “success” or “failure” are easier to calibrate; yet in multi-species case studies, phenomena such as competition, facilitation and tolerance as well as stochastic factors such as the weather and fire may completely change the baseline on which “success” or “failure” is defined.

Historically speaking, the term “succession” *sensu* Odum (1969)³⁶ comprised the principal framework on which the restoration and conservation practices should be built: Odum (1969) addressed that succession results from modification of the physical environment and is defined as “...an orderly process of community development that is reasonably directional and therefore predictable...” and “culminates in a stabilized ecosystem...”. Prevention from disturbance was thus seen as the ultimate tool to accomplish restoration and therefore (one may dare to extrapolate) high performance.

PBF *Fagus* forest (beech forest 9110, 9130, 92/43 EE habitat type 9110, 9130)

Forest disturbance is known to be central to regeneration process in beech forests worldwide. Good seed production is related to masting events³⁷ which depend on climatic conditions in 1-

³¹ DEFRA (2011) Environmental Key Performance Indicators, Reporting Guidelines for UK business, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69281/pb11321-envkpi-guidelines-060121.pdf (access 12 July 2018)

³² http://incc.defra.gov.uk/pdf/UKBI_2017.pdf, (access 12 July 2018)

³³ https://www.eea.europa.eu/themes/biodiversity/indicators#c5=all&c13=20&c10=&c7=all&b_start=0 (access 1st of June 2018)

³⁴ Butchart *et al* (2010) Global biodiversity: indicators of recent declines, *Science* 328: 1164 - 1168


³⁵ “Operationalization” *sensu* Fox (2017) is the term for taking a concept that’s vague or abstract and making it more precise and concrete, so that it can be put to practical use.

(<https://dynamicecology.wordpress.com/2017/02/15/name-the-most-successful-and-unsuccessful-examples-of-operationalizing-vague-or-abstract-ecological-concepts/>, access 12 July 2018)

³⁶ Odum, (1969) The strategy of ecosystem development. *Science* 164: 262–270 as described in Christensen N.L. (2014): An historical perspective on forest succession and its relevance to ecosystem restoration and conservation practice in North America, *Forest Ecology & Management* 330: 312 – 322

³⁷ Masting events: synchronous production of seeds at long intervals by a population of plants

Peña *et al* (2010): Dynamics of natural regeneration of even-aged beech (*Fagus sylvatica*) stands at different shelterwood densities, *Forest Science* 56: 580 - 588

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2 years before the mast seeding and cannot be foreseen. Once the seeds are there, disturbance as indicated by canopy gaps is central to the regeneration of the species³⁸: beech seedlings become established under a wide range of canopy openings and grow best in Relative Light Intensity (RLI) of 100%. Being shade tolerant, they then develop best at sites with dense regeneration (=high density of conspecific seedlings) and a moderate canopy shelter. It thus becomes clear that *Fagus* seedlings (a diagnostic species of habitat type 9130 and 9110) have a high potential of natural regeneration along the operation strip. Nevertheless, in mixed-species regeneration the relative dominance of each species varies along trophic and water gradients i.e. in highly productive sites *Fagus sylvatica* seedlings may be outcompeted by rapidly growing post – pioneering species. Structural complexity indicators in beech forest as well as herb-layer diversity indices have failed³⁹ to predict the species richness in five (5) groups of beech forest dwellers i.e. saproxylic and epigeous fungi, beetles, birds and lichens, so there seems to be no generalized surrogate group to effectively describe the “status” of a beech forest either in natural condition or in the process of restoration.

PBF *Quercus* forest (oak forest 91M0, 92/43 habitat type⁴⁰)

Oak forests are widespread in the study area in both Greece and Albania and are found as fragmented stands between cultivations in Greece (e.g. TAP Greece KP 0-60), as dry gully vegetation (e.g. several crossing points in TAP Greece) as well as extensive forest (e.g. TAP Greece KP 433-439 and segments in TAP Albania KP 110 – 137). Oak forests are thought of as highly competitive against other tree species in lower altitudes: in a large-scale study⁴¹ in the Iberia, all sampled *Quercus* species are reported to outcompete *Pinus* species with recruitment failure affecting 54-71% of *Pinus* plots. This phenomenon if also occurring in the eastern Mediterranean might indicate a similar highly dynamic condition along the mixed pine-oak forests in TAP Greece KP 48 -58.

PBF *Pinus* forest (pine forest 9540, 92/43 habitat type⁴²)

Pines are substantial components of the vegetation surrounding the Mediterranean Basin. Traits characteristic of these species, such as high light demands, strong drought tolerances, and relatively fast growth-rates enable them to thrive in harsh Mediterranean conditions. Fire-related traits are known to determine the dynamics of regeneration at post-fire situations. Even in the absence of fires, canopy openness is reported⁴³ to be the single major factor determining recruitment in *Pinus brutia* (a key species in TAP Greece pine forests at KP 27-32 and KP 48-63); clear cutting is a silviculture⁴⁴ measure to enhance the regeneration of *Pinus nigra* in managed forests. As a result, the construction zone is expected to strongly favor the species' regeneration locally.

³⁸ Wagner *et al* (2010) Beech regeneration research: from ecological to silvicultural aspects *Forest Ecology & Management* 259: 2172 - 2182

³⁹ Sabatini *et al* (2016) One taxon does not fit all: Herb-layer diversity and stand structural complexity are weak predictors of biodiversity in *Fagus sylvatica* forests. *Ecological Indicators* 69 (2016) 126–137


⁴⁰ Formerly described as 924A, currently as 91M0

⁴¹ Carnicer *et al* (2014) Large-scale recruitment limitation in Mediterranean pines: the role of *Quercus ilex* and forest successional advance as key regional drivers *Global Ecology and Biogeography* 23: 371 - 384

⁴² Formerly described as 924A, currently as 91M0

⁴³ Fyllas *et al* (2008) Regeneration dynamics of a mixed Mediterranean pine forest in the absence of fire *Forest Ecology and Management* 256 (2008) 1552–1559

⁴⁴ Zaghi (2008) Management of Natura 2000 habitats. 9530 *(Sub)-Mediterranean pine forests with endemic black pines. European Commission

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PBF Scrubland habitats (5340, 5350, 5210, 92/43 habitat type)

Scrubland habitats along the entire TAP zone are extremely variable and, in several cases, there is a shifting gradient between 5340 and 5350, depending on whether *Olea europaea* is in high abundance or not (TAP Greece KP 156 – 176). Locally the two habitats may be indistinguishable. The herb – layer comprises similar species in both habitat types.

Meadows (62A0, 6420, 6520, 92/43 habitat type)

Highly diverse habitat types in both Greece and Albania where the seed bank and seed arrival seem to play a major role in natural regeneration processes. In wet meadows for example, it has been shown that suitable abiotic site conditions cannot guarantee successful restoration of floodplain grassland because dispersal and seedling survival may be the limiting factor of re-establishment⁴⁵. Species in fragmented meadow habitats may therefore have poor regeneration probability because of lack of an adequate seed bank or poor dispersal abilities: this is an unlikely condition along the TAP ROW given that meadow habitats surrounding the construction zone occupy a large percentage of the landscape.

Other confounding variables that may affect natural regeneration in all habitat types:

Ecological filters (biotic or abiotic factors) may limit the membership of species in a local community and change recruitment during regeneration⁴⁶. Rare species of poor dispersal ability have poor recolonization abilities and their establishment rate may be very small.

Seed arrival⁴⁷ is assumed to have a stronger positive effect on species richness in disturbed relative to undisturbed communities and many communities seem to be unsaturated with species and thus are open to invasion by both native and exotic species. The practical consequence of this is that habitat manipulation such as artificial seeding along the ROW immediately after construction would comprise an artificial “seed arrival” process thus it is likely to change the species richness patterns during the ROW recovery. Strong evidence of the effect of the seed arrival comes from abandoned fields⁴⁸ previously under cultivation and then left to naturally recolonise with steppe species⁴⁹: in such fields more arable species are present towards the centre of the field despite years after the end of cultivation whereas stress-tolerant steppe species grow close to the boundaries and even there their % in seed banks and seed rain remains very small.

The temporal turnover rate is thought to be a widespread phenomenon strongly affecting the richness and identity of the species present in a certain habitat patch at a certain temporal period: according to a study⁵⁰ in a Greek oak forest, approximately half of the accumulated

⁴⁵ Bischoff (2002) Dispersal and establishment of floodplain grassland species as limiting factors in restoration Biological Conservation 104 (2002) 25–33


⁴⁶ Myers and Harms (2009) Seed arrival, ecological filters and plant species richness: a meta-analysis Ecology Letters 12: 1250 - 1260

⁴⁷ Myers and Harms (2009) as above

⁴⁸ Buttson *et al* (2006) The implications of seed rain and seed bank patterns for plant succession at the edges of abandoned fields in Mediterranean landscapes Agriculture, Ecosystems and Environment 115: 6-14

⁴⁹ *Brachypodium retusum*, *Thymus vulgaris*

⁵⁰ Chaideftou *et al* (2012) How does plant species composition change from year to year? A case study from the herbaceous layer of a sub-mediterranean oak woodland Community Ecology 13(1): 88-96

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number of species recorded during six years of sampling comprise the temporal turnover⁵¹; this means that approximately half of the locally present species are NOT making an appearance every year. Moreover, the species temporal turnover in undisturbed control plots was not significantly different from that in plots where vegetation was recovering naturally without assistance, i.e., plots undergoing ecological succession. As a result, diversity estimates⁵² based on a single year of observations may seriously underestimate species richness on the particular site. The temporal turnover rate may have a strong confounding effect in assessing similarity between ROW and adjacent habitat patches because species that are present in both sites may only appear (i.e. flower) in only one of them in a given year. The phenomenon is well –established in Orchidaceae i.e. in a French Mediterranean site⁵³ the probability of being present varies significantly between species with the median of the average probability being 0,8254; this high inter-annual variability in flowering of orchids is thought to be a result of dormancy induced by unfavorable weather conditions⁵⁵.

Stochastic events may drastically change in an unpredictable way the regeneration processes either along the ROW or the adjacent habitats. For example, masting years related to climatic events as already noted would result in a high beech sapling density on the ROW, this perhaps hindering the establishment of other species. Heavy rainfall if inducing debris flow may locally wash away the species-rich topsoil this again eliminating germination probabilities for species in the seed bank.

2.3 Statistical aspects of spatial indices of similarity/dissimilarity⁵⁶

Spatial correlation is a direct result of spatial autocorrelation⁵⁷: values of a random variable, at paired points, are more or less similar as a function of the distance between them. Spatial autocorrelation is a ubiquitous phenomenon. In ecological terms, if the abundance of species A is high in point X and point Z is at a shorter distance from point X than point Y, one expects that because of spatial autocorrelation the abundance of species A would be higher in point Z than in point Y.

The Mantel test includes any analyses that relate two resemblance or proximity matrices. The Mantel statistic is usually tested by permutation procedures and an alternative method is the Mantel multi-variate correlogram, computed for multivariate data using the normalized Mantel

⁵¹ the proportional effective species turnover index represents the % of the accumulated species richness not presented in a single year, Chaidetou *et al* (2012) as above .

⁵² As well as all other community variables related to them ie evenness, similarity indices and degree of aspatial autocorrelation

⁵³ Vogt–Schilb *et al* (2013) Inter-annual variability in flowering of orchids: lessons learned from 8 years of monitoring in a Mediterranean region of France, European Journal of Environmental Sciences 3: 129–137

⁵⁴ The probability of presence varied from 0.52 (for *Platanthera chlorantha*) to 0.98 (for *Anacamptis pyramidalis*)

⁵⁵ Summer drought can cause premature senescence and death of leaves, which results in insufficient reserves of nutrients for the orchids to flower the subsequent year


⁵⁶ Krebs (1989) Ecological Methodology, HarperCollins, 2nd edition

Legendre and Legendre (1998) Numerical Ecology, 2nd edition, Elsevier

Manly (2001) Statistics for environmental science and management, Chapman & Hall

Legendre and Fortin (2010) Comparison of the Mantel test and alternative approaches for detecting complex multivariate relationships in the spatial analysis of genetic data Molecular Ecology Resources 10: 831–844

⁵⁷ <https://dynamicology.wordpress.com/2013/10/02/autocorrelation-friend-or-foe/comment-page-1/>, access 19 July 2018, also see Annex 4.

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statistic rM and test of significance. This method is useful, in particular, to describe the spatial structure of species assemblages.

With regards to the similarity or dissimilarity coefficients, there are many different ways of estimating them between samples (e.g. quadrats); the selection of which one to use should be based on properties of the data and limitations of the survey. Binary indices only need presence-absence information whereas quantitative indices also need some data on the species abundance. Several types of correlation indices are available and those of most interest to ecologists are the ones insensitive to the sample size.

Species richness *per se* is considered as an inappropriate variable to compare between the ROW and the adjacent habitats: as conventional indices of the species richness comprise the number of species BUT not the species identity, very different habitats (i.e. a disturbed coniferous forest and an arctic meadow) may have the same flora species richness but completely different species in them.