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HANDBOOK

Biodiversity Monitoring South Tyrol

Andreas Hilpold, Matteo Anderle, Elia Guariento, Thomas Marsoner, Marco Mina, Chiara Paniccia, Julia Plunger, Francesca Rigo, Johannes Rüdisser, Alberto Scotti, Julia Seeber, Simon Stifter, Julia Strobl, Maria Suarez-Muñoz, Magdalena Vanek, Roberta Bottarin, & Ulrike Tappeiner

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Contents

1. General considerations and site selection

On initiative of the government of the Autonomous Province of Bolzano-Südtirol (Province Bolzano-Südtirol, Region Trentino-Alto Adige, Italy) a biodiversity monitoring program was established, starting with sampling on terrestrial sites in 2019 and on running water sites in 2021. The Biodiversity Monitoring South Tyrol (BMS in short) is a long-term project with repetitions on a regular basis. The BMS was launched and is conducted by the Institute for Alpine Environment of Eurac Research in collaboration with the Museum for Nature South Tyrol and the province of South Tyrol's Nature Conservation Department, as well as the Department for Agriculture.

BMS surveys biodiversity throughout the area of South Tyrol and within the most important habitat types (Tab. 1, Tab. 2), including near-natural, agricultural, and urban habitats. BMS spans sites from the planar zone up to the high alpine zone. At the center of the monitoring are specified monitoring sites; all surveys are conducted in or directly around these sites (Fig. 1). In total, we investigate 320 terrestrial survey sites over a period of five years, which is 64 single sites per year. For the monitoring of running waters (in short aquatic BMS) we investigate 120 sites in total over a period of four years.

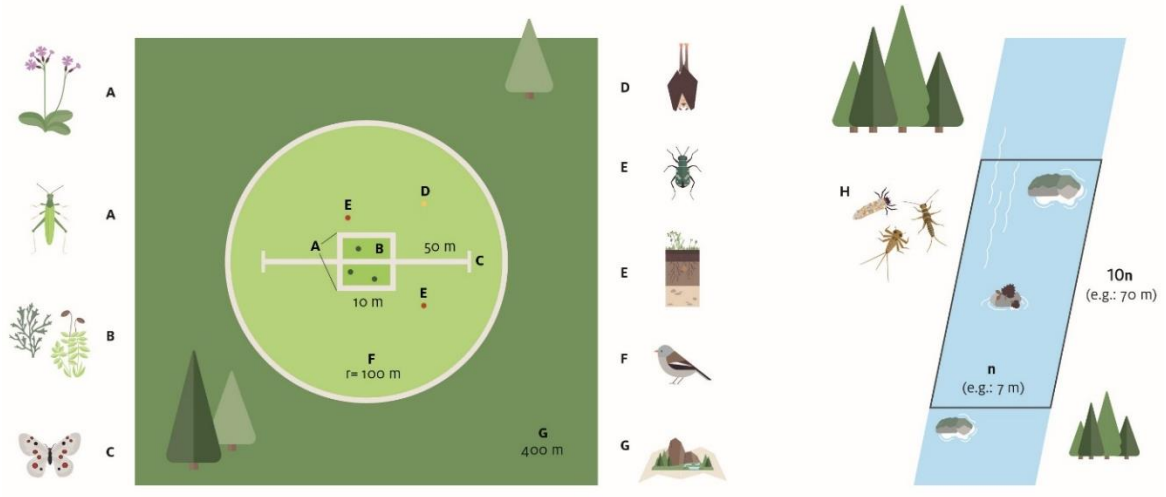


Figure 1: Scheme of field methodology for each organism group in BMS, A-G = terrestrial monitoring part, H = running water monitoring

BMS surveys species groups that react sensitively to climate and land-use changes. The focus groups are vascular plants, bryophytes and lichens, birds, bats, butterflies, and grasshoppers as well as aquatic insect larvae in addition to spiders and other ground or near-ground-living invertebrate groups. Apart from single taxonomic groups, the monitoring includes a survey of the landscape and habitats of the surrounding areas. Within the project, abiotic soil and water parameters in terrestrial and aquatic habitats, are studied respectively. Finally, it also collects several variables regarding agricultural and forest management.

On the terrestrial BMS sites, all plant and animal groups are surveyed in each habitat type. The methodology for the survey of single groups, however, may slightly vary between habitat types. Deviations from the standard protocol are explained in the respective sections of this handbook.

This handbook gives a complete guide to the survey of all taxonomic groups conducted within the Biodiversity Monitoring South Tyrol.

Table 1: Terrestrial habitat types surveyed within the BMS per year and in total. Most habitat types have subcategories depending on elevation belts.

Habitat type terrestrial sites	BMS-code	Per year	Total (five years)
Hay and silage meadows			
colline–montane, subsidized (HNV)	HEM	4	20
subalpine, subsidized (HNV)	HES	2	10
colline–montane, not subsidized	HNM	4	20
subalpine, not subsidized	HNS	2	10
Total		**12**	**60**
Pastures			
colline–submontane	PAC	2	10
montane	PAM	2	10
subalpine	PAS	2	10
Total		**6**	**30**
Alpine meadows			
on calcareous substrates	AMC	2	10
on intermediate substrates	AMI	2	10
on silicious substrates	AMS	2	10
Total		**6**	**30**
Alpine rocky habitats			
on calcareous substrates	ARC	2	10
on intermediate substrates	ARI	2	10
on silicious substrates	ARS	2	10
Total		**6**	**30**
Vineyards			
flat	WYF	2	10
steep	WYS	2	10
Total		**4**	**20**
Apple orchards			
organic production	OAO	2	10
conventional or integrated production (IP)	OAC	2	10
Total		**4**	**20**
Arable land			
maize fields	CFM	2	10
cereal fields	CFC	2	10
Total		**4**	**20**
Forests		12	60
Oak forests (incl. Oak-Scots Pine forests)	FDO	2	10
Manna Ash-Hop Hornbeam forests	FDM	2	10

Beech forests (incl. Beech-Spruce-Silver Fir forests)	FDB	2	10
Spruce and Silver Fir forests	FCP	2	10
Larch-Swiss Pine forests	FCL	2	10
riparian forests	FRI	2	10
Total		**12**	**60**
Wetlands			
peat bogs	BOG	2	10
lake shores	LAK	2	10
Total		**4**	**20**
Settlements			
cities and larger towns	SEC	2	10
smaller villages	SEV	2	10
industrial and commercial areas	SEI	2	10
Total		**6**	**30**
Total, all terrestrial habitat types		**64**	**320**

Table 2: Types of running waters surveyed within the BMS per year and in total. *For each stream category 10 sampling points were selected throughout the region, 2 of which – defined as "reference points" – are scheduled to be sampled each year. Three stream categories are sampled every year.

Habitat type running waters	**BMS-code**		**Per year**	**Total (four years)**
Glacier-fed running waters				
Stream cat. 1: glacier-fed, montane, big discharge, medium to steep, silicatic	GMRS	12352	2 + 8*	10
Stream cat. 2: glacier-fed, alpine, small discharge, steep, mixed, geology	GALN	13133	2 + 8*	10
Stream cat. 3: glacier-fed, alpine, medium discharge, steep, silicatic	GABS	13232	2 + 8*	10
Surface water running waters				
Stream cat. 4: surface water, colline, small discharge, mixed slope, silicatic	RCLS	31162	2 + 8*	10
Stream cat. 5: surface water, montane, small discharge, steep, carbonatic	RMLC	32131	2 + 8*	10
Stream cat. 6: surface water, montane, small discharge, steep, silicatic	RMLS	32132	2 + 8*	10
Stream cat. 7: surface water, montane, medium discharge, steep, carbonatic	RMBC	32231	2 + 8*	10
Stream cat. 8: surface water, montane, medium	RMBS	32232	2 + 8*	10

discharge, steep, silicatic				
Stream cat. 9: surface water, montane, big discharge, medium to steep, silicatic	RMRS	32352	2 + 8*	10
Stream cat. 10: surface water, alpine, small discharge, steep, carbonatic	RALC	33131	2 + 8*	10
Stream cat. 11: surface water, alpine, small discharge, steep, silicatic	RALS	33132	2 + 8*	10
Stream cat. 12: surface water, alpine, medium discharge, steep, silicatic	RABS	33232	2 + 8*	10
Total			**48**	**120**

1.1 Terrestrial site selection

We selected the single study sites using a stratified selection approach, using the previously mentioned categories of land use as strata. Within the single strata we partly performed a random site selection. Randomization was not used for sites that are dangerous to access (see table 2 and the following subchapters for details). We used different geographical baseline data to calculate the total area of the different habitat strata in South Tyrol, in which we then made a point selection. For farmland we used the management categories applied by the Department for Agriculture of the Province within the database of agriculturally used areas in South Tyrol (LAFIS 2020) except for extensive subsidized hay meadows for which we used data from the Nature Department of the Province (data unpublished). For forest characterization we used the data from the forest typology map published by the Forest Department of the Province in 2010 (Provincia Autonoma di Bolzano 2010). Alpine sites were manually selected that are easily accessible via existing roads or cable cars. Tab. 3 specifies the selection criteria for all terrestrial sites. Once the single sites were preselected a field check was necessary. Within this work task we checked accessibility and asked owners for their permission. Additionally, we checked if the site really represents the selected habitat type. Sometimes there were errors in the geographical baseline data, or the habitat type had changed in the foregoing years. If there were larger deviations, we searched for an alternative in the close surroundings of the selected coordinates.

Table 3: Selection criteria for single habitat categories.

Habitat type	Selection criterion
Hay and silage meadows	
colline–montane and subalpine, subsidized (HNV)	Randomized within HNV subsidized areas
colline–montane and subalpine, not subsidized	Randomized within LAFIS meadow area
Pastures	
colline–submontane	Not randomized, see subchapter
montane	Partly randomized within LAFIS pasture area, partly not, (see subchapter)
subalpine	Randomized within LAFIS pasture area, adjustment after check for accessibility (see subchapter)
Alpine meadows	Not randomized, see subchapter
Alpine rocky habitats	Not randomized, close to alpine meadow sites (see subchapter)
Vineyards	Randomized within LAFIS vineyard area
Apple orchards	Randomized within LAFIS apple orchard area
Arable land	
maize fields	Randomized within LAFIS maize field area
cereal fields	Randomized within LAFIS cereal field area
Forests	
All forest types except riparian forests	Randomized within forest typology map
riparian forests	Not randomized, see subchapter
Wetlands	Not randomized, see subchapter
Settlements	Not randomized, see subchapter
Running waters	Selectively/stratified randomized, see chapter 2.11

Within the entirety of all areas of a given habitat type, we randomly selected sampling sites evenly distributed over the territory of South Tyrol. To avoid a spatial "clumping" of the sites in the main valleys where the highest density of managed habitat types is located, we performed a pre-selection based on a grid. The distribution of the sites is based on the mapping grids of the floristic mapping of Central Europe (Niklfeld, 1971). The same grid is also used for floristic and faunistic mapping of South Tyrol (cfr. Wilhalm et al. 2014; www.florafauna.it). Each grid cell („Quadrant“) has a geographical longitude of 5 min and a latitude of 3 min (= 6.3 x 5.6 km). There are approximately 260 grid cells in South Tyrol. For each habitat type only areas within grid cells where the habitat type is present/occurring with at least 20 ha were preselected. Of these all areas smaller than 1 ha were excluded (exceptions for cereal fields with 0.5 ha). Of the remaining areas one was randomly selected for each grid cell using the ArcGIS tool subset feature (random generator ACM599) and additionally 2 substitutes were selected. In a final step, 10 sites (20 in the case of montane hay meadows) were randomly selected from the pre-selection. If the selected site was found to be unsuitable during the visit (wrong habitat) or the owner did not give their consent, one of the substitute plots within the grid cell was chosen. To allow for a balanced sampling design a minimum distance of 1 km between the single sites of any habitat category was maintained.

The exact coordinates of the sites within the selected areas were selected using the ArcGIS tool to create random points within the previously selected final areas that were placed at least 30 m from the edge of the habitat area.

1.2 Site selection running waters

In order to detect the maximum possible biodiversity, aquatic monitoring sites for running waters were selected considering the entire stream and river network of South Tyrol. Since the classification of river typologies included in the EU Water Framework Directive (2000/60/EC)(European Parliament and Council 2000) only considers catchments whose surface is > 10km^2, we developed a new method mainly based on the classification of river typologies developed by the Swiss Federal Office for the Environment (Schaffner et al. 2013).

Table 4: Classification codes and affiliations.

criteria	**water origin**	**elevation**	**discharge**	**slope**	**geology**
code	X0000	0X000	00X00	000X0	0000X
classification	1 glacier 2 spring 3 surface water	1 colline 2 montane 3 alpine	1 small 2 medium 3 big	1 flat 2 medium steep 3 steep	1 carbonatic 2 silicatic

More specifically, five geological, topographic, and morphological parameters - water origin, elevation, slope, main geology of the riverbed, discharge (Tab. 4, Fig. 4) – were combined to assign a type to each stream or river segment of South Tyrol, where a segment is the portion of stream/river where the above-mentioned parameters remain constant through space.
All parameters were derived through GIS analysis (Fig. 2), and then added to each stream or river using ArcGIS 10.3 (ESRI 2014) spatial allocation tools (*intersect* for vector data*, add surface information* for rasters) and the geocatalogue of the province of Bolzano (https://www.provinz.bz.it/natur-umwelt/natur-raum/Default.asp?404;natur-raum/themen/landeskartografie.asp):

- The water origin was determined by identifying rivers which originate directly from or near glaciers or which start near one or multiple springs. All other streams were classified as surface water streams.
- The elevation was quantified using the DigitalTerrainModel-2.5m and assigned to classes according to Tab. 5.
- The slope raster was created using the *slope* ArcGIS Function on the DigitalTerrainModel-2.5m and the values where then assigned to classes according to Tab. 5.
- For the geology parameter the shapefile based on the geological overview map of South Tyrol was used and all formations were assigned as silicatic or carbonatic rocks based on the correct lithology.
- To estimate the average discharge of each stream segment, the *flow accumulation* was calculated using an annual water-balance raster as input weight. Afterwards, to link this information to the streams the highest flow accumulation near each stream segment was selected (*snap pour point*). By multiplying this flow accumulation value with the pixel cell size in m² and dividing it by the number of seconds per year we got the average annual discharge in L/s. The stream segments were then assigned to classes according to Tab. 5.

Table 5: classes and thresholds for elevation, discharge and slope.

Elevation	
class	threshold
colline	<600 m
montane	600-1800 m
alpine	>1899 m
Discharge	
class	threshold
small	< 0.05 m^3/s *
medium	0.05 - 1 m^3/s
big	> 1 m^3/s
Slope	
class	threshold
flat	< 0.5 %
medium steep	0.5 – 5 %
steep	> 5 %

*only streams with a discharge of >0.02 m^3/s were considered because of the risk of selecting intermittent streams

Out of 18 types identified for South Tyrol, 12 were retained by aggregating some of them together (Fig. 2). This choice was motivated by the decision to have 10 streams/rivers for each type, in order to have a balanced scheme suitable for consistent statistical analyses. The code of the stream/river types shows that: for example, the last number of the stream type 13133, "3", indicating the geology class, is the result of merging the two geology classes "carbonate" and "silicate" (see Tab. 5 & Fig. 2). For the final selection process of the actual potential sampling sites, a pre-sample of 20 streams for each of these 12 types was selected using the ArcGIS function *Subset features* with seed value 1 and random generator type ACM599. The advantage of this tool in selecting sites was that it selected streams well distributed all over South Tyrol, since it is originally intended to produce a training dataset for a surface model.
Out of the 240 randomly selected streams the final sampling points selection (10 + 2 for each stream/river type) was done manually by looking at each location on the most recent Orthophoto (https://geoportal.buergernetz.bz.it/geodatendienste.asp, 2015/2017) and after having visualized additional accessibility information (e.g. distance and elevation difference to nearest road, distance along a hiking trail to nearest road – accessibility was a priority factor). Additionally, locations nearby sampling points that are already sampled by the Autonomous Province of Bolzano/Bozen for duties connected to

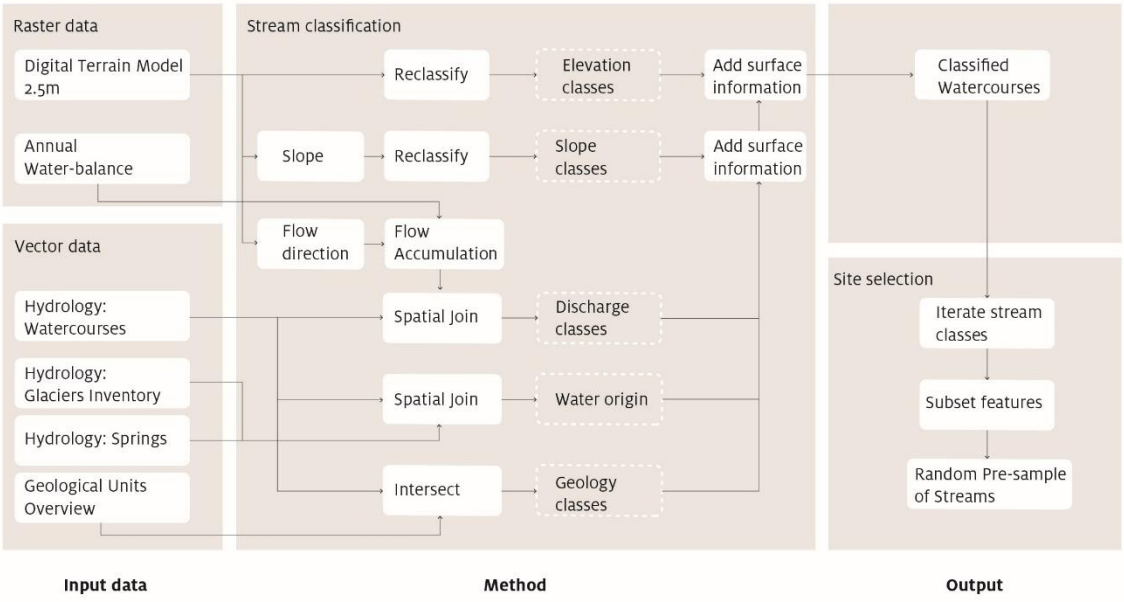


Figure 2: Schematic workflow of the preparation of the single datasets used for the identification of the stream types sampled during the biodiversity monitoring South Tyrol in ArcGIS.

water quality assessments of “EU Water Framework Directive” received a low priority during the selection process.

Eventually, each stream type contained 10 streams. Therefore, in total 120 sampling sites were identified distributed all over South Tyrol.

Every year three entire stream/river type categories are sampled as well as two streams/rivers of every stream/river type (as geographically apart as possible). Thus, each year 48 sites are sampled (Fig. 3 & 4):

- 24 points are considered as reference sites for assessing temporal variability, so this subset (with the same 24 sampling points) is sampled annually.
- 4 are additional sites whose re-sampling is scheduled to happen every 4 years.

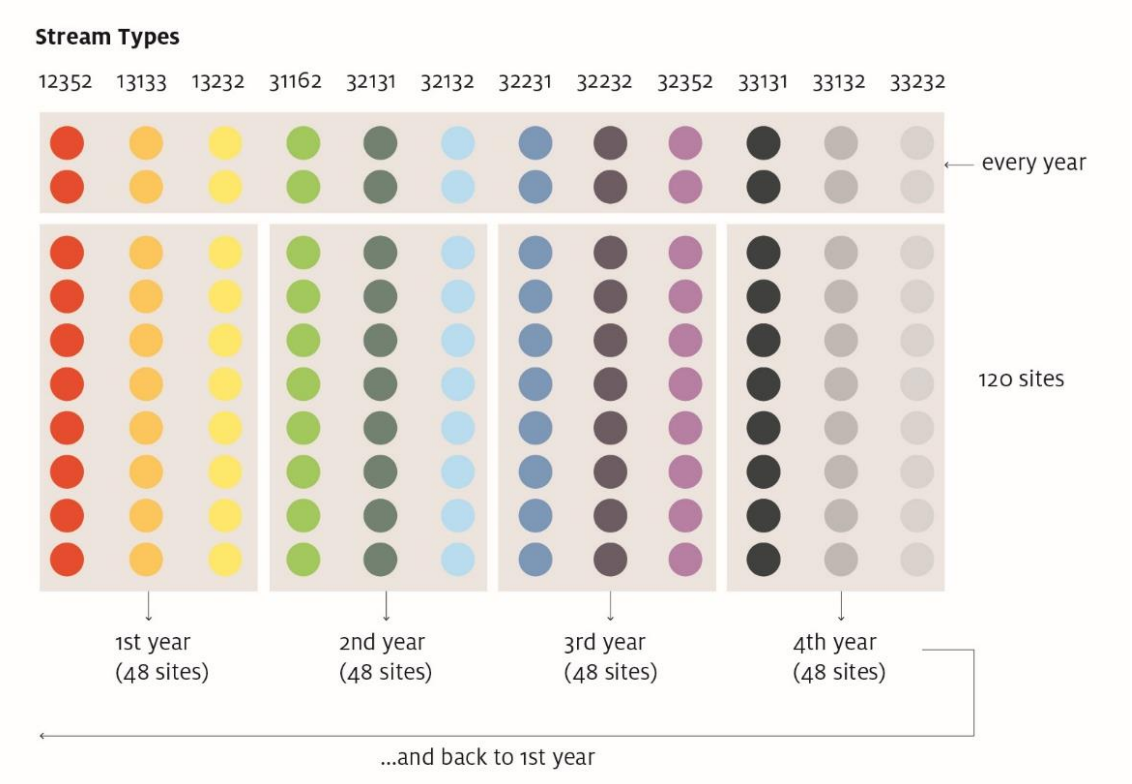


Figure 3: Individual codes of the final stream types and BMS sampling scheme for running waters in South Tyrol. Each number of the code refers to the parameters that define the stream type (see Tab. 5). For example: stream type 13133 refers to the river type of glacial water origin (1), alpine elevation (3) small discharge (1), steep slope (3), with mixed geology (2+1=3). This last example with geology shows how the identified types were in some cases merged, due to the lack of a suitable number of sites in statistic terms. See text for more details.

Figure 4: Examples for different stream types. Upper row glacier-fed stream categories, middle row carbonatic surface water, lower row silicatic surface water

1.3 Detailed description of terrestrial habitat categories

1.3.1 Hay and silage meadows

Meadows are a very heterogeneous habitat type. Depending on mowing frequency, fertilization, bedrock, exposure and inclination, altitude level, climate and history of use, different types of meadows develop. Due to the limited number of samples, we had to apply severe restrictions. In total, the meadows were divided into two categories based on elevational zonation (Fig. 5):

- Colline–montane zones: 250 – 1800 m a.s.l.
- Subalpine zone: 1800 – 2200 m a.s.l.

Due to the fact that meadows in South Tyrol are very heterogeneous and, on the other hand, a very important and characteristic habitat for South Tyrol, the total number of sites is relatively large: 40 meadows in the lower vegetation belts and 20 in the subalpine belt. These 60 sites were subdivided into two subcategories. Half of the sites were selected from meadows which receive **High Nature Value (HNV) subsidies** (*Landschaftspflegeprämien / Premi incentivanti per la cura ed il mantenimento del paesaggio*), and the other half from among those **without specific high nature value (HNV) subsidies**. Non-subsidized hay meadows are usually managed intensively or semi-intensively whereas for the subsidized ones extensive management is a precondition for receiving subsidies. The term “intensive meadow” refers to flat (usually levelled) meadows with a very good nutrient supply (= fertilization), with a high mowing frequency (varying according to altitude: from 3 cuts in low altitudes to one cut at high altitudes) and with an early first mowing date. “Extensive meadows” are not or only slightly fertilized (only remote stable manure), the mowing frequency is lower (usually 1 cut per year), the first mowing date is relatively late, usually after the 15th of July.

Table 6: HNV subsidized types of the Autonomous Province of Bolzano-South Tyrol and their congruency with Habitats Directive types.

German name	Italian Name	Habitats Directive	Code
Magerwiesen	prati magri	*Species-rich Nardus grasslands, on silicious substrates in mountain areas (and submontane areas in Continental Europe)*	6230
		Semi-natural dry grasslands (Festuco-Brometalia)	6210(*)
Niedermoorwiesen	prati a torbiera bassa	*Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)*	6410
		[mown] *Alkaline fens*	7230
Artenreiche Bergwiesen	prati di montagna ricchi di specie	*Lowland hay meadows*	6510
		Mountain hay meadows	6520

Several meadow types in South Tyrol belong to a habitat type listed in the Habitats Directive (Tab. 6). Virtually all subsidized meadow types are Directive habitats. The categories within the South-Tyrolean subsidization scheme however, are strongly simplified and are not totally congruent with the Habitats Directive habitat types (Tab. 6). In most cases, non-subsidized meadows do not fall into a Habitats Directive type. However, the subsidies are based on a voluntary basis and farmers must actively apply for them. Occasionally, they therefore waive the subsidies even if their land would be eligible. However, experience from the first survey years showed that this is rarely the case and that virtually all the surveyed areas in the "not subsidized" category were indeed not eligible.

Figure 5: Upper row: Intensively managed montane meadow in Passeiertal/Passiria (left); extensive montane meadow in St. Vigil/St. Vigilio (right); Lower row: intensively managed subalpine meadow in Zirog (Brennero/Brenner; left); and extensive subalpine meadow Seiser Alm/Alpe di Siusi (right).

1.3.2 Pastures

Grazed areas in South Tyrol can be found from the valley to the high mountains. While grazing from the colline to the montane belt is mostly limited to single, mostly isolated areas, often close to farmsteads, it is mostly carried out over large areas in the subalpine belt. The habitat category “pasture” in the BMS is limited to those areas that are primarily kept open by grazing and excludes grazed meadows.

Pastures were subdivided into three subcategories (Fig. 6) based on elevational zonation.

- Colline–submontane zone, 250 – 800 m a.s.l.
- Montane zone, 800 – 1800 m a.s.l.
- Subalpine zone, 1800 – 2200 m a.s.l.

Within these three subcategories no further division has been made. Grazing in South Tyrol is predominantly extensive. Most pastures therefore fall into the category of HNV farmland. A large share of pastures in all elevation zones belong to a habitat type listed in the Habitats Directive. South exposed pastures of the colline to lower montane zone, especially in the continental valleys, are covered with dry

meadow types of the Habitats Directive *Sub-continental steppic grasslands* (6240*), in less continental areas also with *Semi-natural dry grasslands (Festuco-Brometalia)* (6210(*)). Pastures on acidic soils of all exposures of the montane to subalpine elevation zone are frequently covered by *Species-rich Nardus grasslands* (6230). Additionally, we find pastures of Cynosurion and Poion alpinae on soils well supplied with water and nitrogen. Both are not part of the Habitats Directive 92/43/EEC.

Figure 6: Colline-submontane pasture Goldrain/Coldrano; montane pasture Latzfons/Lazfons; subalpine pasture Rodenecker Alm/Alpe di Rodengo.

1.3.3 Vineyards

Vineyards are mostly found in the Etsch/Adige and Eisack/Isarco valley and in Vinschgau/Val Venosta. Within the category we distinguished between flat and steep vineyards (Fig. 7). In each of these subcategories, we chose 10 sites. We consider those which have a mean inclination below 20% (11.3°) as flat and steep ones above 30% (16.7°). Vineyards younger than 4 years were excluded. However, if the areas are replanted in the future the sites will be maintained even if the time is less than four years. Due to the very specific requirements for the cultivation of grapevines, vegetation and ecological conditions are very similar in all vineyards. We refrained therefore from elevational stratification.

Figure 7: Flat vineyard next to Salurn/Salorno and steep vineyard next to Feldthurns/Velturno.

1.3.4 Intensive Apple orchards

The area of apple cultivation in South Tyrol reaches from the colline to the lower montane zone. We subdivided the category into two subcategories:

- conventional or integrated production (IP)
- organic production

Due to very specific management, vegetation and ecological conditions are very similar in all intensive apple orchards. We refrained therefore from elevational stratification. The selected apple orchards are all intensive, i.e., they consist of rows of small, individually planted trees (max. height of usually less than 3m, Fig. 8). Traditional orchard meadows ("Streuobstwiesen") with larger single trees and a cultivation of the undergrowth as grassland were not considered in this category. Intensive apple orchards younger than 5 years were excluded. However, if the areas are replanted in the future, the sites will be maintained, even if the time is less than four years.

Figure 8: Apple orchard with integrated production next to Kurtatsch/Cortaccia; Organic apple orchard Albeins/Albes.

1.3.5 Arable land

We distinguished between two main types of arable land: maize fields and fields of other cereal species (in short cereal fields; Fig 9). While maize fields to produce silage maize are an integral part of intensive grassland farming and are therefore common in most of the country, cereal fields are relatively rare in South Tyrol. Deviating from the basic scheme, the minimum size of the single habitat areas for cereal fields was chosen to be 0.5 ha and the necessary minimum area per grid cell size was 10 ha.

Figure 9: left side: Cereal field next to Brixen/Bressanone; right side: Maize field in Sand in Taufers/Campo Tures.

1.3.6 Alpine meadows and rocky areas

In total, 60 alpine areas at an altitude of approx. 2300 to 3000 m a.s.l. are investigated. We assigned the areas to two major categories: Areas with a closed meadow layer ("alpine meadows") and more extreme areas dominated by rock, screes, and open soil (referred to as "rocky alpine habitats") which are more common in the high alpine zone. Both categories are subdivided by their substrate into three subcategories (Fig. 10):

- Alpine meadows / rocky alpine habitats on calcareous substrates (10 + 10 sites)
- Alpine meadows / rocky alpine habitats on silicious substrates (10 + 10 sites)
- Alpine meadows / rocky alpine habitats on intermediate substrates (10 + 10 sites)

A first coarse selection of single sites was made in the office by using the geological map of South Tyrol. Due to logistic reasons the exact selection of the alpine sites was not made randomly but they were specifically selected during a site visit to the preselected target area. This is on the one hand because the alpine terrain cannot be safely walked on in large areas. On the other hand, numerous inspections are necessary for monitoring and the selection of remote survey points would require a disproportionate amount of effort to reach them.

The calcareous substrates encompass both dolomite and limestone rocks and screes. Silicate substrates encompass metamorphic rocks, i.e., phylids, schists and gneiss. Finally, intermediate substrates are not defined very precisely. They encompass metamorphic rocks with high lime content (incl. marble, calcescists) and volcanic rocks (porphyds, granite etc.). The first two substrate types were usually easy to identify. The intermediate rocks, however, often only occur in restricted geographical areas. To minimize fieldwork the two site types (alpine meadow and alpine rocky habitat) are always located in site pairs on one single mountain massif. The two sites are located at a minimum distance of 1000 m (exceptionally 800 m) airline.

To minimize walking distances to the sites all investigated areas are accessible via a forest road or a pass road which at least penetrates the subalpine zone (approx. 1900 m). Alternatively, the areas can also be reached via cable car. From the highest reachable point by car or cable car a maximum walking distance of 2 hours is not exceeded.

Figure 10: Left side alpine meadows, right side alpine rocky areas. Upper row: sites on siliceous substrate Ahrntal/Valle Aurina, Walderalm; middle row: sites on calcareous substrates Sellajoch/Passo Sella; lower row: sites on intermediate substrate Vals/Valles.

1.4 Forests

For the BMS project, we selected the most important and representative forest types of South Tyrol. In total we chose six different forest types from the colline to the subalpine belt, four deciduous forests and two coniferous forests. We survey ten sites for each of the following six forest subcategories (Fig. 11):

- Manna Ash-Hop Hornbeam forests
- Oak forests (incl. Oak-Scots Pine forests)
- Beech forests (incl. Beech-Spruce-Silver Fir forests)
- Spruce and Silver Fir forests
- Larch-Swiss Pine forests
- Riparian forests

Selection of the forest sites is based on randomized preselection. Once the sites were selected they were checked. If the site was difficult and/or dangerous to access a site with similar vegetation in the close surroundings was selected. Preselection was conducted with the map of the potential forest vegetation of South Tyrol (Provincia Autonoma di Bolzano 2010). An exception to this procedure was made for riparian forests where we followed the same workflow for the wetlands. Our selection was based mainly on the data of protected areas in South Tyrol.

Figure 11: Examples of forest sites within the BMS. Upper row left: Oak forest Leifers/Laives; upper row right: Hop hornbeam forest Lana; middle row left: Beech-Silver fir forest Buchholz/Pochi; middle row right: Spruce Forest Flaggertal/Vallaga; lower row left: Larch Forest Lichtenberg/Montechiaro; lower row right: Riparian Forest Schluderns/Sluderno.

1.5 Wetlands

Due to the very small-scale and scattered presence of this habitat type no randomization was used to select wetland sites. Instead, a representative selection of lakes and peat bogs was used (Fig. 12). It was important to us to represent the most important wetland areas in the country. The selection of the bogs was based on the South-Tyrolean wetland inventory (Göttlich 1991).

Figure 12: Examples of bogs and lakes within the BMS. Left: Biotop Rasner Möser/Biotopo Rasun-Anterselva, bog; right: Lake Mitterstieler Weiher/Lago di Mezzo

1.6 Settlements

For the category Settlements we selected a total of 30 sites which were subdivided into three subcategories (Fig. 13):

- cities and larger towns
- smaller villages
- industrial and commercial areas

For the category “cities and larger towns” settlements with at least 5000 inhabitants and a dense town center were selected. Sites were not chosen randomly but were chosen from the orthophoto. All towns had to have an urban character. It was important that the centers of the individual parts of the country were represented, which are the following:
Bolzano/Bozen (2 sites), Merano/Meran (1), Brixen/Bressanone (1), Bruneck/Brunico (1), Sterzing/Vipiteno (1), Naturns/Naturno (1), Schlanders/Silandro (1), Innichen/San Candido (1) and Laives/Leifers (1)
For the category “smaller villages” we chose villages with less than 1000 inhabitants (mostly <500) in all parts of South Tyrol. The single villages had to be surrounded by agricultural areas or near-natural habitats but not by industrial or commercial areas, i.e., they had to have a real rural character with a strong imprinting of agriculture. The chosen villages were the following: Penon/Penone, Karneid/Cornedo, Stilfs/Stilves, Matsch/Mazia, Untertelfes/Telves di Sotto, Albions, Pfunders/Fundres, Altrei/Anterivo, Platt im Passeier/Plata, Enneberg/Marebbe and Missian/Missiano (alternatively Ahornach/Acereto).
For the category “industrial and commercial areas” we chose larger industrial polygons near to the main towns of South Tyrol. In less urbanized areas these polygons are partly not directly connected to the town. Bolzano/Bozen (1), Merano/Meran (1), Brixen/Bressanone (1), Bruneck/Brunico (1), Sterzing/Vipiteno (1), Prad/Prato (1), Schlanders/Silandro (1), Innichen/San Candido (1) and Laives/Leifers (1) and Egna/Neumarkt (1).

Figure 13: Examples for settlement sites, left side site photo, right side orthophoto from Geobrowser: upper row, villages SEV, Albions; middle row, cities, and larger towns, Vipiteno/Sterzing; lower row, industrial and commercial areas SEI, Bolzano/Bozen.

1.7 Localization

To find single monitoring sites in the field, we prepared Keyhole Markup Language (KML) files for every survey year so that each researcher from the BMS can easily visualize and locate them using smartphones and/or tablets. We created a Google Maps project with all the KML files. All the single experts are provided with the link to this project. If changes are made to the points, they are automatically visible to all researchers. To be able to locate the points even if there is no or poor network availability, the KML file with the site coordinates can also be loaded locally on smartphones on a navigation app with hiking maps available offline. There is a set of freely available apps that are mostly based on OpenStreetMaps. Additionally, we prepared text documents with maps and notes that help to localize single sites.

1.8 Permits

To avoid conflicts and to allow for longer-term use of the selected sites, the surveys in numerous habitat types are only carried out after prior consultation and after obtaining signed permission from the landowners (or leaseholders). This does not seem necessary for the following habitats: alpine grasslands and alpine rocky areas, settlement areas, bogs, lakes, and watercourses. In settlements we aim to inform the local population by publishing in the local news (“Gemeindeblatt”) or on the municipality website after talking to the mayor or the head of the village (“Fraktionssprecher”). To store data of single landowners a privacy agreement must be signed (Appendix 15.7).
For all points located in protected areas an application for a permit for the removal of organisms is submitted to the Nature Conservation Department (28, Nature, Landscape and Spatial Development).

2 Vascular plants

2.1 General considerations

The botanical survey is performed for most habitat types following the sampling methodology of the Eurasian Dry Grassland Group (EDGG) (Dengler et al. 2016). Exceptions are forests, where the monitoring area is enlarged by a factor of 10. In settlements and at lake shores a transect method is applied.

To ensure a complete list of occurring species, the sites are surveyed during the optimal time period (see Tab. 7). The best suited survey time is when most plants are flowering and/or fruiting. In orchards, meadows and arable land the best moment is usually before mowing or harvesting. For some habitat categories an additional survey is necessary in which only supplementary species are noted. This is applied when there are large floristic differences between the seasons mainly due to ephemeral species growing either in early spring or in late summer/autumn.

Table 7: Sampling calendar for the botanical survey. Green marking: main survey, yellow marking: additional survey. In the last column it is indicated whether the standard methodology (S) or a modified approach (M) is used for the botanical part of the BMS.

Habitat type [BMS-Code]	April	May	June	July	Aug.	Sept.	Sampling method
Vineyards [WYF, WYS]							M
Apple orchards [OAC, OAO]							M
Montane hay meadows [HEM, HNM]							S
Colline/montane pastures [PAC, PAM]							S
Deciduous forests [FDB, FDM, FDO]							M
Settlements [SEC, SEI, SEV]							M
Wetlands [LAK, BOG]							M
Subalpine hay meadows [HES, HNS]							S
Arable land [CFC, CFM]							S
Subalpine pastures [PAS]							S
Coniferous & riparian forests [FCP, FCL, FRI]							M
Alpine meadows [AMC, AMI, AMS]							S
Alpine rocky habitats [ARC, ARI, ARS]							S

2.2 Preparation for fieldwork and sampling material

Before starting with fieldwork thorough preparation is necessary. Several tools are necessary for the survey (Fig. 14), especially for delimiting the plots and collecting vouchers.

Figure 14: Sampling material for the botanical survey: 1. Plant press for herbarium specimens; 2. 2 m folding ruler, 10 m and 50 m measuring tape; 3. Tent pegs; 4. Reel with 150 m string for delimiting the forest plots 5. Tablet with GIS Software for habitat mapping; 6. Digital camera for photo documentation; 7. Field book and pen; 8. Folding lens and field guide for identifying species in the field; 9. Magnets and small spade; 10. Handheld GPS; 11. Color spray can for marking corner points.

2.3 Setting up the monitoring plots and vegetation survey

Upon arrival at the survey site one has to localize the exact monitoring site. From the first repetition onwards the plot is localized by searching for magnets which were buried during the first survey (see chapter 2.3.1). For this a magnet detector is necessary.

The monitoring plots are 100 m² squares established parallel to the slope (see Fig. 15). Unlike the EDGG sampling methodology, where the orientation of plots follows cardinal direction, the plots are oriented toward the slope. In those (rare) cases a site is totally flat, the sampling methodology of the EDGG is followed.

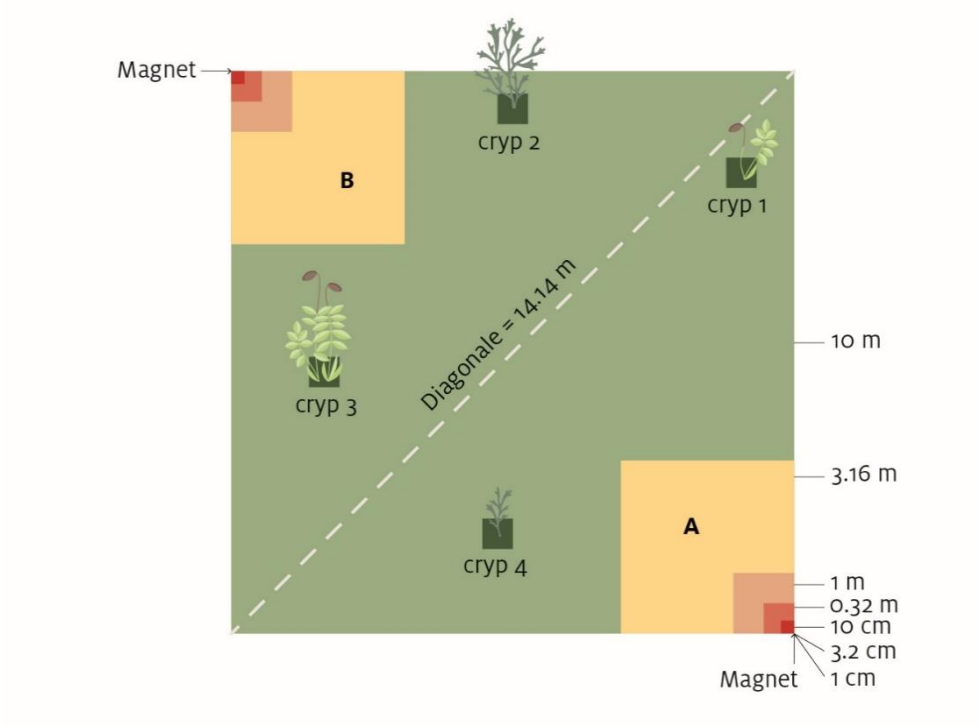


Figure 15: Arrangement of the biodiversity monitoring sites for botanical surveys (modified from Dengler et al. 2016)

Inside the 100 m² the bottom right 10 m² subplot is called subplot A (Fig. 15) and the top left 10 m² subplot is called subplot B. Starting from the corner point of the subplot A the corner point of the subplot B is placed at a diagonal distance of 14.14 m. The measuring tape is fixed with pegs at 0 m and at 20 m and is extended at the 10 m mark until two straight lines are obtained. The 10 m² subplots (3.2 m side length) are also delimited with measuring tape and pegs. The 1 m² (1 m side length) and 0.1 m² (32 cm side length) subplots are delimited with a 2 m folding ruler, while for the 0.01 (10 cm side length), 0.001 (3.2 cm side length) and (1 cm side length) 0.0001 m² subplots the survey area can be estimated easily. Starting from the 0.0001 m² subplot of each 10 m² subplot, a species list is created comprising all species that are additionally recorded in each subplot using the shoot presence method. For all species in the two 10 m² subplots, a percentage coverage for the corresponding layer (herb, shrub, tree) is estimated. In addition, we estimate the cover values for bryophytes, lichens, litter, dead wood, stones and rocks, gravel, fine soil, and faeces. To facilitate realistic cover estimates, we use “estimation aids”, these are squares of different sizes with their corresponding coverage percentages within a 10 m² plot (Tab. 8). At the end, the total species list of the 100 m² survey area is completed.

Table 8: “Estimate aid” Areas of completely filled squares that correspond to certain percentage cover values in 10 m² plots.

Percentage cover value	Area in m²	Area in cm²	Edge length of square in cm
5	0.5	5000	70.7
4	0.4	4000	63.2
3	0.3	3000	54.8
2	0.2	2000	44.7
1	0.1	1000	31.6
0.5	0.05	500	22.4
0.1	0.01	100	10.0
0.05	0.005	50	7.1
0.01	0.001	10	3.2
0.005	0.0005	5	2.2
0.001	0.0001	1	1.0

2.3.1 Localization

The GPS coordinates are read from the corner point of subplot A and the corner point of subplot B in the WGS84 latitude-longitude projection - EPSG:4326 (Garmin Etrex 20) and magnets (3 x 1.5 cm) are buried at a depth of about 10 cm in the soil. No magnets are buried in arable land and settlements.

2.3.2 Photos

The monitoring sites are documented by photos that are as representative as possible. Preferably a reflex camera with a wide-angle lens is used. Alternatively, smartphone cameras can also be used. It is, however, important to follow specific rules when taking pictures. The photos are arranged in a specific order to facilitate subsequent renaming in the office:

1. Survey sheet with BMS-Code, coordinates, date, notes, species list (also in order to have a backup)
2. 1 m² area in subplot A from above
3. Subplot A
4. – 7. From the center point 4 images clockwise starting upwards
8. 1 m² area in subplot B from above
9. Subplot B

2.3.3 Simplified botanical survey

For some habitats and for special projects a simplified protocol is applied. The single plot sizes correspond to standard protocol, i.e., 100 m² for grasslands, alpine sites, orchards, vineyards, fields and bogs and 1000 m² for all forest types. For lakes and settlements transect surveys are conducted with an approximate plot size of also 1000 m². First, a complete species list is created. Smaller nested plot surveys within the area are not conducted. Instead, we assign abundance categories, as explained in Tab. 9.

Table 9: Abundance categories. The categories are based on those specified in the GLORIA manual (Pauli et al. 2015) with the modifications as defined for habitat mapping of South Tyrol (Abteilung Natur, Landschaft und Raumentwicklung der Autonomen Provinz Bozen-Südtirol 2018). The third column shows the cover values in percent which are used for the further analyses.

Category	Definition	Equivalent cover for subsequent calculations
r (rare)	Single individual to few individuals in different places	0.01%
s (scattered)	The species is widespread in the area but does not necessarily occur uniformly; sometimes the species is not noticeable at first sight, but it cannot be overlooked when searching the area more closely;	0.1%
c (common)	Occurring frequently and widespread within the survey area – presence is obvious at first glance, coverage is low, however	1%
sd (sub-dominant)	The species is an important part of the vegetation matrix but coverage is relatively week (< 25%).	10%
cd (co-dominant)	The coverage of the species is between 25 and 50%	30%
d (dominant)	Very abundant making up a high proportion of the phytomass often forming more or less patchy or dense vegetation layers; species covers more than 50% of the area of the plot	70%

2.3.4 Identification and voucher preparation

Critical species that cannot be identified at species level in the field (e.g., *Alchemilla*) or species that need to be **re-determined** are collected outside the survey area and herbarized. Herbarium vouchers are labelled with (provisional) labels. The following information is noted on the voucher: BMS-code, date of collection, presumed species or genus name, and the name of the locality. The vouchers are pressed in a plant press between absorbent paper. Once they are dry, they have to be stored in dry and dark conditions. Regular controls against insects are necessary to avoid damage. Final determination of the voucher is done in the lab with a binocular or by an expert for the respective species group. Finally, herbarium vouchers are stored in the collection of the Museum of Nature South Tyrol.

2.4 Modifications of the standard protocol for some habitat types

2.4.1 Vineyards

For vineyards a metal or concrete column is chosen as the corner point of subplot A. Starting from this a 10 m x 10 m square is pegged out with the tape measure and pegs (see Fig. 16).

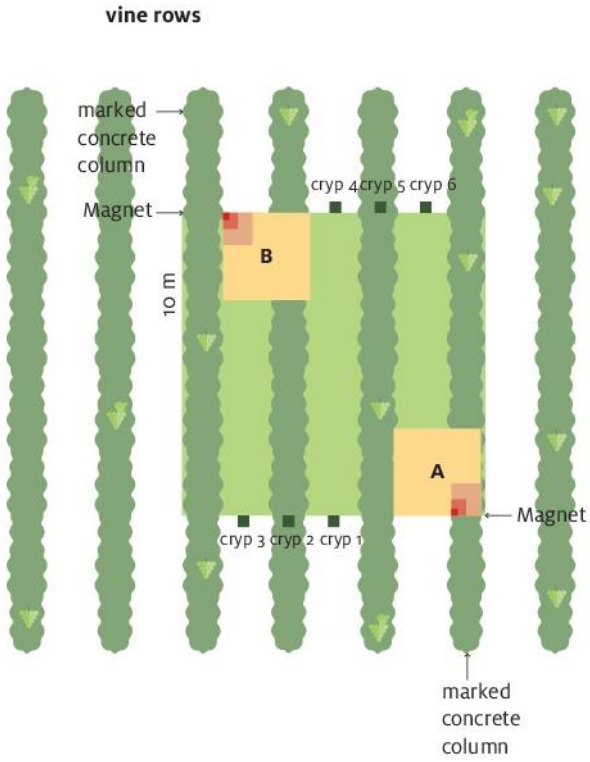


Figure 16: Arrangement of biodiversity monitoring sites for botanical surveys in vineyards.

The vineyard columns in the corner points are marked with color: at a height of approx. 30 cm a red ring is sprayed around the column with a vertical line in the direction of the center of the site. Subplot A is marked with a tape measure starting from corner point A. The opposite subplot B is set up in the same way with the corner point B in the first row fully located within the 100 m² square.

2.4.2 Apple orchards

Construction and marking of the 100 m² square are conducted as for vineyards. A different method is used for the subplots (Fig. 17), as the area between and below the apple trees has a very different vegetation due to different management and site conditions. Two subplots (A, B) are carried out between the tree rows (*Fahrgasse*) and two subplots (C, D) underneath the apple trees (*Unterstockbereich*). Subplots A and B are 5 m × 2 m rectangles placed centrally between the tree rows. Subplots C and D are 1 m × 1 m squares placed underneath the apple trees following the standard method for the 1 m^2 square size.

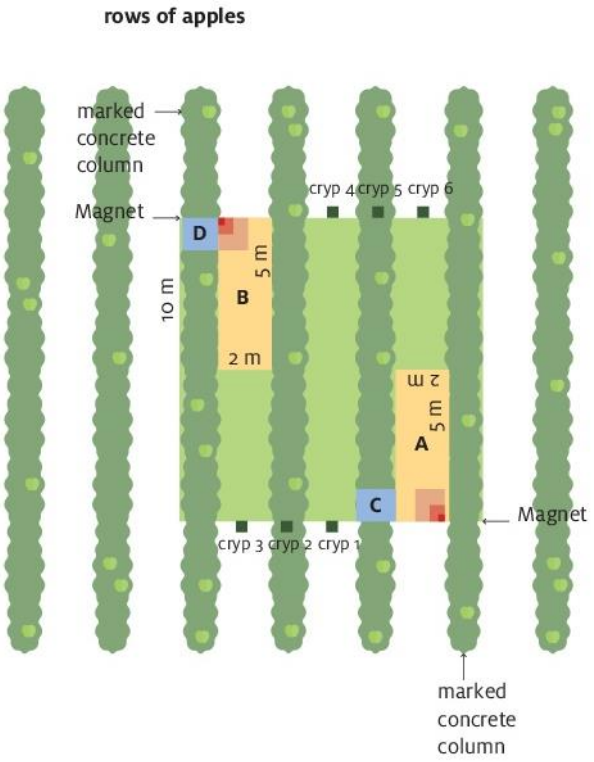


Figure 17: Arrangement of biodiversity monitoring sites for botanical surveys in apple orchards.

2.4.3 Forests

In forests the plot size is increased tenfold leaving out the lowest level (1 cm × 1 cm). In correspondence to the standard EDGG protocol, a coverage estimation is made in two 100 m² subplots (10 m side length). A species list is collected in 1000 m² (31.6 m × 31.6 m).

At the corner points trees are marked with a color spray can in the direction of the center of the side. At the corner points trees or solid rocks are marked with a color spray can in the direction of the center of the side. If there is no tree or rock in the immediate vicinity it is possible to drive a wooden pillar into the ground and mark that.

Photos: **1.** survey sheet, **2.** 10 m² square in corner Point A, **3.** 100 m² subplot A, **4.-7.** trees with markings of the corner points starting from corner point A clockwise. **8.-11.** 4 photos in clockwise direction from the center starting with upwards, **12.** 10 m² square in corner point B, **13.** 100 m² subplot B.

2.4.4 Settlements

In settlements a transect survey is conducted along a transect parallel to the street where the survey site is situated (Fig. 18). The center of our survey site is exactly in the middle of this transect line, i.e. the transect line extends in both directions for 50 m.

Therefore, before starting the survey one should define the starting and the end points by measuring a distance of 50 m from the survey site center parallel to the street in both directions. To localize the starting and end points of the transect line better a representative reference object (e.g.: house number, street crossing) nearby the starting and end points can be noted. The GPS coordinates are read from the starting and the end points of the transect.
Once the transect line is defined two separate 100 m-long surveys on both sides of the street are conducted. The first survey starts at the starting point of the 100 m line, the second one starts at the end point of the transect line and goes in the opposite direction. Both surveys are conducted on the right side of the street following the direction of the vehicles.

The survey is restricted to areas accessible to the public without trespassing fences or other kinds of delimitations. Quite often publicly accessible areas are not delimited by a clear but an irregular line. Plants growing behind fences and in private gardens within a distance which can still be reached by a stretched arm are also included. The survey follows this irregular line since a repetition is otherwise almost impossible. Side streets and larger parking lots are to be excluded from the survey. Any deviation from this scheme should be clearly defined and documented.
Once all species were carefully listed a rough estimation of the abundance of each plant species is performed using the abundance categories indicated in Tab. 9.
For settlements a second survey in September is recommended, surveying primarily species that could not yet be surveyed in spring or summer due to their phenology.

Photos: **1.** Survey sheet, **2.** From a representative reference object at the starting point, **3.** From the starting point in the direction of the transect **4.** From the end point in the direction of the transect, **5.** From a representative reference object at the end point.

Figure 18 Arrangement of biodiversity monitoring sites for botanical surveys in settlement areas. For details see text.

2.4.5 Arable Land

In addition to the standard sampling methodology a species list along a 100 m transect along the margin of arable land is created. This margin should be preferably located either toward another field or toward a road. The surveyed stripe covers the whole ecotone area between the field and the adjacent habitat type (usually another field or a road). An estimation of the abundance of each plant species is made using the abundance categories from Tab. 9.
The GPS coordinates are read from the starting and the end points of the transect.
Photos: **1.** Survey sheet, **2.** From the starting point in the direction of the arable land, **3.** From the starting point in the direction of the transect **4.** From the end point in the direction of the arable land, **5.** From the end point in the direction of the transect.

2.4.6 Lakes

In total three surveys are to be conducted for lakes. One survey is conducted in a transect parallel to the lake shore and two perpendicular to the shoreline (Fig. 19). The surveys are done if possible at lake shore sides with an ecotone between open water surface, macrophyte vegetation and forest. Within a distance of 50 m parallel to the shoreline a complete species list is created (tangential transect). The 50 m transect includes an area of 20 m towards the lake. That means that the total surveyed area amounts to 1000 m² and is therefore congruent to that of the forest sites. In this area, all species are listed and afterwards abundance categories are assigned (Tab. 9).
In addition, 2 transects (L1, L2) are surveyed perpendicular to the lake shoreline. A third transect (L3) is optional. Starting from a prominent point (e.g., a large tree), a species list is compiled for every square meter until reaching the vegetation-free water surface and the abundance of each species is assessed according to a 3-digit scale (1 rare, 2 scattered, 3 frequently occurring). Submerged vegetation is only surveyed if it can be reached without a boat. For re-localization the starting points of the perpendicular transects are marked with a color spray can, GPS-Coordinates are taken and magnets are buried in the soil.

Photos: **1.** Survey sheet, **2.** From the starting point in the direction of the transect **3.** At the starting point of the two (three) perpendicular transects in the direction of the transect (incl. the starting tree), **4.** From the end point in the direction of the transect.

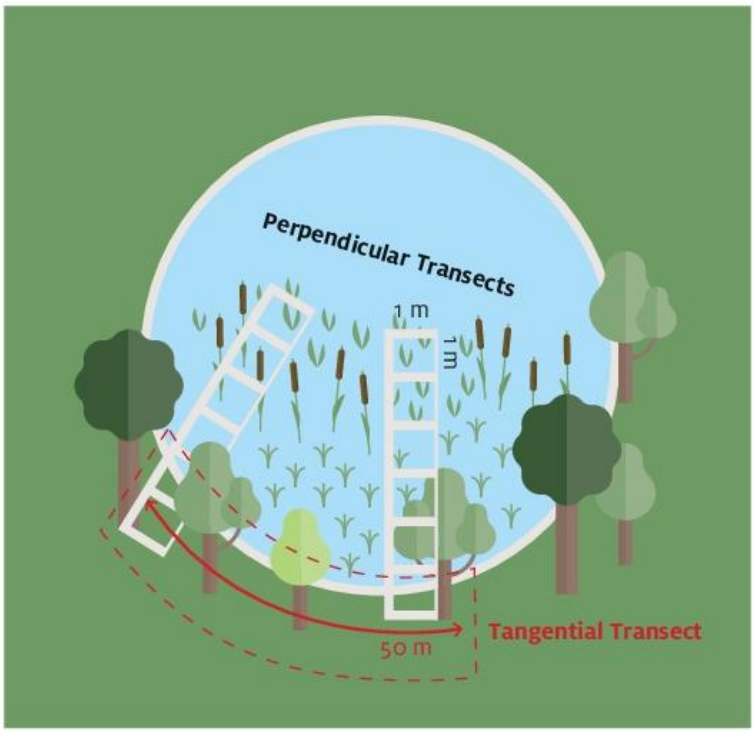


Figure 19: Arrangement of biodiversity monitoring sites for botanical surveys in lake shores. The third perpendicular transect is optional.

3 Bryophytes and lichens

3.1 Sampling and storing of samples

Bryophyte and lichen samples are taken in the same four random 0.1 m² subplots (32 cm × 32 cm). The subplot size in forests, lake shores and settlements is 10 times bigger (1 m²; 1 m × 1 m). The subplots are chosen randomly usually by throwing a yardstick. They are not marked for resurvey after the first survey. For sampling they are delimited by a yardstick (see Fig. 15, cryp1 - 4). Exceptions are vineyards (Fig. 16, cryp1 - 6) and apple orchards (Fig. 17, cryp1 - 6) where the sampling of lichens and bryophytes takes place in six single patches: two are collected below the vines/trees (*Unterstockbereich*) and four in the intermediate area (*Fahrgasse*). In case of settlements and lake shores the samples are taken in four random 1 m² squares along the transects.

In settlements two samples are taken for every transect preferably on the sidewalks and the subplots are placed in locations with occurrences of bryophytes (frequently between the paving stones).

When collecting the aim is to obtain a complete set of all species which can be distinguished macroscopically. Bryophytes and lichens growing on dead wood or stones are collected as well except for crustaceous lichens. Epiphytic bryophytes and lichens however, are not collected, unless they have fallen from the trees and lay loosely on the ground. The bryophyte and lichen samples of every single subplot are immediately stored in a separate paper bag. After taking the four samples for both bryophytes and lichens we check whether additional morphospecies occur in the 100 m² survey area that were not found in the four sampling plots. If so, they are collected in an additional bag (“pooled sample”). The bags are labelled as follows: BMS-Code, location, date, sample number (“1|4” – “4|4”, “pooled”). For subplots with no bryophytes or lichens no sampling is conducted, avoiding empty bags. For better storage the samples of one site are stored together in a larger paper bag. If the samples are wet, they are put on a newspaper for few days in order to let them dry. The bags with the samples must be stored in dry and dark conditions.

3.2 Identification and voucher preparation

The identification of both bryophytes and lichens is done by external collaborators. Once all species of a single site have been determined, all plant material of one single bryophyte or lichen species is merged. Of this bryophyte/lichen material a representative amount is put into a new paper bag or ideally into a cryptogam capsule of the Museum of Nature of South Tyrol. It must be labeled properly with species name, plot code, dates of collection and identification and name of the identifier. Afterwards it is ready to be integrated into the cryptogam collection of the Museum.

4 Birds

4.1 Preparation for fieldwork and sampling material

The bird survey is mainly conducted by acoustic and visual identification by experts and only a few items are needed (Fig. 20).

Figure 20: Sampling material for the bird survey: 1. Telescope for identifications beyond a 100-meter distance with 25 to 50 magnification; 2. Two binoculars with a resolution of 10×42 and 8×42; 3. Datasheets and pen for data collection and site conditions; 4. Field guide for bird identification, mainly for intern training.

4.2 Survey methods

To monitor bird populations we use point counts according to the Pan European Common Bird Monitoring Scheme methods (Fig. 21; PECBMS; Bibby et al. 1992; Sutherland, 2006). To identify bird species we use both visual and acoustic clues. During the survey a distinction is made between birds observed within and outside a 100 m radius from the plot center to better relate bird data to local conditions (Ribic et al. 2009; Assandri et al. 2016, 2017; Brambilla et al. 2017). The duration of each visual and acoustic observation is 10 minutes (Fornasari and Mingozzi 1999). The surveys are conducted between mid-April and mid-July in accordance with the beginning of the bird breeding season and depending on local conditions (mainly due to the specific plot elevation, see Tab. 10). With this methodology we can exclude most migratory birds. The surveys start after sunrise and end at 11 a.m. For sites in the colline and montane zone a total of three repetitions are conducted, while for alpine sites, due to short seasonality, only two repetitions are conducted. Surveys in adverse weather conditions such as strong wind or heavy rain/snow are avoided. Within the survey the numbers of individuals and their life status are noted, i.e., if there are clear signs of mating or breeding activities.

Figure 21: When birds are surveyed their occurrence inside and outside of a 100 m radius around the study site has to be distinguished.

Table 10: Sampling calendar for the bird survey. Green areas: first visit, yellow areas: second visit, orange areas: third visit.

Habitat type [BMS-Code]	April		May		June		July	
Vineyards [WYF, WYS]								
Apple orchards [OAC, OAO]								
Montane hay meadows [HEM, HNM]								
Colline / montane pastures [PAC, PAM]								
Deciduous forests [FDB, FDM, FDO]								
Settlements [SEC, SEI, SEV]								
Wetlands [LAK, BOG]								
Subalpine hay meadows [HES, HNS]								
Arable land [CFC, CFM]								
Subalpine pastures [PAS]								
Coniferous and riparian forests [FCP, FCL, FRI]								
Alpine meadows [AMC, AMI, AMS]								
Alpine rocky habitats [ARC, ARI, ARS]								

4.3 Field protocol: general information

For each single monitoring site the following information is reported in the first part of the data entry form (Appendix 15.2):

1. Code of the assessed site (e.g., 308_SEI_2).
2. Name of the locality (for example: Industrial zone of Laives).
3. Date of the survey.
4. Name of the surveyor
5. Start and end time of the survey at each site.
6. Visit number (from 1 to 3) of the survey for each site.

For each plot the part relating to weather conditions present in the first page has to be completed. In particular, the boxes representing the sky and wind conditions have to be ticked. There are also comment boxes additional information can be noted that could be valuable for future reference.
Inside the field form there are three columns to collect data related to the monitored avifauna:

1.species name
2.number of individuals observed within a radius of 100 m distance from the centroid
3. number of individuals observed outside a radius of 100 m distance from the centroid

4.4 Social behavior and nesting activities

Additional information is necessary (Tab. 11) to transform the data into an estimate of nesting pairs. This information is signed in predefined codes following the Italian Bird Monitoring (MITO 2000) protocol. The codes are also reported at the bottom of the protocol sheet.

Table 11: Codes for noting social behavior and nesting activity. A combination of two codes is only allowed in the below-mentioned cases.

Code	Observation
C	Male singing or displaying some other territorial behavior
M	Male, not singing
F	Female
A	Adult with undetermined sex
J	Young birds not fit for flight or just flown in (note how many)
U	Individual with undetermined age
R	Nesting activity (transporting of: food for the nestling, fecal sacs, nesting materials etc.)
V	High-flying, passing bird. Presence not strictly connected to the site
Code combinations	
MR	Male engaged in any reproductive activity
FR	Female engaged in any reproductive activity
MV	Male in transfer flight
FV	Female in transfer flight
Example	
11 MV	Eleven males in transfer flight (It is also possible to add the number of the observed individuals, for example if 11 males in flight have been seen the code 11 MV can be assigned)

Additionally, the following rules have to be followed:

- For correct assessment of the avifauna it is necessary to also count those individuals who move away from the buffer area of a 100 m radius because they were disturbed by the arrival of the surveyor.
- It is very important that the use of the codes is respected so that the data collected can be stored easily and clearly.
- It is essential that the observations are recorded individually and not summed by species since their meaning in terms of the number of pairs could, in both cases, be different. For example, if the surveyor sees 4 sparrows in flight and later sees another 16 flying, they must indicate "4V, 16V" and not "20V".
- In the case of individuals flying and singing at the same time (e.g., as for *Lullula arborea*) the individual should be indicated with "C" and not with "V" or "CV".

It is also requested to list the observed/heard species at one single site assigning a nesting category defined by a numerical code according to the conventions of the National Atlas of Italy (Fornasari et al. 2010) on the back of the sheet (Tab. 12). The numerical codes are also reported on the back of the sheet.

Table 12: Numerical breeding codes.

Breeding code	Type of observation
Impossible breeding	
0	Species observed but suspected to be still on Migration / Species not breeding in South Tyrol
Possible breeding	
1	Species observed in breeding season
2	Species observed in breeding season in suitable nesting Habitat
3	Singing male present during its breeding period, hearing singing or drumming as a territorial behavior, seen male lekking
Probable breeding	
4	Pair present in suitable habitat in breeding season
5	Territorial behavior (singing, aggressive behavior with neighbors, etc.) observed in the same territory on two different days 7 or more days apart
6	Mating behavior: lekking, mating or exchange of nourishment between adults
7	Visit of a probable nesting site
8	Agitated behavior or anxiety calls from adults suggesting probable presence of nest or young nearby
9	Brood patch on adult examined in the hand suggesting Incubation
10	Transport of material or construction of a nest; excavation of a cavity by woodpeckers.
Confirmed breeding	

11	Distraction-Display or injury feigning
12	Used Nest or eggshells found (occupied or laid within period of survey)
13	Recently fledged young (nidicolous species) or downy young (nidifugous species). Careful consideration should be given to the likely provenance of any fledged juvenile capable of significant geographical movement. Evidence of dependency on adults (e.g., feeding) is helpful. Be cautious, even if the record comes from a suitable habitat
14	Adults entering or leaving nest-site in circumstances indicating Occupied Nest (including high nests or nest holes, the contents of which cannot be seen) or adults seen incubating
15	Adult carrying a fecal sac
16	Adult carrying food for young
17	Eggshells from recently hatched chicks
18	Nest seen with an incubating adult
19	Nest containing eggs or juveniles (seen or heard)

5 Bats

5.1 General considerations

An efficient non-invasive method to assess bat activity and occurrence on a large scale is based on ultrasonic detection. Bats emit vocalizations continuously to move around, to feed and to communicate with their conspecifics. Every single bat species is characterized by a typical call sequence. Moreover, the emitted sound can provide information on bat species or genera and on behavior. For instance, based on recorded echolocation it is possible to distinguish calls for orientation, social calls which are used for intraspecific communication and "feeding buzzes", which are used for locating prey and recognized by an increase in repetitions of echolocation pulses used for locating prey (Barataud 2015). Bat-detectors can be used for active monitoring, i.e., handheld by an expert visiting roosts (e.g., counting bats flying out) or survey transects during parts of the night. Otherwise they can be automated for a longer time-period (e.g., complete nights) and installed on an e.g., tree or pole to record bat calls and to analyze them afterwards, called passive monitoring (Fig. 22). Both methods, active and passive monitoring have their advantages and disadvantages. While calls recorded via active monitoring can yield higher quality calls (longer and clearer), passive monitoring over longer time-periods has been found to have a higher probability of detecting all bat species on-site (Teets et al. 2019). In any case, the subsequent analysis and identification of recorded call sequences has to be carried out by an expert (Walters et al. 2012). Advantages and disadvantages were evaluated to assess the sampling design in the project "Biodiversity Monitoring South Tyrol." We chose stationary bat-detectors (i.e., passive monitoring) to assess a passive standardized monitoring system on a regional scale and to gain the highest detection probability of a great part of the occurring bat species on-site.

Bat assessments within the BMS are carried out using bat-detectors, "BATLOGGER A+" from Elekon (BATLOGGER 2020), which are well suited for passive monitoring programs. It is a detector including a data-logger which records bat calls in real-time and full spectrum and stores them for later processing on a micro-SD memory card.

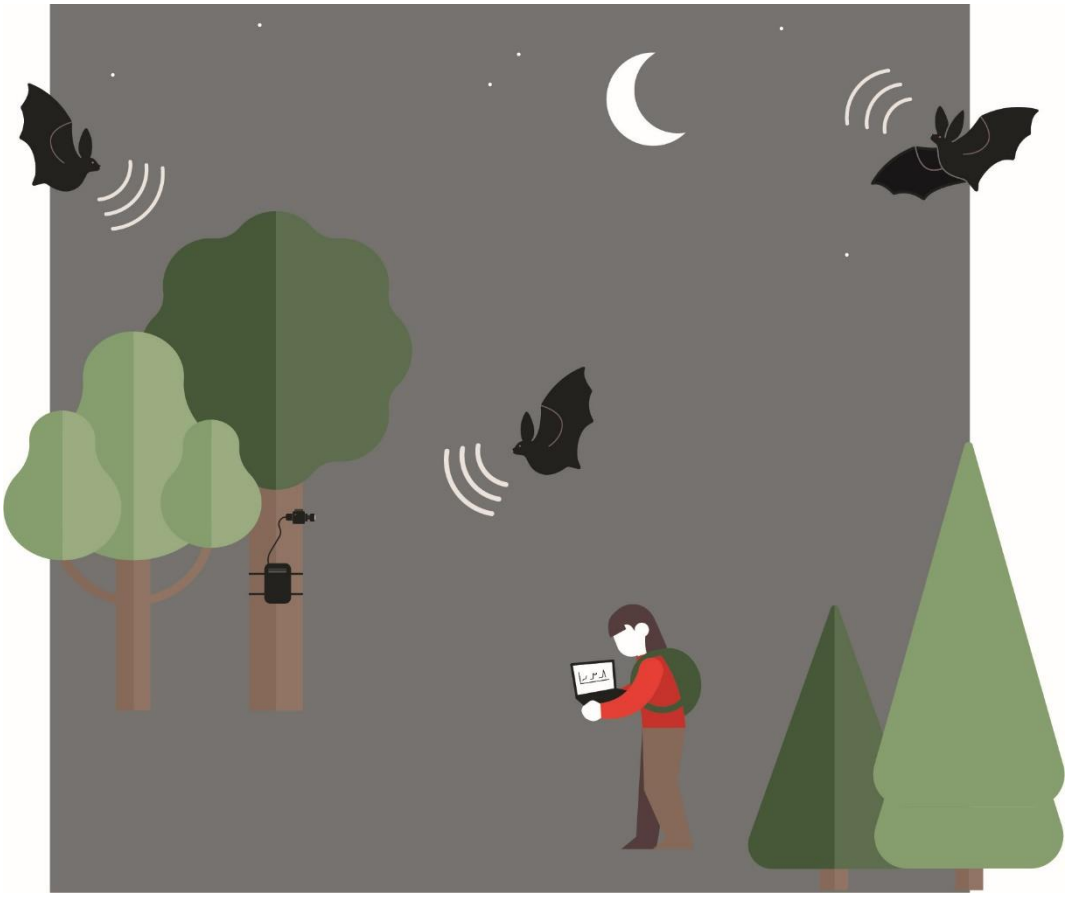
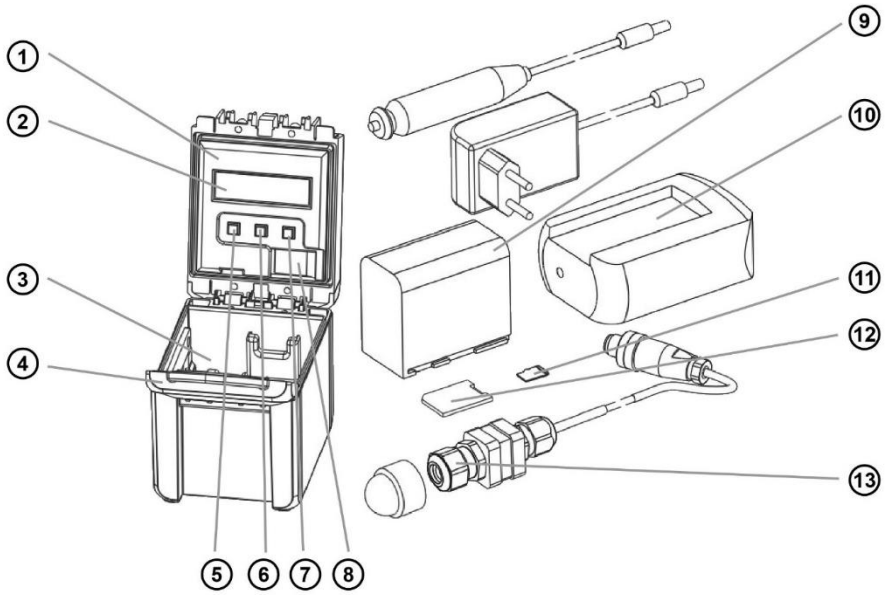


Figure 22: The batlogger is situated in a strategically good spot such as a branch of a tree and fixed almost horizontally. The device is set to start recording at sunset and stop at sunrise and bat activity is recorded on three consecutive nights. More information in the text.

Besides the bat calls, “BATLOGGER A+” also stores the time, date, and instant air temperature (Fig. 23). The ultrasonic signal is digitized directly without changes and with a high sample rate of 312.500 Hz. BATLOGGER A+ continuously analyses the signal and only stores it on an SD card when bat activity is recognized. The signals are recorded on the internal RAM and, if certain criteria are fulfilled (e.g., see “*period trigger*” below), and then subsequently stored as recording files (sequences of echolocation calls) on the SD card. Apart from bat calls which are stored as standard audio files (.wav), all additional information is stored in a text format (.xml file).



1. Case with cover
2. LC-Display
3. Battery slot
4. Closing latch
5. Left Key (<<)
6. Menu Key (MENU)
7. Right Key (>>)
8. Micro SD card slot
9. Battery
10. Charger with power adapters
11. Micro SD card
12. SD card adapter
13. Microphone with cable 2m and cover
14. Microphone connector

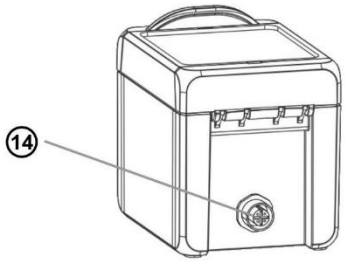


Figure 23: “BATLOGGER A+” from Elekon. Technical device component (BATLOGGER 2020).

5.2 Preparation for fieldwork and sampling material

Before fieldwork can start a set of items have to be prepared (Fig. 24). It is especially important that the batloggers are equipped with fully charged batteries and that the micro-SD cards are not full. Microphones and cables must be tested repeatedly during the field season to ensure that they are in perfect working order. The producer provides a self-test to check the BATLOGGER A+" microphones. A technical verification of all equipment should be done by the producer at least every two/three years.

Figure 24: Sampling material for bat survey: 1. Bat logger including microphone, batteries and sd card; 2. Safety chains for the logger and strings to install and direct the microphone; 3. Field sheet to write the survey date and other important notes such as the bat logger code 4. Computer, software, hard disk, and books to identify and store bat calls.

5.3 Technical settings and placement

The device is installed, where possible, precisely on the BMS site following given coordinates. The microphone is fixed almost horizontally and inclined down slightly so that rain or dew cannot cause waterdrops on the microphone top, which would compromise its function. It is positioned on an elevated point which can be trees, shrubs or other taller structures like pillars, fences, and rocks or on an improvised pole (Fig. 25). The microphone is typically positioned at a height of 1.5 m above ground. It is important that no obstacles are in front of the microphone to ensure optimal recording of the bat calls. The orientation of the microphone is not random but aimed in the direction where the passage of bats is expected. These are often corridors or linear structures that the bats are thought to orientate towards. Hence, especially in dense forests or areas with high vegetation, the microphone is aligned in the direction of an expected flight corridor. In vineyards and apple orchards the microphone is fixed on branches or columns and aligned to the linear structure presented by crop rows. In urban areas flight corridors can be represented by streets and alleys and the device must be placed in the direction of these structures. In settlements, electric powerlines, lamps, and other electromechanical devices producing ultrasonic sound can cause disturbances, so the "BATLOGGER A+" should not be positioned near them or at least at a minimum distance of about 200 m. In very windy areas, especially high alpine locations or lakes the

microphone must be placed away from the main wind direction and if possible, the wind-exposed side should be covered e.g., with stones or rocks. The device is set to start recording at sunset and stop at sunrise therefore the time and date must be set. We have set all devices with the coordinates of the city of Bolzano. Based on this information the start and end of the recording will be adapted to the current calendar day and varying length of nights.

Bat activity is recorded on three consecutive nights. The selected time period of three days is chosen to buffer the effect of adverse weather conditions on single nights, during which bat activity is significantly lower due to lower insect numbers. So, wherever possible nights with no precipitation, no strong wind (tree branches should not move strongly) and not colder than 8/10 °C at night are preferred for the survey. If possible, it is recommended to avoid full moon nights since bat activity might be influenced (Appel et al. 2017). In any case, during longer periods of bad weather the devices should not be set up. In addition, three consecutive nights seem to augment the possibility of observing a large part of the present bat species diversity in the most efficient way (Skalak et al. 2012). Bat activity is recorded from May to October depending on the elevation of single sites and microclimatic conditions (Tab. 13). At sites below 500 m a survey in early May and late October is possible. For sites up to about 1000 m sampling is held between May and September. At sites between 1000 m and 1500 m the months June–early September are preferable while paying attention to local micro-climatic conditions. At high elevations (AMS, AMC, AMI, ARS, ARC, ARI, PAS, HNS, HES > 1500 m) surveys are conducted between July and early August so for these areas a lot of attention should be paid to the long-term weather situation.

Depending on the season and on the sampling plots singing orthoptera cause a lot of background noises. In our project the recording "*period trigger*" is set. This setting excludes the majority of grasshopper and cricket noises and records only bat calls which are characterized by their sinusoidal vocalizations.

Table 13: Field calendar for bats. In green the perfect periods for data collection. In yellow variable sampling periods depending on the altitude of the sites. All sites between 1500 and 1800 meters are sampled between June and August depending on the temperature. Subalpine and alpine sites are sampled in July only.

Habitat type [BMS-Code]	May	June	July	Aug.	Sept.	Oct.
Vineyards [WYF, WYS]						
Apple orchards [OAC, OAO]						
Settlements [SEC, SEI, SEV]						
Wetlands [LAK, BOG]						
Arable land [CFC, CFM]						
Deciduous forests [FDB, FDM, FDO]						
Coniferous and riparian forests [FCP, FCL, FRI]						
Montane hay meadows [HEM, HNM]						
Colline / montane pastures [PAC, PAM]						
Subalpine hay meadows [HES, HNS]						
Subalpine pastures [PAS]						
Alpine meadows [AMC, AMI, AMS]						
Alpine rocky habitats [ARC, ARI, ARS]						

Figure 25: On the left: Power-up and setting check before BATLOGGER A+ installation. On the right: A BATLOGGER A+ in a riparian forest site.

5.4 Data recording, storage, analysis, and species identification

To store recordings micro-SD cards with 32 GB and 128 GB are used. The 32 GB SD cards are large enough to store three days of bat surveys at most sites. For places with expected high bat activity (e.g., lakeshores, urban areas) it is recommended to use larger storage.
After three survey nights the recorded data are stored in the BMS folder and named with its BMS-Code and year of survey. The data including bat calls (.wav format) and metadata are saved in the cloud of the Biodiversity Monitoring Project as well as in a specific server (alpenv-bat). After secure storage in the cloud the data can be deleted from the micro-SD.
To identify bat calls different open-source programs are available. In the Biodiversity Monitoring South Tyrol we use BatExplorer (Elekon BatExplorer 2020) and BatScope 4 (Obrist and Boesch 2018). BatExplorer is user friendly and allows the user to measure different parameters directly on the displayed call sequences. Starting from a first identification provided by automated classification software (measurement of echolocation call parameters i.e., peak frequency, duration, etc.), a manual species identification was performed following the methods described in Barataud, (2015), Russ, (2021) and Middleton et al. (2014). Only for the species *Pipistrellus pipistrellus* we use an automated recognition task in the classification software (suggested species by the software with an accuracy probability of > 90 %).
To implement the data output call sequences with feeding buzzes and social calls are marked with one or two stars respectively if they are recognizable in each BatExplorer project (Elekon BatExplorer 2020).
For a lot of bat species present in South Tyrol call sequences can be determined to species level (Tab. 14). However, for some species a clear determination on species level with acoustic monitoring is not possible; similarly, some calls are not identifiable without doubt (Russo and Voigt 2016). These calls/sequences are summed up where possible to genera or group level (Tab. 14). This approach is used for recordings belonging to the genus *Myotis* and *Plecotus,* because their call characteristics show large overlaps within the genus. Only for good recordings or social calls can we identify some species of *Myotis*: *M. nattereri*, *M. emarginatus* and *M. daubentonii*, the latter is easily identifiable at water sites (lakes). *Myotis myotis* and *Myotis blythii* are signed as a separate group because they can be distinguished from smaller species of the genus *Myotis* but not among themselves.
The two species *Pipistrellus kuhlii* and *Pipistrellus nathusii* are considered as a group because a distinction based only on orientation calls is impossible when social calls are absent, while the relatively rare social calls of the two species allow for certain determination. *Vespertilio murinus, Eptesicus serotinus, Eptesicus nilssonii, Nyctalus noctula* and *Nyctalus leisleri* are determinable when their call sequences are long and the number of typical calls is high (e.g., min > 10 calls per recording). However, frequently for these species a group must be used (Nyctaloids) because there are often only a few calls in their call sequences which are not sufficient for a reliable species classification. Calls recognized as bat calls but not assignable to a specific group we added to the category “indeterminable.” For details of the identifications see Tab. 14.

Table 14: Level of identification for bat species in South Tyrol using call analyses. P: possible; A: always; N: not possible. For *Pipistrellus nathusii* and *P. kuhlii* the species identification is possible only with social calls.

Family	Species	Determination on species Level	Determination on genus Level	Determination as a group
Rhinolophidae	*Rhinolophus hipposideros*	A	A	A
	Rhinolophus ferrumequinum	A	A	A
Vespertilionidae	*Myotis daubentonii*	P	A	A
	Myotis emarginatus	P	A	A
	Myotis nattereri	P	A	A
	Myotis bechsteinii	P	A	A
	Myotis myotis	P	A	A
	Myotis brandtii	N	A	A
	Myotis mystacinus	N	A	A
	Myotis blythii	P	A	A
	Nyctalus leisleri	P	A	A
	Nyctalus lasiopterus	P	P	A
	Nyctalus noctula	P	A	A
	Eptesicus serotinus	P	A	A
	Eptesicus nilssonii	P	A	A
	Vespertilio murinus	P	A	A
	Pipistrellus pipistrellus	A	A	A
	Pipistrellus pygmaeus	A	A	A
	Pipistrellus nathusii	P	A	A
	Pipistrellus kuhlii	P	A	A
	Hypsugo savii	A	A	A
	Barbastella barbastellus	A	A	A
	Plecotus auritus	N	A	A
	Plecotus macrobullaris	N	A	A
Molossidae	*Tadarida teniotis*	A	A	A
Miniopteridae	*Miniopterus schreibersii*	A	A	A

6 Grasshoppers, crickets and mantids

6.1 General considerations

The grasshopper survey within the BMS includes grasshoppers and locusts (Caelifera), bush crickets and related groups (Ensifera) and mantids (Mantodea). In the following text we use the term “grasshoppers” referring to all three groups.
The methodology for the grasshopper survey follows (Hilpold et al. 2020) for most habitat types and the text parts below are largely adopted from this article. The method consists of two parts: i) sweep netting along a defined transect, and ii) an exhaustive search within an area of 100m^2. The methodology is used for all assessed terrestrial habitats except for urban habitats and lake shores, where only transect surveys are applied. In the case of forest sites the plot size is enlarged by a factor of 10.

6.2 Preparation for fieldwork and sampling material

The necessary sampling equipment as shown in Fig. 26 should be prepared and checked before the survey. “Fauna Helvetica” (Coray and Thorens 2001), “Grasshoppers and Crickets of Italy” (Iorio et al. 2019) and “Die Heuschrecken Deutschlands und Nordtirols” (Fischer et al. 2020) are considered ideal literature for species identification.

Figure 26: Sampling material for the grasshopper survey: 1. Sweep net; 2. Beat net; 3. Collecting recipients, empty and with ethanol; 4. Magnifying glass; 5. Literature for species identification; 6. Field sheet to write the survey data (Appendix 15.1).

6.3 Survey conditions and phenological issues

Weather conditions are important for a successful survey of grasshoppers since most Caelifera species avoid singing at low temperatures. Preferably, surveys should be conducted between 9 a.m. and 5 p.m. However, this is highly dependent on local climatic conditions and the surveyor has to decide from case to case if a survey is meaningful or not.

In contrast to many other animal groups sampling grasshoppers is relatively easy. In most cases a single survey in mid-summer will be sufficient to assess the full species spectrum, given that species under survey are present as adult individuals (Tab. 15). The presence of adults is crucial, as many taxa cannot be identified to species level as larvae. Thus, the survey period needs to be adapted correspondingly.

In grasslands of the planar to colline zone, the presence of at least some adults can be expected as early as late June or July for most species. In steppe-like grasslands of the montane belt, adults may occur later, i.e., by the end of July (e.g., *Chorthippus mollis*) (Zuna-Kratky et al. 2017). In subalpine and alpine grasslands the occurrence of adult specimens cannot be expected before the beginning of August. However, a few genera deviate from this pattern: some crickets (e.g., *Gryllus campestris*) endure winter as subadults and in high summer adults tend to be rare. The same holds true for many groundhoppers (*Tetrix* spp.). In contrast to other grasshoppers, *Gryllus* and *Tetrix* can often be identified as larvae, which means that a survey in mid or late summer should cover all grasshopper species.

Table 15: Sampling calendar for the botanical survey. Green areas: main survey, red areas: suboptimal survey period; yellow area: additional survey in spring.

Habitat type [BMS-Code]	May-June	Jul. 1° Half	Jul. 2° Half	Aug. 1° Half	Aug. 2° Half	Sep. 1° Half	Sep. 2° Half, - Oct.
Vineyards [WYF, WYS]							
Apple orchards [OAC, OAO]							
Arable land [CFC, CFM]							
Montane hay meadows [HEM, HNM]							
Subalpine hay meadows [HES, HNS]							
Colline/montane pastures [PAC, PAM]							
Subalpine pastures [PAS]							
Deciduous forests [FDB, FDM, FDO], riparian forests [FRI]							
Coniferous forests [FCP, FCL]							
Settlements [SEC, SEI, SEV] colline-submontane							
Settlements [SEC, SEI, SEV] montane							
Wetlands [LAK, BOG]							
Subalpine hay meadows [HES, HNS]							
Alpine meadows [AMC, AMI, AMS]							
Alpine rocky habitats [ARC, ARI, ARS]							

6.4 Installation of plots

The plots are similar and their size and shape are identical to the botanical survey plots that correspond to EDGG Biodiversity plots (Dengler et al. 2016; Fig. 27). Since the botanical and grasshopper surveys are usually not conducted the same day plots need to be installed separately. The centroid of the BMS site is used also as an approximate centroid of the grasshopper plot. The procedure of plot installation is explained in detail in the botanical section of the handbook. Especially in species-poor habitats (e.g., spruce forests, alpine rocky habitats) exact installation of the plot is not mandatory.

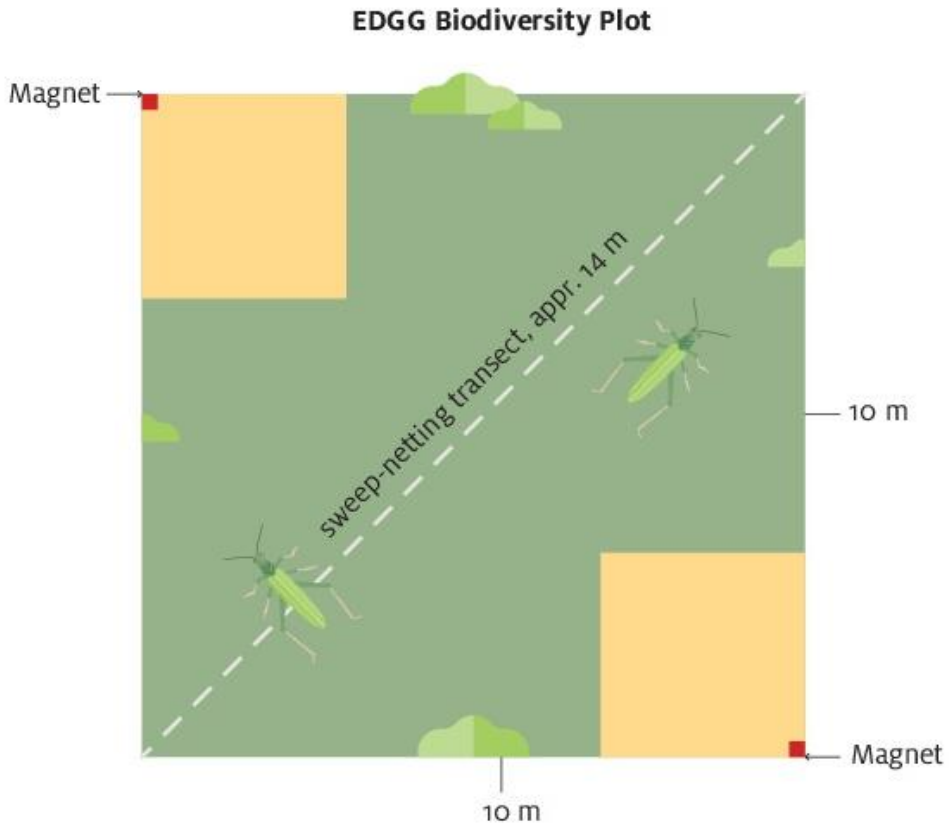


Figure 27: Scheme for survey of grasshoppers. The survey is started by sweep-netting the diagonal transect followed by an exhaustive search in the 100 m² plot. It is important to check shrubs and grass tussocks for Ensifera species and sites with bare ground for certain Caelifera species (e.g., *Tetrix* spp., *Oedipoda* spp.). The yellow squares show the 10-m² subplots within the EDGG Biodiversity Plots in which the vegetation surveys are conducted (not necessary in grasshopper surveys).

6.5 Transect survey

The survey starts with sweep-netting along the diagonal of the biodiversity plot whereas the direction of this transect is not relevant. The transect must be walked at a slow pace (approximately 2 km/h). Sweeping height depends on the height of the vegetation: in the case the vegetation is low sweeping has to be done directly at ground level; in the case the vegetation is high (e.g., in mesic hay meadows) sweeping has to be done in the upper part of the vegetation layer.

After the transect every individual caught in the net needs to be counted. Optimally, this is done by opening a small cleft in the net and taking individuals out one-by-one. First, adult individuals should be

assessed and subsequently released. If identification is doubtful specimens should be collected and preserved for later identification. After identification and counting all adult individuals and juvenile individuals are counted. If juveniles are very abundant caught individuals might be transferred to some sort of transparent container that enables easy counting. Also, juvenile individuals should be identified to the lowest taxonomic level that can be solidly inferred. While species level identification might not be possible for most juvenile individuals genus level identification is often possible. This applies for example for juveniles of the genera *Calliptamus* spp, *Mantis*, *Gryllus*, or *Oecanthus*. Therefore, juveniles should also be carefully checked if they can be identified.

6.6 Exhaustive search

An exhaustive search is started with an acoustic assessment. Some species groups are much easier to distinguish by their songs than by their morphology (e.g., *Chorthippus biguttulus* group). The acoustic survey also helps to find elusive taxa. Some bush dwelling Ensifera are cryptic and very mobile, and it is very difficult to detect them with methods other than by song. If the surveyor is not familiar with the songs of a species a mobile sound device (cell phone) is very useful and helps to memorize the song and to identify it later (e.g., Roesti and Rutschmann, 2020, for Central European Orthoptera). It is important to carefully check patches with bare soil as certain species prefer this microhabitat type, e.g., *Oedipoda* spp., *Tetrix* spp. and to check single shrubs or large herbs and grass tussocks for Ensifera and mantids. Additionally, it is important to check small patches of short vegetation in the plot as additional species might be restricted to such patches (e.g., *Omocestus haemorrhoidalis*, *O. petraeus*). The surveying time is 30 minutes. If two surveyors are present this time has to be divided by two (i.e., two surveyors have 15 minutes each).

6.7 Assigning frequency classes

The frequency classes in Tab. 16 refer to adult and subadult individuals. If specimens are observed in an early larval stage that cannot be identified to species level their frequency class should be assessed anyway. As stated in 6.6., this should be done on the most accurate taxonomic level possible (e.g., Acrididae juvenil = IV). Such information is still informative for later analyses if, for example, total frequencies between plots are compared.

Table 16: Frequency classes used in the sampling.

Class	Criteria
I	1 individual. In addition, there should be no sign of more individuals of the same species outside of the plot.
II	2–5 individuals in the plot; if you have only one individual in the plot, but you have observed more of them close to the plot give also II
III	6–10 individuals
IV	11–20 individuals
V	21–50 individuals
VI	More than 50 individuals

6.8 Grasshoppers from pitfall traps

Grasshoppers from pitfall traps should be identified. This material is very useful to complement the species list obtained via the survey. If a species of a pitfall trap has not been found in the survey the species can be added to the species list for a given site. These data need to be clearly highlighted as pitfall material in the list and should not be merged with the field survey data. Depending on the follow-up analyses, these additional data might be included or not.

6.9 Modifications of the standard protocol for some habitat types

6.9.1 Forests

The survey area in forests is enlarged by factor 10 meaning that a single plot has a total surface of 1000 m². Each side of the survey plot measures 31.6 m and the diagonal transect has a length of 44.7 m. An exhaustive search should also be done in the entire area of the plot. A detailed search in every part of the plot might be hardly feasible and search efforts should eventually be focused on smaller lighter areas within the plot, for example on rocky outcrops or small meadow patches. Some katydid cricket species are usually found on branches (e.g., *Meconema* spp.) and thus a beat net should be used for the exhaustive search. Additionally, the soil surface should be searched for *Nemobius sylvestris*. Sometimes adult individuals are missing and only juveniles can be found. Other forest species inhabit mainly small crevices between stones and rocks (e.g., *Troglophilus* spp., *Gryllomorpha dalmatina*).
Most grasshopper species prefer sunny conditions. Due to dense tree cover and site exposition the sun may reach the ground only for a few hours of the day. For the grasshopper survey this means that it is not always possible to find optimal conditions. More than one single survey might be useful. Additionally, pitfall traps can be helpful – specially to detect crevice-inhabiting and nocturnal species.

6.9.2 Lake shores

Lake shores are ecotones between water habitats and terrestrial habitats for which a plot-based method is not appropriate. Instead, a transect based method similar to the method used for the butterfly survey is better suited. Specifically, the total transect length is 50 m and the transect should be installed parallel to the lake shoreline. In general, the transect is installed directly on the limit between woody and open vegetation. It corresponds to the tangential transect of the botanical survey. Lake shores are relatively heterogeneous and often exhibit a quick transition between forest and reed (e.g., Lago di Varna/Vahrner See, Lago di Monticolo/Montiggler See). Some also exhibit transition to lower sedge vegetation (e.g., Lago di Dobbiaco/Toblacher See) or may not show any emergent macrophyte vegetation at all.
After defining the 50 m transect it is sampled by walking slowly back and forth where all grasshoppers that are visually or acoustically present in an imaginary cubic sphere of 2.5 m in each direction can be noted. This first transect sampling should be done for at least 5 minutes. The second part of the survey extends the sampling area for 10m to the right and to the left of the transect resulting in an area of 1000m^2. This second step involves an exhaustive search of 25 minutes of this area. This area corresponds to the surveyed area in forests. During the survey both sweep and beat nets should be used. Especially in lakes surrounded by forest sunlight might be present for a few hours per day only (depending on the exposition). Thus, it might be difficult to find optimal conditions for the grasshopper survey and more than one survey might be necessary (similar to forest surveys). Pitfall traps may also help to complement the species survey on the site.

6.9.3 Settlements

Settlements are very heterogeneous and usually species-poor habitats. Here we apply a transect method adapted to the special geometry of the settlements characterized by streets. A transect of 50 m should be defined from the centroid of the survey site. The centroid acts also as a central point for the transect. The survey procedure should be done as described for lake shores. The total area surveyed should also include approximately 1000 m² and is therefore similar to other (species-poor) habitats. Within the surveyed area vegetation should be sweep-netted and shrubs and tree branches beat-netted.

6.9.4 Vineyards and orchards

Due to their intermediate character between tree-dominated and open habitats vineyards and orchards are surveyed on a surface of 400 m² (usually 20 x 20 m).
As vineyards are relatively warm and offer good conditions for overwintering, spring singing activity can be high. In spring we very frequently find adult individuals of *Chorthippus brunneus*, *Omocestus rufipes* and *Gryllus campestris*. Later in the year vine plants get larger and the habitat becomes more shadowy. Therefore, a first survey should be conducted in May followed by a second survey in summer as usual.

7 Butterflies

7.1 General considerations

Butterfly monitoring follows a two-step approach (already used by the VielFalter Projekt; Rüdisser et al. 2017) combining a transect sampling with a time area count to best record the butterfly community of each sampling site (Barkmann et al. 2023; Fig. 28). Potentially all flying and resting individuals of butterflies (Lepidoptera: Rhopalocera) are recorded. Sampling comprises four replicated sampling rounds per site to cover both seasonal and weather-related changes in the presence and abundance of species.

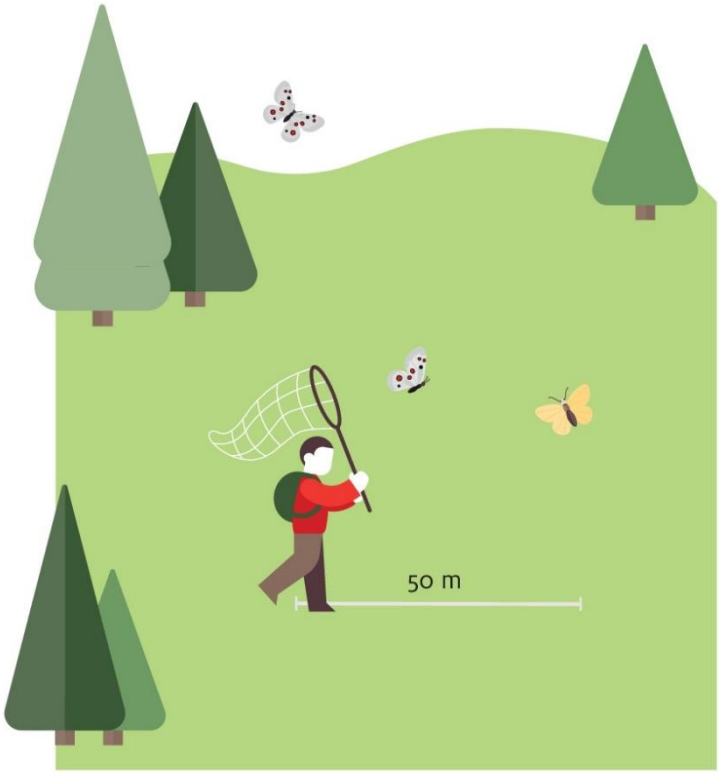


Figure 28: First, the 50m transect is sampled by walking slowly forward and sampling or recording all butterflies observed sitting or passing in an imaginary rectangle of 2.5m per side and 5m in front. This initial sampling should take approximately 5 minutes.

7.2 Preparation for fieldwork and sampling material

For a successful butterfly survey a small number of items are necessary (Fig. 29).

Figure 29: Sampling materials for the butterfly survey: 1. Sweep net; 2. Small binoculars with close focus regulation (optional); 3. Sampling tubes; 4. Field guides for identifying species in the field; 5. Killing glass containing ethyl acetate and envelopes when vouchers are needed; 6. Protocol sheet (Appendix 15.3).

7.3 Weather conditions and sampling period of the year

The weather conditions should be fair since the flight activity of butterflies directly relates to the actual weather. Minimum conditions should be considered as: no rain; temperature not under 13°C; at least 80 % sunshine if the temperature is > 17°C and 100% sunshine between 13°C and 17°C, also no sampling should take place if the temperature exceeds (35°C); wind not exceeding score 3 according to the Beaufort scale.

Furthermore, the timing of sampling is also of major importance and should occur between May and August (September) depending on the habitat (Tab. 17) and between 10:00 am and 17:00 pm.

Table 17: Schematic sampling calendar for butterfly surveys within the BMS. Each round should be ideally completed within one month starting with May but allowing for a potential shift of 15 days before and after depending on the location and the actual sampling progress. For alpine sites three sampling rounds are considered sufficient and should not start before the 15th of June. Green areas: optimal time period for most sites; yellow area: suboptimal time period to be considered if annual phenology is shifted or to fulfill replication.

	May		June		July		August		September	
Colline–submontane										
1. Round										
2. Round										
3. Round										
4. Round										
Montane–subalpine										
1. Round										
2. Round										
3. Round										
4. Round										
Alpine										
1. Round										
2. Round										
3. Round										

7.4 Survey methodology

A 50 meter transect with a central point is located in the center of or in the immediate vicinity to the sampling sites selected for all other taxa. The position of the butterfly transect should consider the steepness of the terrain and ideally be placed perpendicular to the slope to allow for an optimal survey. The transect does not need to be a straight line but can also be adapted to the specific landscape. The extension of the area to be surveyed within the 25-minute time count should be delimited with caution to cover a standardized area size of 1000 m^2 (Fig. 30).

First, the 50 m transect is sampled as described by Pollard & Yates (1994), by walking slowly forward and sampling or recording all butterflies observed sitting or passing in an imaginary rectangle of 2.5 m per side and 5 m in front. This initial sampling should take approximately 5 minutes.

The second approach extends the sampling area for 10 m to the right and left of the transect thus covering a 1000 m^2 area. During this second step a time-area sampling of 25 minutes duration within this area is deployed. In total 30 minutes of total sampling time are used for each single sampling round. For each site four sampling events should take place (in the special case of alpine sites where the emergence period of butterflies is shorter, three sampling in total). Three weeks (at least two weeks) should be left between two different sampling events on the same site.

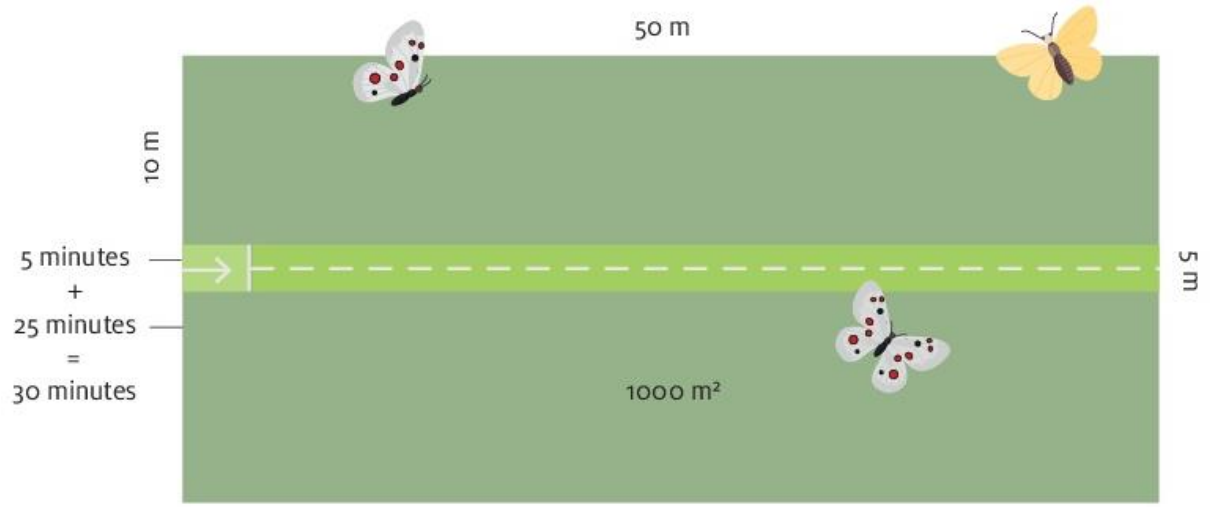


Figure 30: Sampling scheme for the butterfly survey within the Biodiversity Monitoring South Tyrol.

The species and their abundances are noted separately for the transect count and each sampling type should be included in the time-area count. Facultatively, also sex can be noted. Pseudoreplication (i.e., multiple counts of the same individuals such as with territorial males) should be avoided as much as possible and identification of caught individuals might be postponed until after the end of each sampling unit.
All individuals should be identified to species level trying to avoid unidentified counts. Exceptions are 'cryptic' species pairs and occasional individuals that could not be caught (e.g., *Pyrgus* sp. especially *Pyrgus malvae/malvoides; Colias hyale/alfacariensis; Leptidea sinapis/juvernica; Pieris rapae/napi/bryoniae; Pyrgus malvae/malvoides; Aricia agestis/artaxerxes; Melitaea athalia/celadussa/deione/parthenoides*). All species must be identified based on morphology and behavior but not their habitat. Individuals of similar species that have not been caught (e.g., in the case of many individuals or with escaped individuals) are assigned to the species already identified or to the genus. If there are various similar species assign them proportionally to their occurrence. It is highly recommended to take pictures (both of the upper and underside of the wings!) in the field of dubious species identification, rare species etc. For that purpose, it can be very helpful to briefly place the individual butterfly in question into a small transparent zip-lock bag and take photographs of it in dorsal and ventral view, then release the specimen again. Suggested identification literature include (Stettmer et al. 2011; Paolucci 2013; Gergely 2021).

In case of high individual numbers and the need to identify and record all sightings, the time should be stopped and resumed when sampling can be continued. Also, in case of shade by bigger incoming clouds, sampling should be interrupted and resumed only after sunshine is again present for some (e.g., 5) minutes.

7.5 Survey adaptation to some specific habitats

The methodology described above works for all investigated habitat types. There is however, the possibility to change the methodology slightly if the landscape relief does not allow for the installation of a 50 m transect. However, care should be taken to cover the same area size and sampling duration as the standard transect and time count approach.

For specific special projects, the methodology can further be adapted in accordance with experts and the project coordinator.

Finally, depending on the expertise of the expert conducting the survey other day-active Lepidoptera (such as *Zygaena* sp., *Macroglossum stellatarum* and others) can also be noted with the same methodology.

8 Other invertebrate groups, terrestrial sites

8.1 General considerations

Besides specific invertebrate groups (grasshoppers, butterflies) we survey invertebrate communities from selected layers (shrub layer, herb layer, soil surface, litter, soil) to get an overview of the community composition of the most important terrestrial sub-habitats in each habitat type. Suitable methods for each sub-habitat are described below. An overview of the sampling scheme is shown in Fig 31.

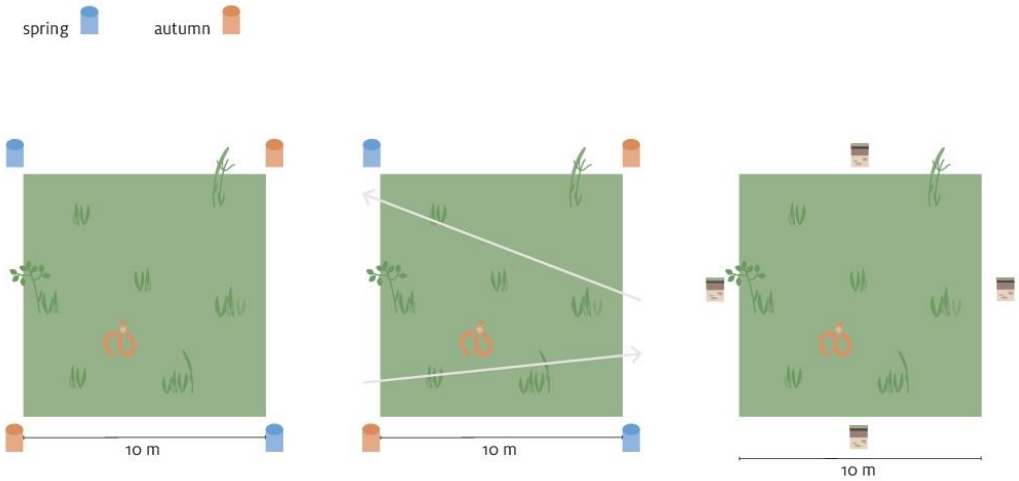


Figure 31: **Schematic representation of the sweep-netting survey (middle)**. The grey arrow represents the transect which we walk along twice each time sweeping 50 times, approx. 20m. The blue cups represent the location of the two pitfall traps in spring and the orange cups the location of the traps in autumn. **Schematic representation of the pitfall trap survey (left)**. The blue cups represent the location of the two pitfall traps in spring and the orange cups the location of the traps in autumn. The pitfall traps are installed diagonally to the two corners of the 10 x 10 m area. If topographical conditions do not permit the installation in a diagonal way, the pitfall traps are installed along a transect of 10 m. **Schematic representation of the soil core survey (right).** The soil blocks represent locations where we take each of the four soil samples. Soil samples are not taken from bogs, lakes, and alpine rocky sites.

8.2 Preparation for fieldwork and sampling material

Before sampling starts a larger number of items have to be prepared (Fig. 32.). Depending on the sampled habitat not all items have to carried to the field.

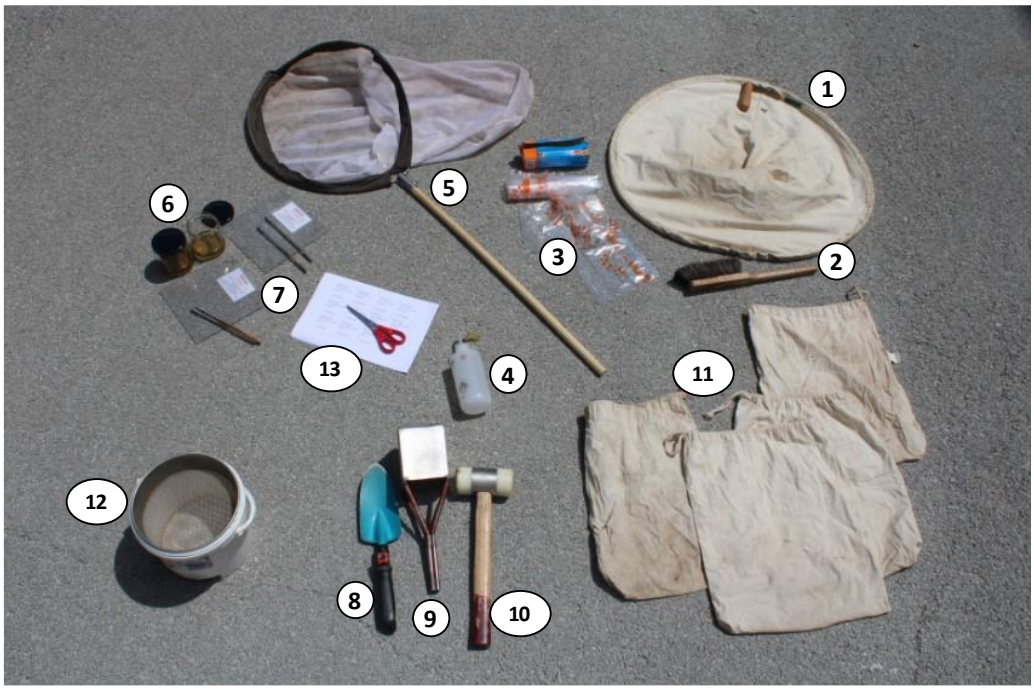


Figure 32: Sampling material for invertebrate sampling: 1. Beating net; 2. Hand broom for beating on branches and collecting the animals in the collection tube; 3. Plastic bags; 4. 75% ethanol; 5. Sweeping net; 6. Pitfall trap (glass jar filled with 200 ml propylene glycol); 7. Polycarbonate Lexan® roof with threaded metal bars; 8. Small spade; 9. Soil stamp; 10. Sledgehammer; 11. Linen bag; 12. Bucket with 2mm sieve; 13. Labels.

8.3 Invertebrates in the shrub layer: beat-netting

Invertebrates living on woody vegetation in forest habitats, apple orchards, vineyards, and settlements are collected by beat-netting following a standard protocol. The survey is conducted once a year (Tab. 18) Per site 10 branches of ideally 10 different trees or shrubs are selected at head level. On each branch we beat five times with a wooden stick (or broom) and collect the dropping invertebrates with the beating net (Fig. 32 nr. 1-4). The net has a collection tube in its center for easy collection. After beating on the 10 branches the collection tube is emptied into a labelled plastic bag which is then filled with 75% ethanol to preserve all invertebrates. Beat netting is not done in vineyards, because there the grape shoots are mostly very young and could therefore be damaged.

Table 18: Sampling periods in which beat-netting is conducted at the respective sampling sites. The green fields represent the time period when the survey is conducted, the grey ones represent those sites at which beat-netting is not done.

Habitat type [BMS-Code]	*May*		*June*		*July*		*August*	
Montane hay meadows [HEM]								
Montane hay meadows [HNM]								
Subalpine hay meadows [HES, HNS]								
Colline pastures [PAC]								
Montane pastures [PAM]								
Subalpine pastures [PAS]								
Alpine meadows [AMC, AMS, AMI]								
Alpine rocky sites [ARC, ARS, ARI]								
Arable land [CFC, CFM]								
Apple orchards [OAC, OAO]								
Vineyards [WYF, WYS]								
Colline/montane forests [FDB, FDM, FDO, FRI, FCP]								
Subalpine forests [FCL]								
Bogs [BOG]								
Lakes [LAK]								
Settlements [SEC, SEV, SEI]								

8.4 Invertebrates in the herb layer: sweep netting

Invertebrates living in the herb layer are collected by sweep netting following a standard protocol. Sweep netting is used on all sites where a herb layer is present. At each site a transect is established either horizontally to the slope or in case of flat ground diagonally from one corner of the 10 x 10 m square to the other. We walk along this transect twice each time sweeping 50 times. If shrubs or small trees are present on the transect (for example as is often the case in pastures and forests), they are also swept. After each run the contents of the sweep net are emptied into a labelled plastic bag which is then filled with 75% ethanol to preserve all invertebrates (Fig. 32 nr. 3-5)

Table 19: Sampling periods in which sweep-netting is conducted at the respective sampling sites. The green fields represent the time period when the survey is conducted, the grey ones represent those sites at which sweep-netting is not done.

Habitat type [BMS-Code]	*May*		*June*		*July*		*August*	
Montane hay meadows [HEM]								
Montane hay meadows [HNM]								
Subalpine hay meadows [HES, HNS]								
Colline pastures [PAC]								
Montane pastures [PAM]								
Subalpine pastures [PAS]								
Alpine meadows [AMC, AMS, AMI]								
Alpine rocky sites [ARC, ARS, ARI]								
Arable land [CFC, CFM]								
Apple orchards [OAC, OAO]								
Vineyards [WYF, WYS]								
Colline/montane forests [FDB, FDM, FDO, FRI, FCP]								
Subalpine forests [FCL]								
Bogs [BOG]								
Lakes [LAK]								
Settlements [SEC, SEV, SEI]								

8.5 Invertebrates on the soil surface: pitfall traps

In order to collect surface-active invertebrate fauna, **pitfall traps** are installed twice a year: once in late spring/early summer and once in late summer/early autumn (Tab. 20). In alpine sites we only conduct one sampling campaign per year (i.e., in the summer months). We use glass jars with a diameter of 7.5 cm and a height of 9 cm as pitfall traps which are dug into the soil (Fig. 32 nr. 6). Care should be taken to ensure that the top edge of the glass is level with the soil surface to avoid creating an obstacle for surface-active invertebrates. The traps are protected from rain and other disturbances by a polycarbonate Lexan® roof (Fig. 32 nr. 7) and filled with 200 ml 75% propylene glycol. Pitfall traps are installed diagonally at the two corners of the 10 x 10 m area (the other two corners being chosen in autumn) and are left in the field for at least 14 days (21 days in alpine sites). In alpine rocky sites and in bogs four pitfall traps are installed at each corner because we do not take soil core samples there (due to a lack of a soil layer). If topography does not permit installing the traps diagonally (settlement sites, lake sites or alpine rocky sites) they are installed along a transect of about 10 m in length. When collecting the glass jars are closed with a lid and transported to the lab where the invertebrates are transferred to 75% ethanol for preservation.

Table 20: Sampling periods in which the pitfall trap survey is conducted at the respective sampling sites. The green fields represent the time period for the spring or summer sampling campaign, the yellow ones represent the autumn campaign. In subalpine and alpine habitats no autumn campaign is conducted.

Habitat type [BMS-Code]	*May*		*June*		*July*		*August*		*Sept.*	
Montane hay meadows, extensive [HEM]										
Montane hay meadows, non-subsidized [HNM]										
Subalpine hay meadows [HES, HNS]										
Colline pastures [PAC]										
Montane pastures [PAM]										
Subalpine pastures [PAS]										
Alpine meadows [AMC, AMS, AMI]										
Alpine rocky sites [ARC, ARS, ARI]										
Arable land [CFC, CFM]										
Apple orchards [OAC, OAO]										
Vineyards [WYF, WYS]										
Colline/montane forests [FDB, FDM, FDO, FRI, FCP]										
Subalpine forests [FCL]										
Bogs [BOG]										
Lakes [LAK]										
Settlements [SEC, SEV, SEI]										

8.6 Invertebrates in the litter layer: litter extraction

In early autumn (between mid-September and mid-October) two litter samples per site are taken from all colline/montane forests (except riparian forests because there is no litter layer) to obtain invertebrates living in the litter layer. The sample plot is chosen so that it is representative for the respective forest type (i.e., type of litter, depth of litter layer). On a 50 x 50 cm square, marked out by a meter bar the entire litter layer (L-F-H organic horizons, > 30% organic carbon) is removed and put into a linen bag. Litter samples are then taken to the laboratory and extracted by heat in a modified Kempson apparatus for 5-7 days (until the material is well dried). Invertebrates are collected in propylene glycol and after extraction transferred to 75% ethanol for preservation.

8.7 Invertebrates below the soil surface: soil extraction

To obtain the soil fauna at each site (except alpine rocky sites, lakes, and bogs), four soil core samples per site are taken during late spring and summer months (Tab. 21). With a shovel a 10 × 10 cm (max. 15 cm deep) soil monolith is cut out and put into a linen bag (Fig. 32 nr. 8-11). The samples are taken close to the border of the four sides of the square (10 x 10 m). In the forests, where the area for the botanical survey is larger (31.6 x 31.6 m), we select an area of 10 x 10 m from the center of the area of the botanical survey and take the samples in the same way as in the other areas. Soil samples are then taken to the laboratory and extracted by heat in a modified Kempson apparatus for 10-12 days (depending on the soil moisture). Invertebrates (macro-invertebrates > 2 mm body length) are collected in propylene glycol and after extraction transferred to 75% ethanol for preservation.

Table 21: Sampling periods in which the soil core survey is conducted at the respective sampling sites. The green fields represent the time period when the survey is conducted, the grey ones represent those sites at which we do not take soil core samples.

Habitat type [BMS-Code]	*May*		*June*		*July*		*August*	
Montane hay meadows, non-subsidized [HNM]								
Montane hay meadows, extensive [HEM]								
Subalpine hay meadows [HES, HNS]								
Colline pastures [PAC]								
Montane pastures [PAM]								
Subalpine pastures [PAS]								
Alpine meadows [AMC, AMS, AMI]								
Alpine rocky sites [ARC, ARS, ARI]								
Arable land [CFC, CFM]								
Apple orchards [OAC, OAO]								
Vineyards [WYF, WYS]								
Colline/montane forests [FDB, FDM, FDO, FRI, FCP]								
Subalpine forests [FCL]								
Bogs [BOG]								
Lakes [LAK]								
Settlements [SEC, SEV, SEI]								

8.8 Identifying specimens to order/family/species level

Samples obtained by beat-netting and sweep netting, collected in pitfall traps or extracted from litter and soil samples are stored in urine cups filled with 75% ethanol until further processing. The samples obtained by beat-netting and sweep netting must first be cleaned of all organic material (leaves, bark, blossoms, fruits). Each sample is emptied into a petri dish and pre-sorted using a stereo microscope (e.g., SMZ- 171, SMZ-161 Motic, Hong Kong, China). Individuals belonging to the same taxon (i.e., order or family, depending on available expertise) are counted, recorded, and put into small glass vials, labelled, filled up with 75% ethanol, and closed with cotton wool. Vials containing the same taxon (i.e., all spiders) are put into glass jars and sent to taxonomic experts for species identification. Only for selected taxonomic groups an identification to the species level is planned (Tab. 22).
Labels include taxon name, site code, date of collection, and a database code.

Table 22: Taxonomic level of identification for taxa obtained by the selected methods.

	Order	Family	Species
Araneae			x
Opiliones			x
Pseudoscorpiones			x
Orthoptera			x
Heteroptera			x
Coleoptera		x	
Coleoptera larvae	x	x	
Diptera	x		
Diptera larvae	x	x	
Auchenorrhyncha	x		
Sternorrhyncha	x		
Formicidae	x		
Hymenoptera	x		
Diplopoda		x	
Chilopoda		x	
Lumbricidae			x
Isopoda	x		
Gastropoda	x		

8.9 Extracted taxa from the different methods used

The methods described above are suitable to sample a range of taxa in the respective layers (trees/shrubs, herbaceous, ground surface, litter, and soil), each layer is inhabited by different key taxa (Tab.23).

Table 23: key taxa of the different methods used.

	Beat-netting	Sweep-netting	Pitfall traps	Litter	Soil core
Araneae (ground-dwelling)			x	x	
Araneae (web-building)	x	x			
Opiliones	x		x	x	
Pseudoscorpiones				x	x
Coleoptera (ground-dwelling)			x	x	
Coleoptera (herb layer)	x	x			
Coleoptera larvae					x
Diptera		x			
Diptera larvae					x
Orthoptera		x			
Heteroptera	x	x			
Auchenorrhyncha (Cicadina)	x	x	x		
Sternorrhyncha (Aphidina)	x	x	x		
Formicidae			x	x	x
Lepidoptera		x			
Hymenoptera		x			
Chilopoda			x	x	x
Diplopoda			x	x	
Isopoda			x	x	
Lumbricidae				x	x
Gastropoda			x		

9 Soil types and soil parameters

9.1 General considerations

In addition to a survey of the various organism groups data on the composition, structure and type of the soil are collected at the majority of the terrestrial sites. Only sites with no soil layer at all (alpine rocky areas, very few forests with only litter layer) and settlements are excluded. Also, for this monitoring part the methods are standardized to allow for repetition.

9.2 Preparation for fieldwork and sampling material

A small set of items (Fig. 33) is necessary in order to assess soil type in the field.

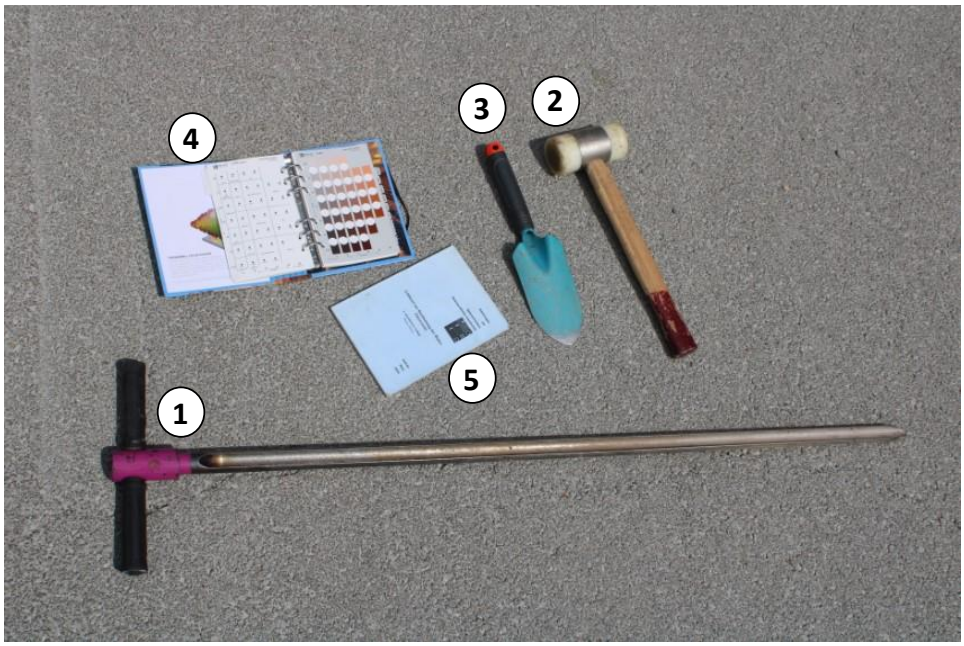


Figure 33: Sampling material for Soil type survey: 1. Pürckhauer soil sampler; 2. Sledgehammer; 3. Small spade; 4. Munsell color charts 5. Austrian soil classification.

9.3 Sampling

At each site the soil type is surveyed using a Pürckhauer soil sampler. It is driven into the soil with a plastic sledgehammer. Soil depth and soil horizons are recorded, and the soil type is determined following the Austrian soil classification (Nestroy et al. 2011). In addition, the soil color of the main horizon is determined using Munsell color charts. This procedure is repeated randomly 3-5 times at each site to account for intra-site variability.

At each site approximately 100 g of soil material is taken with a small spade from a soil depth of 5-15 cm from at least 5 sampling points. These five subsamples are mixed and sieved to 2 mm on-site to obtain a homogenized soil sample for each site.

9.4 Lab work

The sieved soil is dried at air-temperature in the laboratory for at least a week. In case of very moist or highly organic soils, sieving is conducted in the laboratory after drying. At least 400 g of dry weight is required from each site for the following analyses:

- Soil texture: Sand, silt, and clay content are determined using an automated measuring device (Fig. 34; PARIO®, Meter group, Munich, Germany), following manufacturer's guidelines (https://www.metergroup.com/environment/products/pario/)
- Soil organic matter content, Corg, Ntot, macronutrients, pH: 300 g of sieved and dried soil are sent to an external facility for further measurements (Tab. 24).

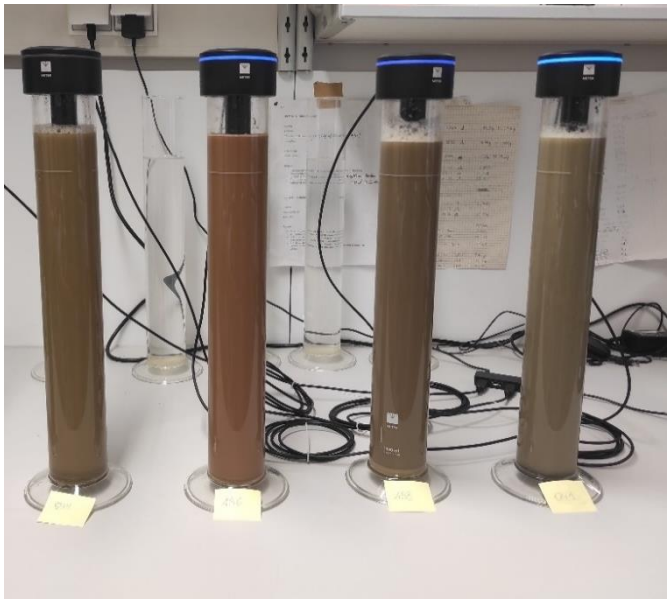


Figure 3314: Ongoing measurement of the soil texture using an automated measuring device (Pario ®, Meter group, Munich Germany).

Table 24: The analyzed parameters in the external facility with the respective norms used for each parameter.

Parameters	Norm
pH	DIN EN 15933:2012
Soil organic matter content (SOM)	ISO 10694:1995 conversion factor 1.72
Carbonate test	5.04mi401 rev.1 2016
Phosphate	ÖNORM L 1087:2012 A.5
Potassium	ÖNORM L 1087:2012 A.5
Magnesium	VDLUFA Methodenbuch I A 6.4.1:2002
Manganese	VDLUFA Methodenbuch I A 6.4.1:2002
Boron	VDLUFA Methodenbuch I A 6.4.1:2002
Zinc	VDLUFA Methodenbuch I A 6.4.1:2002
Copper	VDLUFA Methodenbuch I A 6.4.1:2002
Nitrogen	ÖNORM L1095 (Trockenverbrennung)
Carbon to nitrogen ratio (C/N)	Calculation

10. Habitats and landscape structure, terrestrial sites

Complete habitat mapping is carried out around the centroid of the single sites in a designated square of 200 m in all four cardinal points (habitat-mapping-plot). We used the classification following the Checklist of habitats of South Tyrol (Wallnöfer et al. 2007) that includes natural and anthropogenic habitats.
A botanist conducts the survey directly in the field and maps the homogeneous elements of land with a minimum area of 10 m². We use orthophotos as a baseline to develop cartographic maps. In the case of dry grasslands, wetland habitats or extensive meadows listed in the European Habitats Directive (92/43/EEC) an evaluation of the conservation status is done and a list of all vascular plant species is collected. The methodology is based on guidelines for habitat mapping from the nature department of the Province (Mulser et al. 2019). Vulnerable habitats are mapped entirely also if their spatial expansion is located only partly inside the mapping square plot. Habitats and landscape structures are mapped directly in the field by using QField mobile GIS. Lastly, all data will be stored and shared by a Geographic Information System (see Fig. 35).

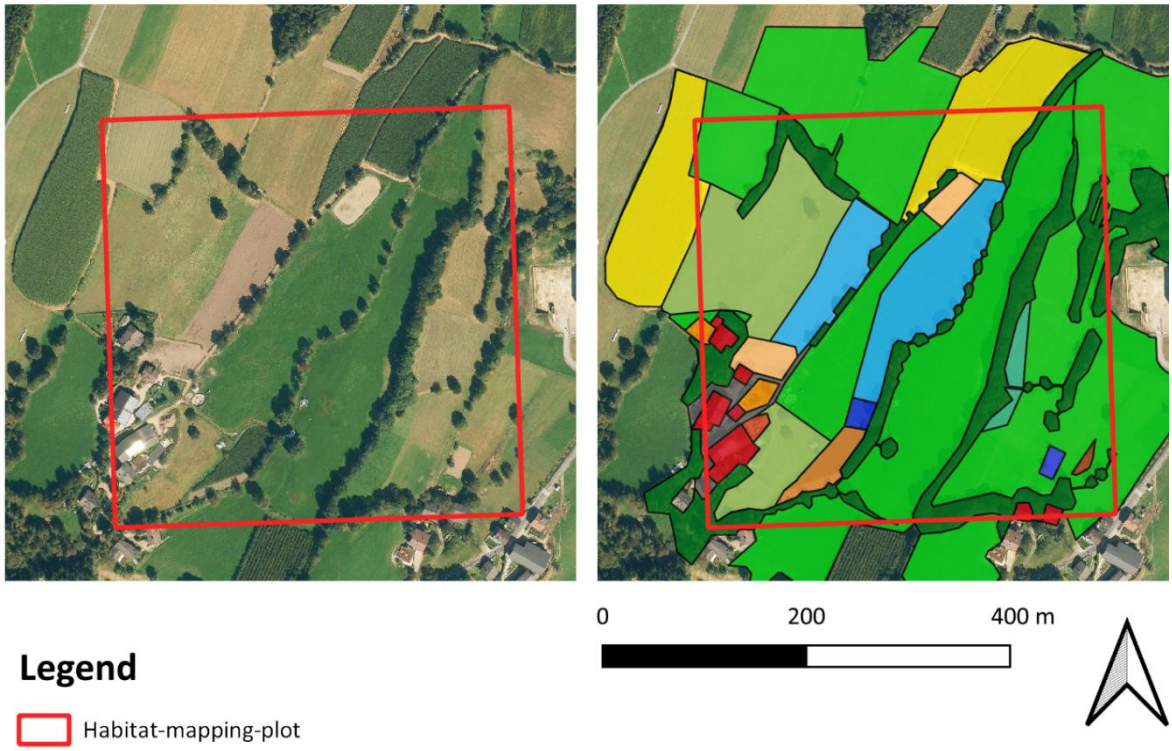


Figure 35: Example of a habitat mapping square plot around a BMS-site. On the left the original and clean orthophoto with the mapping square plot, on the right habitats are mapped according to the checklist of habitats. The names of the single habitat types correspond to the habitat list of Wallnöfer et al. 2007 (only available in German).

11. Management and structural parameters in terrestrial sites

For later analysis we need to assess several variables which mainly refer to specific land use treatments like mowing, grazing, and fertilizing. Additionally, we assess structural parameters like the presence of dry-stone walls or the size of trees. The assessment is conducted within the botanical survey or via consultation with individual farmers. Additional parameters can be assessed also a posteriori by assessing different public GIS databases, e.g., LAFIS (LAFIS 2020) or forest management databases or using historical orthophotos. More detailed information on management and structural parameters is listed in Tab. 25. and Appendix 15.5.

Table 25:List of assessed management categories and structural parameters

Category	description
Id code	Unique code to identify the sampling site.
General Information	General information on the type of management. This class contains some categorical and numerical information including Type of agricultural system adopted by farmers, Grassland categories established by the province government, Habitat type, Abandonment of site management.
Hay cutting and herb treatment	This class collects all information related to "hay cutting and herb treatment". This class contains some categorical and numerical information including: if the site is mown, Frequency at which the site is mown, type of mowing, date of first cut per year, alternate mowing, under-tree treatment type and its frequency, drive-lane treatments type and its frequency
Grazing	This class collects all information related to "grazing". This class includes some categorical and numerical information about if the site is grazed, the season of grazing, a list of animal species grazing the site and approximative grazing intensity
Fertilizing	This class collects all information related to "fertilizing". This class includes some categorical and numerical information including: if the site is fertilized, type of organic or inorganic fertilization used, an index or the exact intensity of fertilization, the frequency of the fertilization type applied and information related to which animal species produces the manure

Irrigation	This class collects all information related to "irrigation". This class includes some categorical and numerical information including: the type of irrigation, the approximate quantity of irrigation or the exact quantity of irrigation
Structure	This class collects all information related to "structure". This class includes some categorical and numerical information on different habitat structures including information hail nets, the color of the hail nets, the training system used, which material is used for posts in vineyard and fruit orchard sites, information relating to whether the site is terraced or dry stoned or if there are any other special structures
Cropping system	This class collects all information related to the "cropping system". This class includes some categorical and numerical information including: the crop rotation system applied at each site, the crop species growing in the season of the survey, the period when the crop is sown, type of tillage conducted at each site and if the cover crops are sown
Forest management	This class collects all information related to "forest management". This class includes some categorical and numerical information including prevalent silvicultural system adopted, type of source where the forest management data are stored, which type of forest management practices are used on the site, the length of time from establishment to harvest, the date of the last harvesting event, evidence of dead wood removal and if the dead wood removed belongs to a specific category
Pesticides	This class collects all information related to "pesticides". This class includes some categorical and numerical information regarding the use of insecticides, acaricides and fungicides

12. Monitoring of running waters

12.1 General considerations

The method for the field surveys was based on the Swiss sampling methodology "Methoden zur Untersuchung und Beurteilung der Fliessgewässer: Makrozoobenthos" (Stucki et al. 2019), and exclusively refers to sampling benthic macroinvertebrates.

A standardized framework concerning "temporal-windows" for sampling events was applied in order to have comparability of the monitoring results through years and elevational gradients (see Tab. 26, taken from Stucki et al. 2019): applying this method even at different elevations, climatic and hydrological conditions as well as macroinvertebrate phenology is always comparable within and between years. In the field we avoided periods with extreme glacier and snow melt or droughts by planning the sampling days on the basis of meteorological conditions up to 14 days before the planned sampling day. Thus, the most stable hydrological and meteorological conditions were chosen for planning the sampling events. Sampling of the 24 "temporal reference" points preferably takes place during the same months every year to allow for further comparability of the results.

Table 26: General time frame for aquatic monitoring surveys based on IBCH_2019 (Stucki et al. 2019). S = Sampling Period; P = Puffer for hydrological exceptions.

Month	January		February		March		April		May		June		July		August	
Time frame/ altitude	01.-15.	16.-31.	01.-15.	16.-28.	01.-15.	16.-31.	01.-15.	16.-30.	01.-15.	16.-31.	01.-15.	16.-30.	01.-15.	16.-31-	01.-15.	16.-31.
200-600 m				P	S	S	P									
601-1000 m						P	S	S	P							
1001-1400m							P	S	S	P						
1401-1800m								P	S	S	P					
>1800 m										P	S	S	P			

12.2 Surveyed area and Sampling grid

The sampling area roughly corresponds to the width of the wetted perimeter x 10. This allowed to estimate the percentage of the different substrate types present in the sampling area (Fig. 36, only substrates covering more than 1% of the sampling area are considered), where 8 plots (i.e., subsamples) were taken.

The different substrate types considered for the sampling were:

1) mobile blocks/boulders: > 250 mm
2) moss: bryophytes
3) hydrophytes: submerged spermatophytes
4) coarse organic matter: leaves, wood, roots
5) big mineral sediments: rocks, pebbles; 250mm > Ø > 25 mm
6) gravel: 25 mm > Ø > 2.5 mm
7) helophytes: amphibious spermatophytes
8) fine, organic sediments: "mud" Ø < 0.1 mm; puddles close to the shore
9) sand and silt: Ø < 2.5 mm fine sediments
10) natural & artificial surfaces: bedrock, stone slabs, walls; block >Ø 250 mm
11) algae: unsuitable habitats like algae, marl or clay

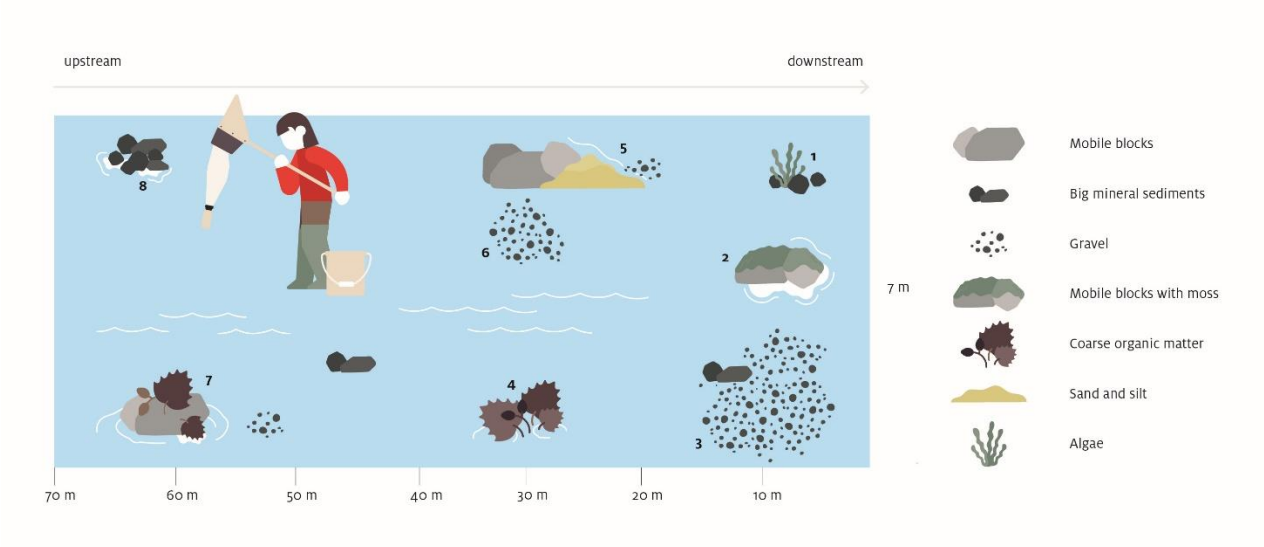


Figure 36: Scheme of a sampled stream stretch with an arbitrary width of the wetted perimeter x 10. In the surveyed stream area 8 subsamples are collected with preferably as many different substrate-stream velocity combinations as possible.

When choosing the eight different subsampling points, priority is given to sampling the maximum number of different substrates (max. eight different substrates), by prioritizing the most habitable substrates for macroinvertebrates (Duan et al. 2008; Stucki et al. 2019). When less than eight different substrates are available current velocity acts as a second level of differentiation among the subsampling points, giving priority to the most-preferred velocity classes of benthic macroinvertebrates within the same substrate type (e.g., Fig. 36: the dominant substrate type gravel is sampled twice – with different velocity classes – since only seven substrate types could be identified for the sampled stream stretch, see also Stucki et al. 2019).

Thus, we sample eight subsamples within a stream/river each one representing a different substrate-stream velocity combination present in the investigated stretch.
The subsamples are collected from downstream to upstream in order to not disturb the habitat of the plots still to be sampled (see Fig. 36).

12.3 Preparation for field work and sampling material

For aquatic surveys several tools and materials are required. A full list of the necessary equipment for the sampling events is presented in Fig. 37.

12.4 Benthic macroinvertebrate sampling

Before the collection of macroinvertebrates, water depth and current velocity, measured with Flowatch - JDC Electronics (Fig. 37, n. 5), were assessed at each subsample point.
To collect representative macroinvertebrate samples in the stretch, the kick-sampling method (mesh-size 500 µm, Fig. 37, n. 6) was applied: the net was placed on the streambed directly downstream of the sampling point. The area in front of the net was then disturbed (approximately quantified in a square of 22 cm per side) dislodging the upper layer of e.g., gravel/cobble and scraping the underlying bed. Larger substrates like big rocks were picked up and rubbed gently by hand to move macroinvertebrates into the net. Large materials accidentally collected in the net were carefully inspected for macroinvertebrates prior to discarding them.

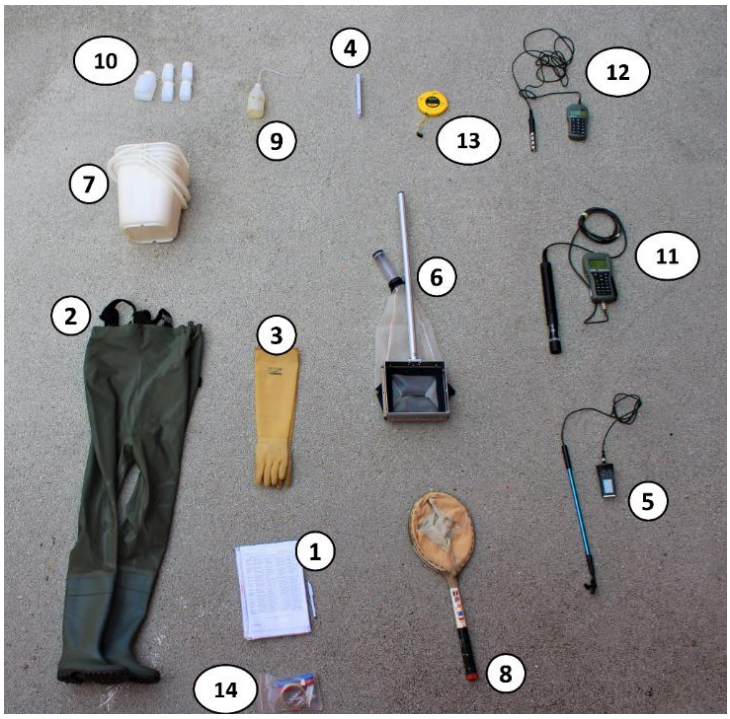


Figure 37: Sampling material for the aquatic survey: 1. Field protocols (macroinvertebrate samples, Pfankuch index, water parameters); 2. Long boots; 3. Gloves; 4. Measuring stick (meters); 5. Flow meter; 6. Kick-net; 7. Buckets; 8. Filtration net (60 µm); 9. Squirt bottle; 10. Sample bottles & ethanol; 11. Portable multi-probe; 12. Portable probe for DO; 13. Measuring tape; 14.); Office bag (pencils, tape, tweezers...)

After rinsing the net the sample was put in a bucket where inorganic material (e.g., gravel, sand) was separated from organic material by repeating elutriation and filtration with a 60 µm net. Subsequently, the filtered sample was put into 90% or 75% ethanol (depending on the amount of organic material present) for further processing in the lab. Each of the 8 sub-samples collected in this way were stored separately for further possible analysis of distinct substrate-stream velocity combinations and the sample bottles were labeled in the field with the following information written with a soft lead pencil on tape (Fig. 38).
All values – water depth, current velocity, substrate coverage, sample & subsample numbers – are documented on an additional "Macroinvertebrate" field protocol (see appendix, chapter 15.4).

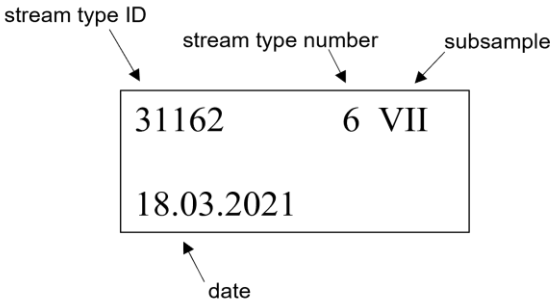


Figure 38: Legend for taped labels of field samples

12.5 Environmental parameters

In addition to the benthic macroinvertebrate samples a set of abiotic parameters was measured in the field. First, the total stream width was measured with a measuring tape (Fig.37, n. 13). In presence of low discharge and/or a limited wetted area (e.g., for streams located in the "carbonate" geologic area) both the streambed (width to bank top) and the wetted perimeter (mid-channel width) were measured.

Table 27: Hach Lange Protocols & reagents used to perform the analysis of dissolved nutrients with a portable spectrophotometer in the lab.

Nutrient	Hach Lange methods & reagents
Total Nitrogen (TN_b)	LCK 138 LATON
Total Phosphorus (P)	LCK 349 Phosphorous total / Phosphate ortho
Orthophosphate (PO_4-P)	LCK 349 Phosphorous total / Phosphate ortho
Ammonium (NH_4)	LCK 304 Ammonium
Nitrate (NO_3-N)	LCK 339 Nitrate
Nitrite (NO_2-N)	LCK 341 Nitrite

For the data collection of aquatic chemical parameters the multiprobe HI9829 (Fig. 37, n. 11) was positioned in the mainstream flow in well mixed water, just upstream of the sampled stream stretch to avoid disturbing bottom sediments. PH-value, ORP (oxygen reduction potential), conductivity, turbidity and temperature were recorded. Additionally, dissolved oxygen was measured with the HI98198 probe
In addition to these parameters, one water sample of 500 mL was collected to perform an analysis of dissolved nutrients. These chemical analyses were performed on the same day of collection using the

portable spectrophotometer Hach DR1900. Tab. 27 reports in detail a reference to the protocols and reagents used to perform these analyses. All the recorded values were documented on the "Water parameters" field protocol (see appendix 15.4).

Additionally, stream geomorphology was evaluated: a series of morphological parameters located between the streambed and the upper banks were evaluated according to the scoring system by Pfankuch, (1975), with the "Pfankuch" field protocol (see appendix 15.4). All the components – upper banks, lower banks & bottom – were assessed by visual evaluation.
The portable probes (Hanna Instruments HI9829 & HI98198) were checked and/or calibrated with reference solutions each month.

12.6 Sampling site documentation

For detailed documentation of each sampling site several pictures were taken both upstream and downstream of the sampling sites, including the riparian zone. Where possible pictures from above (e.g., from a bridge) showing the different substrate types were also taken.

12.7 Lab work

For further processing of the samples the following tools were used in the lab:

- stereomicroscope (up 50x magnification)
- microscope (up to 400x magnification)
- trays for sorting
- ethanol 75%
- tweezers
- reference books for identification
- plastic bottles (100 ml), one per each subsample
- 1.5 ml Eppendorf tubes & species etiquettes for separate storage

Benthic macroinvertebrate samples were sorted – without applying any subsampling - in white trays and organisms were put into 75% clean ethanol. Afterwards taxa were identified to the lowest possible taxonomic level under the microscope and stereomicroscope using appropriate scientific literature (Olmi 1976; Consiglio 1980; Ferrarese and Rossaro 1981; Rossaro 1982; Belfiore 1983; Nicolai 1983; Bauernfeind and Humpesch 2001; Lechthaler and Car 2004; Lechthaler and Stockinger 2005; Lubini et al. 2012). Organisms identified to species level were put into labeled Eppendorf tubes with 75% ethanol. Labels included taxon name, site code and the sampling date. The whole subsample was stored in 100ml bottles also containing the Eppendorf tubes, labeled according to Fig. 39.

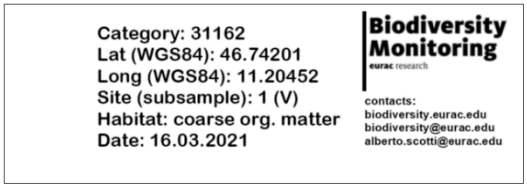


Figure 39: Example of a label for sorted and identified macroinvertebrate subsamples.

13. Protocol for the forest structure survey in terrestrial biodiversity monitoring sites

13.1 Introduction

The present document (see also Appendix 15.6) describes the procedure for establishing and carrying out the survey of forest parameters (e.g., forest structure, composition, microhabitats) in the framework of the Biodiversity Monitoring South Tyrol (hereafter BMS). The forest data collection started in the summer of 2021, while the BMS monitoring program started in 2019. The forest survey data combined with the BMS data will be integrated into a standardised multi-taxon data platform for European forests within the COST Action Bottoms-UP. Additionally, as BMS plots were selected to cover the most representative forest types and elevational belts across the Autonomous Province, such survey contributes to integrating datasets for an up-to-date picture of South Tyrol forest ecosystems in terms of species composition, structural characteristics, health status, and degree of management.

The survey method is based mainly on the fieldwork protocol of the third phase of the Third Italian National Forest Inventory (hereafter INFC15). Most field sampling and criteria explanations were directly taken from the INFC15 field manual (Gasparini et al., 2022). Compared to the INFC15, our survey method was simplified, and the number of variables to collect was reduced to those required for the COST Action Bottoms-UP database and for potential modelling studies (statistical and dynamic) in the context of other projects by Eurac Research. In addition, we collected tree-related microhabitats (Kraus et al. 2016, Larrieu et al. 2018), which were required by the COST Action database but were not included as surveyed variable in the INFC15.

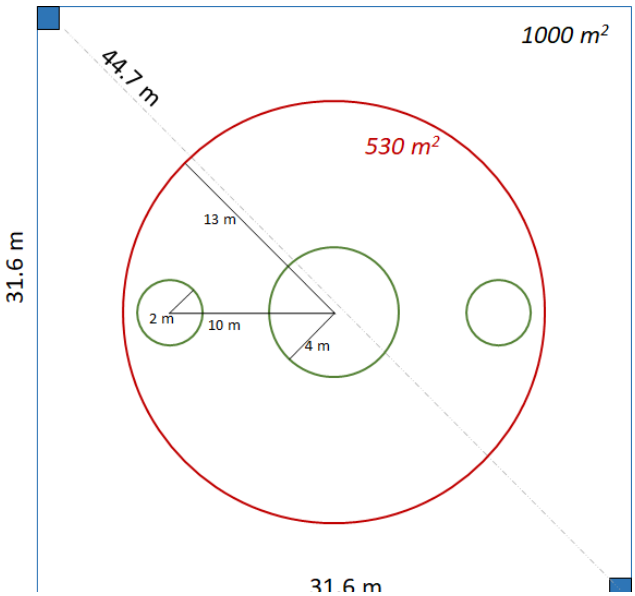


Figure 40: Schematic overview of the 13-m radius forest plot (red, 530 m2) within the squared BMS survey plot (blue, 1000 m2)

13.2 Preparation for the fieldwork and sampling material

Some essential items are necessary for carrying out the sampling of the forest (Fig. 41).

- Vertex clinometer Haglofs (with accessories and transponder), device to measure distances based on ultrasonic sound and angles enabling direct measurements of tree height
- Measuring tapes (x2 or x3)
- Forest callipers (x 2)
- Numbered post-its (or coloured chalk) with pins
- Printed field data sheets and writing rigid tablet
- Tree species identification manual
- Compass

Other materials that should also be carried on in the field:

- Spare batteries (AAA for transponder, CR2 type 3V for Vertex)
- Binoculars (for better assessment of tree microhabitats on crowns and branches)
- 2m lace and peg (for easier marking the radius of the regeneration plots)
- First-aid kit

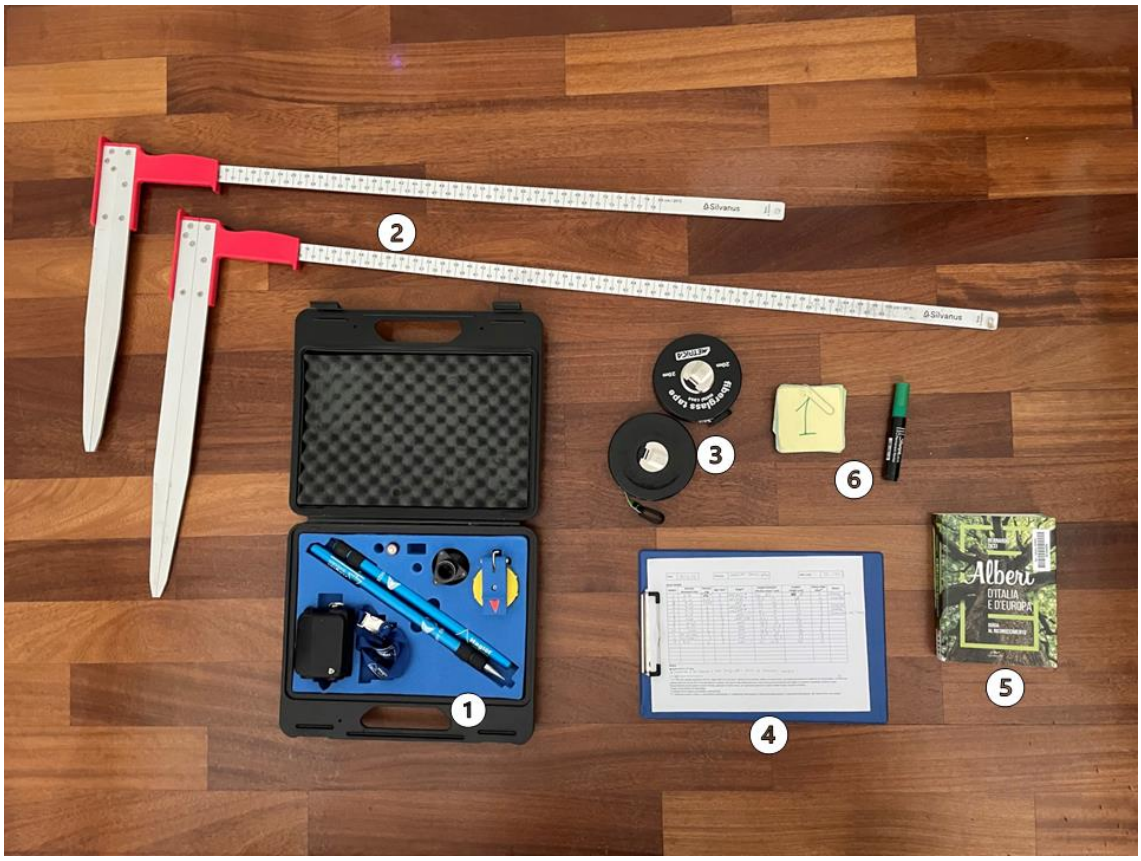


Figure 41: Essential material for fieldwork: 1) Vertex and its accessories; 2) Forest callipers; 3) Measuring tapes; 4) Field data sheets (with writing tablet); 5) Tree species manual; 6) Post-its and various stationery material (pens, markers).

13.3 Sampling methodology

Vertex calibration. Before executing any measurement with the Vertex, it is necessary to calibrate it. This is ideally done in flat terrain (e.g., at the parking lot). To do so, take the Vertex out of its box to let it adapt to the current air temperature for about 10 min. Next, follow manual instructions to calibrate Vertex with a distance of 10 m using the measuring tape in a horizontal l terrain.

Establish the survey plot. Once the approximate location is found following the GPS coordinates, the first thing to do is to identify the exact centre of the BMS plot. Since other researchers marked at least two corners of the square plot during the botanical survey, we would look for their signs (usually red/blue signs on trees/rocks). Photos can help to identify the plot and the element where the blue signs were made. The diagonal between the two corners should measure about 44 meters. Beware that distances for the botanical surveys are not taken with a Vertex; thus, they do not necessarily represent the

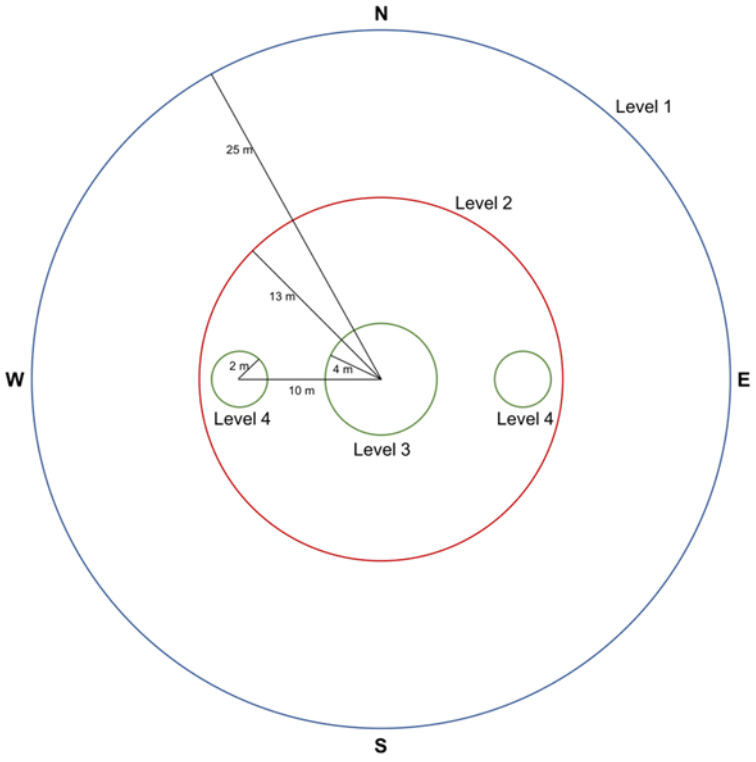


Figure 42: Sampling design of the nested plots (Level 1 to 4).

horizontal distance (i.e., in steep plots, the diagonal may be less than 44m). We then measure the horizontal distance between the two corners of the BMS plot and place the centre of the forest plot in the middle of the diagonal of the squared plot (Fig. 40). Here, we fix the transponder of the Vertex.
Data collection. The overall forest survey duration can last from 2 to 4 hours; this depends on the number of trees in the plots, the morphology and slope, and the number of people carrying the survey. Ideally, the work is executed with 4-5 persons, divided into two groups (Team A, Team B) and following sequential methodological steps.

Team A (optimally 2-3 persons):

- Use pins and post-it (or chalks) to mark and number trees[1] with diam. > 4.5 cm within the inner plot (4m radius around plot centre) and trees with diam. > 9.5 cm within the outer plot (13m radius around plot centre).
- Register tree variables (tree ID, species, azimuth, dbh, distance to centre, vitality, social position; Fig.43).
- Identify 10 selected trees out of all marked trees: the 5 closest to the centre, the 3 largest ones excluding the previous 5 and 2 rare (due to size or species) but alive.
- Measure height, crown depth and crown diameters for the 10 selected trees.
- Collect tree-related microhabitats in each tree while collecting the marks and pins (Fig.44).

Team B (optimally 2 persons; 1 person enough in sites without much deadwood):

- Mark the 9 points to take the canopy photographs and take the photos (if weather conditions allow). It is best if the lens is not changed at each photo, but take the DHPs first and then the DCPs.
- Mark regeneration plots East and West (10m from plot centre, 2m radius) and register regeneration data
- Collect deadwood variables from elements above with diam. > 9.5 cm within the outer plot (13m radius around plot centre). Follow the mark in each tree to approximate the distance from the plot centre and use Vertex to detect deadwood elements close to the 13-m radius. See Fig. 44.
- Register stand-level variables (incl. stand slope and exposition).
- Help in collecting microhabitat and preparing the material.

Figure 43: Measurement of tree diameter (left), measurement of crown diameters on selected trees (right)

[1] Although time-consuming, we found that marking each tree with a numbered post-it or chalk on the bark makes things much easier (e.g., if work need to be stopped and resumed, to select trees for height and crown measurement and to survey the microhabitats at the end).

Figure 4324: Measurement of height and diameter of decomposing stumps (left), microhabitat type with code on individual tree (right).

13.4 Notes about the variables in the nested plots

13.4.1 Stand variables (Level 1 – radius 25m or entire BMS site)

Stand variables are assessed visually on a larger interpretation area (25 m radius, Level 1). Thus they should refer to the entire BMS plot and not only to the 13 m plot in which single-tree records are collected. The surveyors can also report notes and characteristics of the site that can be useful for further analysis ad studies (e.g., the presence of other tree species just outside the survey plot, particular morphology of the enlarged site, signs of recent natural disturbances in the proximity of the plot). The criteria for selecting the qualitative variables are based on the *Field Assessment Survey Protocol and Data Collection* of the INFC15 (Gasparini et al. 2016).

- **Forest category and sub-category:** see Table 5.7 in Gasparini *et al*. (2016). Visually assessed. Please report discrepancies between surveyed category and data from the Province forest planning records.
- **Mixing degree**: as in Table 5.9 in Gasparini *et al*. (2016). Visually assessed.
- **Origin**: as in Table 5.10 in Gasparini *et al*. (2016). Visually assessed.
- **Cultural type**: as in Table 5.11 in Gasparini *et al*. (2016). Visually assessed.
- **Concaveness 1 of the site**: as in Table 5.13 in Gasparini *et al*. (2016).
- **Concaveness 2 of the site:** as in Table 5.14 in Gasparini *et al*. (2016).
- **Morphology 1 of the site**: as in Table 5.15 in Gasparini *et al*. (2016).
- **Morphology 2 of the site:** as in Table 5.16 in Gasparini *et al*. (2016).
- **Slope:** inclination of the stand in degrees, grades and percentage, measured from the highest and lowest point to the centre of the plot and a maximum distance of 25 m.
- **Exposition:** orientation of the plot, measured in degrees from the plot centre towards the valley.

- **Degree of damage**: report the presence of pathologies and/or damages due to natural and anthropic disturbances. See in Table 5.35 in Gasparini *et al*. (2016). Code 0 indicates no damages; in this case, it is not necessary to indicate the causes and intensity (see below).
- **Causes and intensity of damage**: as in Tables 5.36 in Gasparini *et al*. (2016). If the intensity of damage is > 30% of forest cover, please report the intensity level as in Tables 5.37 and 5.38.

13.4.2 Standing Trees (Level 2-3 – radius 13m and 4m)

- **TreeID:** tree identifier (sequential number as identified with post-it or written number).
- **Species:** species code (character). No need to report the full scientific name. For consistency, use two characters for genus and two characters for species. See the examples below. The codes are as follows:
- **LADE** = Larix decidua
- **PIMU** = Pinus mugo
- **PICE** = Pinus cembra
- **PIAB** = Picea abies
- **ABAL** = Abies alba
- **SOAU** = Sorbus aucuparia

- **Azimuth:** angle between the tree and the North direction, measured from the centre of the plot to the tree (degrees).
- **Dbh1/Dbh2:** Two perpendicular tree stem diameters measured at breast height (1.30 m) (cm).
- **Distance:** horizontal distance between the tree and the centre of the plot (m). Measure with Vertex unless the slope between the centre and target tree is zero.
- **Vitality code:** Tree health state. See Table 6.4 in Gasparini *et al*. (2016).
- **Social position code:** Tree dominance in relation to the neighbouring trees. See Table 6.7 in Gasparini *et al*. (2016).
- **Height**: tree height (m). Measured on a selection of trees in plot level 2. See the criteria for selection on page 165 in Gasparini *et al*. (2016).
- **Crown depth:** Height of crown base (m). On the same trees selected for height measurement.
- **Crown diam1/2:** Two perpendicular crown diameters, horizontally measured from crown projection (m). On the same trees selected for height measurement. [NOTE: COST Action template refers to "*Crown rad1-4*" instead, therefore requiring applying some assumptions to generate this variable.]
- **TreMn2:** tree microhabitats groups present on the tree

13.4.3 Dead Wood (Level 2)

- **lydwID:** Deadwood element identifier (number).
- **Species/Botanical class:** Species name o botanical class (conifer/deciduous) if species cannot be identified (character).
- **Stump/Log:** Categorisation of the deadwood element into stump or log (character).
- **Age class:** Age of the deadwood element (<12 months / >12 months).
- **Origin:** Origin of the element, if detectable (character).

- **Largest/Smallest/Median diam. :** Largest and smallest element diameters. In the case of very long elements (big branches, stems), the smallest diameter is measured 2 meters away from the largest (cm).
- **Length/Height:** Length or height of the element (cm/m, depending on size).
- **Decay stage class:** Decay stage classification. See Table 6.8 in Gasparini *et al*. (2016).

13.4.4 Regeneration (Level 4)

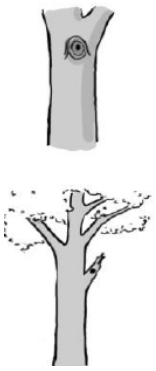
- **SubplotID:** Regeneration subplot identifier (East/West).
- **Species:** Species code (character).
- **Nr. Individuals:** Number of individuals of each size class (number):
    - Height between 50-130 cm
    - Height above 130 cm and diameter at breast height below 2.5 cm
    - Height above 130 cm and diameter at breast height between 2.5 and 4.5 cm
- **Damage:** Damage detected. See Table 5.35 in Gasparini *et al*. (2016).
- **Origin:** Origin of the regeneration. See Table 6.1 in Gasparini *et al*. (2016).

13.4.5 Tree Microhabitats (Level 2)

Structures in living trees such as large dead branches, fungi, lichens, cavities or abnormal structures in the bark are important microhabitats for several forest-dwelling taxa (e.g., beetles, spiders, bats or birds). The more a forest has a high abundance and diversity of such microhabitats, the more valuable it is from an ecological perspective. Some national forest inventories (e.g., Switzerland) started to systematically record microhabitats, while in the Italian NFI, this parameter is not included among the collected records. In our protocol, we record tree-related microhabitats following the European typology of microhabitats (Kraus et al. 2016); it was developed as part of the project Integrate+ by the European Forest Institute. If microhabitats are recorded standardised, the capacity of forests to provide habitat for several taxa can then be compared internationally.

Within the circular plot of 13 m radius (level 2), each tree is inspected for tree-related microhabitat (TreM) presence. Some microhabitats can easily be detected from the ground (e.g., root buttress cavities, dendrotelms); for others, it is recommended to use a binocular (e.g., woodpeckers cavities, dead branches). As an aiding tool in the field, it is recommended to use the smartphone app reporting codes, descriptions and illustrations of the different microhabitat types. Furthermore, the surveyor should be trained regarding the protocol guideline for standardised TreM survey by Larrieu et al. (2018). If possible, it is recommended to take multiple pictures of the different microhabitats, indicating the related tree ID so that structures can be compared between forest plots in case of issues in the identification.

TreMs are recorded with a hierarchical approach. The first represents the general *form* (e.g., CV indicates CAVITIES; seven in total). The second represents the specific *group* (CV1 = Woodpecker cavities; 15 in total). The third is the morphological *characteristics* (CV12 = Woodpecker cavity with diameter between 5-6 cm). When possible, characteristics are indicated. If the identification of morphological characteristics is impossible, then the group is indicated.



CV12	ø = 5 - 6 cm	Cavity entrance about ø = 5 - 6 cm with a larger interior diameter of the cavity. *Picus viridis* builds its cavity into the trunk into the insertion of broken-off branches. The entrance is round in accordance with the round form of the branch insertion. The cavities of the medium-sized woodpeckers such as *Dendrocopos major* are built into decaying branch insertions, dead branches or snags.

Figure 45: Example of tree-related microhabitats from Kraus et al. (2016).

13.5 Canopy photography protocol

This subchapter illustrates the protocol to collect canopy photographs in the BMS forest plots. Ground-based hemispherical and canopy photography have been widely used to describe canophy characteristics and forest light regimes (e.g., forest cover, LAI, canopy openness, gap fraction, and crown porosity) which are relevant for stand structure and multi-taxon diversity analysis (Ohwaki et al., 2017). The protocol has been adapted from Chianucci, 2020.

13.5.1 Material

The necessary material for canopy photography is the following (Figure 46):

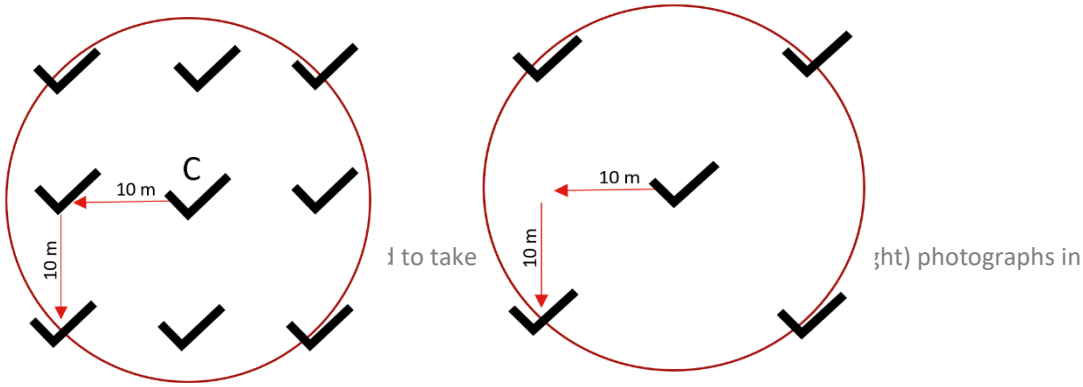
1. Camera (we used a SONY 6000)
2. Fisheye lens
3. Normal lens (50 mm focal)
4. Vertex and transponder (+ measuring tape to calibrate it)
5. Level
6. Tripod

Figure 46: material for canopy photographs; 1: camera; 2: fisheye lens; 3: normal lens; 4: vertex and transponder; 5: level; 6: tripod.

13.5.2 Methodology

We take two types of ground-based photos: Digital Cover Photography (DCP) and Digital Hemispherical Photography (DHP). Both images are taken from the tripod at 1-meter height with the camera levelled and facing upwards. The photos are taken in RAW format, and the exposure depends on the sky conditions and forest type. The optimum exposure would be the one which makes the sky appear as white as possible, providing, in the meantime, the best contrast between canopy and sky (this can be checked in the brightness diagram of the pixels, showing ideally two distant peaks; see Chianucci 2020 for further details).

DCP is a restricted-view method based on collecting images with a narrow lens. It gives canopy attributes for a restricted canopy portion (tree level) (Chianucci, 2020). This method is not very sensitive to light conditions, so it is possible to take photos anytime during the day. We take 9 DCP photos homogenously spaced in the plot as shown in Figure 47. DHP uses a fisheye lens to capture the largest canopy footprint in a single image. It gives direct LAI values and solar radiation at a plot level (Chianucci, 2020). This method is highly susceptible to light conditions, so photos need to be taken close to sunrise/sunset or during overcast days. We take 5 DHP photos homogenously spaced in the plot (Figure 47). These 5 points overlap with those used to take DCP photos.



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15. Appendix

15.1 Protocol for grasshopper survey

Leg.:_____Date:_____Time:_____

BMS Code: _____ Locality: _____

Weather conditions: _____ Temperature: _____°C

Comment: _____

	TRANSECT 14.14 m				
Nr.[1]	**Species/genus/family**	**# adult**	**# subad.**	**# juv.**	**Freq. class[2]**
	EXHAUSTIVE SEARCH (only additional species, not found in transect)				
	Species/genus/family	**Adult y/n**	**Subad. y/n**	**Juv. y/n**	**Freq. class[2]**

[1] Species richness in the plot. Every species should be counted only once. For example, if you have a subadult *Platycleis* sp. and an adult *Platycleis albopunctata*, count it only once, unless it is likely that they are two different species. [2]Frequency classes: I = 1 individual, II = 2-5 ind.; III = 6-10 ind.; IV = 11-20 ind.; V = 21-50 ind.; VI > 50 ind.

15.2 Protocol for ornithological survey

	ID site	Zone
	Date	
	Surveyor	
	Time start	Time end
SKY	Visit n.	

CONDITION:

1	Clear	5	Covered
2	Cloudy for 1/4	6	Light rain
3	Cloudy per 2/4	7	Foggy
4	Cloudy per 3/4	8	Snowing

WIND INTENSITY:

A	Absent	D	Strong (shakes large branches)
B	Weak (moves leaves)	E	Very strong (moves trees)
C	Moderate (shake leaves and branches)		

	SPECIES	N total individuals	BRIDING		
			poss.	prob.	conf
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					

Impossible breeding
0. Species observed but suspected to be still on Migration / Specie not breeding in South Tyrol.

Possible breeding
1. Species observed in breeding season
2. Species observed in breeding season in suitable nesting Habitat
3. Singing male present during its breeding period, hearing singing or drumming as a territorial behavior, seen male lekking
Possible breeding
4. Pair present in suitable habitat in breeding season.
5. Territorial behavior (singing, aggressive behavior with neighbors, etc.) observed in the same territory on two different days 7 or more days apart
6. Mating behavior: lekking, mating or exchange of nourishment between adults
7. Visit of a probable nesting site
8. Agitated behavior or anxiety calls from adults, suggesting probable presence of nest or young nearby.
9. Brood patch on adult examined in the hand, suggesting Incubation
Confirmed breeding
10. Distraction-Display or injury feigning
11. Used Nest or eggshells found (occupied or laid within period of survey)
12. Recently fledged young (nidicolous species) or downy young (nidifugous species). Careful consideration should be given to the likely provenance of any fledged juvenile capable of significant geographical movement. Evidence of dependency on adults (e.g., feeding) is helpful. Be cautious, even if the record comes from suitable habitat
13. Adults entering or leaving nest-site in circumstances indicating Occupied Nest (including high nests or nest holes, the contents of which cannot be seen) or adults seen incubating
14. Adult carrying a fecal sac
15. Adult carrying food for young
16. Eggshells from recently hatched chicks
17. Nest seen with an incubating adult
18. Nest containing eggs or juveniles (seen or heard)

	Species	Inside 100 m	Outside 100 m
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			

CODE: C male singing or displaying some other territorial behavior; **M** male, not singing; **F** female; **J** young birds not fit for flight or just flown in; **U** individual with undetermined age; **A** adult with undetermined sex**; V** high-flying, passing bird. Presence not strictly connected to the site; **R** nesting activity (transporting of: food for the nestling, fecal sacs, nesting materials etc.)

15.3 Protocol for butterfly survey

Sampler ID	Site ID	Date	Location	
Start	End	Temp.	Sun	
Notes	Veg. Height	Wind	Clouds	
		Sun	Flowers	
Species	5 min / 50 m Transekt	25 min 1000m²	Voucher (n)	Notes
Pyrgus				
Hesperia comma				
Thymelicus				
Papilio machao				
Pieris rapae				
Pieri napi				
Pieris				
Leptidea				
Colias crocea				
Goneopterix rhamni				
Lycaena phlaeas				
Polyommatus icarus				
Lysandra bellargus				
Argynnis pahia				
Boloria euphrosyne				
Boloria pales				
Boloria				
Vanessa cardui				
Vanessa atalanta				
Aglais urticae				
Melitaea athalia				
Melitaea				
Parage aegeria				
Lasiommata megera				
Coenonympha pamphilus				
Maniola jurtina				
Melanargia galathea				
Erebia euryale				
Erebia aethiops				
Erebia medusa				
Erebia				

ID-stream : Collector: **Date/Time:**

Current Velocity (in ~ cm/s)		V > 150		150 > V > 75		75 > V > 25		25 > V > 5		V < 5	
Substrate	Coverage (%)										
Mobile Blocks > 250 mm		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Moss (Bryophytes)		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Submerged Spermatophytes (Hydrophytes)		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Coarse Organic Matter (leafs, wood, roots)		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Big Mineral Sediments (rocks, pebbels) 250 mm > Ø > 25 mm		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Gravel 25 mm > Ø > 2,5 mm		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Amphibious Spermatophytes (Helophytes)		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Fine Sediments +/- organic "Mud" Ø < 0.1 mm Puddles		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Sand and Silt Ø < 2,5 mm		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Nat. & Artificial Surfaces (Bedrock, Stone Slabs, Wall) Block > Ø 250 mm		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	
Algae or (if missing) Marl and Clay		d=	n	d=	n	d=	n	d=	n	d=	n
		V=		V=		V=		V=		V=	

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Stream Width [m] :

Water Quality Parameters

ID-stream:……..___ Collector:…….. Date/Time:……..

Parameter	Value	Unit	Threshold
pH-value			
ORP		mV	
conductivity		µs/cm	
turbidity		FNU	
temperature		°C	
DO		% ; mg/l	
total Nitrogen (TN_b)		mg/l	1 - 16 mg/l
total Phosphorus (P)		mg/l	0.15 - 4.50 mg/l
Orthophosphate (PO_4-P)		mg/l	0.05 - 1.50 mg/l
Ammonium (NH_4)		mg/l	0.015 - 2 mg/l
Nitrate (NO_3-N)		mg/l	0.23 - 13.50 mg/l
Nitrite (NO_2-N)		mg/l	0.015 - 0.6 mg/l

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Field protocol for the visual evaluation of the Pfankuch Index and the channel

ID-stream: _____ **Date and time:** _____

Pfankuch D.J. 1975. Stream reach inventory and channel stability evaluation. USDA Forest Service Northern Region, Montana.

UPPER BANKS	EXCELLENT		GOOD		FAIR		POOR	
Landform slope	Bank slope gradient <30%	2	Bank slope gradient 30-40%	4	Bank slope gradient 40-60%	6	Bank slope gradient >60%	8
Mass-wasting (existing or potential)	No evidence of post or any potential for future mass-wasting into channel.	3	Infrequent and/or very small. Mostly healed over. Low future potential.	6	Moderate frequency and size, with some raw spots eroded by water during high flows.	9	Frequent or large, causing sediment OR imminent danger of same.	12
Debris jam potential (floatable objects)	Essentially absent from immediate channel area.	2	Present but mostly small twigs and limbs.	4	Present, volume and size are both increasing,	6	Moderate to heavy amounts, mainly larger sizes.	8
Vegetative bank protection	>90% plant density. Vigor and variety suggests a deep, dense, soil binding root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	6	50-70% density. Lower vigor and species form a somewhat shallow and discontinuous root mass.	9	<50% density plus fewer species and vigor indicate discontinuous and shallow root mass.	12
Channel capacity	Ample for present plus some increases. Peak flows contained. Width to Depth (W/D) ratio <7.	1	Adequate. Overbank flows rare. W/D ratio 8 to 15.	2	Barely contains present peaks. Occasional over-bank floods. W/D ratio 15 to 25.	3	Inadequate. Overbank flows common. W/D ratio >25.	4
LOWER BANKS								
Bank rock content	65% with large, angular boulders 30cm numerous.	2	40 to 65'%, mostly small boulders to cobbles 15-30cm.	4	20 to 401, with most in the 7.5-15cm diameter class.	6	<20% rock fragments of gravel sizes, 2.5-7.5 cm or less.	8
Obstructions (flow deflectors Sediment traps)	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	2	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	4	Moderately frequent, unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.	6	Frequent obstructions and deflectors cause bank erosion. Sediment traps' full channel migration occurring.	8
Undercutting	Little or none evident. Infrequent raw banks <150cm high.	4	Some, intermittently at outcurves and constrictions. Raw banks <30cm.	8	Significant. Cuts 15-30cm high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some >30cm high. Failure of overhangs	16
Deposition	Little or no enlargement of channel or point bars.	4	Some new increase in bar formation, mostly from coarse gravels.	8	Moderate deposition of new gravel and coarse sand on old and some new bars.	12	Extensive deposits of predominantly fine particles. Accelerated	16
STREAM BED								
Rock angularity	Sharp edges and corners, plane surfaces roughened.	1	Rounded corners and edges. Smooth and flat.	2	Corners and edges wel1 rounded in two dimensions.	3	Well rounded in all dimensions.	4
Brightness	Surfaces dull, darkened or stained. Not "bright".	1	Mostly dull, but may have up to 35% bright surfaces.	2	Mixture, 50-50% dull and bright i.e. 35-65%.	3	Predominantly bright, 65%, exposed surfaces.	4
Consolidation or particle packing	Assorted sizes tightly packed and/or overlapping.	2	Moderately packed with some overlapping.	4	Mostly a loose assortment with no apparent overlap.	6	No packing evident. Loose, easily moved.	8
Bottom size distribution & stable	No change in sizes evident. Stable materials 80-100%	4	Distribution shift slight. Stable materials 50-80%.	8	Moderate change in sizes. Stable materials 20-50%	12	Marked change. Stable materials 0-20%	16
Scouring and deposition	<5% of the bottom affected by scouring and deposition.	6	5-30% affected. Scour at constrictions and where steep. Pool deposition.	12	30-50% affected. Deposits and scour at obstructions, constrictions, and bends	18	> 50% of bed in a state of flux or change nearly year-long.	24
Clinging aquatic vegetation (moss and algae)	Abundant, growth largely moss, dark green, perennial. In swift water too.	1	Common. Algal forms in low velocity and pool areas. Moss and swifter waters.	2	Present but spotty, mostly in backwater areas. Seasonal blooms	3	Perennial types scarce or absent. Yellow-green, short term bloom present.	4
COLUMN TOTALS								

Reach score of: <38 = Excellent, 39-76 = Good, 77-114 = Fair, 115+ = Poor

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stability respectively

15.5 Protocol Management and structural parameters in terrestrial sites

	Name	Type	description	details
	site code		**Unique code identifying each entry**	
General Information	**agricultural_system**	**Q**	Type of agricultural system adopted by farmers	The categories are organic; conventional; integrated; biodynamic; other
	category_landscape_subsidy	**Abt.28/LAFIS**	landscape subsidy categories following the definition of the province (Abt.28/Rip28).	The categories are keine Landschaftspflegepraemie, Artenreiche Bergwiesen, Magerrasen und Niedermoorwiesen, Schilffläche, Bestockte artenreiche Wiese, Bestockte Fettwiese, Bestockte Weide, Kastanienhaine und Streuobstwiesen, Moore und Auwälder, Hecken
	abandoned	**E/Q**	Abandonment of site management. Possible exception: Hay meadows which are cut every second year.	Categories are yes (no cultivation in the year of the survey) or no.
	years_abandonment	**E/Q**	Number of years between the abandonment of the site and the description	
	year_cultivation_started		Year of first cultivation of the current crop	
	grassland_classes_province		Grassland categories established by the provincial government	Decision of the province (Beschluss vom 23. März 2016, Nr. 310: Ausbringung von Mist, Gülle und Jauche aus der Viehwirtschaft für Flächen in Natura 2000-Gebieten: Genehmigung und Umsetzung der Managementleitlinien)
	checklist_habitat_ST		List of habitat types occuring in South Tyrol (sensu Wallnoefer et al. 2007)	
	habitat_directive		Habitats occurring in South Tyrol inserted in the European Union Habitats Directive	
	provincial_registry_code		Indicates the code of the cadastral parcels where the site is located	
	comments_general_information		comment on general information	
Hay cutting and herb	**mown**		Indicates if the site is mown	The categories are yes or no
	mowing_frequency		Number of cuts per years. Frequency at which the site is mown	The categories are: 0.33 = mown every third year on a regular base; 0.5 = mown every

				second year on a regular base; 1 = mown once a year; 2 mown twice a year
	mowing_type		Indicates the type of mowing	The categories are: Scythe (Sense); strimmer (Handmähgerät/Fadenmäher); bar mower (Balkenmäher); rotary cutter (Kreiselmäher); motorised, not defined; not defined
	date_of_first_cut_per_year		Indicates the date of first cutting in every year of monitoring	
	alternate_mowing		Indicates whether alternate mowing is applied	Alternate mowing means that not all lanes are mown at the same time, as usually every second lane is mown later. It is applied mainly in vineyards and apple orchards. Sometimes also the edges of hay meadows can be later mown. Categories are yes; no; sometimes; edges of hay meadows mown later
	undertree_treatment		Indicates which undertree treatment is applied	Applies to both vineyards and fruit orchards. In case of vineyards, it refers to the area surrounding the grapevines. Categories are herbicides; hand mowing; mulching; mixed system with herbicides; mixed system without herbicides; inter-row cutting; tillaging
	drivelane_treatment		Indicates which drive-lane treatment is applied	Applies to both vineyards and fruit orchards. Categories are herbicides; hand mowing; mulching; mixed system with herbicides; mixed system with herbicides; tillaging
	frequency_undertree_treatments		Indicates the frequency of undertree treatment	The frequency ranges from 0 to 10. if not known, then "unknown" applies
	frequency_drivelane_treatments		Indicates the frequency of drive-lane treatment	The frequency ranges from 0 to 10. if not known, then "unknown" applies

	comment_herb_treatments		Comments about herb treatment	Frequently farmers will have very individual solutions for herb treatment
Grazing	**grazing**		Indicates if the site is grazed	Grazing applies only to domestic animals. If wild animals graze sometimes, it is not considered as grazing. Categories are yes; no
	grazing_season		Indicates the season of grazing	Categories are spring, summer, autumn, winter, all year round, spring and summer, spring and autumn, summer and autumn
	date_of_first_grazing_per_year		Indicates the date of first grazing in every year of monitoring (day of year)	
	grazing_duration		Indicates the duration of grazing	Information derives from the farmers directly or from expert opinion
	animal_LSU		Table of animals and corresponding LSU value	Bovine animals, pigs, poultry, rabbits, ungulata
	grazing_animal		animal species and corresponding quantity grazing the site	
	grazing_LSU		Conversion of grazing animals into livestock units (LSU)	The reference unit used for the calculation of livestock units (=1 LSU) is the fooder equivalent of one adult dairy cow producing 3 000 kg of milk annually, without additional concentrated foodstuffs.
	pasture_area		Area of relevant pasture (ha)	
	grazing_intensity		Indicates approximate grazing intensity on the site	value between 1 -5
	grazing_load		Load of LSU on the site. Number of LSU / ha / grazing duration (grazing_LSU/pasture_area/grazing_duration)	Grazing intensity (n ha-1 period-1)

	comment_grazing		Comments about grazing	Individual solutions of single farmers might be very different and no category of the above mentioned might apply
Fertilizing	**fertilizing**		Indicates if the site is fertilized	Categories are yes or no
	fertilizing_type_organic		Type of organic fertilization used	Categories are liquid manure p.p. (Gülle), liquid manure p.p. (Jauche), solid manure, liquid and solid manure, organic synthetic fertilizers, no organic fertilizers
	fertilizing_type_anorganic		Type of anorganic fertilization used	Categories are phosphorus, nitrogen, potassium, calcium, sulfur, micronutrients, phosphorus & nitrogen, phosphorus & nitrogen & potassium
	fertilizing_quantity_approx		Indicates the approximate intensity of fertilization	Expert opinion, using information from farmers and/or direct observations in the field. Categories are very high; high; medium; low; no fertilization
	farm_LSU		Indicates the number of livestock per farm (calculated as LSU; German RGVE)	The reference unit used for the calculation of livestock units (=1 LSU) is the fooder equivalent of one adult dairy cow producing 3 000 kg of milk annually, without additional concentrated foodstuffs.
	farm_area		Indicates the intensively used area per farm (ha own plus leased area)	

	fertilizing_calc		Indicates the mean fertilization amount per intensively used area (kg ha^{-1})	The nitrogen input is converted from LSU density via manure livestock unit (DGVE). One livestock unit corresponds to the annual manure production of a cow weighing 600 kg (cf. SCHWEIZERISCHE BUNDESKANZLEI 2017: 6).105 kilograms of nitrogen are calculated for 1 LSU (cf. AMT FÜR UMWELT 2017; BIO SUISSE 2008: 1). Applied accordingly to a LSU (= 500 kg weight), 87.5 kg result in the nitrogen content of a LSU.
	fertilizing_quantity_exact		Indicates the exact intensity of fertilization.	Quantity of nitrogen applied on the site (from 0 to 5000 kg N/ ha / year)
	frequency_organic		Indicates the frequency organic fertilizers are applied	The frequency ranges from 0 to 10. if not known, then "unknown" applies
	frequency_anorganic		Indicates the frequency anorganic fertilizers are applied	The frequency ranges from 0 to 10. if not known, then "unknown" applies
	manure_animal		Indicates which animal species produces the manure	Bovine animals, pigs, poultry, rabbits, ungulates
	comment_fertilizing		Comments about fertilizing	Individual solutions of single farmers might be very different and no category of the above mentioned might apply
Irrigation	**irrigation_form**		Indicates the type of irrigation	Categories are no irrigation; drip irrigation; sprinkler; canal irrigation (Waale)
	irrigation_quantity_approx		Indicates the approximate quantity of irrigation	Categories are low; middle; high
	irrigation_quantity_exact		Indicates the exact quantity of irrigation	From 0 to 5000 l/m²
	comment_irrigation		Comments about irrigation	Individual solutions of single farmers might be very different and no category of the above mentioned might apply

structure	**hail_nets**		Indicates if hail nets are applied on the site	Applies to both vineyards and fruit orchards. Categories are yes; no; partly
	hail_net_color		Indicates the color of the hail nets	Applies to both vineyards and fruit orchards
	training_system		Indicates the training system used on the site	Applies to both vineyards and fruit orchards
	posts_material		Indicates the material used for posts on the site	Applies to both vineyards and fruit orchards
	fruit_tree_size		Indicates the fruit tree size on the site	Applies to both vineyards and fruit orchards
	terraced		Indicates if the site is terraced	The categories are yes or no
	special_structures		Indicates if special structures exist on the site	Categories are dry stone walls, stone wall with cement, mix of dry and cement stone walls, cyclopean walls, cement walls, wall of cement structures, stone cairns, wood piles, hedges, flowering strips, individual tress, ponds, watercourses
	comment_structure		Comments about structures	Not predefined single structures, e.g., power pylons. Also, descriptions of single structures might be inserted.
cropping system	**crop_rotation**		Indicates the crop rotation system applied on the site	Applies to arable land
	crop_species		Indicates the crop species growing in the season of the survey	Applies to arable land
	sowing_period		Indicates the period when the crop is sown	Categories are winter type; spring type; two crops per year
	tillage		Indicates if tillage is conducted on the site	Categories are yes; no; partially
	sowing		Indicates if cover crops (e. g. in orchards or vineyards) are sown	Categories are no sowing, fodder grasses, cereals, grasses and herbs (autochthonous), grasses and herbs (allochthonous), others

	plough_depth		Ploughing depth in m	
	comment_cropping_and_sowing		Comments about cropping system	Individual solutions of single farmers might be very different and no category of the above mentioned might apply
forest management	**forest_management**		Prevalent silvicultural system adopted	
	planning_instrument		Source where forest management data are stored	
	forest_management_practices		Indicates which forest management practices are used for the protection, production and harvesting of timber	
	harvesting_duration		Indicates the length of time from establishment to harvest	
	date of last harvesting event		Indicates the date of the last harvesting event	
	dead_wood_removal		Indicates evidence of dead wood removal and if the dead wood removed belongs to a specific category	
	comment_forest_management		Comments about forest management	
pesticides	**insecticides**		Information regarding the use of insecticides	Categories are chemical-synthetic; organic; insecticides used, type unknown; chemical-synthetic, with neonicotinoids; not applied
	acaricides		Information regarding the use of acaricides	Categories are chemical-synthetic; organic; acaricides used, type unknown; not applied
	fungicides		Information regarding the use of fungicides	Categories are chemical-synthetic; organic; fungicides applied, type unknown; not applied

	amount_insect_acaricid_et_al		Number of applications	
	amount_fungicid		Number of applications	
	comment_pesticides		Comments on pesticide usage	

15.6 Data Sheets for forest surveys

The field data sheets (see below) must be printed and carried in during the fieldwork (ita. "*Schede di rilevamento dei caratteri qualitativi e quantitativi del popolamento*"). These tables are a simplified version of those found in Gasparini *et al.* 2016 (Allegato M).

In a second stage, information on forest management and interventions is usually derived from forest planning data sheets. However, the surveyors can indicate in their notes the approximate type of management regime and silvicultural interventions observed in the plot so that they can be compared with other available information.

Following data collection, each data sheet is scanned, and data are digitised in spreadsheets. Missing variables required for the COST Bottoms UP database (basal area, volume, tree height for all trees, etc.) are subsequently calculated. These calculations are executed with the software R and eventually saved in a consistent data format (.csv) which can be easily converted into Excel spreadsheets containing all surveyed data or only the variables required for the COST Bottoms UP database.

STAND VARIABLES

Date		

Persons	

BMS code	

Forest category and sub-category (Table 5.7)	
Mixing degree (Table 5.9)	
Origin (Table 5.10)	
Cultural type (Table 5.11)	
Development stage (Table 5.12)	
Concaveness 1 (Table 5.13)	
Concaveness 1 (Table 5.14)	
Morphology 1 (Table 5.15)	
Morphology 2 (Table 5.16)	
Slope	
Exposition	
Degree of damage (Table 5.35)	
Causes and intensity of damage (Tables 5.37, 5.38)	

Plot drawing

Date		Persons		BMS code	

STANDING TREES

TreeID	Species	Azimuth[2] (degrees)	Dbh1/ Dbh2 (cm)	Distance (m)	Vitality code[3]	Social position code[4]	Height (m)	Crown depth (m)	Crown diam1/2 (m)	TreMn2[5]

[2] Direction from plot centre to tree
[3] 1: vivo ed integro; 2: vivo con leggere menomazioni; 3: vivo con moderate menomazioni; 4: vivo con forti menomazioni; 5: vivo ma troncato; 6: morto (secco), ma integro; 7:morto e troncato. See Table 6.4 for more details.
[4] 1: posizione dominante; 2: posizione intermedia; 3: dominato o sottoposto. See Table 6.7 for more details.
[5] TreMn2: code of tree microhabitat in each tree as in Kraus et al 2016 Catalogue of tree microhabitats – Reference field list

Date		Persons		BMS code	

STANDING TREES

TreeID	Species	Azimuth[6] (degrees)	Dbh1/ Dbh2 (cm)	Distance (m)	Vitality code[7]	Social position code[8]	Height (m)	Crown depth (m)	Crown diam1/2 (m)	TreMn2

[6] Direction from plot centre to tree

[7] 1: vivo ed integro; 2: vivo con leggere menomazioni; 3: vivo con moderate menomazioni; 4: vivo con forti menomazioni; 5: vivo ma troncato; 6: morto (secco), ma integro; 7:morto e troncato. See Table 6.4 for more details.

[8] 1: posizione dominante; 2: posizione intermedia; 3: dominato o sottoposto. See Table 6.7 for more details.

Date		Persons		BMS code	

DEAD WOOD

lydwID	Species/ Botanical class	Stump/ Log	Age class[9]	Origin[10]	Largest/Smallest /Median diam.[11] (cm)	Length/ Height (cm)	Decay stage class[12]	Notes

[9] <12 mesi (Le ceppaie asportate nell'arco degli ultimi 12 mesi sono in genere di consistenza intatta, di colore chiaro, con eventuale presenza di segatura e/o di essudati); >12 messi (Le ceppaie asportate da più di 12 mesi presentano in genere uno stato di decomposizione più o meno avanzato (la consistenza del legno è in blocchi o polverosa, anche se meno frequentemente potrà apparire ancora intatta), appaiono di colore scuro, con eventuale presenza di corpi fruttiferi fungini, muschio e licheni)

[10] Origin of the element (if detectable)

[11] If different from largest and smallest, otherwise NA

[12] 1: Materiale recente, intatto; 2: parzialmente decomposto; 3: mediamente decomposto; 4: fortemente decomposto; 5: totalmente decomposto. See Table 6.8 for more details.

Date		Persons		BMS code	

REGENERATION

SubplotID (East/West)	Species	Nr. individuals			Damage[13]	Origin[14]
		h 50-130 cm $\varnothing_{1.3\ cm}$ -	h > 130 cm $\varnothing_{1.3\ cm}$ <2.5 cm	h > 130 cm $\varnothing_{1.3\ cm}$ 2.5-4.5 cm		

Notes

[13] 0: Disturbi o danni assenti; 1: Danni da pascolo o selvaggina; 2: Danni da neve o altri fattori meteorici; 3: Danni da altra causa o causa ignota

[14] 1: Naturale (Piantine provenienti da semi dispersi naturalmente o rinnovazione agamica per via naturale (es. polloni radicali)); 2: Artificiale (Piantine provenienti da intervento artificiale (da impianto o da seme)); 3: Agamica (Getti originati dal ricaccio di una ceppaia, a seguito di un taglio).

15.7 Privacy form for landowners or tenant farmers

Informationsschreiben zum Forschungsprojekt Biodiversitätsmonitoring Südtirol sowie zum Datenschutz und Einwilligungserklärung

Sehr geehrte Damen und Herren,

Eurac Research – Forschungszentrum in Bozen führt eine Forschungsstudie im Rahmen des Projektes Biodiversitätsmonitoring Südtirol durch.

Mit gegenständlichem Informationsschreiben möchten wir Sie über die Durchführung des Projektes und den Schutz der personenbezogenen Daten, die im Rahmen der Forschungsstudie erhoben werden, informieren.

Die Teilnahme am Projekt ist freiwillig. Das Team des Projektes bedankt sich für die freundliche Zusammenarbeit und Ihren wertvollen Beitrag. Die Mitarbeiter stehen für weitere Informationen zur Verfügung: Andreas Hilpold (Projektkoordinator und Mitarbeiter des Institutes für Alpine Umwelt Eurac Research), E-Mail: Andreas.Hilpold@eurac.edu, Tel.Nr. +39 0471 055 345

I. Forschungsprojekt

Das Biodiversitätsmonitoring Südtirol ist ein Langzeitprojekt mit dem Ziel, die Entwicklung der gesamten Südtiroler Biodiversität aufzuzeigen. Für weitere Details siehe Broschüre.

Für die Durchführung der Studie, wofür auch personenbezogene Daten verarbeitet werden, sind folgende Phasen vorgesehen:

1) Durchführung von Erhebungen vor Ort

In einer ersten Phase werden vor Ort Erhebungen für die Studie durchgeführt.

Der/die Grundeigentümer/in gewährt bis auf Widerruf den Mitarbeitern von Eurac Research (oder einer von Eurac Research benannten Person) Zugang zum Grundstück, um folgende Tätigkeiten durchzuführen:

- Erhebung Daten zu Tieren und Pflanzen, Bewirtschaftungsdaten, Koordinaten
- Fotodokumentation Fläche;

Es werden folgende personenbezogene Daten des/der Eigentümer/in erhoben:

- Name, Adresse, Kontaktdaten

Diese personenbezogenen Daten werden zu folgenden Zwecken erhoben:

- Name, Adresse und Kontaktdaten: zur Kontaktaufnahme zwecks Anfragen und ggf. Terminvereinbarung bzw. Ankündigung und Übermittlung der Ergebnisse.

Die Durchführung der Erhebungen fügt dem Grundstück keinerlei Beschädigung zu. Sollten wider Erwarten Schäden am Grundstück entstehen, übernimmt Eurac Research die Verantwortung für Schäden, die im Rahmen dieser Studie verursacht werden könnten.

Sämtliche Kosten für die Durchführung der Erhebungen werden ausschließlich von Eurac Research übernommen. Dem Eigentümer steht kein Entgelt zu.

Eurac Research übermittelt die erhobenen Daten dem/der Eigentümer/in.

Die Arbeiten (in der Broschüre erklärt) finden von April bis September statt.

II. Datenschutzaufklärung

Im Sinne der Europäischen Datenschutzgrundverordnung Nr. 2016/679 (DSGVO) sowie der nationalen Gesetzgebung informieren wir Sie über die Verarbeitung Ihrer Daten im Rahmen des Forschungsprojektes. Die Verarbeitung Ihrer personenbezogenen Daten erfolgt von Seiten der Forscher, die in den Tätigkeiten der Forschung einbezogen sind, nach den Prinzipien der Verarbeitung nach Treu und Glauben, Rechtmäßigkeit und Transparenz sowie der Vertraulichkeit.

1. Verantwortlicher der Datenverarbeitung, Auftragsverarbeiter und Data Protection Officer (DPO)

Verantwortlicher der Datenverarbeitung ist Eurac Research, mit Sitz in 39100 Bozen, Drususallee 1, in der Person des Präsidenten und gesetzlichen Vertreters *pro tempore*.

Der DPO kann unter folgender E-Mail-Adresse kontaktiert werden: privacy@eurac.edu

2. Zweck und Rechtsgrundlage für die Verarbeitung

Die von Ihnen dem Verantwortlichen für die Datenverarbeitung übermittelten personenbezogenen Daten werden ausschließlich zu folgenden Zwecken verarbeitet:

- Teilnahme an der Forschungsstudie und somit Verwendung der Daten zu Forschungszwecken, wie unter Punkt I spezifiziert;

Die personenbezogenen Daten, die verarbeitet werden, sind unter Punkt I angegeben. Die erhobenen Daten sind angemessen, relevant und auf das für die Zwecke der Verarbeitung notwendige Maß beschränkt.

Die Rechtsgrundlage der Datenverarbeitung stellt die Einwilligung der betroffenen Person zur Verarbeitung der sie betreffenden personenbezogenen Daten für die genannten Zwecke dar.

3. Empfänger der personenbezogenen Daten und Übermittlung der Daten

Die personenbezogenen Daten können von den Mitarbeitern des Institutes für Alpine Umwelt- Eurac Research, die Zugang zu personenbezogenen Daten haben und dem Verantwortlichen unterstellt sind und die zu diesem Zwecke ernannt und angemessen ausgebildet wurden, verarbeitet werden.

Die Daten können an externe Dienstleister (u.a. Datenanalyse), die zu diesem Zweck als Auftragsverarbeiter ernannt werden, mitgeteilt werden.

Die Veröffentlichung wissenschaftlicher Ergebnisse (z.B. Publikationen von wissenschaftlichen Artikeln) erfolgt ausschließlich in anonymisierter Form bzw. in einer Weise, dass die betroffene Person nicht identifizierbar ist.

Eurac Research veröffentlicht ausschließlich die Koordinaten und Fotos der Fläche in der öffentlich zugänglichen Web App, welche im Rahmen des Projektes erstellt wird. Ein indirekter Rückschluss auf die am gegenständlichen Projekt teilnehmenden Person könnte, aufgrund dieser Daten, möglich sein.

4. Aufbewahrungszeitraum

Die Aufbewahrung der Daten erfolgt nur für die Zeit, die zur Erreichung der angegebenen Zwecke/ und auf jeden Fall zwecks Einhaltung der damit verbundenen gesetzlichen Fristen (Art. 2946 ff. ZGB) unbedingt notwendig ist; danach werden die Daten vernichtet oder anonymisiert.

5. Obligatorische oder freiwillige Mitteilung der Daten und mögliche Folgen der Nichtbereitstellung

Die Mitteilung der personenbezogenen Daten erfolgt auf freiwilliger Basis; eine eventuelle Verweigerung bringt jedoch die Unmöglichkeit der Teilnahme am Projekt mit sich.

6. Bestehen automatisierter Verarbeitungen

Es findet keine Entscheidungsfindung statt, die allein auf die automatisierte Verarbeitung der personenbezogenen Daten basiert.

7. Rechte der betroffenen Person

Die betroffene Person hat das Recht auf Zugang zu den personenbezogenen Daten, auf Berichtigung oder Löschung derselben Daten, das Recht auf Einschränkung der Verarbeitung, das Widerspruchsrecht, das Recht auf Datenübertragung, auf Beschwerde u.a. bei der zuständigen nationalen Aufsichtsbehörde, sofern eine

Verletzung in der Verarbeitung der personenbezogenen Daten vermutet wird, sowie sämtliche andere von den geltenden Gesetzesbestimmungen anerkannten Rechte (Artt. 15 ff. DSGVO). Ist für die Verarbeitung der personenbezogenen Daten eine Zustimmung erteilt worden, so besteht das Recht, diese Zustimmung zu widerrufen.
Die Ausübung der genannten Rechte kann mittels Kontaktaufnahme unter E-Mail privacy@eurac.edu erfolgen.

I. EINWILLIGUNG ZUR TEILNAHME AM PROJEKT

Die/Der Unterfertigte

_____

ERKLÄRT Inhalte und Ziele des oben genannten Projektes verstanden zu haben und **freiwillig am Projekt** teilzunehmen und Eurac Research die in der Folge genannten Rechte einzuräumen ***(bitte Zutreffendes ankreuzen)***:

JA NEIN

☐ ☐ Ich bin damit einverstanden, den Mitarbeitern von Eurac Research Zugang zum eigenen Grundstück zu den genannten Zwecken zu gewähren.

☐ **ERKLÄRT**, dass der Eigentümer in Kenntnis der Teilnahme am Projekt und mit der zur Verfügungstellung der Fläche für die genannte Zwecke einverstanden ist (nur bei gepachteten Flächen anzukreuzen).

Die Zustimmung kann jederzeit ohne Angaben von Gründen schriftlich unter biodiversity@eurac.edu widerrufen werden, was zur Folge hat, dass die Erhebungen nicht fortgeführt werden. Die bereits erhobenen Daten können jedoch zukünftig für die angegebenen Zwecke weiterverwendet werden. Bereits erfolgte Publikationen sowie Datenanalysen in aggregierter Form sind vom Widerruf nicht betroffen.

_____ _____

Ort und Datum Unterschrift

II. EINWILLIGUNG ZUR VERARBEITUNG DER PERSONENBEZOGENEN DATEN

Die/Der Unterfertigte **ERKLÄRT** das Informationsschreiben von Eurac Research gemäß EU-Verordnung 2016/679 und nationaler Gesetzgebung erhalten und verstanden zu haben und **STIMMT** der Datenverarbeitung **ZU**.

_____ _____

Ort und Datum Unterschrift

III. Datenanalyse, Berichte, Veröffentlichungen, WebApp

Eurac Research verwendet die Daten für Analysen und Interpretationen der Daten und wissenschaftliche Publikationen, ggf. fließen die Daten auch in Berichte ein bzw. werden medial kommuniziert.
Im Rahmen der Studie werden die Daten auf eine öffentlich zugänglichen WebApp auf der Seite des Biodiversitätsmonitorings https://biodiversity.eurac.edu/ geladen.
Sämtliche Urheberrechte verbleiben im Eigentum von Eurac Research.
Die Daten werden dem/der Eigentümer/in kostenlos zur Verfügung gestellt.

III. EINVERSTÄNDNISERKLÄRUNG AUDIO-VIDEO-FOTO

Der/die Unterfertigte ermächtigt hiermit Eurac Research (bzw. die von Eurac Research ermächtigten Personen) im Rahmen des Projektes Biodiversitätsmonitoring Südtirol Fotos sowie eventuell Videoaufnahmen des Grundstückes zu machen und diese Aufnahmen in jedweder Form und mit jedem geeigneten Mittel, einschließlich Webseiten, für Veröffentlichungen verwenden, mitteilen, veröffentlichen und/oder verbreiten zu können.
Weiters erteilt der/die Unterfertigte seine/ihre Zustimmung, dass Eurac Research die Bilder und Aufnahmen zu den oben genannten Zwecken kostenlos und für unbeschränkte Zeit verwendet.
Der/Die Unterfertigte bestätigt keinerlei Forderungen bezüglich obiger Erklärungen geltend zu machen und in diesem Zusammenhang auf jegliche Rechte, Ansprüche und Klagen zu verzichten.

JA	**NEIN**	
☐	☐	Ich bin damit einverstanden, dass die erhobenen Daten, einschließlich der Koordinaten und Fotos der Fläche, in der projektbezogenen WebApp veröffentlicht werden und die Nutzung dieser Daten an Dritte übertragen werden können gemäß der Data Policy (siehe Link).

_____ _____

Ort und Datum Unterschrift

15.8 Land use questionnaires for landlords or tenant farmers

15.8.1 Questionnaire for apple or wine farmers

Fragebogen: Obstanlagen, Weinberge

Code und Lokalität der Fläche _____ Name Bewirtschafter*in_____

Name Ausfüller*in (Kürzel) _____ Datum _____

Allgemeine Informationen (Obstanlagen, Weinberge, Äcker)

Landnutzungsart *agricultural_system*	☐ biologisch ☐ konventionell ☐ integriert	☐ biodynamisch ☐ andere _____
Kategorie Landschaftspflegeprämie *category_landscape_subsidy*	☐ Kastanienhaine und Streuobstwiesen	
Ist die Fläche aufgelassen? *abandoned*	☐ ja ☐ nein	
Wie viele Jahre aufgelassen? *years_abandonment*	Anzahl der Jahre seit der Auflassung _____	
Startjahr Kultur *year_cultivation_started*	Jahr _____	
Kommentare *comments_general_information*		

Mahd und Unkrautbekämpfung

Wann mähen Sie das erste Mal? *date_of_first_cut_per_year*	*Monat Anfang (1-10), Mitte (10-20), Ende (20-31)* _____	
Mähen sie alternierend? *alternate_mowing*	☐ ja ☐ nein ☐ manchmal _____	
Wie häufig entfernen Sie die Vegetation im Unterstockbereich? *frequency_undertree_treatments*	Zahl zwischen 0 und 10 angeben_____ ☐ mehr als 10mal ☐ weniger als 3 ☐ 3 und mehr ☐ unbekannt	
Wie entfernen sie die Vegetation im Untersstockbereich? *undertree_treatment*	☐ Herbizide ☐ mit Hand gemäht ☐ Mulchen ☐ gemischt mit Herbiziden	☐ gemischt ohne Herbiziden ☐ inter-row cutter ☐ Fräse ☐ Bürste ☐_____

Wie häufig entfernen Sie die Vegetation in der Fahrspur? *frequency_drivelane_treatments*	Zahl zwischen 0 und 10 angeben ☐ mehr als 10 ☐ weniger als 3 ☐ 3 und mehr ☐ unbekannt	
Fahrspur-Behandlung *drivelane_treatment*	☐ Herbizide ☐ mit Hand gemäht ☐ Mulchen ☐ gemischt mit Herbiziden	☐ gemischt ohne Herbiziden ☐ inter-row cutter ☐ Fräse ☐ Bürste
Kommentare Mähen/Mulchen *comment_herb_treatments*		

Düngung

Wird die Fläche gedüngt? *fertilizing*	☐ ja ☐ nein ☐ manchmal _____	
Wissen Sie die genaue Menge an Kilogramm Stickstoff/Hektar? *fertilizing_quantity_exact*	Kilogramm Stickstoff/ha _____	
Wie hoch schätzen Sie ihre Düngungsintensität ein? *fertilizing_quantity_approx*	☐ 1 = sehr hoch ☐ 2 = hoch ☐ 3 = mittel	☐ 4 = niedrig ☐ 5= keine Düngung
Benutzen Sie organische oder anorganische Dünger?	☐ ja ☐ nein ☐ manchmal _____	
Welche Art von organischen Dünger benutzen Sie? *fertilizing_type_organic*	☐ Gülle ☐ Jauche ☐ Mist ☐ Gülle und Jauche	☐ Mist und Jauche ☐ organische synth. Dünger ☐ keine organischen Dünger
Wie häufig bringen Sie organische Dünger aus? *frequency_organic*	Zahl zwischen 0 und 10 angeben_____ ☐ weniger als 3 mal ☐ 3 mal und mehr ☐ Unbekannt	
Von welchem Tier stammt die Gülle/Mist? *manure_animal*	☐ Rinder ☐ Pferde/Esel (Equidae) ☐ Schafe ☐ Ziegen	☐ Hühner ☐ Schweine ☐ Andere
Welche Art von anorganischen Dünger benutzen Sie? *fertilizing_type_anorganic*	☐ Phosphor ☐ Stickstoff ☐ Kalium ☐ Calcium	☐ Schwefel ☐ Mikronährstoffe ☐ Phosphor und Stickstoff ☐ Phosphor, Stickstoff und Kalium

Wie häufig bringen Sie anorganische Dünger aus? *frequency_anorganic*	Zahl zwischen 0 und 10 angeben_____ ☐ weniger als 3 mal ☐ 3 mal und mehr ☐ unbekannt
GVE Betrieb *Farm LSU*	Anzahl _____
Kommentare zur Düngung *comment_fertilizing*	

Bewässerung

Bewässern Sie die Fläche?	☐ ja ☐ nein ☐ manchmal _____
Wie bewässern Sie die Fläche? *irrigation_form*	☐ Tröpfchenbewässerung ☐ Überkronenberegnung ☐ beides ☐ Waale **hier auch oft gemischt: zum Beispiel für Frostschutz Überkronen, später aber auch Tröpfchen; im Vinschgau oft beides (Überkrone damit Fahrspur nicht austrocknet)*
Wie würden Sie ungefähr die Bewässerungsmenge einschätzen? *irrigation_quantity_approx*	☐ 1 = niedrig ☐ 2 = mittel ☐ 3 = hoch
ungefähre Bewässerungsmenge in Liter/m2 angeben? *irrigation_quantity_exact*	Wasser [l/m2]_____
Kommentare zur Bewässerung *comment_irrigation*	

Struktur

Haben Sie Hagelnetze	☐ Ja	☐ nein	☐ teilweise
Welche Farbe hat das Hagelnetz? *hail_net_color*	☐ Grau	☐ Weiß	☐ schwarz
Wie ist die Anbauform? *training_system*	☐ Spalier (Weinreben) ☐ Kordon (Weinreben) ☐ Pergel (Weinreben)	☐ enge Abstände (Apfelanbau) ☐ weitere Abstände (Apfelanbau) ☐ Einzelne Bäume, weit auseiander (Streuobst)	
Material der Pfosten *posts_material*	☐ Holz ☐ Eisen ☐ Beton	☐ gr. Pfosten Holz, kl. Pfosten Beton	

		☐ gr. Pfosten Beton, kl. Pfosten Eisen ☐ gr. Pfosten Holz, kl. Pfosten Bambus ☐ gr. Pfosten Beton, kl. Pfosten Bambus
Wie groß sind die Apfelbäume? *fruit_tree_size*	☐ sehr klein: < 2.5 m ☐ klein: 2.5 - 3.5 m ☐ mittel: 3.5 - 5 m	☐ groß: 5 - 10 m ☐ sehr groß: > 10 m

Einsaaten und ackerbauliche Nutzung

Werden die Fahrgassen angesäht? *sowing*	☐ keine Ansaat ☐ Futtergräser ☐ Getreidearten	☐ Gräser und Kräuter (autochton) ☐ Gräser und Kräuter (allochton) ☐ Anderes
Wann erfolgt die Ansaat? *sowing_period*	☐ Winter ☐ Frühjahr ☐ Zwei Kulturpflanzen/Jahr	
Bearbeiten Sie den Boden? *tillage*	☐ ja ☐ nein ☐ teilweise	
Kommentare zur Fruchtfolge und Aussaat *comment_cropping_and_sowing*	*Inkl. Beschreibung von zusätzlichem ackerbaulichem Nutzen*	

Pflanzenschutzmittel

Bringen Sie Insektizide aus und welche? *insecticides*	☐ chemisch-synthetische ☐ organische ☐ Insektizide ja, Art ist unbekannt ☐ chemisch-synthetische mit Neonicotinoiden ☐ keine Insektizide
Wie oft bringen Sie Insektizide in der Saison aus? *amount_insecticides*	Anzahl der Applikationen/Saison
Bringen Sie Akarizide aus und welche? *acaricides*	☐ chemisch-synthetische ☐ organische ☐ Akarizide ja, Art ist unbekannt ☐ keine Akarizide
Wie oft bringen Sie Akarizide in der Saison aus? *amount_acaricides*	Anzahl der Applikationen/Saison _____
Bringen Sie Fungizide aus und welche? *fungicides*	☐ chemisch-synthetische ☐ organische ☐ Fungizide ja, Art ist unbekannt ☐ keine Fungizide

Wie oft bringen Sie Fungizide in der Saison aus? *amount_fungicides*	Anzahl der Applikationen/Saison _____
Kommentare zu Pestiziden *comment_pesticides*	

15.8.2 Questionnaire for farmers with meadows or pastures

Fragebogen: Grünland

Code und Lokalität der Fläche _____ Name Bewirtschafter*in_____

Name Ausfüller*in (Kürzel) _____ Datum _____

Allgemeine Informationen (Obstanlagen, Weinberge, Äcker)

Landnutzungsart *agricultural_system*	☐ biologisch ☐ konventionell ☐ integriert	☐ biodynamisch ☐ andere _____
Kategorie Landschaftspflegeprämie *category_landscape_subsidy*	☐ Keine Landschaftspflegeprämie ☐ Artenreiche Bergwiese ☐ Magerrasen und Niedermoorwiesen ☐ Bestockte artenreiche Wiese	☐ Bestockte Fettwiese ☐ Bestockte Weide ☐ Kastanienhaine und Streuobstwiesen
Ist die Fläche aufgelassen? *abandoned*	☐ ja ☐ nein	
Wie viele Jahre aufgelassen? *years_abandonment*	Anzahl der Jahre seit der Auflassung _____	
Startjahr Kultur (bei neu angelegten Wiesen) *year_cultivation_started*	Jahr _____	
Kommentare *comments_general_information*		

Mahd und Unkrautbekämpfung

Wird die Fläche gemäht? *mown*	☐ ja ☐ nein	
Wie häufig mähen Sie? mowing_frequency	☐ 0.33 = alle 3 Jahre ☐ 0.5 = alle 2 Jahre ☐ 1 = einmal/Jahr ☐ 2 = zweimal/Jahr	☐ 3 ☐ 4 ☐ Anders_____
Welches Gerät benutzen Sie? mowing_type	☐Sense ☐Motorsense ☐Balkenmäher	☐Kreiselmäher ☐motorisiert, nicht definiert ☐nicht definiert
Wann mähen Sie das erste Mal? *date_of_first_cut_per_year*	*Monat Anfang (1-10), Mitte (10-20), Ende (20-31)* *_____(_____)*	
Mähen sie alternierend? [wird die ganze Wiese gleichzeitig gemäht] *alternate_mowing*	☐ nein ☐ ein Teil der Wiese früher, einer später ☐ die Ränder der Mähwiesen später gemäht	
Kommentare Mähen *comment_herb_treatments*		
Wird die Fläche beweidet? grazing	☐ ja ☐ nein	

In welcher Jahreszeit wird beweidet? grazing_season	Frühling Sommer Herbst Winter das ganze Jahr Frühjahr und Sommer Frühjahr und Herbst Sommer und Herbst
Wann beginnt die Beweidung? date_of_first_grazing_per_year	**siehe Anhang**
Wie lange dauert die Beweidung? **grazing_duration**	Anzahl in Tage
Art des Weideviehs auf der Fläche grazing_animal	**siehe Anhang**
Anzahl des Weideviehs auf der Fläche	
GVE-Wert für das entsprechende Weidevieh **grazing_LSU**	**siehe Anhang (neben "Art des Weideviehs")**
Weidefläche **pasture_area**	untersuchte Weidefläche in ha
Berechnung der Weideintensität grazing_load	Rechung (selber ausrechnen): grazing_LSU/pasture_area/grazing_duration
Intensität der Beweidung grazing_intensity	1: keine Beweidung 2: niedrige Intensität 3. mittlere Intensität 4: hohe Intensität 5: sehr hohe Intensität
Weidetiere entwurmt?	☐ ja ☐ nein → Womit:_____ _____ Frequenz: _____
Kommentare zur Beweidung comment_grazing	

Düngung

Wird die Fläche gedüngt? *fertilizing*	☐ ja ☐ nein ☐ manchmal _____	
Wissen Sie die genaue Menge an Kilogramm Stickstoff/Hektar? *fertilizing_quantity_exact*	Kilogramm Stickstoff/ha _____	
Wie hoch schätzen Sie ihre Düngungsintensität ein? *fertilizing_quantity_approx*	☐ 1 = sehr hoch ☐ 2 = hoch ☐ 3 = mittel	☐ 4 = niedrig ☐ 5= keine Düngung

Benutzen Sie organische oder anorganische Dünger?	☐ ja ☐ nein ☐ manchmal _____	
Welche Art von organischen Dünger benutzen Sie? *fertilizing_type_organic*	☐ Gülle ☐ Jauche ☐ Mist ☐ Gülle und Jauche	☐ Mist und Jauche ☐ organische synth. Dünger ☐ keine organischen Dünger
Wie häufig bringen Sie organische Dünger aus? *frequency_organic*	Zahl zwischen 0 und 10 angeben_____ ☐ weniger als 3 mal ☐ 3 mal und mehr ☐ Unbekannt	
Welche Art von anorganischen Dünger benutzen Sie? *fertilizing_type_anorganic*	☐ Phosphor ☐ Stickstoff ☐ Kalium ☐ Calcium	☐ Schwefel ☐ Mikronährstoffe ☐ Phosphor und Stickstoff ☐ Phosphor, Stickstoff und Kalium
Wie häufig bringen Sie anorganische Dünger aus? *frequency_anorganic*	Zahl zwischen 0 und 10 angeben_____ ☐ weniger als 3 mal ☐ 3 mal und mehr ☐ unbekannt	
GVE Betrieb *Farm LSU*	Anzahl _____	
Wie groß sind die Flächen, die Sie düngen? farm_area	Gedüngte Fläche in ha	
Wie viel Kilogramm Calcium bringen Sie auf den Hektar aus? fertilizing_calc	Calcium [kg/ha]	
Von welchem Tier stammt die Gülle/Mist? *manure_animal*	☐ Rinder ☐ Pferde/Esel (Equidae) ☐ Schafe ☐ Ziegen	☐ Hühner ☐ Schweine ☐ Andere
Kommentare zur Düngung *comment_fertilizing*		

Bewässerung

Bewässern Sie die Fläche?	☐ ja ☐ nein	☐ manchmal ☐
Wie bewässern Sie die Fläche? *irrigation_form*	☐ Beregner ☐ Waale	
Wie würden Sie ungefähr die Bewässerungsmenge einschätzen? *irrigation_quantity_approx*	☐ 1 = niedrig ☐ 2 = mittel ☐ 3 = hoch	
ungefähre Bewässerungsmenge in Liter/m2 angeben? *irrigation_quantity_exact*	Wasser [l/m2]_____	

Kommentare zur Bewässerung *comment_irrigation*	

Übersaat & Herbizide

Werden die Flächen angesäht? *sowing*	☐ keine Aussaat ☐ Futtergräser (Übersaat!)	☐ Anderes
Setzen sie Herbizide zur Bekämpfung von Problemunkräutern ein (zB Alpen-Ampfer)	☐ Ja ☐ punktuell und selten ☐ regelmäßig	

15.8.3 Questionnaire for farmers of annual crop fields

Fragebogen: Äcker

Code und Lokalität der Fläche _____ Name Bewirtschafter*in_____

Name Ausfüller*in (Kürzel) _____ Datum _____

Allgemeine Informationen (Äcker)

Landnutzungsart *agricultural_system*	☐ biologisch ☐ konventionell ☐ integriert	☐ biodynamisch ☐ andere _____
Ist die Fläche aufgelassen? *abandoned*	☐ ja ☐ nein	
Wie viele Jahre aufgelassen? *years_abandonment*	Anzahl der Jahre seit der Auflassung _____	
Startjahr Kultur *year_cultivation_started*	Jahr _____	
Kommentare *comments_general_information*		

Mahd und Unkrautbekämpfung

Wie häufig im Jahr entfernen Sie Unkräuter im Feld? *frequency_undertree_treatments*	_____
Wie behandeln Sie Unkräuter? *undertree_treatment*	☐ Herbizide ☐ Keine Behandlung
Kommentare Unkrautbekämpfung *comment_herb_treatments*	

Düngung

Wird die Fläche gedüngt? *fertilizing*	☐ ja ☐ nein ☐ manchmal _____	
Wissen Sie die genaue Menge an Kilogramm Stickstoff/Hektar? *fertilizing_quantity_exact*	Kilogramm Stickstoff/ha _____	
Wie hoch schätzen Sie ihre Düngungsintensität ein? *fertilizing_quantity_approx*	☐ 1 = sehr hoch ☐ 2 = hoch ☐ 3 = mittel	☐ 4 = niedrig ☐ 5= keine Düngung
Benutzen Sie organische oder anorganische Dünger?	☐ ja ☐ nein ☐ manchmal _____	

Welche Art von organischen Dünger benutzen Sie? *fertilizing_type_organic*	☐ Gülle ☐ Jauche ☐ Mist ☐ Gülle und Jauche	☐ Mist und Jauche ☐ organische synth. Dünger ☐ keine organischen Dünger
Wie häufig bringen Sie organische Dünger aus? *frequency_organic*	Zahl zwischen 0 und 10 angeben_____ ☐ weniger als 3 mal ☐ 3 mal und mehr ☐ Unbekannt	
Welche Art von anorganischen Dünger benutzen Sie? *fertilizing_type_anorganic*	☐ Phosphor ☐ Stickstoff ☐ Kalium ☐ Calcium	☐ Schwefel ☐ Mikronährstoffe ☐ Phosphor und Stickstoff ☐ Phosphor, Stickstoff und Kalium
Wie häufig bringen Sie anorganische Dünger aus? *frequency_anorganic*	Zahl zwischen 0 und 10 angeben_____ ☐ weniger als 3 mal ☐ 3 mal und mehr ☐ unbekannt	
GVE Betrieb *Farm LSU*	Anzahl _____	
Von welchem Tier stammt die Gülle/Mist? *manure_animal*	☐ Rinder ☐ Pferde/Esel (Equidae) ☐ Schafe ☐ Ziegen	☐ Hühner ☐ Schweine ☐ Andere
Kommentare zur Düngung *comment_fertilizing*		

Bewässerung

Bewässern Sie die Fläche?	☐ ja ☐ nein ☐ manchmal _____
Wie bewässern Sie die Fläche? *irrigation_form*	☐ Tröpfchenbewässerung ☐ Überkronenberegnung ☐ beides ☐ Waale **hier auch oft gemischt: zum Beispiel für Frostschutz Überkronen, später aber auch Tröpfchen; im Vinschgau oft beides (Überkrone damit Fahrspur nicht austrocknet)*
Wie würden Sie ungefähr die Bewässerungsmenge einschätzen? *irrigation_quantity_approx*	☐ 1 = niedrig ☐ 2 = mittel ☐ 3 = hoch
ungefähre Bewässerungsmenge in Liter/m2 angeben? *irrigation_quantity_exact*	Wasser [l/m2]_____
Kommentare zur Bewässerung *comment_irrigation*	

Fruchtfolge (Äcker)

Betreiben Sie Fruchtfolge? *crop_rotation*	☐ keine Fruchtfolge ☐ Zwei Kulturen/Jahr ☐ Zwischenfrucht	☐ Zwei-Felder-System ☐ Drei-Felder-System ☐ Vier-Felder-System
Welche Kulturpflanze bauen Sie an? *crop_species*	☐ verschiedene Getreidearten ☐ Dinkel ☐ Mais ☐ Weizen ☐ Gerste ☐ Roggen ☐ Hafer	☐ Kartoffeln ☐ Gemüse ☐ Hülsenfrüchte ☐ Buchweizen ☐ zunächst Getreide, danach Buchweizen ☐ _____
Wann erfolgt die Aussat? *sowing_period*	☐ Winter ☐ Frühjahr ☐ Zwei Kulturpflanzen/Jahr	
Bearbeiten Sie den Boden? *tillage*	☐ ja ☐ nein ☐ teilweise	
Können Sie mir die Pflugtiefe in [m] angeben? *ploug_depht*	Pflugtiefe in m _____	
Kommentare zur Fruchtfolge und Aussaat *comment_cropping_and_sowing*		

Pflanzenschutzmittel

Bringen Sie Insektizide aus und welche? *insecticides*	☐ chemisch-synthetische ☐ organische ☐ Insektizide ja, Art ist unbekannt ☐ chemisch-synthetische mit Neonicotinoiden ☐ keine Insektizide
Wie oft bringen Sie Insektizide in der Saison aus? *amount_insecticides*	Anzahl der Applikationen/Saison: _____
Bringen Sie Fungizide aus und welche? *fungicides*	☐ chemisch-synthetische ☐ organische ☐ Fungizide ja, Art ist unbekannt ☐ keine Fungizide
Wie oft bringen Sie Fungizide in der Saison aus? *amount_fungicides*	Anzahl der Applikationen/Saison _____
Kommentare zu Pestiziden *comment_pesticides*	