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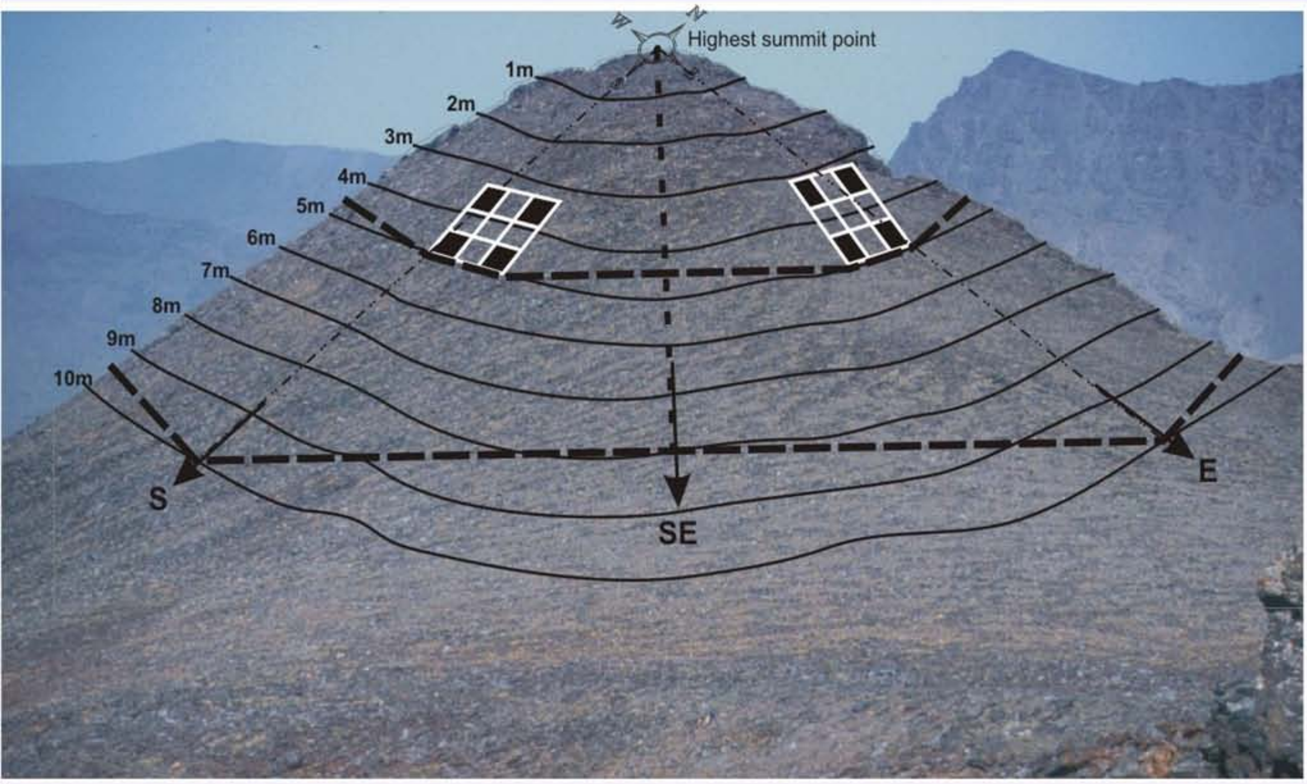
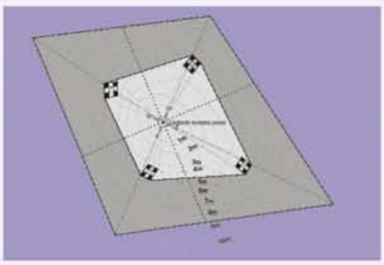
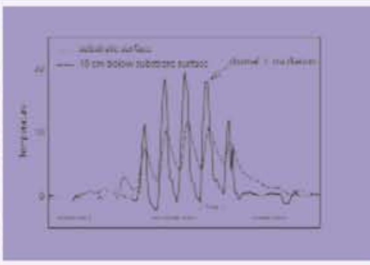
The GLORIA* Field Manual - Multi-Summit Approach

Editors: Harald Pauli, Michael Gottfried, Daniela Hohenwallner, Karl Reiter,
Riccardo Casale and Georg Grabherr



*Global Observation Research Initiative in Alpine Environments – a contribution to the Global Terrestrial Observing System (GTOS)





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The GLORIA Field Manual – Multi-Summit Approach

Summary

Rapid climate change threatens biodiversity – of alpine ecosystems in particular. The EU FP-5 project *GLORIA-EUROPE* has established a long-term monitoring network to study climate change-induced impacts on Europe's mountains. The major forthcoming step of *GLORIA* (the *Global Observation Research Initiative in Alpine Environments*) is the extension from the European to the global level.

This field manual contains the complete guidelines for the site selection, the setup and documentation of permanent plots, the data recording, and for the data management. Thus, the manual shall assure a standardised setup and monitoring procedure which is a crucial requirement for this much-demanded large-scale in-situ observation network on alpine biota.

The *GLORIA** Field Manual

Multi-Summit Approach

*Global Observation Research Initiative in Alpine Environments – a contribution to the Global Terrestrial Observing System (GTOS)

Editors: Harald PAULI, Michael GOTTFRIED, Daniela HOHENWALLNER, Karl REITER & Georg GRABHERR

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CONTENTS

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The preparation of this manual and the first large-scale application was part of the project *GLORIA-EUROPE (EVK2-CT-2000-0056)*, financed by the *EU 5th RTD Framework Programme*. "This project has an enormous potential" was the stimulating statement of the European Commission's officer Alan Cross at the start of the project. Thanks to the good co-operation among all members of the project consortium and with the responsible EC scientific officer Riccardo Casale, *GLORIA-EUROPE* acted as an efficient pilot project towards the global implementation of the long-term observation network.

Preface

GLORIA, the "Global Observation Research Initiative in Alpine Environments", is an initiative towards an international research network to assess climate change impacts on mountain environments. A standardised sampling design, such as *GLORIA*'s *Multi-Summit approach* described here, is required so that data from different mountain regions can be compared.
This paper is the fourth and final version of the field manual of *GLORIA*'s *Multi-Summit approach,* which focuses on monitoring biota and climate on mountain summits of selected target regions. The manual represents the technical description of the approach; it does not include considerations on the analysis of results or on how to report these results to the scientific community and to the public.

Chapters 1 to 6 of the manual outline the rationale for establishing an international observation network for mountain biota. Chapter 7 focuses on selection criteria of mountain ranges and on monitoring sites for such a network. Chapter 8 describes the standardised design and methods, structured into subchapters and working steps outlining the procedure in the field. The working steps are numbered alphabetically (from a to v) and are marked with a grey line down the left side of the text. Chapter 9 provides information about the data input and the data base management. Boxes show additional details or note general considerations concerning a particular method or working step. Terms used in this manual are described in a glossary.

The third version of the manual was the guideline for the first Europe-wide field application in the summers 2001 and 2002, when 18 target regions with a total of 72 summit sites where successfully established. This first large-scale application was part of the project *GLORIA-EUROPE* within the *5th RTD Framework Programme* of the European Union. In addition, *Multi-Summit* sites were already established in Switzerland, Italy, New Zealand, and Peru, and researchers have started with the fieldwork in Australia and in the US Rocky Mountains.
This final version resulted from a thorough discussion during the *GLORIA* workshop on Tulbinger Kogel, Austria, in October 2002, where 40 scientists of the *GLORIA-EUROPE* consortium and participants from Europe and overseas came together to exchange their experiences in the field-application of the *Multi-Summit approach*. For all changes made in this fourth version, it was kept in mind that existing data sets, recorded along the guidelines of the third version, remain compatible to data obtained by future reinvestigations. The main changes are: the previous chapters 6 and 7 were combined into a revised chapter 7, devoted to the site selection; subchapter 8.4.2 was completely revised; in Annex II, the sampling forms changed accordingly, and two new sampling forms were included; the previous content of Annex III was replaced by information on coding for the photo documentation.
For any future application of the *Multi-Summit approach*, use this fourth version of the field manual. Nonetheless, critical comments to this manual are always appreciated, and in any case, see the *GLORIA* web site: www.gloria.ac.at before starting with the field work.
Once again, a kind thank you to all persons who have contributed to the development of the *GLORIA Multi-Summit approach*.

The *GLORIA* co-ordination Vienna, June 2003

1 Introduction

The purpose of the research initiative *GLORIA* (*Global Observation Research Initiative in Alpine Environments*) is to establish a long-term observation network for the comparative study of climate change impacts on mountain biodiversity (GRABHERR et al. 2000a, PAULI et al. 2003).
The Earth's biosphere is currently experiencing and will continue to experience rapid climate change according to the recent assessment report of the *IPCC* (MCCARTHY et al. 2001). The balance of evidence suggests a discernible human influence on the global climate (HOUGHTON et al. 2001). Predictions of atmospheric warming of 1.4 to 5.8 K over the period 1990-2100 (HOUGHTON et al. 2001) may drastically alter existing biosphere patterns. All ecosystems will experience climate change, but ecosystems of the alpine life zone (i.e. the high mountain environments above the treeline) are considered to be particularly sensitive to warming because they are determined by low temperature conditions.
Long-term records provide evidence for an ongoing climate warming in high mountain environments (HAEBERLI et al. 1996; PRICE & BARRY 1997). Direct and indirect (e.g. change of permafrost patterns and of disturbance dynamics) effects of climate change may affect biodiversity and may lead to the extinction of a variety of species. How severe such "extinction scenarios" will be can only be documented by long-term in situ monitoring. In contrast to meteorology and glaciology, however, almost no long-term observations exist for detecting the impacts of climate change on alpine ecosystems. Among the few exceptions are old records from summit habitats of the Alps dating back to the 19th century. Re-surveying of these historic summit sites showed that vascular plants have been establishing at higher altitudes than recorded earlier (GRABHERR et al. 1994, 2001). Thus, it is assumed that an upward migration of plants, induced by recent climate warming, is an already ongoing process. Recent meta-analyses and literature reviews provided ample evidence of ecological impacts of recent climate change, from low-temperature determined terrestrial to tropical marine environments (WALTHER et al. 2002, PARMESAN & YOHE 2003, ROOT et al. 2003).
The challenge of *GLORIA* is to establish a long-term observation network that uses a standardised monitoring protocol in all major mountain systems on Earth. This is in line with international research demands, e.g. the *Mountain Research Initiative* (*MRI*) of *IGBP* (BECKER & BUGMANN 1997, 1999) and the *Global Terrestrial Observation System* (*GTOS*). *GLORIA* is being conducted in close co-operation with the *Global Mountain Biodiversity Assessment* (*GMBA*) of *DIVERSITAS* (KÖRNER & SPEHN 1999).
GLORIA focuses on the alpine life zone (or high mountain area), which is defined here as the area above the low-temperature determined treeline and includes the treeline ecotone, the alpine, and nival elevation zones. The alpine life zone represents the only terrestrial biogeographic unit with a global distribution (KÖRNER 1999). In many countries, high mountain vegetation experiences less pronounced or no direct human impacts compared with lower altitudes. For these reasons, the alpine life zone provides a unique opportunity for comparative climate impact monitoring.
This ***Multi-Summit*** **field manual** provides the guidelines for a standardised field application of the basic *GLORIA* monitoring method. It was designed to be universally applicable in the world-wide range of alpine environments from polar to tropical latitudes. In Europe, *Multi-Summit* sites have already been established in 18 mountain regions throughout the continent by the project *GLORIA-EUROPE* within the *5th RTD-Framework Programme* of the European Union.

2 Objectives and aims

The aim of *GLORIA*'s *Multi-Summit approach* is to establish a long-term observation network to obtain standardised data on alpine biodiversity and vegetation patterns on a global scale. Its purpose is to assess risks of biodiversity losses and the vulnerability of high mountain ecosystems under climate change pressures.
In-situ observations on the species level appear to be crucial for this purpose, because plant communities will not respond to climate warming as a whole, but single species will respond in different ways (AMMANN 1995, GRABHERR et al. 1995, GOTTFRIED et al. 1998). What is too warm for one species may still be appropriate for an other, or where one species may respond by migration an other one may have restricted possibilities to move to new habitats. Thus, species migration driven by climate warming can form new assemblages at the current sites and at new sites. Such differential movements of species could result in a disruption of the connectedness among many species in current ecosystems (ROOT et al.

2003), and may be accompanied by significant biodiversity losses and by changes in ecosystem functioning. KÖRNER (2002) pointed out that one of the benefits of biological richness is that it insures against "system failure". Intact vegetation provides safety, particularly in mountain environments, where slopes are only as stable and safe as the integrity and stability of their vegetation. Functional redundancy among the species of an ecosystem may not play an important role for long periods of time, but drastic changes of the abiotic constraints can cause it to become the life-preserver that sustain ecosystem functioning on fragile mountain slopes.

Therefore, the basic attempt of *GLORIA* – the *Multi-Summit approach* – aims to:

(a) provide standardised, quantitative data on the altitudinal differences in species richness, species composition, vegetation cover, on the soil temperature and on the snow cover period in mountain systems world-wide.

(b) assess the potential risks for biodiversity losses due to climate change by comparing the current distribution patterns of species, vegetation, and environmental factors along vertical and horizontal (biogeographical) gradients.

(c) provide a baseline for the long-term monitoring and observation of species and vegetation to detect climate-induced changes of vegetation cover, species composition and species migration (at observation intervals of 5 to 10 years or even longer, if appropriate).

(d) quantify the temporal changes of biodiversity and vegetation patterns for providing a substantial input to data-based scenarios on risks for biodiversity losses and on risks for ecosystem instability.

3 Stating the role of *GLORIA*

The role of *GLORIA* is to establish and to maintain an effective and globally applicable network for the in-situ observation of terrestrial species communities facing climate change. Alpine ecosystems fulfil the requirements of such a network, because they (1) occur on all continents and in all major life zones on Earth, (2) are perceived as sensitive to climate change, and (3) are comparable on a world-wide scale.

***GLORIA* takes advantage of the indicative value of sensitive alpine organisms for the documentation of the ecological implications of climate change. The effective use of such indicators depends on ground-based observations and cannot be substituted by space-borne investigations.**

Comparability, simplicity and economy were the main considerations in designing the *Multi-Summit approach* for an effective large-scale network. The low-instrument and low-cost approach, together with the short time required in the field makes the method workable even in expedition conditions.

Therefore, field experiments, extensive phenological observations, and costly sampling procedures have to be excluded from the basic approach. Randomised sampling strategies and large numbers of replicates would be useful from a statistical point of view, but they are not feasible in high mountain ecosystems in most cases.

Over the longer term, and as a supplement to this basic approach, other designs such as the *Single-Mountain approach* (PAULI et al. 1999) and experimental designs may also be applied at *GLORIA* master sites (see Box 3.1).

The main focus of the basic approach lies on biodiversity and on vegetation patterns. Changes in species richness may be detectable at time-scales of 5 to 20 years, whereas clear signals for changes of vegetation cover and structure may become obvious over a longer period (e.g. 20 to >50 years).

The strength of *GLORIA*'s *Multi-Summit approach* will be the large number of reference sites, arranged along the fundamental climatic gradients in both the vertical and the biogeographical dimensions. The establishment of such a multi-site network is a challenge that can only be met by a world-wide community of committed ecologists. It wholly depends on researchers who are willing to establish the foundations for a long-term programme, which will yield results for future generations. Maintaining the structures required for an active long-term observation

network will also depend on an effective co-ordination, on a close co-operation with governmental and inter-governmental authorities and with NGOs, and on the transparency to the public.

Box 3.1: *GLORIA* master sites and **additional indicators.** Master sites are planned to carry out scientific investigations which cannot be included in the *Multi-Summit approach*, but which support the interpretation of the summit observations. Such master sites will be based on existing research capacities and infrastructures. The research activities may include an extended monitoring (e.g. by using other organism groups with high indicator value such as bryophytes, lichens, selected arthropod groups, nematodes, in addition to vascular plants), experimental and modelling approaches. Targeted studies on , e.g., primary productivity, microbial activity of soils, plant phenology and growth parameters, plant propagation, grazing impacts, precipitation patterns, permafrost patterns and on nitrogen depositions may be of interest for the interpretation of changes in biodiversity and vegetation patterns. *GLORIA* aims to provide the stimulus and the scientific framework for researchers to make the effort of establishing a high mountain master site.
Some of the additional indicators such as bryophytes and lichens identified to the species level, or nematodes, may even be included in the *Multi-Summit approach* on an optional basis. Such optional activities (*OPA*s) are not described here in detail, but are planned to be presented at the *GLORIA* web site: www.gloria.ac.at. For cryptogam species see also Box 8.6.

4 Why to focus on high mountain environments ?

High mountains are defined as mountains extending beyond the natural high-elevation and low-temperature determined treeline (or its substitutes). In general, high mountain landscapes are shaped by glaciers (glaciation was present at least in the Pleistocene), and frost is an important factor for pedogenesis and soil structure (compare TROLL 1966).

The alpine life zone or high mountain biome (or its local variants, e.g., oro-mediterranean, afro-alpine, high-andean, páramo, puna) is particularly appropriate for a large-scale network to determine the effects of global processes such as climate change, for the following reasons:

→ The high mountain biome is unique in occurring at all latitudes – it is distributed over all life zones or zonobiomes (sensu WALTER 1985). Therefore, it is the only terrestrial biome where climate-induced changes along all fundamental climatic gradients (in altitude, latitude, and in longitude) can be compared.

→ Mountain regions show steep ecological gradients, resulting from the compression of thermal life zones. Hence, mountains are hot spots of organismic diversity (BARTHLOTT et al. 1996), often with a high degree of endemism (e.g. QUÉZEL 1953; HEDBERG 1969; PAWLOWSKI 1970; GRABHERR et al. 2000b). The potential losses caused by climate change are therefore high.

→ The presence of narrow ecotones is a key aspect of mountains. This makes a boundary shift readily recognisable.

→ High mountain ecosystems are comparatively simple, at least in the upper elevation levels. They are dominated by abiotic, climate-related ecological factors – the importance of biotic factors such as competition decreases with elevation. Therefore, ecosystems at the low-temperature limits of plant life are generally considered to be particularly sensitive to climate change. The effects of climate change may be more pronounced compared to ecosystems of lower altitudes (KÖRNER 1994).

→ High mountain environments comprise real wilderness habitats with ecosystems undisturbed by direct anthropogenic influence – it is the biome with the highest degree of naturalness in many countries. This allows the study of impacts caused by climatic change without or with only minor masking effects caused by human land use.

→ Most high mountain plants are long-lived species which are likely to be little responding to transient climatic oscillations. A sustained change in climate, however, is suspected to cause shifts in plant distributions and may threaten their long-term survival. Therefore, high mountain plants are particularly amenable for monitoring effects of climate change.

→ As a result of the predominance of long-lived perennial species, vegetation sampling need not be repeated within one season because all or almost all species can be seen at the height of a single growing season. Note, however, that this does not hold for all mountains (e.g. in mountains of equatorial latitudes, where many species may be seen throughout the year, but some may be absent at any time during the year).

5 Research questions

There are two sets of research questions:

I Questions addressing the current patterns of mountain biota along elevation gradients:

(I-1) What are the patterns of species richness, abundance and vegetation cover along elevation gradients in different mountain regions (also in relation to known geographical distributions of species) ?

(I-2) How do these patterns relate to environmental gradients ?

(I-3) What are the most important potential direct and indirect effects of climate change on high mountain biota in the different mountain regions ?

(I-4) What are the potential risks for distinct species, species groups (e.g. endemics), life forms or functional groups because of

- changing climatic constraints (e.g. change of snow cover patterns, of water availability)
- changing habitat stability (e.g. erosion dynamics)
- changing competition pressure (e.g. due to upward migration of species from lower altitudes or due to an expected expansion in abundance of some species within their current altitudinal range).

(I-5) What measures can be taken to mitigate climate-induced biodiversity losses ?

II Questions addressing the temporal changes in patterns:

(II-1) Does species richness change within the study site ?

(II-2) Is there change in vegetation cover and vegetation structure?

(II-3) Is there change in the abundance or cover of species and in species composition ?

(II-4) If there are changes, is there a (global) pattern related to altitude, latitude and longitude ?

(II-5) Can observed changes in vegetation patterns be related to observed climatic change ?

(II-6) Are there any signals which indicate climate-induced threats for species, species groups (e.g. endemics), life forms or functional groups; are determined signals consistent with the risk assessment according to question (I-4) ?

(II-7) Is there an urgent need for adaptive management measures be taken to ameliorate climate-induced threats to biodiversity?; if yes, how can they be applied in a sustainable way ?

6 Why mountain summit areas as reference units ?

The tops of mountains, of course, are somewhat exceptional habitats concerning their outstanding geomorphologic position, their climatic conditions, their hydrology, and hence their vegetation. Furthermore, they cover only a small part of the total alpine life zone. At a first glance, it may appear to be disadvantageous to focus on mountain summits for a large-scale comparison. Nevertheless, there are several good arguments why summit habitats are particularly amenable reference units for a large-scale comparison of climate change effects (**Note: the term summit refers not just to the very top, but to the summit area from the top down to the 10-m contour line**):

→ Summits are well-defined topographic units which can provide comparable conditions; they comprise habitats of all exposures (north, east, south, west) within a small area.

→ On summits, shading effects from neighbouring land features are usually absent. Therefore, the climatic conditions on a summit are mostly defined by the altitude. It is difficult or almost impossible to find such comparable units on any other topographical feature, where diurnal and seasonal variation in insolation much depends on shading by neighbouring features.

→ The species composition in summit areas is typical for the respective elevation because the flora is not enriched by elements from higher altitudes. This is often not the case in slope situations, and particularly not near to watercourses, where species may immigrate from higher elevations during disturbance events.

→ Summits often have a high diversity of habitats, such as for example plant communities associated with the topographic position. Thus, a high variety of niches, causing high species richness, can be expected. The presence of narrow transition zones between habitats or vegetation types may enable a rapid recognition of climate-induced shifts of boundaries.

→ Conversely, summits may function as traps for upward-migrating species due to the absence of escape routes for cryophilic species with weak competitive abilities. This is particularly critical on isolated mountains with a high percentage of endemic species occurring only at the uppermost elevation levels (GRABHERR et al. 1995; THEURILLAT 1995; PAULI et al. 2003).

→ Summit areas are not prone to severe disturbance such as debris falls or avalanches. This enhances the value for long-term observations.

→ Summits are prominent landmarks which can be easily relocated for reinvestigations.

For these reasons, mountain summits are considered as the most appropriate sites for comparing ecosystems along climatic gradients. For the selection of monitoring sites, however, certain criteria have to be considered:
a) for selecting a target region containing an appropriate set of summit sites along an elevation gradient (see chapters 7.1 and 7.2) and
b) for selecting adequate summit areas to avoid potential disadvantages which can occur in some cases (see chapter 7.2).

7 The *GLORIA* site selection

7.1 The *target region*

A *GLORIA target region* should comprise a suite of at least four summits which represent an elevation gradient from the natural treeline ecotone (where applicable) up to the limits of (vascular) plant life, or in regions where these limits are not reached, up to the uppermost vegetation zone (see Fig. 7.1); a *target region* is the mountain area in which these four summits are located (see the example in Fig. 7.2).

All summits of a *target region* must be exposed to the same local climate, where climatic differences are caused only by altitude. The four summits of a *target region* should not be distributed across a major climatic shed. For example, summits located on the pronounced windward side of a mountain range cannot be in the same *target region* as those on the pronounced leeward side (see Fig. 7.3), or summits located in the wetter outer part of a mountain system cannot be combined with those located in the dryer inner part. In (larger) mountain systems, showing such climatic differences, two or more different *target regions* are suggested.

There is neither a minimum nor a maximum limit for the extent of the area of a *target region,* provided that the general climatic situation among the selected sites does not show fundamental differences along a horizontal gradient. Therefore, a *target region* should be as small as possible, but as large as necessary to meet the criteria for summit selection given in subchapter 7.2.

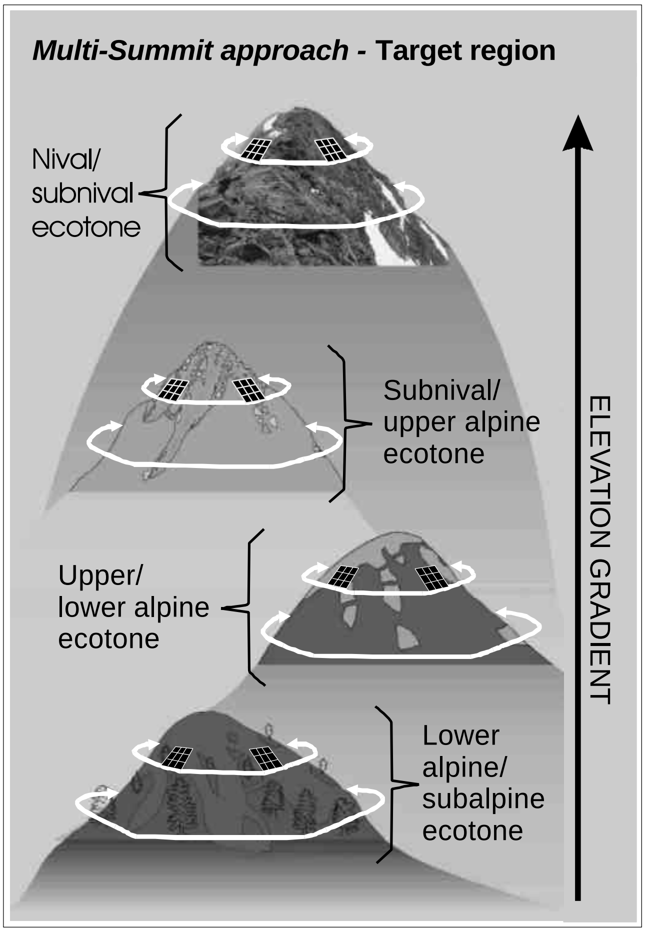


Fig. 7.1 Four summits of different altitude represent a *target region* (compare Box 7.1). The white lines indicate the lower boundaries of the *5-m* and of the *10-m summit area*, respectively; for explanations see chapter 8.1).

7.2 Summit selection

The first and crucial task when starting with a new *GLORIA target region* is to select a set of suitable summits, which **(1)** represent the characteristic vegetation patterns of the mountain region along the elevation gradient (see subchapter 7.2.1), and which, at the same time, fulfil **(2)** the criteria required for monitoring, as given in subchapter 7.2.2.

Annex II of this manual shows a sampling form for the *target region* (**Form AII.0**). This form is included to provide general information about the *target region* and about each selected summit, based on the guidelines and definitions in the following subchapters 7.2.1 and 7.2.2; i.e., indications and comments on the altitudinal vegetation zones or their major ecotones, on the bedrock material, on human land use, as well as on the criteria for the summit selection (see 7.2.2 and also **Form AII.1.2** in Annex II).

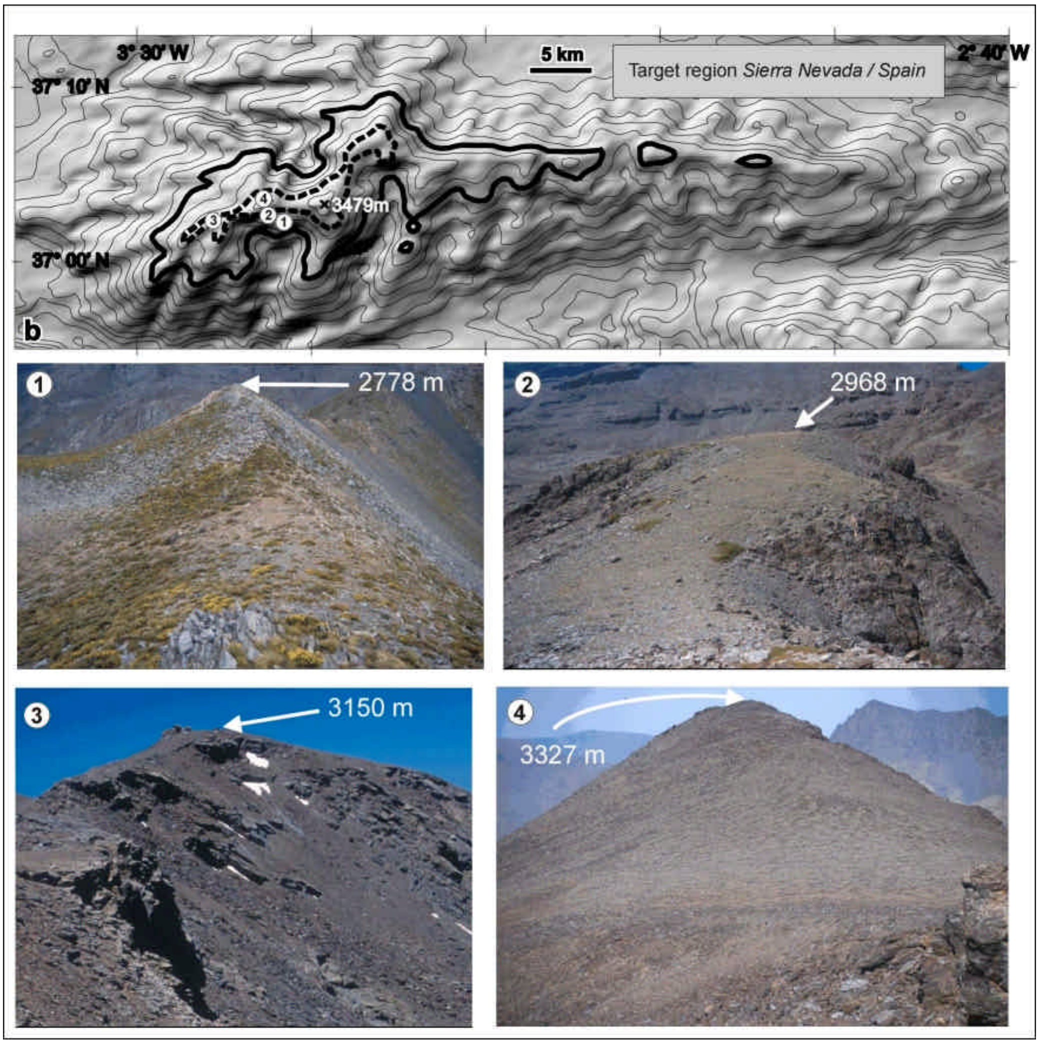


Fig. 7.2 Example for a *target region*: Sierra Nevada/Spain with selected summits of different altitude.

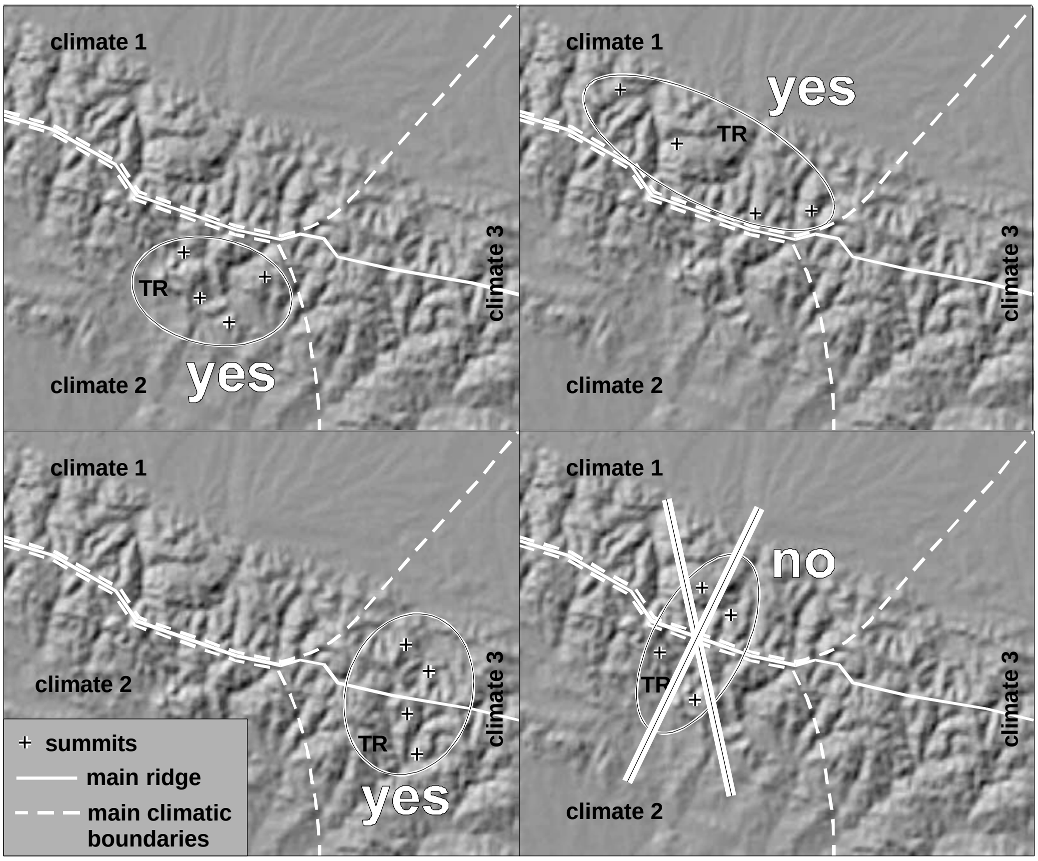


Fig. 7.3 Selection of *target regions.* A *target region* should not cross main boundaries of regional climate.

7.2.1 The elevation gradient

The ideal positions of the four summits are within the **ecotones between the vertical vegetation zones**, because climate-induced changes are most likely to occur first in these transition zones. Such an arrangement could be, for example: *summit 1*: treeline ecotone, *summit 2*: transition between the lower and the upper alpine zone, *summit 3*: transition from the upper alpine to the nival zone, *summit 4*: close to the limits of vascular plant life; **see Box 7.1** for definitions of vegetation zones. This ideal case, however, is seen to be rather theoretical, because obvious boundaries marking the limits of vegetation zones are usually lacking. On the other hand, summit areas often represent ecotonal situations anyway, e.g., along the gradient from the northern to the southern slope of the summit. Therefore, the summit selection may not stress on an exhaustive search for ecotones, but should focus on finding a series of summits which represent an **altitudinal gradient** of **vegetation patterns, characteristic** for the respective **mountain region**.
Mountain regions, however, where the alpine life zone does not show a clear vertical zonation should not be excluded. This is particularly the case, where mountains only slightly extend into the alpine life zone and where alpine biota are restricted to a small area. These biota are considered to be particularly prone to climate-induced threats. In these cases, the selected summits should be **distributed in equal elevation intervals**, as far as this is possible.

Four summits are required for the basic arrangement within a *target region*. Exceptionally, a *target region* may consist of only three summits; e.g., where three good summits (see under 7.2.2) are available, but a fourth appropriate summit is really absent. Three summits, however, is the minimum number to represent an elevation gradient, and thus **three summits is the absolute minimum requirement** to be considered as a *GLORIA target region*.

Until this point, any mountain region that extends into the alpine life zone is potentially appropriate for a *GLORIA target region.* In addition, however, *GLORIA* summits must meet several criteria which are crucial for applying the standardised observation settings as well as for an effective monitoring of climate-induced impacts on mountain biota (see subchapter 7.2.2). Not all mountain areas may meet these criteria – and it is better to shift to an other area rather than to establish a *target region* with inappropriate summits.

Box 7.1: Vegetation zonation in high mountain areas

The *GLORIA target regions* are restricted to areas from the low-temperature determined treeline ecotone upwards; i.e. the area which coincides with the alpine life zone. Therefore, some definitions (compare Körner 1999, Grabherr et al. 2003) and considerations are given here.
The **forestline** (or timberline), marking the lower limit of the treeline ecotone, is defined as the line where closed (montane) forests end.
The **treeline** is the line where groups of trees taller than 3m end.
The **tree species line** is the line beyond which no adult tree species, including prostrate ones or scrub, occur.
The **treeline ecotone** is the zone between the forest line and the tree species line.

The **alpine life zone** is the area from the treeline ecotone upwards.

The **alpine zone** is the zone between the treeline and the upper limit of closed vegetation (where vegetation is a significant part of the landscape and its physiognomy). The alpine zone of some mountain regions is further subdivided into a **lower alpine zone** (the zone where dwarf-shrub communities are a significant part of the vegetation mosaic) and an **upper alpine zone** (where grassland, steppe-like and meadow communities are a significant part of the vegetation mosaic).
The **nival zone** is the zone of open vegetation above the upper alpine zone, where vegetation is not a significant part of the landscape.
The **alpine-nival ecotone** (or **subnival zone**) is the transition between the upper alpine and the nival zone; it is assumed that it coincides with the permafrost limit in many mountain regions.

(Box 7.1 – continued)
Considerations concerning the treeline ecotone: For an optimal applicability of the sampling methods, the vegetation on the lowest summit of a *target region* should not be dominated by tree species or tall shrubs. For example, frequency counts in the *1m x 1m quadrats* are not possible where trees or shrubs occur (compare chapter 8.4.1.2), because the method is designed for the alpine, predominately dwarf, vegetation. Thus, for the lowest summit, a site within the upper part of the treeline ecotone should be selected, where trees or shrubs only sparsely occur. Further, the summit should lie within the potential natural treeline ecotone, and not at the present treeline, if the latter has been lowered significantly owing to human interference.

In mountain systems, where no treeline exists, or where the treeline is substituted by human land use, the alpine life zone may be defined as those part of the landscape, which was shaped by glaciers (which were present at least in the Pleistocene) and where frost is an important factor for pedogenesis and substrate structure (TROLL 1966).

7.2.2 Criteria for *GLORIA* summits

Not only the uppermost peak of a mountain is considered here as a summit, but any hump in a ridge which projects **more than 20 elevation metres above the surrounding land features**.
The following scheme for the summit selection (see Fig. 7.4) shows **six criteria**, arranged in rows, and **three main categories,** arranged in columns, to evaluate a particular summit along these criteria (see below).
The criteria are not ranked for their priority – a summit must pass through all of them. The first two, *"volcanism"* and *"consistent climate"*, may be evaluated before stepping into the field, just by using maps and literature. Yet, for *"consistent climate"*, further evaluation in the field is suggested. For the remaining four criteria, a pre-selection can be made in the lab, but the final evaluation can only be carried out by visiting the sites: the criterium *"geomorphological shape"*, focuses on terrain requirements for establishing the standardised observation settings. The criteria *"habitat situation"*, *"bedrock material"*, and *"land use/land use history"* focus on influences other than climate, which can mask a monitoring of climate-induced effects along the elevation gradient (see also the considerations under 7.2.2.1).
The evaluation categories are: *"recommended"*, *"not recommended"*, and *"must be avoided"*.
The same scheme as shown in Fig. 7.4, but fitted with checkboxes, is included as "**form** for the **summit selection**" (see **Form AII.1.2** in Annex II). This form is obligatory for all *GLORIA* summits.

How to evaluate a summit:

Go stepwise through all six criteria of the scheme (Fig. 7.4) by selecting one of the evaluation categories for each criterium. Use **Form AII.1.2** by marking one of the checkboxes for each criterium. The following cases can result from this evaluation:

(1) If the summit passes through all criteria within the grey-shaded category ***"recommended"***, it has an "ok" for becoming a *GLORIA* summit.

(2) If the summit falls in **only one** criterium into the category ***"not recommended"***, an alternative summit should be selected. Where not alternative can be found, the summit may be included. In this case, comments about the critical criterium are obligatory in the "sampling form for the *target region*" (see **Form AII.0**, in Annex II).

(3) If the summit falls in **two or more** criteria into the category ***"not recommended"***, the summit is not appropriate. An alternative summit **must** be selected. If no alternative can be found, shift to an other mountain region.

(4) Where a summit falls in **only one** or with more criteria into the category ***"must be avoided"***, the summit is not appropriate. An alternative summit **must** be selected. If no alternative can be found, shift to an other mountain region.

CRITERIUM	CATEGORY FOR EVALUATION: RECOMMENDED – Best case	RECOMMENDED	RECOMMENDED – "at least" case	NOT RECOMMENDED	MUST BE AVOIDED
1. Volcanism	The summit is **not** an **active** or **dormant volcano** and no such volcano is in the close vicinity				**Active** (including **dormant**) **volcanism** present
2. Consistent climate	The summit is exposed to the same local climate as the other summits of the target region; differences are **only** caused by the altitudinal climatic gradient		The local climate on the summit does not obvoiusly deviate from the other summits; the differences are **mainly** caused by the altitudinal climatic gradient	Summit lies within the area of the same local climate as the other summit sites, but local effects lead to a significant deviation, e.g., owing to a pronounced overshadow by neighbouring land features	The local climate on the summit is different from the other summits; e.g. the summit lies beyond a main climatic shed (for example, in mountain systems with pronounced windward/ leeward differences)
3. Geo-morphologic summit shape	Perfect moderately **cone-shaped summit** (the same slope situation towards all directions)	Summit with **irregular cone shape**, where *3m x 3m quadrat clusters* can be positioned **without any deviations** from the standard design	Summit with **irregular cone shape**, where all four *3m x 3m quadrat clusters* can be positioned with **minor**, but acceptable, horizontal **deviations** from the stand.design (comp. 8.3.2)	**1)** The summit slopes are too **steep**, too **rugged** or their surface is too **unstable** for establishing plots on all sides of the summit or for applying all sampling methods; or **2)** the summit is so **flat** that the 5-m level lies beyond 50m surface distance from the *HSP*, respectively the 10m-level lies beyond 100 surface distance (compare also Box 8.4)	**1)** Summit where work cannot be carried out without climbing equipment owing to steepness or substrate instability (dangerous sites must be avoided); **2)** Very flat plateau shaped summit areas where the sampling design cannot be applied
4. Habitat situation (representativity of the vegetation for the respective ecotone or elevation zone)	The vegetation within the summit area represents the characteristic patterns of zonal plant communities of the respective ecotone or elevation zone		The vegetation within the summit area shows at least the main characteristics of the respective ecotone or elevation zone (in cases, where vegetation is generally very scattered, potential habitiats, appropriate for vascular plants to establish, must be available)		Summit habitat is hostile to plant growth owing to its geomorphology (e.g., summit is composed of boulders, screes or plain rocks lacking potential habitats for vascular plants)
5. Bedrock material	The same bedrock as on the other summits of the target region		Bedrock deviating, but no obvious substrate-related influence on the species composition	Deviating bedrock material has an obvious, but minor influence on the substrate-related species composition	Bedrock is contrasting to the other summits regarding the influence on the species composition (e.g., a summit with siliceous substrate such as gneiss in a series of calcareous limestone summits)
6. Land use and land use history	Pristine (no land use impact)	No present land use, and the influence from historic land use is negligible	Low to moderate impact from land use, but without remarkable changes over a long period (e.g. for > than a century)	**1)** Remarkable land use change within the last 100 years from **high to low** impact, where former impacts on the vegetation are still visible; or **2)** moderate to high impacts over a long period, causing obviously altered vegetation, but plant communities are not substantially changed due to land use impacts, or **3)** the summit is not recommended owing to any other reason related to land use	**1)** Remarkable land use change within the last 100 years from **low to high** pressure, where the impacts on the vegetation are clearly visible; or **2)** generally strong land use impacts causing substantially changed plant communities (e.g. nitrophilous vegetation), or **3)** the summit must be avoided owing to any other reason related to land use
	SUMMIT ACCEPTED				**SUMMIT AVOIDED**

Fig. 7.4 Scheme for the summit selection

7.2.3 Considerations on criteria for summit selection

Human disturbance pressure

Monitoring the effects of changing climatic factors is the aim of *GLORIA*. Thus, summit areas should not be affected by heavy pressure from human land use (see Fig. 7.5) as impacts by grazing animals (trampling, grazing, and fertilising) and trampling effects by hill walkers may cause substantial changes in species composition and vegetation patterns. Such effects are likely to mask any climate-induced changes.

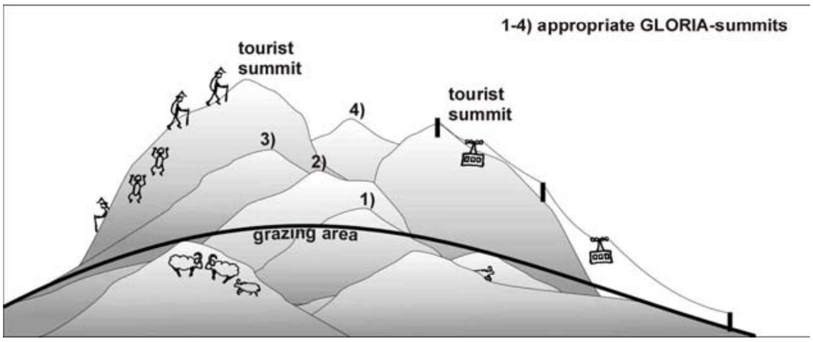


Fig 7.5
Avoiding human impact: summits frequently visited by tourists or located in an area of heavy grazing (either by livestock or by wild ungulates) are not appropriate.

In many mountain regions of the world, alpine ecosystems are affected by direct human influences – particularly by domestic stock grazing (e.g., BOCK et al. 1995; MOLINILLO & MONASTERIO 1997; ADLER & MORALES 1999; BRIDLE & KIRKPATRICK 1999). In such cases, selection should focus on the least affected sites, preferably in national parks or nature reserves, where human disturbance pressure can be expected to remain low in the future (see also Box 8.8 in chapter 8.4.1.2).

Geomorphologic shape of the summit area

Summits should be of "moderate" geomorphologic shape (for a definition see the glossary under: *moderately shaped summits*). Very steep summits as well as flat tops, forming plateaux, are unsuitable for the application of the *Multi-Summit* method.
Further, many steep summits have few micro-habitats for plants to establish and are thus of little use for observing vegetation changes (see Fig. 7.6; for summit examples see Fig. 7.2).
Flat summit areas or plateaux are typical for some mountain regions (e.g. in parts of the Andes, the Tibetan plateau, in some arctic and subarctic areas), where "moderately shaped" summits may be difficult to find. In such cases, some modifications of the method, described in Box 8.4 (chapter 8.3.2) may be considered.
A *GLORIA* summit need **not** be the uppermost peak of a mountain. It may be any distinct, suitably shaped and identifiable peak. As a rule of thumb, it should project at least by 20 elevation metres above the surrounding land features. Note also that the highest peaks often have the disadvantage of being the main target of hill walkers and climbers.

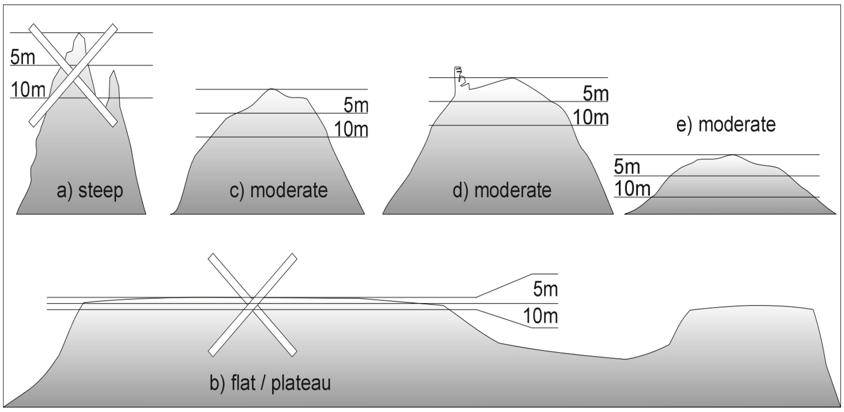


Fig 7.6 Geomorphologic shape.
(a) Summit areas which are to steep (either for recording or for providing habitats for vascular plants) are to be avoided.
(b) Flat, plateaux-shaped summits are not appropriate: the recording area would be too large; but an option to include even such flat summits (when no moderately shaped summits are present) is given in Box 8.4, chapter 8.3.2.
(c-e) Moderately shaped summits should be selected.

Bedrock of the summit area

All summits within a *target region* should be composed of similar bedrock. In particular, summits of strongly contrasting bedrock, e.g. calcareous and siliceous, should be avoided, because differences in species richness and species composition would be confounded by substratum-related factors.
Furthermore, mountain regions with active volcanoes should be avoided. Active volcanism may have masking effects.

No mountain system is likely to yield an ideal set of summits. However, detailed knowledge and a careful selection will enable the researcher to find a mountain region, where a set of summits sufficiently fulfils the criteria mentioned above.

8 The sampling design

This chapter contains the detailed description on how to establish a monitoring site on a mountain summit. An overview is given below:

8.1 Plot types and design outline

The sampling design for each summit consists of:

(a) ***sixteen 1m x 1m permanent quadrats***, arranged as the four corner quadrats of the four *3m x 3m quadrat clusters* in all four main compass directions, yielding 16 1m-quadrats per summit (=***16-quadrat area***)

(b) ***Summit area sections***, with 4 sections in the upper summit area (***5-m summit area***) and 4 sections in the lower summit area (***10-m summit area***). The size of the *summit area section* is not fixed but depends on the slope structure and steepness.

The timing of the fieldwork should allow the observation and easy recognition of most species during a single visit. Additional visits may help with the determination of some doubtful species.

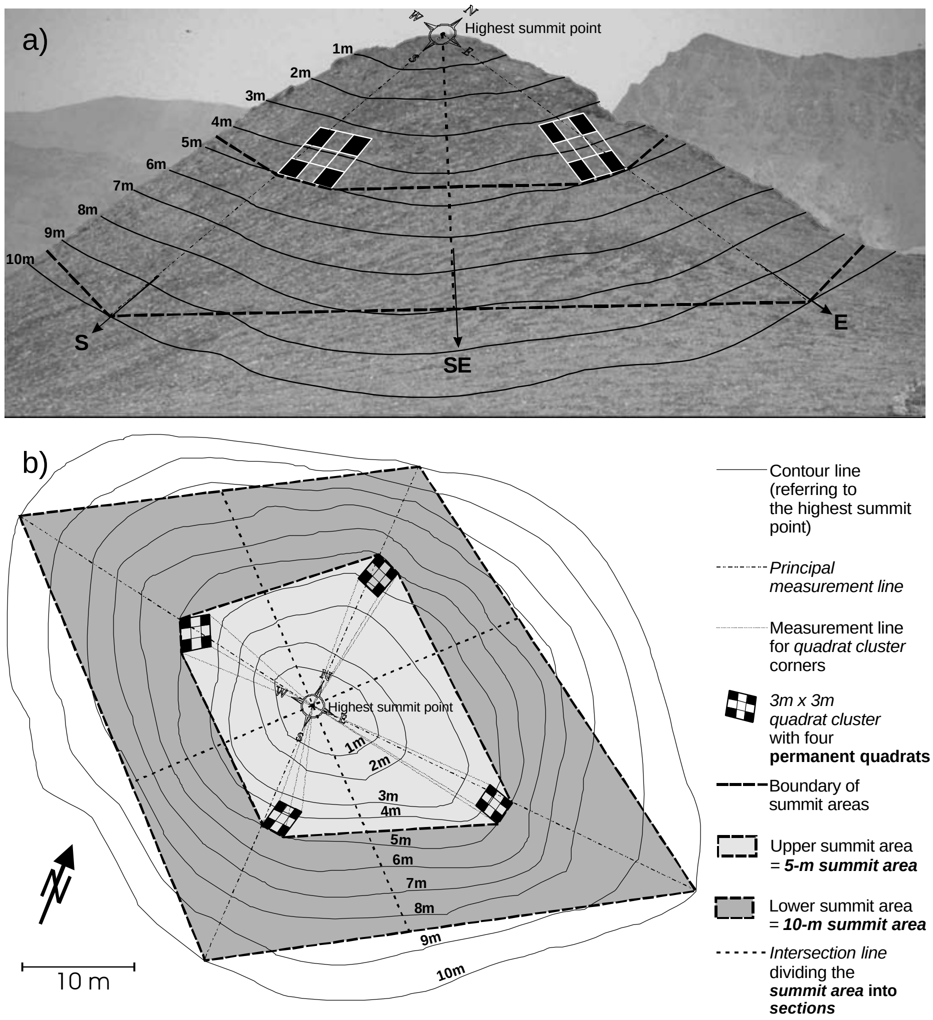


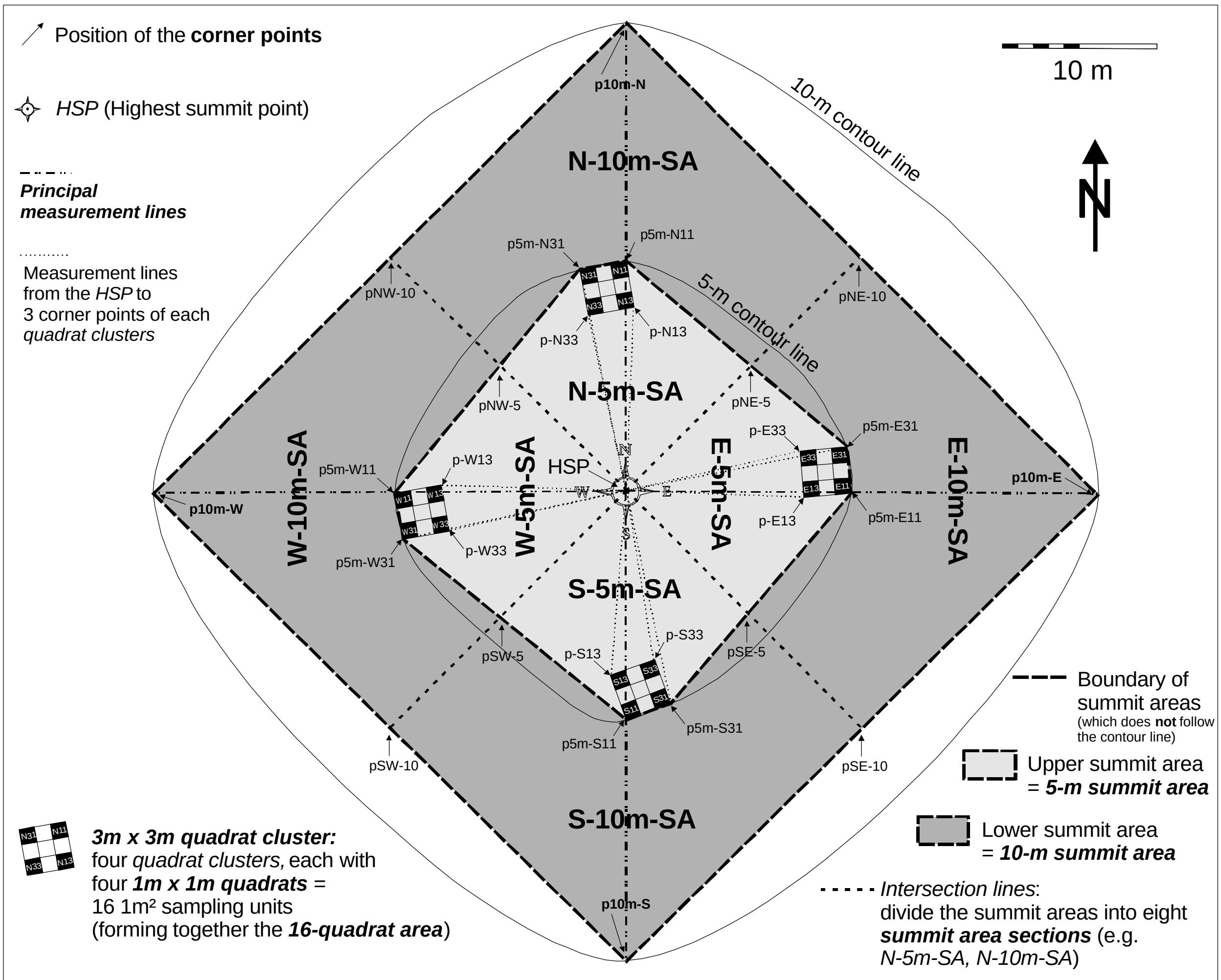
Fig. 8.1 The *Multi-Summit* sampling design shown on a hypothetical example summit: **(a)** oblique view with schematic contour lines; **(b)** top view. The *3m x 3m quadrat clusters* and the corner points of the summit areas are arranged in the main geographical directions. Deviations from the exact direction (e.g. the W-direction in this example and in Fig. 8.6) may be necessary in some cases (see subchapter 8.3.2). The *quadrat clusters* can be arranged either on the left or on the right side of the principal measurement line, depending on the nature of the terrain and habitat. As a general rule, left and right is always defined in the sight to the summit.

An illustration of the plot arrangements is shown in Fig. 8.1 with an oblique and a top view on an example summit. Fig. 8.2 shows the scheme of the sampling design with the code numbers of all measurement points and sampling plots.

This design was first applied in the Northeastern Limestone Alps, Austria (in 1998) and in the Sierra Nevada, Spain (in 1999, PAULI et al. 2003). In 2001, 72 summits throughout Europe were established along this design as long-term observation sites.

The full procedure, which includes the set-up and the recording, requires between 3 days and about 10 days per summit for two investigators (dependent on vegetation density and species richness). This estimation includes the sampling of vascular plants, but excludes recording bryophytes and lichens identified to a species level.

Note that at least two field workers are absolutely necessary for establishing the permanent recording areas and settings.



The **corner points:**

p5m-N11, p5m-E31, p5m-E11, p5m-S31, p5m-S11, p5m-W31, p5m-W11, p5m-N31: the 8 lower corner points of the *3m x 3m quadrat clusters* at the **5-m level;** they determine the position of the *quadrat clusters* and the lower limit of the *5-m summit area*	***p-N13, p-E13, p-S13, p-W13, p-N33, p-E33, p-S33, p-W33m*** : the 8 upper corner points of the *quadrat clusters*
p10m-N, p10m-E, p10m-S,p10m-W : the 4 corner points at the **10-m level**; they determine the lower limit of the *10-m summit area;* **The *principal measurement line*** for each main direction starts at the *HSP*, runs through one of the points at the 5-m level (e.g. *p5m-N11 or p5m-N31*) and ends at the points at the 10-m level;	***pNE-5, pNE-10, pSE-5, pSE-10 pSW-5, pSW-10, pNW-5,pNW-10*** : the 8 corner points at the *intersection lines* (these points usually lie above the 5-m level and the 10-m level, respectively) **The *summit area sections*** are delimited by these points, by the *HSP*, and the points at the 5-m and 10-m levels;

Fig. 8.2 Scheme of the *Multi-Summit* sampling design.

8.2 Materials and preparations

Before field work, the following materials and tools should be prepared (see also the checklist in Annex I):

For measuring the position of plots and corner points of the summit area: two rolls of flexible 50-m measuring tapes; a compass; a clinometer or an electronic spirit level (e.g. Swiss Level, which gives a beep signal when positioned horizontally); small rolls of measuring tapes (e.g. of 3m length). Optional (in addition) are an altimeter and a Differential GPS with sub-metre accuracy.

For delimiting the 1m x 1m permanent quadrats: four sampling grids of 3m x 3m with 1m x 1m cells. These grids should be made of flexible measuring tapes fitted together to a grid with small metal blanks (for instructions see Fig. AI.1 in Annex I). About 100 pieces of ordinary 100 mm nails and thin wire for mounting the sampling grids in the field. Adhesive tape to repair the grids in the field.

For delimiting the summit area: two rolls of thin string (each about 500 m long) and four rolls of the same type (about 100 m each). The length of these strings depends on the summit shape (the flatter the summits are, the longer the strings must be). The colour of the string should contrast with the surface colour (e.g. white or yellow).

For permanent marking: per summit about 80 aluminium tubes (0.8 or 1 cm in diameter) in various lengths (between 10 and 25 cm) or other material appropriate for the relevant substrate (e.g. durable white or yellow paint) and a small chisel (cold cutter or marking rock). Markings should not be obvious to hill walkers.

For photo documentation: a standard 24mm x 36mm Single Lens Reflex camera with lenses of focal lengths of 28mm and 50 mm, or a digital camera; colour film material (colour negative film and/or slide film; see Box 8.13); a small blackboard (e.g., 15 x 20 cm) and a piece of chalk for including the plot number and date in the photographs; a signal stick or rod (1.5 to 2 m) to mark the corner points on the photos.

For the recording procedures: sampling sheets (see the Forms in Annex II); compass, clinometer or electronic spirit level (i.e. the same devices as used for plot positioning); one wooden (or aluminium) 1-m² grid frame with 100 grid cells of 0.1 x 0.1 m (for instructions see Fig. AI.2 in Annex I), templates for cover estimations (see Fig. AI.3a & b in Annex I).

For permanent temperature measurements: Miniature temperature loggers (for details see chapter 8.4.3), permanent markers, and adhesive tape to protect the loggers.

8.3 The set-up of the permanent plots

8.3.1 The highest summit point *(HSP)*: determination of the principal reference point

The highest summit point (*HSP*) is the starting point of all measurements. The *HSP* is usually the middle of the summit area of moderately shaped summits. Rocky outcrops at one side of the summit area, which may exceed the elevation of the middle culmination point (compare Fig. 7.6), should be ignored.

■ WORKINGSTEP **a Marking the *HSP*:** This point should be marked with a small cross cut into the solid rock (Fig. 8.3) when no triangulation point is present. For sites lacking a solid rock to mark, metal stakes or other appropriate markers for permanent marking should be used. Note that this mark should persist for decades.

Fig. 8.3 Permanent cross mark at the highest summit point *(HSP).*

8.3.2 Establishing the *3m x 3m quadrat clusters* and the summit area corner points

THE DESIGN

Quadrat clusters: In each of the four main directions (i.e. the true geographic N, E, S & W) a *3m x 3m quadrat cluster* has to be positioned (see Fig. 8.1 and 8.2). Each *quadrat cluster* consists of nine *1m x 1m quadrats*, delineated by a grid within a 3m x 3m square (as prepared before field work). The lower boundary of each quadrat cluster should lie at the 5-m contour line below the summit (with a tolerance of +/- 0.5 m). The lower left **or** the lower right corner point of the *quadrat clusters* should be arranged in the main geographic direction (N, E, S, or W) as seen from the highest summit point. Thus, the quadrat cluster can either lie to the right or to the left side of the line indicating the main geographic direction (compare Figs. 8.1 & 8.2).

A deviation from the main geographic direction may be necessary if the 3m x 3m grid falls on:

(1) too steep terrain to allow safe work or trampling would cause excessive damage, or

(2) it falls on a bare outcrop or boulder field, where available area for plant establishment is negligible.

In these cases, the *quadrat cluster* should be positioned at the nearest suitable location to the original line.

Summit area-corner points: The lower corner points of the *3m x 3m quadrat clusters* are identical to the corner points of the upper summit area (= the *5-m summit area*).
The four lower corner points of the lower summit area (= the *10-m summit area*) lie along the straight line connecting the *HSP* and the 5-m corner point (= the *principal measurement line*), at 10 m elevation below the *HSP* (compare Fig. 8.2).

The suggested working sequence described in this subchapter must be repeated for each main geographical direction (N, E, S, & W) and is demonstrated here for the N-direction with the following **workingsteps b-d** (compare with Figs. 8.2, 8.4 & 8.5; see also the measurement protocol sheet (**Form AII.1.1** in Annex II):

■ WORKINGSTEP **b** **Determination of the *principal measurement line* (the compass direction, the vertical extension, and the length of this line):** i.e. from the *HSP* straight down through a point at the 5-m level to the endpoint at the 10-m level.

→Person A stands with a compass and the measurement protocol (**Form AII.1.1**, see Annex II) at the *HSP* and fixes a 50-m measuring tape at this point. He/she points out the **geographic N-direction** (see Figs. 8.4 & 8.5, and Box 8.1).

→Person B begins walking in the indicated geographic N-direction unwinding the measuring tape and focusing at the highest summit point with a clinometer or an electronic spirit level. On reaching an exact horizontal view of the *HSP*, a temporary marker is placed on the ground. The elevation difference between the marker and the *HSP* equals the eye-height (i.e. the body length from feet to eyes) of person B. This process is repeated until the 5-m point is reached (see Fig. 8.5).

→When reaching the 5-m level, person B decides if the location is appropriate for spreading the *3m x 3m quadrat cluster* – if not, another location at the 5-m level, positioned as close as possible to the exact geographical N-direction, is chosen (if a deviation is necessary, stay, in any case, within the area delimited by the NW and the NE intersections lines which will be established later in workingstep **g**).

→The determined point at the 5-m level (this will be either point p5m-N11 or p5m-N31, see workingstep **c**), will be marked with a small aluminium tube and with some stones to aid the further set-up procedure (in workingstep **c**).

→From the point at the 5-m level, person B continues downward to the 10-m level, being guided by person A, who is to ensure that the *HSP* and the points at the 5-m and the 10-m levels lie on the same line. The 10-m point (p10m-N) will be marked again with a small aluminium tube and with some stones.

→Person B tightens the 50-m measuring tape (held by

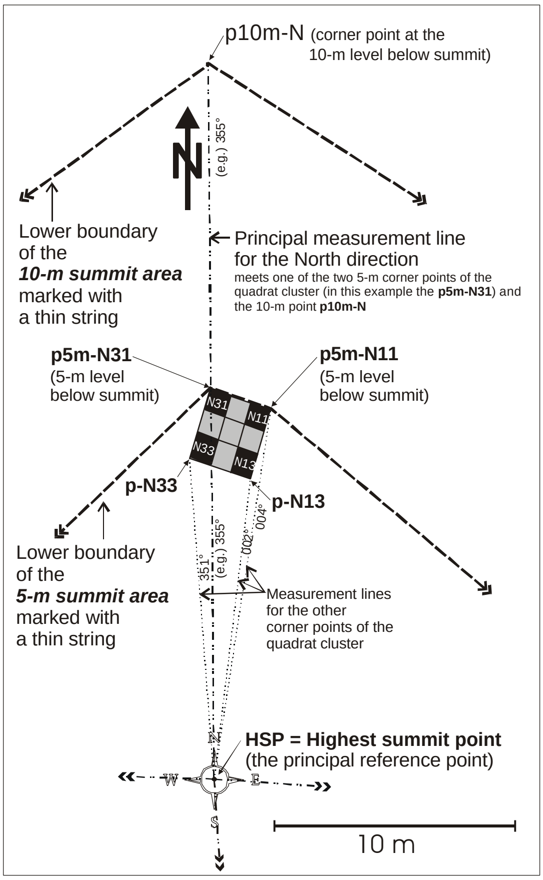


Fig. 8.4 Measurement of the compass direction from the *HSP* to the corner points of the *3m x 3m quadrat cluster* and to the *10-m point.* If in our example, the magnetic declination was **5° E,** it needs to be corrected in the following way: 355° on the compass (instead of 000°/360°) should be used to give the true north for the *principal measurement line* (see also Box 8.1).
Nonetheless, deviations from the true north may be necessary if terrain or habitat is not appropriate for establishing the *3m x 3m plot cluster* (compare text in workingstep **b**).

person A to ensure that the tape is straight through the marked 5-m point), and calls the distance read from the measuring tape at the 10-m point (see Box 8.3);
→person A, listening to person B, enters the distance value into the protocol (**Form AII.1.1**, Annex II);
→person A (standing on the *HSP*) focuses the compass on person B (standing on the 10-m point) and takes a reading of the magnetic compass direction. If person B is not visible to person A, person B holds up a signal rod perpendicularly;
→person A enters the magnetic compass direction into the protocol sheet (compare Box 8.1).

Box 8.1: Compass measurements. The magnetic N-direction can deviate considerably from the geographic N-direction in some regions and can change in comparatively short periods of time. Therefore, the magnetic declination (i.e. the angle between the direction of the **geographic North Pole** and the **magnetic North Pole**) has to be identified and indicated on the measurement protocol sheet (**Form AII.1.1**, Annex II). To fix a point in the geographic N-direction, for example, the measuring person defines:
(a) the magnetic N-direction with the compass, (b) corrects it for the magnetic declination and
(c) guides the person, who fixes the points, to the corrected geographic N-direction.
This applies to all directions (N, E, S, W as well as to NE, SE, SW, NW; see also below in this box).
However, in any case, only the measured magnetic compass directions has to be indicated (i.e. degrees on the 0-360° scale as indicated on the compass; see also Fig. 8.4). This is relevant for all numeric indications of angles in the sampling protocols.
For measuring compass directions, an accuracy of +/- 2° can be normally reached with an ordinary field compass.

Magnetic declination: The magnetic declination should be indicated in degrees (360 ° scale) with its correct sign (+ or –) at the top of the measurement protocol (**Form AII.1.1**, Annex II).
For example, **– 6** (= 6° W = 6° west of the geogr. North Pole), +**20** (= 20° E = 20° east of the geogr. North Pole). In southern Europe and in the European Alps, the magnetic declination is currently only between 1° and 3° E. There are larger declinations, e.g., in N-Sweden (currently 5° E), Caucasus (6° E), Southern Ural (about 13° E), Northern Ural (23° E), Central Brooks Range, Alaska (about 25° E) or on central Ellesmere Island, N-Canada (about 77° W). These examples show that it is important to consider the magnetic declination for establishing the permanent plots by using a field compass.
The current magnetic declination of any place, globally, can be obtained from the web site of the US-National Geophysical Data Center, Boulder: http://www.ngdc.noaa.gov/cgi-bin/seg/gmag/fldsnth1.pl

The magnetic declination must be considered for the determination of all 4 principal measurement lines as well as for the 4 intersection lines. For example, the corrected compass readings at a given magnetic declination of **+5** (5° E) are 355° for true/geographic N, 085° for E, 175° for S, 130° for SE; the corresponding values at a magnetic declination of **–10** (10° W) are: 010° (N), 100° (E), 190° (S), 145° (SE). That means, e.g. for the N-direction and a magnetic declination of +5: go towards the compass direction 355° to fix the principal measurement line and the N-cluster (see Fig. 8.4).

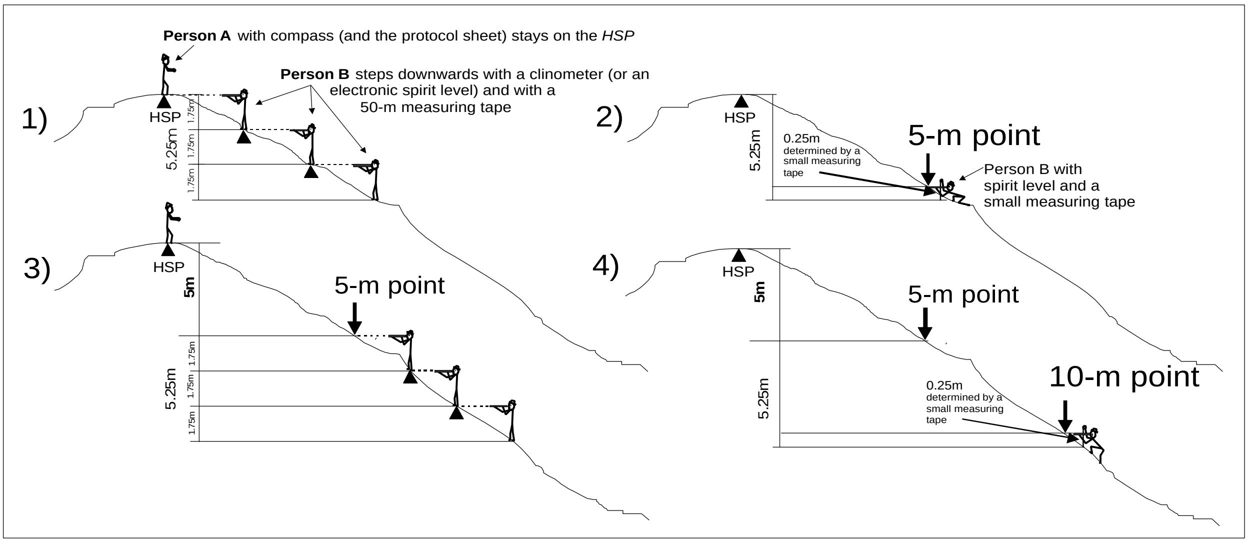


Fig. 8.5 Measurement of the vertical distances: Person A signals the compass direction (see Box 8.1), Person B (with an assumed eye-height of 1.75m), measures the vertical distance. **(1)** Three eye-heights down to the 5.25m level; **(2)** Measuring and fixing of the 5-m point; **(3)** Three eye-heights down to the 10.25m level; **(4)** Measuring and fixing of the 10-m point (for tolerances, see Box 8.3).

■ WORKINGSTEP c **Fixing the *3m x 3m quadrat clusters*:** After the principal measurement line with the positions at the 5-m and at the 10-m levels are determined, the *3m x 3m quadrat cluster* can be placed at the 5-m level. (Fig. 8.7). This should be made by two persons. Particular care is required at this step to avoid trampling impacts in the plot area (see also Box 8.2).
→As indicated above, the measured 5-m point is either the left lower (e.g., p5m-N11) or the right lower corner (e.g., p5m-N31) of the 3m x 3m grid (dependent on the terrain and habitat situation). Both points (p5m-N11 and p5m-N31) have to be on the 5-m level such that the left and right boundaries of the quadrat cluster are more or less parallel to the slope.
→The corner points of each *1m x 1m quadrat* of the grid should be fixed at the surface as far as possible (some corners may stay above the surface). This can be done with ordinary 100 mm nails put through the hole of the blanks (eyelets at the crossing points of the 3m x 3m grid), and/or with stones – a thin wire may be helpful.
→In addition, short aluminium tubes should be positioned at the corners of the quadrats as permanent marks (where applicable). Only the upper 1 to 2 cm of these tubes should project above the surface in order to avoid easy detection by tourists. Where aluminium markers cannot be mounted (e.g. on solid rock), a white or yellow point can be painted with durable paint (only small points to avoid too visible signs for tourists).

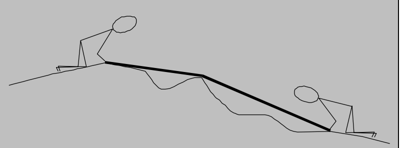
■ WORKINGSTEP d **Measuring the distances and the magnetic compass directions from the HSP to the quadrat cluster corner points:** After the 3m x 3m grid is fixed, person A, standing directly above the *HSP*, reads the compass directions for the 4 outer corner points of the *3m x 3m quadrat cluster*, assisted by person B, who signals the position of each point and who measures the distance (see the measurement protocol sheet, **Form AII.1.1** in Annex II, and Box 8.1).
→ repeat the procedure for distance and compass measurements described in workingstep **b** for each corner point of each quadrat cluster;
→ after entering the 4 distances and the 4 compass readings (of a quadrat cluster) into the protocol, the scribe (person A) should check the relevant box in the measurement protocol (**Form AII.1.1**, see Annex II) to indicate whether, e.g., point *p5m-N11* or point *p5m-N31* lies on the principal measurement line.
Note: always write the magnetic compass directions (i.e. the degree as indicated on the compass).
Optional (in addition) a Differential GPS with sub-metre accuracy can be used for determining vertical and horizontal co-ordinates of the corner points.

Box 8.2: Trampling impacts by the investigators. Trampling impacts during the set-up and removal of plot grids as well as during the sampling should be minimised. Particular care must be taken, e.g., in some lichen- or bryophyte-dominated communities and snowbed communities.
Sleeping pads, such as those commonly used by campers, may be useful during sampling where terrain is appropriate.

Box 8.3: Measurement accuracy and tolerances.

- **Distances** are to be measured to the nearest 1 cm (e.g. 13.63 m). Although this is "over-accurate" on most surfaces and with long distances, there is no reason to round up to lower resolutions.

  Distances are always measured in the shortest straightline from the *HSP* to a corner point with the measurement tape tightened. Therefore, all measurement distances are surface distances and not top view distances.



- **Horizontal angles** measured with the compass are to be indicated with an accuracy of +/- 2°. This can be reached with an ordinary field compass.
- **Vertical angles** of quadrat surfaces, as measured with electronic spirit level or clinometer, can be indicated according to the resolution of the respective device, or may be rounded up to steps of 5° (the 360° scale must be used).
- The **corner points** of the *5-m* and the *10-m summit area* are to be set up with a tolerance of +/- 0.5 vertical metres.

Box 8.4: Modification of the sampling design for flat summit areas. Some mountain ranges may be dominated by flat, plateau-shaped summits, and "moderately" shaped summits may be difficult to find. The sampling area at flat summits would be much larger when setting the 3m x 3m grid at the 5-m level below the highest summit point and the lower corner points of the *10-m summit area* at the 10-m level. This would significantly lengthen the measurement work for setting the plots and the work for summit area sampling. Furthermore, these large summits areas are not ideal for summit comparisons.

Flat plateau summits should be avoided whenever possible, however, when one such summit is recorded, because of the absence of alternative sites, some modifications to the general protocol may be necessary.

It is suggested that as a rule of thumb: if the 5-m level is not reached within 50-m surface distance from the highest summit point *(HSP)*, establish the 3m x 3m grid at the 50-m distance point. Therefore, in these flat terrain situations, the distance measurement with the measuring tape should be done immediately after measuring the vertical distances and before the 3m x 3m grid is established.
Similarly, if the 10-m level is not reached within 100 m, put the 10-m point at the 100-m distance point.
In cases, where the lower boundary of the 3m x 3m grid has to be established above the 5-m level at the 50-m surface distance from the *HSP*, the 10-m point has to be established at the actual 10-m level if this can be reached within a 100-m surface distance from the *HSP*; this means more than 5 m in elevation below the 3m x 3m grid.

8.3.3 Establishing the boundary lines of the summit areas and the *summit area sections*

THE DESIGN
Summit areas: A string around the summit, connecting the 8 corner points at the 5-m level, delimits the upper summit area (= ***5-m summit area***). The corner points at the 5-m level will be connected around the summit in straight surface lines. Thus, the *5-m summit area* reaches the 5-m level below the highest ssummit point only at the 4 clusters, and lies usually above the 5-m contour line between the clusters (compare Fig. 8.1 and 8.2). This helps to keep the area to a reasonable size – particularly at elongated summits. Furthermore, it simplifies the procedure, because an exact marking along the 5-m contour line would multiply the time required, but without enhancing the quality of the data substantially.
The corner points at the 10-m level, connected in the same manner, mark the lower limit of the lower summit area (= ***10-m summit area***), which forms a zone around the *5-m summit area*. The *10-m summit area* does **not** include (or overlap with) the *5-m summit area* (see Fig. 8.6, compare Figs. 8.1 & 8.2).
The distances between the corner points of the *5-m summit area* and between the corner points of the *10-m summit area* will **not** be measured.

Summit area sections**:** Each of the the two summit areas is to be divided into four *summit area sections* by straight lines running from the *HSP* to the summit area boundary lines, in the NE, SE, SW and NW directions (four intersection lines; see Fig. 8.6). The exact geographic direction is to be determined and the distance from the *HSP* to the points, where the two summit area boundary lines cross with the intersection lines is to be measured.

■ WORKINGSTEP **e Establishing the boundary line of the *5-m summit area*:** This can be done by two persons.
→ Person A starts from one of the lower corners of a *3m x 3m quadrat cluster* (e.g. the lower left of the N-quadrat cluster: at point p5m-N11) where a string is fixed.
→Person A then walks with the string to point p5m-E31 of the E-*quadrat cluster*. When this point is reached, the string should be tightened and fixed at this point to connect the two points (p5m-N11 and p5m-E31) in the shortest straight line possible.
→Person B helps person A to keep the straight line.
→This procedure continues by fixing the string also at p5m-E11 of the E-*quadrat cluster* and by heading further to the S-quadrat cluster (an so on), where the same work is repeated until the N-*quadrat cluster* is reached again at its lower right corner (p5m-N31).

■ WORKINGSTEP **f Establishing the boundary line of the *10-m summit area*:** In the same manner, the 4 corner points at the 10-m level (from *p10m-N* to *p10m-E*, *p10m-S*, *p10m-W*, and back to *p10m-N*) will be connected with straight strings.

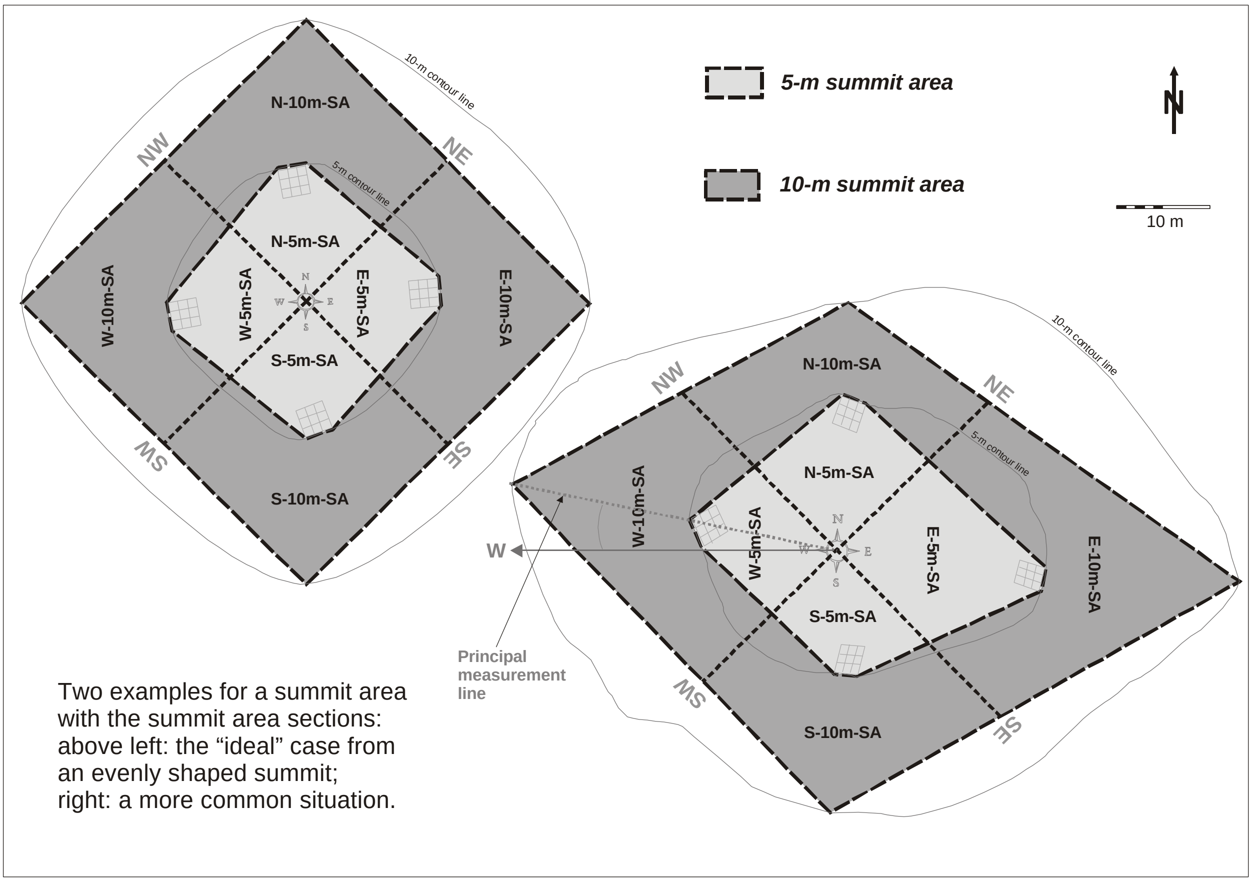


Fig. 8.6 Eight *summit area sections* (= 4 subdivisions of the *5-m summit area* and 4 subdivisions of the *10-m summit area*). The area of the *sections* depends of the shape of the summit. Thus, it is usually different among the main directions (see the right sketch). The sections of the *10-m summit area* are usually larger. The intersection lines always point from the *HSP* to the geographic NE, SE, SW, NW directions, respectively.
In contrast, the principal measurement lines (from the *HSP* to N, E, S, W, respectively) may deviate from their geographic direction, dependent on the habitat situation (e.g. see W-direction in the right sketch; see also workingstep **b** in subchapter 8.3.2).

■ WORKINGSTEP **g Dividing the summit areas into sections:**
→ Person A takes position at the *HSP* and indicates the appropriate compass bearing that runs in between two neighbouring corner points, i.e. NE for the corner points *p10m-N* and *p10m-E*. The same correction for magnetic declination should be taken into account as used for setting up the summit area corner points (see Fig. 8.6 and Box 8.1).
→ After attaching one end of a roll of string to the *HSP*, Person B follows the direction indicated by person A. Where the tightened string crosses the boundaries of the summits areas (e.g. *pNE-5* and *pNE-10*), a marker is placed (e.g. a small aluminium tube and some stones). The procedure is repeated for the remaining three directions. This results in a N, E, S, & W section of the *5-m summit area* as well as of the *10-m summit area* (see Fig. 8.6).
→ Finally, person A takes a compass reading from the *HSP* to the marked points (consider the magnetic declination, see Box 8.1), and person B, supported by person A, measures the surface distance between the *HSP* and the two marked crossing points along each of the 4 intersection lines (e.g., from the *HSP* to *pNE-5* and from *HSP* to *pNE-10)*.
On completing this step, the *summit areas* and quadrats are ready for recording. Before commencing recording, check that all entries have been completed on the measurement protocol (**Form AII.1.1**, see Annex II) including the "checkboxes" for photo documentation of the *1m x 1m quadrats* and the corner points (see chapter 8.4.4 with the workingsteps **o** to **r** and **t**). For measurement tolerances, see Box 8.3; for the reasoning behind these measurements, see Box 8.14.

If all measurements were done correctly, a sketch of the sampling area can be produced – not in the field but afterwards in the lab. Electronic tools that will help to perform this are planned to be developed by the *GLORIA* co-ordination group.

8.4 The recording procedures

8.4.1 Recording in the *1m x 1m quadrats*

Each *3m x 3m quadrat cluster* consists of nine *1m x 1m quadrats* (as set out by the grid of flexible measuring tapes). Vegetation is recorded in the four corner quadrats only, as the others may become damaged through trampling by the investigators during recording. This yields vegetation data for 16 quadrats of 1m x 1m per summit, defined as the ***16-quadrat area***.

8.4.1.1 Detailed vegetation recording in the *1m x 1m quadrats*

In each of the 16 *1m x 1m quadrats* (see Fig. 8.7), the top cover of surface types (vascular plant cover, solid rock, scree, etc.) and species cover of each vascular plant species are recorded. The aim is to **provide a baseline for detecting changes in species composition and in vegetation cover.**
For the sampling sheet see Annex II, **Form AII.3a/b**, and the example in part 2 of Annex II.

■ WORKINGSTEP h **Recording of habitat characteristics:**
In each quadrat, the top cover of each surface type is visually estimated. Top cover is the vertical projection (perpendicular to the slope angle) of each surface type and adds up to 100%, whilst cover, or species cover (see below) takes into account overlaps between layers. In closed vegetation the latter is usually > than 100% (GREIG-SMITH 1983).

→ **Surface types and the estimation of their top cover (%):**
- ***vascular plants****:* top cover of all vascular plants together;
- ***solid rock***: rock outcrops – rock which is fixed in the ground and does not move even slightly (e.g. when pushing with the boot); large boulders which do not move should be considered as solid rock and not as scree (if you are in doubt whether a boulder is scree or solid rock, add it to solid rock);
- ***scree****:* debris material – this includes unstable or stable scree fields, as well as single stones of various size, lying on the surface or +/- fixed in the soil substrate; the grain size is bigger than the sand fraction (as opposed to bare ground);
- ***lichens on soil:*** lichens growing on soil not covered by vascular plants;
- ***bryophytes on soil:*** bryophytes growing on soil not covered by vascular plants;
- ***bare ground****:* open soil (organic or mineral), i.e. the earthy or sandy surface which is not covered by plants;
- ***litter****:* dead plant material.

Each of these types represents a fraction of the 1m²-area; this means that the top covers all surface types present in a quadrat add up to 100%.

→ **Subtypes estimated for top cover:**
- ***lichens below vascular plants:*** lichens growing below the vascular plant layer;
- ***bryophytes below vascular plants****:* bryophytes growing below the vascular plant layer;
- ***lichens on solid rock****:* epilithic lichens on rock outcrops;
- ***bryophytes on solid rock****:* bryophytes on rock growing in micro-fissures where soil material is not visible (as opposed to bryophytes on soil);
- ***lichens on scree****:* epilithic lichens growing on scree or on single stones;
- ***bryophytes on scree****:* bryophytes on scree or stones growing in micro-fissures where soil is not visible;

Each of these subtypes represents a fraction of one of the following surface types: *vascular plants*, *solid rock*, or *scree*. The subtype cover is to be estimated as a percentage of the surface type cover. For example, in a quadrat where 40% is covered by solid rock and half of the rock is covered by lichens, enter the value 50% for the subtype "*lichens on solid rock*" into the sampling form (and not 20%, which would be the percentage referring to the whole quadrat). This is due to a facilitation of the visual estimation.

→ The average aspect of the quadrat (N, NE, E, SE, S, SW, W, or NW) is recorded by using a compass. For the average slope (in degrees, 360° scale) use a clinometer or an electronic spirit level.

■ WORKINGSTEP **i** **Recording of the species composition:**
→ The cover value of each vascular plant species is visually determined (including the vegetative individuals!). The recording of bryophytes and lichens on the species level is optional. Cover values are estimated by using a percentage scale relative to the total quadrat area of 1m². The percentage cover should be estimated as precisely as possible for monitoring purposes, particularly for the less abundant species (see Box 8.5).
Please note that the total cover sum of all vascular plant species may exceed the top cover estimated for vascular plants in workingstep **h** due to overlapping vegetation layers.
See Box 8.5 for general considerations on this method. For considerations concerning the determination of vascular plants with regard to the taxonomic level and concerning cryptogam species see Box 8.6.

Box 8.5: Vegetation records in the *1m x 1m quadrats* – general considerations.

(a) Top cover of surface types: The surface types defined under workingstep h characterise the habitat situation of the plot, based on easily distinguishable surface patterns.

In the preceding 3rd version of this manual, the surface types *"cryptogams growing on soil not covered by vascular plants"* as well as the subtype *"cryptogams below vascular plants"* were not subdivided into bryophytes and lichens, by mentioning the high time-effort for sampling. Resulting from the discussion at the *GLORIA-EUROPE* workshop (October 2002), however, quantitative figures of both bryophytes and lichens are of interest as they are clearly different "functional types" regarding expected responses to climate change.

Therefore, cryptogams are subdivided now into bryophytes and lichens.

(b) Species sampling: Species cover should be estimated as precisely as possible on the percentage scale. Cover-abundance scales used for vegetation relevés (e.g. BRAUN-BLANQUET, 1964) are too coarse for this purpose [for example, low cover values of species (< 1%), which are often put into one class, still show large differences; e.g., a species represented by well-developed individuals may cover not more than 0.01m² (1% of the quadrat), whereas other species, represented by just a few seedlings, often cover less than a 100th of this (< 0.01%)].

- The visual estimation of species percentage cover involves a degree of inaccuracy and may be criticised as being too subjective for long-term monitoring where fieldworkers change. However, it is not the absolute values of species cover that are of importance for monitoring changes in vegetation, but the reproducibility of a method among different observers. It was found by some investigations that changes less than circa 20% are usually attributable to variation between observers (SYKES et al. 1983; KENNEDY & ADDISON 1987; NAGY et al. 2002); therefore only changes larger than that may be attributed to causal factors. When estimating within a standardised 1-m² quadrat, however, precision may be much better for the following reasons.

- The scale on the measuring tapes delimiting the quadrat and the standard quadrat size of 1m² increase the precision of the percentage cover estimation. A particular area covered by a species can easily be transformed into percentage cover values (e.g. an area of 10 x 10 cm equals 1%, 1 x 1 cm equals 0.01%). The use of templates, showing the area of 1%, 0.5% 0.1% etc., facilitates the estimation process, particularly initially (see Figs. AI.3a/b in Annex I). Species cover estimation for broad-leaved species and cushions is rather accurate and reproducible, especially in open vegetation, while the estimation of graminaceous species and of species in multi-layered and dense vegetation requires experience.

(Box 8.5 – continued)

- Supported by a good photo documentation (see under 8.4.4) and by the recording of species in each of 100 0.1 m x 0.1 m cells within each *1m x 1m quadrat* (see 8.4.1.2), the method overall will provide good data for the interpretation of any change in vegetation patterns.

- Visual cover estimation is by far less time-consuming and less destructive than objective measures. It is the only method which provides quantitative data on each species of a given area in a reasonable time.

- An additional advantage of using percentage cover values is the comparability of the altitudinal differences in vegetation cover and structure across the different *target regions*.

Box 8.6: The required **level of taxonomic identification**.

Vascular plants should be identified in the field as accurately as possible; at least to species level (or in taxonomically complex cases to species aggregate level), and if possible to subspecies level. The collection of specimens from the *3m x 3m quadrat clusters* must be strictly avoided.

Cryptogam species. The identification of bryophytes and lichens would be desirable to the species level. However, as identification of some cryptogams may not be possible in the field, and the estimation of individual species cover values is very time-consuming, the sampling of bryophytes and lichens is **not obligatory** for the standard data set of the *Multi-Summit approach*.

In some mountain regions, however, cryptogam species contribute substantially to the phytomass (e.g. in parts of the Scandes). Therefore, sampling of bryophytes and/or lichens was included as an optional activity. In the case that somebody decides to record these species, he/she should be aware of a significant extension of the field work period and of the risk of additional trampling impacts caused by the investigators.

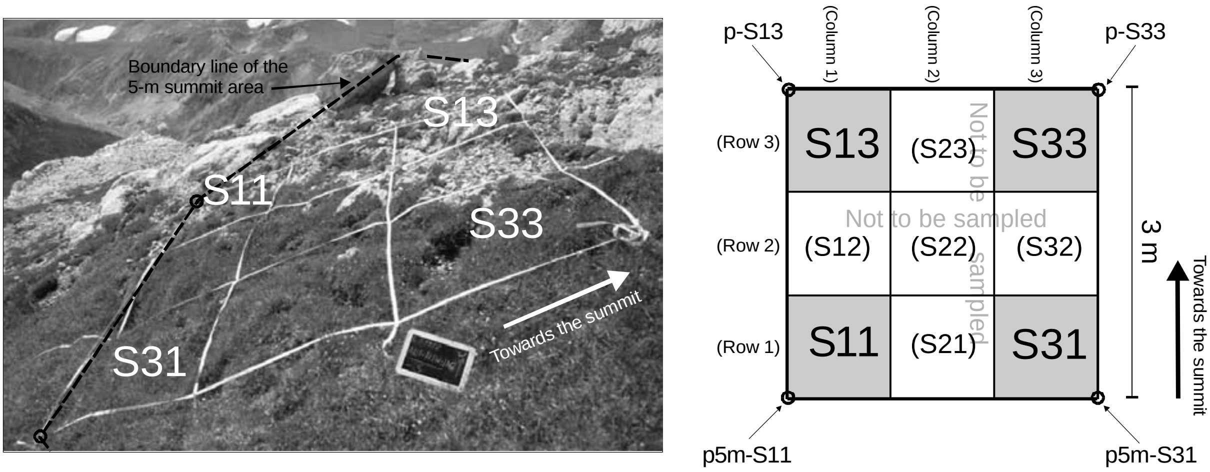


Fig. 8.7 The *3m x 3m quadrat cluster*. Left, example from the NE-Alps (2250m), *quadrat cluster* in the S-direction; right, scheme of the *quadrat cluster* with the quadrat codes and numbers of the measurement points (corner points). The quadrat codes consist of 3 digits: 1st digit: a letter which denotes to the main compass direction, 2nd digit: a number referring to the column of the cluster numbered from left to right (left and right always defined in the sight to the summit), 3rd digit: a number referring to the row of the cluster numbered from bottom to top (in the sight to the summit). For example, S31 is the quadrat in the southern *quadrat cluster* positioned in the third column (i.e. the right side) and in the first row (i.e. the lower side; see also Box 9.2 for coding).

8.4.1.2 Frequency counts in the *1m x 1m quadrats*

Frequency counts of species (vascular plant species obligatory, cryptogams optional) and of obvious grazing impacts should be done in all 16 *1m x 1m quadrats*. The aim is to **detect changes of vegetation patterns on a fine-scaled level** (compare Box 8.7).
As a general rule, frequency counting should not be made in individual quadrats where the grid frame cannot be mounted, to avoid inexact results. This can be the case on summits within the treeline ecotone, where small trees or shrubs may occur within the quadrats (compare Box 7.1).
In addition, features indicating the presence of grazing mammals will be recorded. Three grazing-related features will be distinguished: (1) **faeces/droppings**, (2) **browsing damage**, and (3) **trampling** (see also Box 8.8).
For the sampling sheet see Annex II, **Form AII.4a/b**, and the example in part 2 of Annex II.

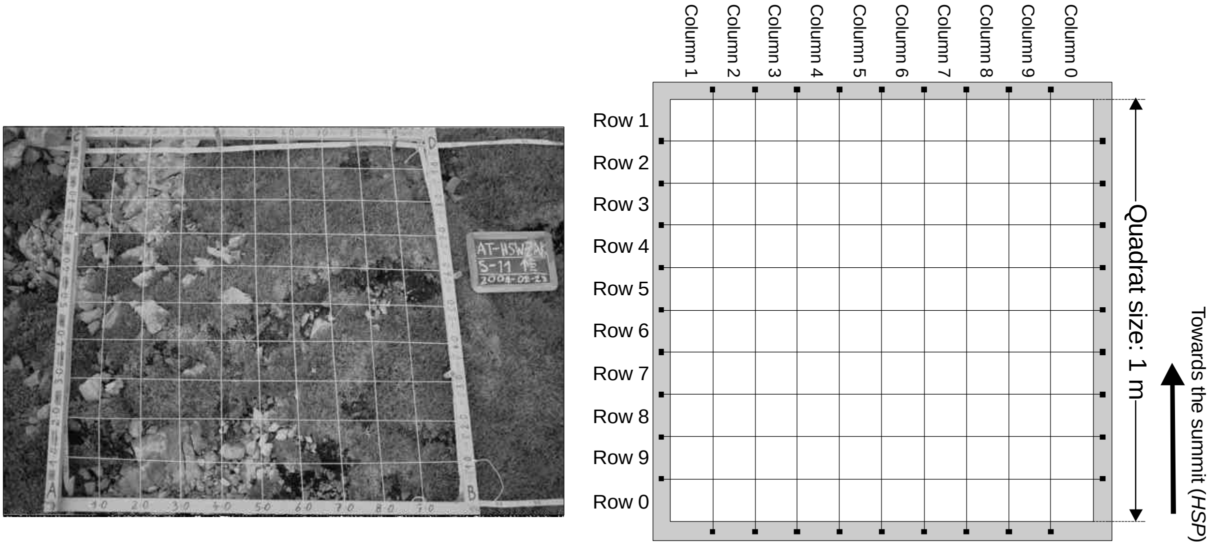


Fig. 8.8 Grid frame for frequency counts of species. Left, grid frame mounted in rugged, steep terrain; right, scheme of the 1m x 1m grid frame, subdivided into 0.1m x 0.1m cells for recording species presence and grazing-related features in each cell.

■ WORKINGSTEP j **Frequency counts with the grid frame:** A wooden (or aluminium) grid frame with 100 cells of 0.1m x 0.1m, delimited by thin white strings (see Fig. 8.8 and Fig. AI.2 in Annex I for construction details) will be used for the frequency counts.
→ In each cell, presence of vascular plant species (cryptogams optional) and of grazing features will be recorded. All species seen inside a grid cell must be recorded as present for that particular cell. Thus, a species is considered as present when showing plant parts within the boundary strings of the 0.1m x 0.1m grid cell, regardless of where it is rooted.
Note that recording must always be made perpendicular to the slope angle (i.e. perpendicular to the grid frame plane). Particular care should be taken on uneven relief, where the grid frame cannot be positioned flat on the surface.

See also Box 8.7 for general considerations and Box 8.8 for grazing impacts

Box 8.7: Frequency counts – general considerations. Records on the presence of species obtained by the 100-cells grid frame are used to monitor changes in vegetation patterns on a fine-scaled level. An accurate relocation of the grid frame at each successive recording is a precondition for reliable monitoring records. Therefore, a careful photo documentation of each quadrat, with the grid frame mounted, is crucial (see also subchapter 8.4.4).

Box 8.8: Human land use and grazing impacts. As mentioned in subchapter 7.2.3, human trampling or grazing by livestock and wild living mammals may mask possible climate-related changes. Thus, sites being strongly affected by human land use should be avoided. In some mountain regions, however, it is difficult to find grazing-free summits. Therefore, it is important to include an estimation of grazing impacts and to provide comments on human land use in the *target region*:

a) Notes on the main type of human land use, on the land use history, and on changes of management practices are to be made in the sampling form for the *target region* (see **Form AII.0** in Annex II).

b) Comments on impacts related to grazing should be given for each *summit area section* (in **Form AII.5a** in Annex II) – particularly regarding visible features indicating grazing: feaces/droppings, browsing damage, trampling.

c) The presence of grazing indicators (1) ***faeces/droppings***, (2) ***browsing damage*** (clipped shoots and leaves), and (3) ***trampling*** (e.g., hoof marks, foot prints, broken lichens, and scuffed tussocks) is recorded in each 0.1 m x 10 m grid cell of the quadrats. This can be made without much extending the recording time.
Only impacts caused by mammals (including the small mammals) are to be recorded – and not those caused by other animals, such as arthropods.

8.4.2 Recording in the *summit area sections*

The four sections of the *5-m summit area* together with the four sections of the *10-m summit area* form a set of eight plots covering the total summit area (compare Fig. 8.6). In each *summit area section*
(1) the **percentage top cover** of surface types, and
(2) a **complete species** list and **percentage cover** of each species will be recorded.
The main focus lies in **detecting changes in species richness and species migrations.**

Cover records on top cover surface types characterise the habitat situation of the summit area. Further, the total top cover of vascular plants (i.e. one of the surface types) is a reference value for the cover estimations of species. Complete species lists of vascular plants (bryophytes and lichens optional) are crucial for assessing plant invasions into the summit area. For general considerations concerning species recording in the *summit area sections* see Box 8.9.
For the sampling sheet see Annex II, **Form AII.5a/b**, and the example in part 2 of Annex II.

■ WORKINGSTEP **k** **Percentage top cover estimation for the suface types**:
Vascular plants
Solid rock
Scree
Lichens (excluding epilithic lichens)
Bryophytes
Bare ground
Litter

These surface types are the same as used in the *1m x 1m quadrats* (for definitions see workingstep **h** in subchapter 8.4.1.1).

■ WORKINGSTEP **l** **Complete species list and estimation of species percentage cover:**

→ Make a careful observation in each entire *summit area section* in order to record all species which occur. It is crucial to find each occurring species in order to provide a baseline to detect changes of species richness, disappearance and immigration of species.

→ Estimate the percentage cover of each species occurring in the *summit area section*. Percentages refer to the entire area of the *summit area section*. Make the estimation by using numeric values (e.g., 65, 20, 12, 4, 1, 0.5, 0.01% etc.), but avoid the use of cover classes scale (for example, do not assign indications such as 1-5%, 75-100%, < 0.1%, < 1%, < 10%). See Box 8.9.
→ In addition, mark those species which occur only **locally** within the *summit area section* (i.e. those species which can easily be overlooked, because they occur only at one or a few locations). For such species you must describe briefly the location(s); e.g., in the central part of the section; 1 m S of the *HSP*; 2 m NNW of pNE-5; at the lower boundary approximately 3 m from pSW-10; etc. Wherever possible, give an indication about the absolute cover or the abundance of the locally distributed species (e.g. 1/2 square metre; 3 individuals; 2 seedlings; etc.). Compare the sampling form for the *summit area section* (**Form AII.5a/b** in Annex II) and the example in part 2 of Annex II.

Box 8.9: Percentage cover estimations in the *summit area sections* – general considerations.

Top cover values of surface types and species cover values obtained from the summit area are used to compare the altitudinal differences of habitats and vegetation cover across the different *target regions*. The subdivisions into *sections* allow for analyses of exposure effects on species and vegetation patterning. The most important purpose, however, is to provide a baseline to monitor changes in species richness in order to assess the disappearance and invasion of species. Thus, it is **crucial to detect all species**.
In addition to the complete species list, a quantitative measure of the abundance or coverage of each species within the particular section is required for a sensitive monitoring strategy.
Two sampling methods were originally used to provide such data. Both methods were discussed at the *GLORIA-EUROPE* workshop (October 2002) and criticised for the following disadvantages:

(a) Step-pointing: this is a quantitative measure for the more common species (Evans & Love 1957, Bayfield 1971). Records are obtained by walking 200 steps in a random route across each *summit area section*. Each species hit by the mapping pins, mounted at the toes of the boots, is mapped. Step-pointing was not applicable on several summits due to terrain constraints (e.g. when slopes were too steep or terrain was too rugged) or where the vegetation is particularly sensitive to trampling (e.g. some lichens-dominated communities). In addition, it was criticised because it only works well where vegetation cover is high and where the number of species is low, combined with a high evenness.

(b) Visual abundance estimation: this method uses qualitative abundance classes (dominant, common, scattered, rare, very rare) estimated for each species. It gives relatively accurate estimations at the lower end of the abundance scale, but is less precise at the medium and high abundance levels. Although this method has been recommended as a fast-working monitoring method by most of the fieldwork teams, it was criticised for being biased because of subjectivity – particularly due to the difficulty in providing precise definitions of the abundance classes appropriate for all plant growth forms. Further, the limitations of qualitative abundance values in multivariate analysis have to be taken into account.

Therefore, **visual percentage cover estimation** of **species** will replace the above two methods. The time effort will be about the same as for both previously used methods together. Yet, the visual species cover estimation is the best solution, because there is no other single method that fulfils the following requirements concurrently:

- The method is **simple** and works without inexact definitions.
- It provides **quantitative data** on how much is there of each single species of a given area.
- at the same time it is by far **less destructive** and
- by far **less time-consuming** than objective measures.

The method is the same as the species cover estimation used in the quadrats. The difference, however, is that the plots are larger, of various size, and the entire plot area sometimes cannot be looked over from one viewpoint. This involves that the degree of accuracy and thus the sensitivity in detecting changes in cover is much lower (particularly for species occurring with medium to low cover and with a scattered distribution).
Despite these limitations, the method is suitable to detect changes in species richness, the disappearance or the immigration of species.

(Box 8.9 – continued)

The following guidelines are to be considered in order to optimise the method:

(1) Start with an inspection of the entire plot area.

(2) Start the species list with the obviously most common species.

(3) Continue with a careful inspection until all species occurring within this area are entered into the list. Keeping this list in a rank order will facilitate the cover estimation afterwards.

(4) Estimate the percentage cover and assign a value for each species. Do not use cover classes (for example, avoid indications such as: 1-5%, 25-50%, < 0.1%, < 1%, < 10%, or > 50%). A grouping into cover classes has the disadvantage of limiting a ranking of the species (see the example below). Therefore, make the cover estimation by always keeping a ranking of the species in mind. In other words, where it is impossible to estimate the cover of a species precisely, it will be possible, in many cases, to decide that one species covers slightly more (or less) than an other.
Further, cover classes restrict the data handling. Therefore, the data input tool of the *GLORIA* data base does not except cover indications such as 1-5%, < 1% etc.

Example: A ranking of species is limited when cover classes are used. The right column in this example shows values from an estimation without using any grouping into classes. The advantage of these values is that a ranking is less limited, but they should not suggest a much higher accuracy regarding to the actual percentage covered by a species.

Species	Percentage classes at 10 % intervals	Percentage classes with smaller graduation at the bottom of the scale (Braun-Blanquet 1964)	Logarithmic percentage classes	Estimation without grouping into classes
Carex cuvula	>60-70	>50-75	>10-100	70
Oreochloa disticha	>30-40	>25-50	>10-100	35
Avenula versicolor	>10-20	>5-25	>10-100	12
Poa alpina	>0-10	>5-25	>1-10	8
Veronica bellidioides	>0-10	1-5	>1-10	3
Phyteuma hemisphaericum	>0-10	1-5	>1-10	2
Euphrasia minima	>0-10	<1	>0.1-1	1
Gentiana bavarica	>0-10	<1	>0.1-1	1
Erigeron uniflorus	>0-10	<1	>0.1-1	0.5
Veronica alpina	>0-10	<1	>0.01-0.1	0.02
Salix herbacea	>0-10	<<1	>0.001-0.01	0.005

(5) Additional notes for a particular species must be given if it is distributed only on one or a few spots within the *summit area section* (i.e. notes on the position within in the plot, and wherever possible, the absolute size of the individual or group of individuals or the number of individuals). This is of relevance for reinvestigations, particularly in cases where such species occurrences are close to the plot boundary. For an example see part 2 of Annex II.

8.4.3 Continuous temperature measurements

8.4.3.1 Temperature data loggers

Among other climatic features, high alpine biota are highly controlled by temperature and snow cover. Parameters related to these regimes are relatively easy to measure (directly for temperature, indirectly for snow) by using miniature data loggers buried in the substrate. Whether a distinct location is covered by snow or not can be inferred from the shape of the diurnal temperature oscillation (GOTTFRIED et al. 1999, GOTTFRIED et al. 2002), even when measured at 10 cm substrate depth (Fig. 8.9).

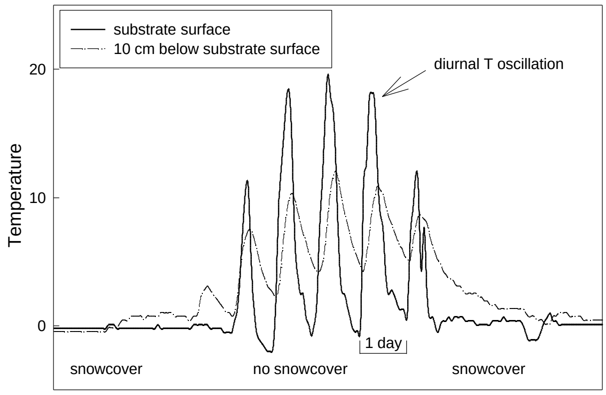


Fig. 8.9 Temperature series as measured at the substrate surface and 10 cm below the surface. The series from the buried logger match the surface series with a time lag of only a few hours. Data from Schrankogel, Tyrol, Austria, at 3108 m a.s.l.

In the *GLORIA* process such data will be used **(a) to compare summits along the altitudinal gradient within and between target regions according to their temperature and snow regimes** and **(b) to detect long-term climate changes**.

Currently the most appropriate instruments are *Onset StowAway Tidbit -20/+50°C mini-data loggers*. These loggers are sealed in epoxy and therefore robust against physical damage. At a sampling interval of one hour, memory and batteries should be alive for at least 3 years. Even if the battery fails, data should be held, as EEPROM memory is used. See Fig. 8.10 for technical specifications.

If such devices are unavailable, other instruments can be used provided they are of similar specifications.

The loggers shall be installed in the substrate (at -10 cm; see Fig. 8.12) for two reasons:
a) they are shaded from direct solar insolation and surface winds and therefore site-specific errors are minimised;
b) they are hidden from tourists and animals.

StowAway TidbiT

Completely Sealed Underwater Temperature Logger with Optic Communication Features and Specifications

- Waterproof to 1000 feet
- 5 year non-replaceable battery (typical use*)
- Completely sealed in epoxy; very durable
- Capacity: 32,520 measurements
- Small size: 1.2" wide x 1.6" tall x 0.65" thick (30 x 41 x 17 mm) and 0.8 oz.
- Two measurement ranges†: +24°F to +99°F (-4°C to +37°C) and -4°F to +122°F (-20°C to +50°C)
- User-selectable sampling interval: 0.5 seconds to 9 hours, recording times up to several years
- Blinking LED light shows if temperature goes out of user-determined limits
- Uses optic communications through Optic Base Station for launch and readout
- Readout and relaunched in the field with optional Optic Shuttle
- Precision components eliminate the need for user calibration
- Programmable start time/date
- Triggered start with coupler or magnet
- Memory modes stop when full or wrap-around when full
- Nonvolatile EEPROM memory retains data even if battery fails
- Multiple sampling with minimum, maximum or averaging
- Blinking LED light confirms operation
- Time accuracy: ±1 minute per week at +68°F (+20°C)
- Mounting tab
- Compliance certificate available
- NIST-traceable temperature accuracy certification available

*16 three-month deployments in water (+35° F to +80°F) with 4 minute or longer intervals (no multiple sampling)

Fig. 8.10 Technical specifications of *StowAway Tidbit* T loggers.
URL: http://www.hobohelp.com//Product_Pages/temperature_pages//4201_S.tidbit.html

8.4.3.2 The *Three-level design* for temperature measurements

Although the suggested devices are relatively cheap, a hierarchy of measurement designs using different numbers of loggers, according to the available funding, is suggested. However, from the experiences of GLORIA-Europe, it is highly recommended to apply **level C** for obtaining high-density climate data and for reasons of compatibility with already existing GLORIA measurements.

Level C: recommended. This is the usual GLORIA climate measurement design.
Four T loggers are positioned on each summit, one in each *3m x 3m quadrat cluster* (see Fig. 8.11). This scheme provides valuable information on the climatic situations in the four main directions (e.g., on different snow accumulation patterns). This is the optimum approach and should be established wherever possible. This scheme was applied in the *GLORIA-EUROPE* project in summer 2001 at 71 summits.

Level B: rather not recommended. This is a cheaper but less informative design.
Two loggers per summit are positioned in those two *3m x 3m quadrat clusters* that best represent the two main climatic directions (e.g., N and S). In which two of the four geographic directions the loggers are positioned should be decided in the field. Although cheaper then the level C design, this approach has remarkable disadvantages (see below).

Level A: not recommended. This is the cheapest design but the information obtained is very low.
One T logger per summit is used near the *HSP* (highest summit point; see Figs. 8.2 & 8.11). Although this is the lowest-cost approach it has critical disadvantages: a) the very summit top is often the least typical place in the summit area regarding vegetation structure and micro-climate (especially for snow cover);
b) no information about climatically different slope directions can be inferred from a one-logger-sampling.
However, if budgets are insufficient for more loggers, some overall climatic features of the summit can be described to some extent using this approach.

Experiences from GLORIA-Europe:
On all GLORIA-Europe summits established in 2001, the level C design was applied. On a few of them, a combination of level C and level A was tested. The comparison showed that series from *HSP*-loggers (level A) hardly reflect the situation on slopes (i.e., in the *3m x 3m quadrat clusters,* level C). Even two loggers per summit (level B) seem to be not enough to compare different summits sufficiently.
Moreover, all synoptical analyses of GLORIA are based on the level C design (4 loggers per summit). New data of a level B or even level A design can be linked to these analyses only with very strong limitations.

Therefore it is **highly recommended** to apply a **level C** design for climatic measurements, if any possible!

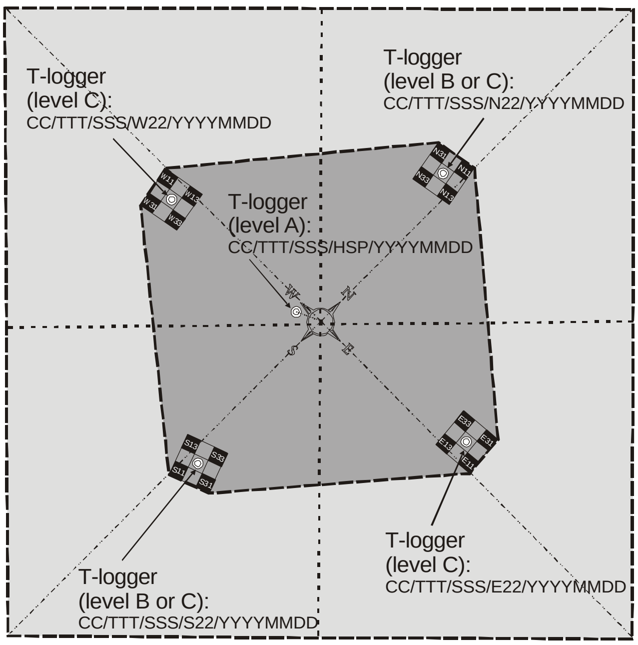


Fig 8.11 T logger positioning: Depending on the number of loggers available, three levels of T measurement can be applied.
Level C: four loggers, one in each *3m x 3m quadrat cluster*. This is the usual design.
Level B: two loggers in *3m x 3m quadrat clusters* in the main climatic directions (e.g., the direction with most and least snow accumulation, respectively).
Level A: one logger at the highest summit point.

See also chapter 8.4.3.3 and Box 8.12; for the full-length-loggercodes see Box 9.2.

Box 8.10: Other meteodata. The inclusion of other climatic parameters in the *GLORIA Multi-Summit* protocol, such as precipitation and/or soil moisture, as well as data on nitrogen deposition, are certainly of interest for detecting climate-induced signals. Although feasible low-cost methods for measuring these parameters are difficult to accommodate, possible strategies on how to include these parameters should be given careful consideration – at least in a small subset of the *Multi-Summit* sites. Suggestions on this would be very appreciated.

Box 8.11: Before starting with any climatic measurements. The technical progress regarding measuring climate is highly dynamic, especially for mini-data loggers. Furthermore, some details on sampling rates etc. remain to be defined. As for any other instructions in this manual, please check out the updated information on the *GLORIA* website: www.gloria.ac.at , before planning or starting the climatic measurement program.

8.4.3.3 Positioning of the T data loggers

■ WORKINGSTEP m **Preparations**

Each temperature logger must have a *GLORIA*-wide standardised full-length-code in the following structure:

CC/TTT/SSS/PPP/YYYYMMDD (see Box 9.2 for the meaning of these codes and for examples).

■ WORKINGSTEP n **Positioning of the data logger:**

Level A:

→Define the nearest point to the *HSP* (see Fig. 8.2 and 8.11) where a logger can be buried 10 cm below the substrate surface.

→Follow the instructions in Box 8.12. For the protocol, measure the logger's position relative to the *HSP* (see **Form AII.2** in Annex II).

alternatively:

Level B:

→Select the **two** *3m x 3m quadrat clusters* which represent the two most contrasting climatic directions on the summit.

→In each *3m x 3m quadrat cluster*, define in the central quadrat (e.g. N22) a position where a logger can be buried 10 cm below the substrate surface. In the ideal case, this position should be in the plot centre, but, on the other hand, it should represent an average surface situation (e.g., not directly aside a steep solid rock). In those cases where the logger cannot be positioned in the central quadrat of the quadrat cluster, choose a proper position in another quadrat, but avoid the corner quadrats (in other words: position the logger, e.g., in the quadrats N12, N21, N23, or N32; for quadrat numbers compare Fig. 8.7 and Box 8.12). Generally, the logger position should represent the presumed average microclimate situation of the *3m x 3m quadrat cluster* as nearly as possible.

→Follow the instructions in Box 8.12. For the protocol, measure the logger's distance relative to both lower corner points of the *quadrat cluster* (e.g., *p5m-N11* and *p5m-N31*; see Box 8.12).

alternatively:

Level C:

Same as for level B, but for all **four** *3m x 3m quadrat clusters*.

Box 8.12: How to install a temperature data logger.

Instructions for workingstep **n**:

→The logger was previously programmed for the correct sampling rate and started (i.e., "launching the logger"). The current GLORIA standard are 24 measurements per day, i.e., a sampling rate of **1 hour**. However, contact the GLORIA website: www.gloria.ac.at for details on logger launching.

→Dig a small, 10-cm-deep hole, taking care not to destroy the surrounding substrate texture too much.

→Assemble the full-length-code for the logger (depending on its installation position you have chosen; see Box 9.2). Indicate this code both in the protocol (**Form AII.2**, see Annex II) **and** on the back side of the logger body (use a waterproof marker).

→Read the logger serial number (usually indicated somewhere on the logger body; on *StowAway Tidbits* on the **left** side of the logger body) and enter it into the protocol.

→If using *StowAway Tidbits*, stick adhesive tape around the logger's body to protect the optical interface on the front face.

→Fix a short string (approx. 10 cm) into the loop (this will help to find the device again in the future).

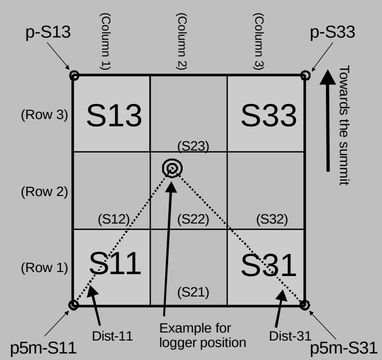
→Put the logger into the hole. Make sure that the logger lies approximately 10cm below the surface level.

→Measure the distance of the hole centre to the relevant measurement points (different in level A and B/C; see figure below in this box and text in this chapter) and enter the data into the protocol.

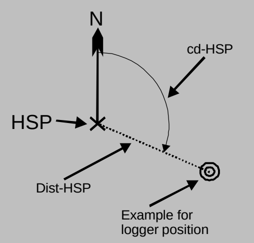
→Make two or more photos of the open hole (one including the plot boundary, or *HSP*, respectively, and one zoom to the logger's vicinity). Put a marker to the exact logger position (e.g., the tip of a knife or pencil). Adding other visual hints to the view (e.g., a measuring tape indicating direction and distance to any measurement point) enhances the value of the photo. Check the *photo checkbox* on the field form (**Form AII.2** in Annex II). See Fig. 8.12 and also chapter 8.4.4 for general remarks on photo documentation.

→Carefully refill the hole. Make sure that the short string tied to the logger does not extend to the surface. It should aid in finding the logger again after digging one centimetre into the substrate, but an easy detection by tourists must be avoided.

→Make two or more photos of the **closed** hole (see remarks above). These will be crucial for retrieving the loggers with minimal damage to the plot substrate structure. Check the *photo checkbox* on the field form. Write the installation date and time into the protocol.



Example for a **level C** or **B** logger position



Example for a level **A** logger position

The measured values of 'Dist-HSP' and 'Cd-HSP', or 'Dist-11' and 'Dist-31', respectively, have to be entered in **form AII.2**.

Fig. 8.12
Temperature data loggers: Mini data loggers for T are buried in the substrate at –10 cm.
Left, logger position opened. Centre: logger position closed. Right, *StowAway Tidbit* temperature logger (compare Fig. 8.10).

8.4.4 The photo documentation

The photo documentation is **crucial for the accurate reassignment of the plots and for documenting the whole visual situation of the quadrat** (see also Box 8.13). For the photo documentation it is vital to keep exactly on the *GLORIA* coding scheme (see Box 9.2 and Annex III).

■ WORKINGSTEP **o** **Photo documentation of the highest summit point (*HSP*):** Although this point will be marked permanently, this principal measurement point must be carefully documented with photos (detail photos, see Fig. 8.3, as well as photos showing its position from the distance; see Box 9.2 and workingstep **p** for coding; item code = *HSP*).

■ WORKINGSTEP **p** **Photo documentation of the *1m x 1m quadrats*:** Photographs must be taken of all 16 quadrats from a top view position (perpendicular to the slope angle, as far as possible). This can be done using a standard 24x36mm Single Lens Reflex camera and a lens of 28mm focal length (see Box 8.13). Alternatively, a digital camera may be used. Photos should preferably be taken in diffuse light, because direct sun light causes extreme contrasts, which is unfavourable for depicting surface structure and texture.
Each *1m x 1m quadrat* should be photographed with and without the frequency grid frame (see Fig. 8.13). Both are crucial for future monitoring investigations. Particularly for sampling with the grid frame (100 cells of 0.1 m x 0.1 m per quadrat) a very exact repositioning is a precondition for monitoring – the most feasible approach that allows an exact repositioning is a good photo documentation.
The following information has to be included in the photograph (best on a small blackboard positioned near the left or the right side of the quadrat): all obligate code elements (see Box 9.2 and Annex III), i.e.: Date, country code, *target region* code, summit code, item code (e.g., N31, S11, etc.), and an arrow pointing towards the north direction or towards the *HSP* (compare Fig. 8.13). White boards are not recommended because writing may not be visible on the photo.
Detail photos (e.g. each quarter of a quadrat), which might allow the identification of species, are a further option.

Fig. 8.13 Left, *1m x 1m quadrat*; Right, the same quadrat with frequency grid frame mounted.

■ WORKINGSTEP **q** **Photo documentation of the *3m x 3m quadrat clusters*:** overview photos should be taken of each *3m x 3m quadrat cluster* from various sides (e.g., see Fig. 8.7). Do not forget the blackboard with the codes (coding as in workingstep **p**; item codes = N, E, S, or W, respectively) and an arrow towards the north direction or towards the *HSP*.

■ WORKINGSTEP **r** **Photo documentation of the corner points of the *summit area sections*:** The following items have to be documented:
(1) the highest summit point (*HSP*) made in workingstep **o**;
(2) of the four 10-m points: coding as in workingstep **p**; item codes = *p10m-N, p10m-E, p10m-S, p10m-W*;

(3) and of the eight summit area points: coding as in workingstep **p**; item codes = *pNE-5, pNE-10, pSE-5, pSE-10, pSW-5, pSW-10, pNW-5, pNW-10;*
These points should be marked with a signal stick or rod (1 to 1.5 m length) to make them visible on the photo: the small aluminium tubes and/or stones used as permanent markers are insufficient for this purpose (Fig. 8.14). An overview as well as a detailed photo should be made of each point, always with the blackboard included with the relevant codes and an arrow pointing towards the north direction or towards the *HSP*.

Fig. 8.14 The 10m-point (*p10m-W*) on Pulpitito (Sierra Nevada/Spain, 2760m), marked with a signal rod for photo documentation.

■ WORKINGSTEP s **Photo documentation of the position of the temperature logger(s):** (see Fig. 8.12 and Box 8.12). Use the codes as in workingstep **p**, but write a prefix LOG- in front of the item code. Do not forget the arrow towards the north direction or towards the *HSP*.
Examples: 2002/07/29 AT˙HSW˙GHK˙LOG-N22; 2002/08/14 AT˙HSW˙WEK˙LOG-HSP;

■ WORKINGSTEP t **Photo from the entire summit:** Take a photo of the summit (e.g., from a neighbouring hump) to show the geomorphologic shape and the general situation (compare Fig. 7.2). Use the blackboard including the codes, if possible (use SU-OV as item code; see Annex III for codes). Do not forget the arrow towards the north direction or towards the *HSP*.

■ OPTIONAL WORKINGSTEP u **Other detail photos:** If you think that it might be important to do more detailed photo documentation, e.g., on the position of intersection lines and other lines, such photos are highly appreciable. For coding of these details use the next-lying obligate item (compare workingsteps **o-r**). If this item is not seen on the photo view, add an arrow on the blackboard pointing from the written code in the direction of the item to which the code belongs. Also do not forget the north or *HSP* arrow.

Also highly appreciable are photos from (special) plants of your area.

Box 8.13: Photo documentation – general considerations. Paper copies of the photographs (from colour negative film or slide film) have proven to be the most important reference for a fast and accurate reassignment of plots. Photos allow the plots to be re-established without repeating the time-consuming measurements.

• Moreover, photos are much more than instruments to relocate the plots. They document the entire visual situation of the permanent plots in ways that are of great comparative value after many years.

• For both the above reasons, the photo documentation should be made carefully and, whenever possible, **not** under direct sunlight to avoid hard contrasts.

• Ensure that each photograph is labelled with its full-length-photocode (see Box 9.2) written on a blackboard which is to be included in the view wherever applicable.

• Mark the "photo checkboxes" in the Forms **AII.1.1** and **AII.2** (see Annex II) to control whether all obligatory photos were taken.

Colour negative or slide film:

• The advantage of slides: more natural colours, a probably higher sharpness of pictures, which can be enlarged with a slide projector;

• The advantage of colour negatives: paper copies are the appropriate material for reassigning the plot positions. A colour negative film yields both negatives for the archive as well as the paper copies – thus photos need not be scanned and printed on paper (more-time consuming and more expensive using slide films). Further, photo scanners for paper copies may be more widely available.

In summary, the use of colour negatives is the recommended solution, if not both film types are used anyway. A further recommended option is the use of a digital camera.

Focal length of lens:

For depicting the full *1m x 1m quadrats* a 28mm wide angle lens is sufficient for persons taller than about 1.8m. For smaller persons, a lens with a shorter focal length may be necessary. Photos of the corner points and loggers etc. may be made with standard 50mm lenses, or with other lenses appropriate in the particular case. Optional detail photos from the quadrats should preferably be made with a standard 50mm lens to avoid distortion.

Digital cameras:

Use the highest pixel resolution available with your camera to get as much information as possible.

8.5 Removal of plot delimitations and considerations for future reassignment

■ WORKINGSTEP V **Removal of plot delimitations:** all 3m x 3m grids and all strings delimiting the *summit area sections* have to be removed after all previous steps of chapter 8 are finalised. Only the small aluminium tubes (or other appropriate markings) and the temperature data logger remain at the summit site. **Before you remove the delimitations, check Forms AII.1.1 and AII.2** (see Annex II) to ensure that **all plots/items have been documented with photographs!**

For future reassignment see Box 8.14.

Box 8.14: Considerations for future reassignment.

The fast and accurate reassignment of the plots for monitoring investigations will be done based on photographs from the quadrats and the corner points. Thus, the time-consuming measuring work, as described in chapter 8.3, usually need not be repeated for future monitoring investigations. Nevertheless, these measurements are essential:

(a) to determine the directions and the 5-m and 10-m levels;

(b) to draw a detailed outline of the sampling design to be used for two purposes: to find the plot areas for reinvestigations, and to calculate the area of the *summit area sections*;

(c) and to re-establish the plots in cases where this is not possible by photographs (e.g. due to severe disturbance events or due to unexpectedly pronounced vegetation changes). In these cases, repeating the measurements may be necessary.

9 Data structure, storage and management

First of all an important note:

Box 9.1: Remain informed about the current structure of sampling protocols and about standards of data storage and sharing.
All your data should be fed into the *Central GLORIA Database*. This database is currently maintained at the *GLORIA* server in Vienna and holds already all *GLORIA* data collected until now.
With this final version of the manual, the overall structure of sampling methods, field forms, as well as the database structure should have come to a stable state. However, minor changes in these structures are still possible.

Therefore:
Before planning any field work and data input, please see the *GLORIA* web site (www.gloria.ac.at) for the latest available information and downloads of the current standards and tools.

In the following, a short description on the principle data structure is given.

9.1 Data structure

Each contributor is expected to

(a) prepare the own field data (compare the Forms AII.0 to AII.5 in Annex II):

- administrative data on the *target region* and *summits*;
- data on the position of the permanent quadrats and the corner points of the *summit area sections*;
- percentage cover values and presence/absence values from the *16-quadrat areas*;
- species data from the *summit area sections*;
- administrative data on the *temperature measurements;*
- *temperature logger data* (in co-operation with the *GLORIA* co-ordination).

(b) prepare a list of all plant species occurring in your data set. Check this list for consistency of species names with the *GLORIA* species list provided under www.gloria.ac.at. Contact the *GLORIA* co-ordination for nomenclature problems and details.

(c) Send this list to the *GLORIA* co-ordination. The list will be cross-checked again for synonyms against the species names already included in the *Central GLORIA Database*.

9.2 Data input and storage

Electronic tools for data input are available at the *GLORIA* server. Contact the *GLORIA* co-ordination for a password which gives you access to your personal version of *GDIT* (the *Gloria Data Input Tools*). They are prepared by the *GLORIA* co-ordination and will include the final species list of your *target region* (see points b and c above). In advance, you may download a trial version of the *GDIT* tools from the *GLORIA* web page for testing.

9.3 Data management

The *GDIT* tools provide the opportunity to electronically submit your data to the *GLORIA* co-ordination. The data will be included in the *Central GLORIA Database* and will be partly available on the internet according to the publishing rules negotiated within the *GLORIA* consortium.
In any case, the contributor retains the ownership of his/her data, and any further use for purposes of a meta-analysis depends on the permission of the contributor.

9.4 Maintaining the photo documentation

The original photo documentation materials should be stored in your office together with your original field forms for further monitoring. **But it should also be delivered digitally to the *GLORIA* co-ordination to be included in the *Central GLORIA Database*.**

Therefore, it is highly recommended that you scan your photos, if you have not used a digital camera. All digital photo files have to be renamed according to the *GLORIA*-unique coding system. Please see Box 9.2 and Annex III as well as the *GLORIA* web site for more information on how to do this and to deliver the materials to the *GLORIA* co-ordination.

Box. 9.2: *GLORIA*-unique codes for various items in forms and photographs.

Various items in the *GLORIA* data set must have a *GLORIA*-wide specific coding, which is used in forms, on photographs, for temperature loggers, as well as in the database.

Country codes: The two-digit *ISO 3166* codes are used. Examples: AT..Austria, GE..Georgia, NZ..New Zealand, CL..Chile; see a full list at www.gloria.ac.at .

Target region codes: These three-digit alphanumeric codes are created **solely** at the *GLORIA* co-ordination to avoid code conflicts; please contact us to obtain a TR code. Examples: SNE..Sierra Nevada/Spain, HSW..Hochschwab/Austria.

Summit codes: Three-digit character codes (avoid numbers). Each researcher who is responsible for a *target region* shall select such codes carefully for his/her summits, avoiding coding conflicts within the TR. Examples: ZAK..Zagelkogel, GHK..Ghacktkogel.

These three code elements must be indicated in the header of any field protocol form.

All measurement points. Their codes are indicated in Fig. 8.2.

All sampling areas. Their codes are indicated in Fig. 8.2. Special care should be devoted to the coding of *1m x 1m quadrats*, as indicated in Fig. 8.7; e.g., if you stand below the lower boundary of a *3m x 3m quadrat cluster*, which is installed southwards of the summit, and look towards the summit, then the left lower *1m x 1m quadrat* is coded S11 (the first column and first row of the cluster), whereas the right lower quadrat is coded S31 (the third column and first row). The other quadrats are coded in a similar way according to their column-row-position in the cluster. This coding is similar to what is used in many geographic maps and GIS applications.

Full-length-codes:

These are used for items that may be used or recorded separately from sampling protocols. Such items should be coded with full-length-codes, which are a combination of the Country-, Target region-, and Summit-code followed by other code elements.
They are used, e.g., for:

Temperature data loggers: For each logger, indicate the full-length-loggercode on the logger **and** in the protocol as:
CC_TTT_SSS_PPP_YYYYMMDD with CC..countrycode, TTT..target region code, SSS..summit code, PPP..plot code (always *HSP* for level A loggers; always use the quadrat code as described in Fig. 8.7 for level B or C loggers), YYYYMMDD..date (year month day) of installation of the logger in the field.

(Box 9.2 – continued)
Examples for full-length-logger codes are:
AT_HSW_ZAK_HSP_20010711 for a level A temperature logger in Austria, Hochschwab, Zagelkogel, highest summit point, installed on 11th of July 2001;
ES_SNE_TCA_W22_20020801 for a temperature logger in Spain, Sierra Nevada, Pico del Tosal Cartujo, western *3m x 3m quadrat cluster* - quadrat 22, installed on 1st of August 2002.

Photographs: Wherever applicable, a blackboard with indications should be included in the photo view (see Box 8.11 and figures in chapter 8). Whenever a distinct *GLORIA* item is photographed, such as measurement points, plots, data loggers, indicate the relevant code elements in the correct sequence. As separator of the code elements you may use a point (˙) to save space on the blackboard.
On any photo, do not forget to indicate the date on the blackboard.

Examples for photo codes are:
AT˙HSW˙GHK˙N33˙19990817 for a photograph of a *1m x 1m quadrat* in Austria, Hochschwab, Ghacktkogel, *1m x 1m quadrat* N33, on 17 August 1999.
ES˙SNE˙TCA˙p10m-S˙20010703 for a photograph of: Spain, Sierra Nevada, Pico del Tosal Cartujo, southern summit area corner point at the 10-m level, on 3 July 2001.

On photos of data loggers, write also the prefix LOG- in front of the plot code onto the blackboard.

Remark: on the blackboard, you may alternatively write the date in the upper left corner and separated by slashes, for better readability.

USE THESE CODES FOR ANY REFERENCES IN YOUR GENERAL COMMENTS OR ANY OTHER TEXTS, WHEREVER APPLICABLE.

Coding of species names:

Coding of species names is relevant for two different schemes in the *GLORIA* process: a) for fieldwork, and b) for data input

(a) **Fieldwork:** you are free to enter your own codes, dummy codes, or full species names into the field protocols. However, it is vital for the future that you attach a list to your field protocols which correlates your field codes to meaningful species names.

(b) **Data input:** The final *GLORIA*-standardised coding for species names will be maintained at the *GLORIA* website. When using the electronic data input tools (*GDIT*), you will see a drop down list with species names to support your input. The database itself will automatically store the internal *GLORIA* species codes. That means that you need not to take care of them. More information on this is included in the *GDIT* package.

PLEASE ALWAYS KEEP INFORMED ABOUT THE CURRENT CODING CONVENTIONS AT www.gloria.ac.at
and

PLEASE SEE ALSO ANNEX III OF THIS MANUAL FOR REMARKS ON CODING.

Glossary of terms used in this manual (in numeric/alphabetic order; terms in the text of this glossary written in *italics* are also listed alphanumerically as headwords):

1m x 1m frequency grid frame: wooden (or aluminium) frame with quadrat size of 1m² and cell divisions of 0.1m x 0.1m; see Fig. AI.2 in Annex I.

1m x 1m quadrat: permanent 1m² quadrats for detailed vegetation recording at the 4 corner positions within the *3m x 3m quadrat clusters*.

3m x 3m quadrat cluster: quadratic 9m² area with 3m side length positioned in each of the 4 main *geographic directions* referring to the *HSP* with its lower side at the 5-m level.

3m x 3m sampling grids: grids constructed of flexible measuring tapes with 3 x 3 subdivisions (i.e. nine *1m x 1m quadrats*); see Fig. AI.1 in Annex I.

5-m level: the elevation level at the 5-m contour line referring to the *HSP*.

5-m summit area: the upper summit area, divided into 4 *summit area sections* for recording. This area reaches the *5-m level* at the 2 lower corner points (*p5m-...*) of each *3m x 3m quadrat cluster*. Between the *quadrat clusters*, this area lies in normal cases above the *5-m level* because the corner points are connected with the shortest straight lines possible. The 5-m summit area also includes the quadrats of the *3m x 3m quadrat clusters*.

10-m level: the elevation level at the 10-m contour line referring to the *HSP*.

10-m summit area: the lower summit area, divided into 4 *summit area sections* for sampling. The lower boundary of this area is delimited by 4 corner points (*p10-.*) at the *10-m level* in each of the 4 main *geographic directions*, which are connected with the shortest straight lines possible. The *10-m summit area* lies between this line and the lower limit of the *5-m summit area*.

16-quadrat area: the sum of all *1m x 1m quadrats* of a summit; these are 16 in number (4 per *quadrat cluster* in 4 clusters).

Alpine life zone: the area from the low-temperature determined *treeline ecotone* upwards. The term is applied to the *high mountain biome* world-wide and to any low stature vegetation between the climatic *treeline ecotone* and the highest tops of mountains (compare KÖRNER 1999).

Alpine-nival ecotone (or subnival zone): the transition between the *alpine zone* and the *nival zone*; it coincides with the permafrost limit.

Alpine zone: the zone between the *treeline* and the upper limit of closed vegetation (where vegetation is a significant part of the landscape and it physiognomy; cover is usually >20-40%); in some mountain regions subdivided into a lower alpine zone (dominated by dwarf-shrub communities) and an upper alpine zone (dominated by grassland communities).

Bare ground: *surface type* used for *top cover* estimations: open soil (organic or mineral), i.e. the earthy or sandy surface which is not covered by plants.

Central GLORIA Database**:** This database is currently maintained at the GLORIA server in Vienna and holds all GLORIA data collected until now (see under www.gloria.ac.at).

Clinometer: any instrument to measure the slope angle – for the *Multi-Summit approach* this device should enable an exact horizontal view to any visible point within the summit area. This is important for determining the *5-m level* and the *10-m level* below the *HSP*.

Coding: various items must have a GLORIA-wide standardised code, which is used in sampling forms, photographs, temperature data loggers, as well as in the data base. These codes define the country, the *target region*, the *summit*, the plot, the corner points of plots, and the date of recording. (see Box 9.2 & Annex III for coding used in the *photo documentation*).

Compass direction: determined at the *HSP* by using the 360° scale; i.e. the magnetic compass direction usually deviating from the geographic direction. Both compass direction and the *magnetic declination* must be known to point out the main geographic directions (N, E, S, W).

Contour lines: isolines which connect points of equal altitude; the contour line at the *5-m level* as well as those at the *10-m level* have to be determined in order to establishing the plots. *Contour lines* and the elevation levels refer here to the *highest summit point*.

Bryophytes on soil not covered by vascular plants*: surface type* used for *top cover* estimations: bryophytes growing on soil separately from vascular plants.

E-5m-SA: the upper *summit area section* of the east-direction, delimited by the corner points: *HSP, pSE-5* at the *intersection line, p5m-E11, p5m-E31*, and *pNE*-5 at the *intersection line.*

E-10m-SA: the lower *summit area section* of the east-direction, delimited by the corner points: *p5m-E11, pSE-5* and *pSE-10* at the *intersection line, p10m-E, pNE-10 and pNE-5* at the *intersection line,* and *p5m-E31.*

Ecotone: used here as the transition zone between elevation zones, e.g. the *treeline ecotone*, the *alpine-nival ecotone*.

Electronic spirit level: may be used alternatively instead of a clinometer for determining the *5-m* and the *10-m level* and for measuring slope angles (e.g. "Swiss Level", with a display showing the degrees of the angle and with a beep signal when positioned horizontally or vertically).

Flexible measuring tapes: rolls of tape measure with a centimetre scale which can be wound up. 50-m tapes are best for measuring the *HSP*-corner point distances, short tapes (usually 2-m, or 3-m) for measuring data logger distances from the nearest measurement points and for measuring the exact vertical distances at the *5-m* and *10-levels*.

Forestline (or timberline): the line where closed (montane) forests end.

Frequency counts: this terms is used here for presence/absence records of plant species (vascular plant species obligatory, cryptogam species optional) and of *grazing impacts* within the *16-quadrat area* by using a *1m x 1m grid frame*.

GDIT: see under *GLORIA data input tools.*

Geographical direction: the directions relative to the geographic North Pole; main (or cardinal) geographic directions: N, E, S, W, to be used for fixing the *principal measurement lines*; geographic directions of 2nd order: NE, SE, SW, NW, to be used for fixing the *intersection lines.* Note that these directions are different form the *compass directions* in most cases due to the *magnetic declination*.

GLORIA data input tools (GDIT): Electronic tools for data input available at the GLORIA server (see www.gloria.ac.at).

Grazing impacts: disturbance caused by grazing mammals (human livestock as well as wild-living mammals) may mask climate-induced changes. Therefore, features indicating grazing, i.e. faeces/dropping, browsing damage, and trampling, will be recorded (within the *16-quadrat area* as precence/absence records sampled with the *frequency grid frame* and comments on these grazing indicators are to be given on the sampling for the *summit area section)*.

High mountain biome (or high mountain environment): generally corresponds to the *alpine life zone*. According to TROLL (1966), high mountain areas are determined by 1) their position above the natural low-temperature treeline, 2) a landscape shaped by glaciers, which were present at least in the Pleistocene, and 3) frost as an important factor for pedogenesis and substrate structure.

Highest summit point: the culmination point of a *summit*, used as the principal measurement point. At *moderately shaped summits*, it lies +/- in the middle of the summit area. Rocky outcrops, which may occur elsewhere in the summit area and may exceed the altitude of the central culmination point, should not be used as the principal measurement point.

HSP: the ***h****ighest* ***s****ummit* ***p****oint.*

Intersection lines: 4 straight lines from the *HSP* to the boundary lines of the *5-m summit area* and the *10-m summit area*, positioned in the exact *geographic directions* of second order (NE, SE, SW, NW). The measurement points *pNE-5, pNE-10, pSE-5* etc. are positioned at the crossing points of these lines with the boundary lines of the *summit areas*.

Lichens on soil not covered by vascular plants*: surface type* used for *top cover* estimations: lichens growing on soil separately from vascular plants.

Litter*: surface type* used for *top cover* estimations: dead plant material.

Magnetic declination: the angle between the direction of the magnetic and the geographic North Pole. For the current magnetic declination of any place world-wide see: http://www.ngdc.noaa.gov/cgi-bin/seg/gmag/fldsnth1.pl

Master sites of GLORIA: well equipped research stations in a particular *target region*, where scientific investigations which cannot be included in the *Multi-Summit approach* are planned. These investigations serve for the interpretation of the summit observations; e.g., targeted studies on any parameter important for ecosystem functioning, testing of additional indicator organisms other than vascular plants (see also *optional activities*) – these may include monitoring, as well as experimental and modelling approaches.

Measurement lines: straight lines between the *HSP* and the *measurement points*. The lengths of these lines and the *compass direction* from the *HSP* have to be measured (i.e. the *principal measurement lines*, the lines from the *HSP* to all corner points of the *3m x 3m quadrat clusters*, and the *intersection lines).*

Measurement points: all points within the *summit area* used as delimitation points (corner points) of permanent plots.

Moderately shaped summit: summits which 1) are not too steep, so that measurement and sampling work can be done without using climbing equipment; 2) have a clear culmination point, where the distance to the *5-m levels* in all main *geographical directions* is less than 50m, and the distance to the *10-m levels* is less than 100m.

Multi-Summit approach: the basic approach of *GLORIA* for the comparison of climate-induced changes of high mountain biota along the vertical and horizontal climatic gradients. Summit sites arranged in different altitudes in a *target region* will be used as reference units. Such *target regions* should be distributed over all major biomes *(zonobiomes)* on Earth. The standardised sampling design, as described in this manual, should be applied on each summit.

N-5m-SA: the upper *summit area section* of the north-direction, delimited by the corner points: *HSP, pNE-5* at the *intersection line, p5m-N11, p5m-N31,* and *pNW*-5 at the *intersection line.*

N-10m-SA: the lower *summit area section* of the north-direction, delimited by the corner points: *p5m-N11, pNE-5* and *pNE-10* at the *intersection line, p10m-N, pNW-10 and pNW-5* at the *intersection line,* and *p5m-N31.*

Nival zone: the zone of open vegetation above the *alpine zone,* where vegetation is not a significant part of the landscape.

Optional Activities (OPAs): activities in addition to the basic requirements of the *Multi-Summit approach* (e.g. concerning additional indicator organisms, like cryptogam species, selected arthropod groups, nematodes, additional meteo data). Such activities may be included in the *Multi-Summit approach* on an optional basis or may be carried out in the planned *master sites of GLORIA* – an open field of debate.

p (-N13, -N33, -E13, -E33, -S13, -S33, -W13, W33): the upper corner points of the *3m x 3m quadrat clusters* (they usually lie above the *5-m level*).

p5m (-N11, -N31, -E11, -E31, -S11, -S31, -W11, -W31): the lower corner points of the *3m x 3m quadrat clusters* (they lie at the *5-m level* in each main *geographic direction*; one of these points per main *geographic direction* also lies at the *principal measurement line).* The *p5m-...* points also delimit the *5-m summit area.*

p10m (-N, -E, -S, -W): the lower corner points of the *10-m summit area* (they lie at the *10-m level* in each of the main directions at the lower end points of the *principal measurement lines*).

Photo documentation: essential for the fast and accurate reassignment of the sampling plots for reinvestigations. The position of each: *3m x 3m quadrat cluster*, *1m x 1m quadrat*, corner point of the *summit area sections*, and the *HSP* have to be carefully documented with photos – in addition the *temperature logger* position and a view of the entire *summit* (see Annex III for coding).

Principal measurement line: the straight lines from the *HSP* through one of the *p5m-...* points to the *p10m-.* point in each of the main *geographic directions.* Deviations of these lines from the exact *geographic direction* may be necessary if habitat or terrain in the exact direction is not appropriate for the *3m x 3m quadrat cluster*.

Quadrat: used here for permanent *1m x 1m quadrat*s for detailed vegetation recording.

Quadrat cluster: used here for *3m x 3m quadrat cluster*s positioned in the 4 main *geographic directions* of a summit.

S-5m-SA: the upper *summit area section* of the south-direction, delimited by the corner points: *HSP, pSW-5* at the *intersection line, p5m-S11, p5m-S31,* and *pSE*-5 at the *intersection line.*

S-10m-SA: the lower *summit area section* of the south-direction, delimited by the corner points: *p5m-S11, pSW-5* and *pSW-10* at the *intersection line, p10m-S, pSE-10 and pSE-5* at the *intersection line,* and *p5m-S31.*

Scree*: surface type* used for *top cover* estimations: debris material – this includes unstable or stable scree fields, as well as single stones of various size, lying on the surface or +/- fixed in the soil substrate; the grain size is bigger than the sand fraction (as opposed to *bare ground*).

Solid rock: *surface type* used for *top cover* estimations: rock outcrops – rock which is fixed in the ground and does not move even slightly (e.g. when pushing with a boot).

Species cover: percentage cover of each species in the *1m x 1m quadrat* recorded by visual estimation (e.g. $0.1m^2$ surface cover of a species corresponds with 1%, irrespective of relief or slope angle). In dense vegetation, cover of all species together can exceed 100%, because of overlapping layers. Intra-specific overlaps are ignored. All vascular plant species will be recorded (bryophytes and lichens on the species level are optional). Percentage species cover is also recorded in the *summit area sections*.

Subtypes of surface types: to estimate the percentage cover of bryophytes and of lichens growing below the *surface type vascular plants*, or on the *surface type*s *solid rock,* and *scree*. Cover percentages of these subtypes refer to the area covered by the relevant *surface type* (used only in the *1m x 1m quadrats*).

Summit: culmination points in a mountain system. This can be even a small hump in a ridge which projects at least 20 elevation metres above the surrounding land features.

Summit area**:** the entire sampling area of a summit site: i.e., *16-quadrat area, 5-m summit area* (which includes the *16-quadrat area),* and *10-m summit area.*

Summit area section**:** the 4 subdivisions of the *5-m summit area* and the 4 subdivisions of the *10-m summit area* (8 sections per *summit).* These sections are used as sampling units to estimate the top cover of *surface types,* and the *species cover* of all vascular plant species within the *summit area*.

Summit selection (criteria): the evaluation of a GLORIA summit is made along six criteria: (1) volcanism – must be absent, (2) climate – must be consistent among all *summits* of a *target region,* (3) geomorphologic summit shape – sites should be a *moderately shaped summits*, (4) habitat situation – should be typical for the respective elevation zone of the region, potential sites for plants to establish must be available, (5) bedrock material - must be consistent among all summits of a target region, (6) land use / land use history – pristine areas preferred, areas with remarkable changes in human land use practices in recent times must be avoided.

Surface types: sampling features for *top cover* estimations in the *16-quadrat area.* These are: *vascular plants, solid rock, scree, bare ground, bryophytes on soil, lichens on soil* (both if not covered by vascular plants)*, and litter.* The same types will be used *summit area sections*.

Target region: the mountain area in which 4 summit sites, representing the regional elevation gradient, are located. The general climatic situation within this area should not show fundamental differences along a horizontal gradient.

Temperature data loggers: small instruments (StowAway Tidbit loggers are currently suggested) used for continuous temperature measurements on the *summits* at 10cm below soil surface (measuring interval of one hour). Aim is to compare the temperature regimes and to detect the length of the snow-cover period along the elevation gradient.

Treeline: is the line where groups of trees taller than 3m end.

Treeline ecotone: is the zone between the *forestline* and the *tree species line*.

Tree species line: is the line beyond which no adult tree species (including prostrate one or scrub), occur.

Top cover: the vertical projections of each *surface type* in percent within the *1m x 1m quadrat* (in a view perpendicular to the slope angle). Top cover of all surface types present within a quadrat adds up to 100%.

Vascular plants*: surface type* used for *top cover* estimations: all vascular plants together.

W-5m-SA: the upper *summit area section* of the west-direction, delimited by the corner points: *HSP, pNW-5* at the *intersection line, p5m-W11, p5m-W31,* and *pSW*-5 at the *intersection line.*

W-10m-SA: the lower *summit area section* of the west-direction, delimited by the corner points: *p5m-W11, pNW-5* and *pNW-10* at the *intersection line, p10m-W, pSW-10 and pSW-5* at the *intersection line,* and *p5m-W31.*

Zonobiome: the major subdivisions of the geo-biosphere, determined by the prevailing climate as the primary independent factor in the environment. According to WALTER (1985), nine *zonobiomes* are distinguished.

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The *GLORIA* Field Manual

Multi-Summit Approach

ANNEX I: Materials for the plot set-up and for recording

Checklist for materials and equipment

For measuring the position of plots and of the corner points of the summit area:

- a **compass**
- a **clinometer** or **electronic spirit level** (e.g. Swiss Level)
- **two rolls of flexible 50-m measuring tapes**
- **two 3-m measuring tapes**

Optional (in addition):

- altimeter
- Differential GPS with sub-metre accuracy

For delimiting the *1m x 1m quadrats*:

- **four sampling grids of 3m x 3m** with 1m x 1m cell size (per *target region*; see Fig. AI.1 in Annex I).
- **about hundred pieces of ordinary 100 mm nails**
- **thin wire**
- **adhesive tapes** (for repairing grids)

For delimiting the *summit area sections*:

- **two rolls with a thin string** (each with about **500 m** length; can be shorter for steeper summits)
- **four rolls** with the same type **of string** (about **100 m** each; can be shorter for steeper summits).

For permanent marking:

- about **80 short aluminium tubes** per summit (0.8 to 1 cm in diameter, in various lengths between 10 and 25 cm) or other appropriate material
- **durable white or yellow paint** (as an option to the aluminium tubes)
- a **small chisel (or cold cutter)**

For photo documentation:

- a **24x36mm Single Lens Reflex camera** with **lenses** of **28mm** and **50mm** focal length; as an alternative, a digital camera is recommended
- **colour film material** (colour negative film is recommended, optional in addition slide film; about 100 exposures per summit)
- a **small blackboard** (e.g. 15 x 20 cm)
- **chalk** and a **small sponge** or something else to clean the blackboard
- a **signal stick** or **rod** (1.5 to 2 m)

For the recording procedures:

- **sampling forms** (see Annex II)
- **writing material** (including pencil for rainy conditions)
- compass (as above)
- clinometer or electronic spirit level (as above)
- **wooden (or aluminium) grid frame of 1m x 1m** for frequency counts (see Fig. AI.2 in Annex I)
- **templates for cover estimations** (see Fig. AI.3a & b in Annex I)

For temperature measurements:

- **miniature temperature datalogger(s)** (preferably Stowaway Tidbit); at least one, better two or four such devices per summit (see chapter 8.4.3).
- **permanent markers** (for marking the loggers with code numbers)
- **adhesive tape** (for protecting loggers)

Step 1. Preparation of 8 pieces of flexible measuring tapes of 4 m length: These pieces are cut off from e.g. a 50-m tape measure roll (the first at the 3.5 m mark, the second at the 7.5 m mark, and so on).

Step 2. At each metre mark of all 8 tapes, a round hole of 0.4 cm diameter is punched in the middle of the tape (= 4 holes per tape).

Step 3. The 8 tapes are arranged into a 3 x 3 m grid: column tapes and row tapes are fixed together with small metal blanks (i. e. eyelets of 0.4 cm diameter). Eyelets are put through the 2 holes at each crossing point and riveted with special pliers which are usually sold with the eyelets.
The result is a 3 x 3m grid with 1 x 1m subdivisions. Note that each subdivision is slightly smaller than 1 m^2, because of the width of the tape. This minor reduction of each quadrat area is accepted because of two advantages: (1) the construction of the tape is less complicated because the inner width of the quadrat need not be measured before punching the holes; (2) the scale at the delimitations of the sampling quadrat ranges exactly from one to the next metre mark - this is helpful for cover estimation. Each tape juts out from the 3 x 3m grid area for 0.5m on each side. This is helpful for fixing the grid in the field.

Four such grids are to be constructed (one for each *3m x 3m plot cluster*). Grids are to be removed after field work at one summit site is finalised. Therefore, one set of 4 grids is sufficient for one *target region*.

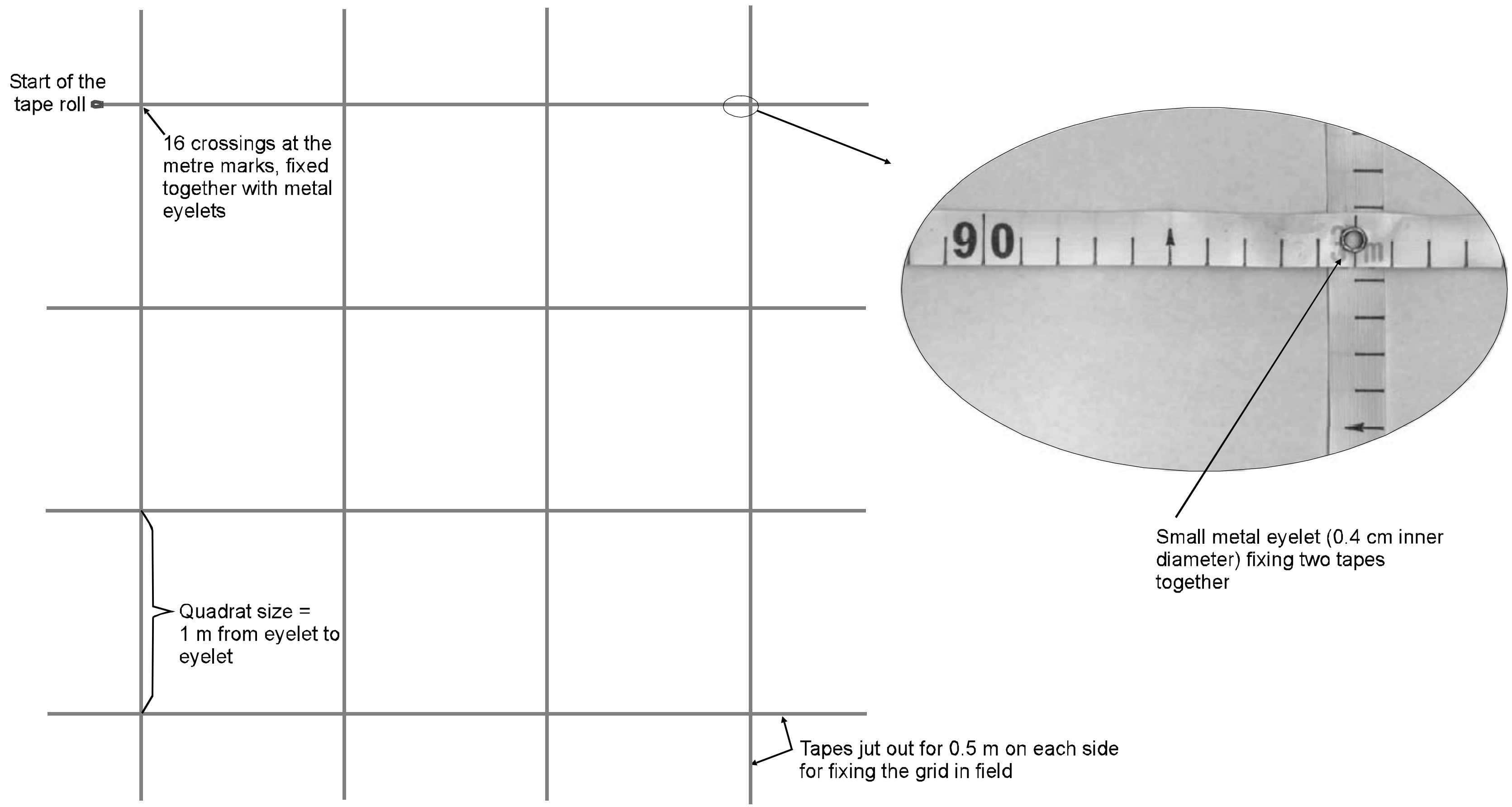


Fig. AI.1. Construction of the 3m x 3m grids.

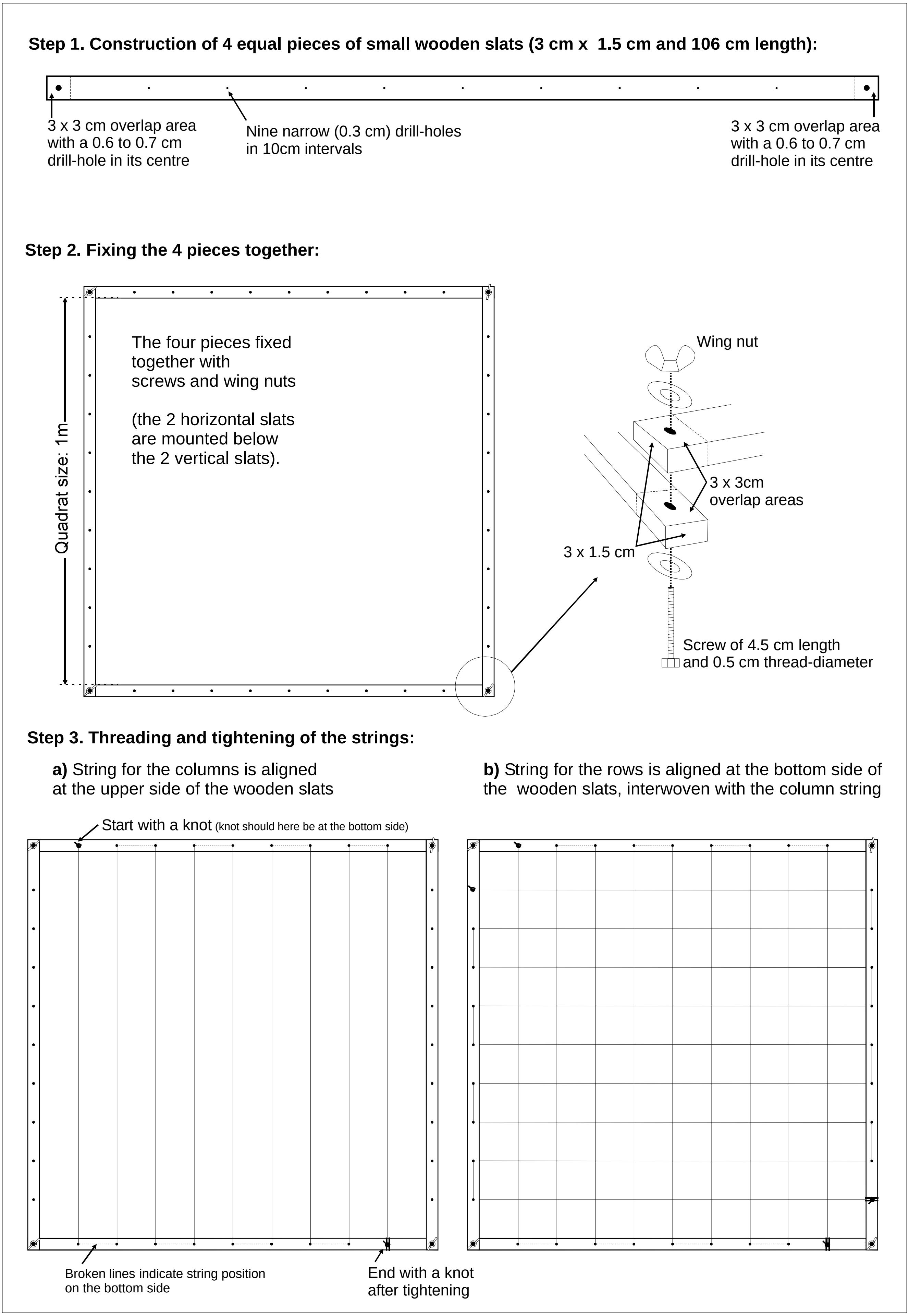
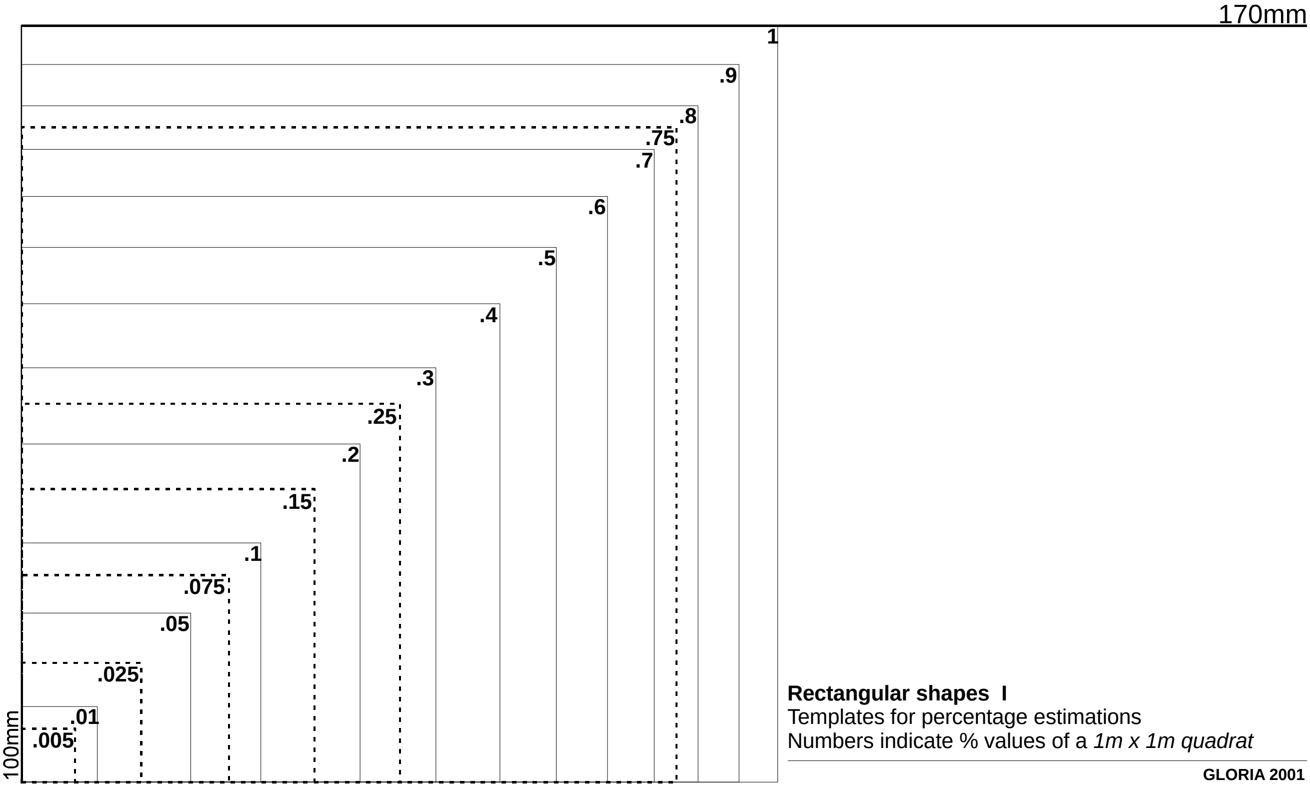
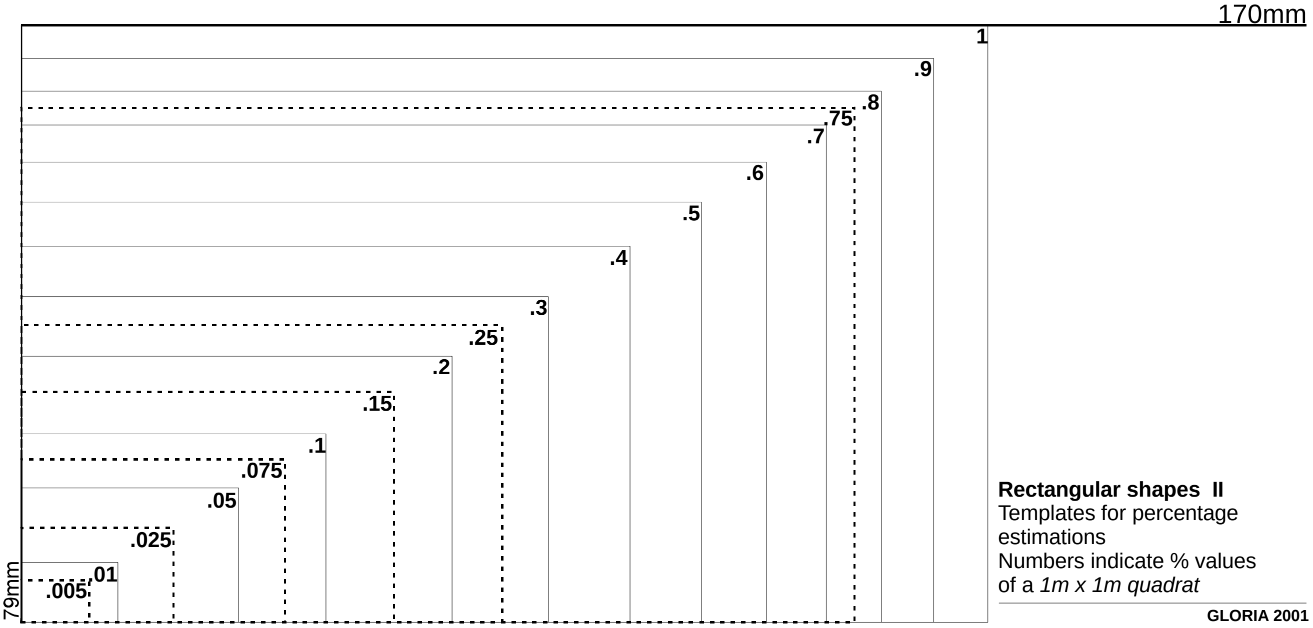


Fig.AI.2. Construction of the 1m x 1m grid frame for frequency counts.





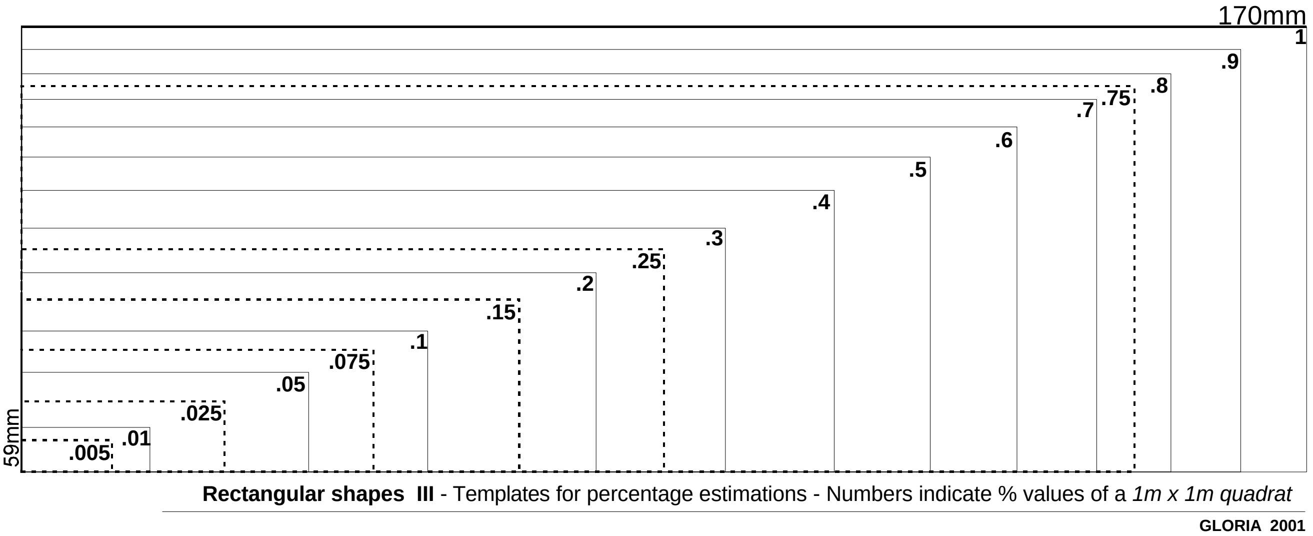
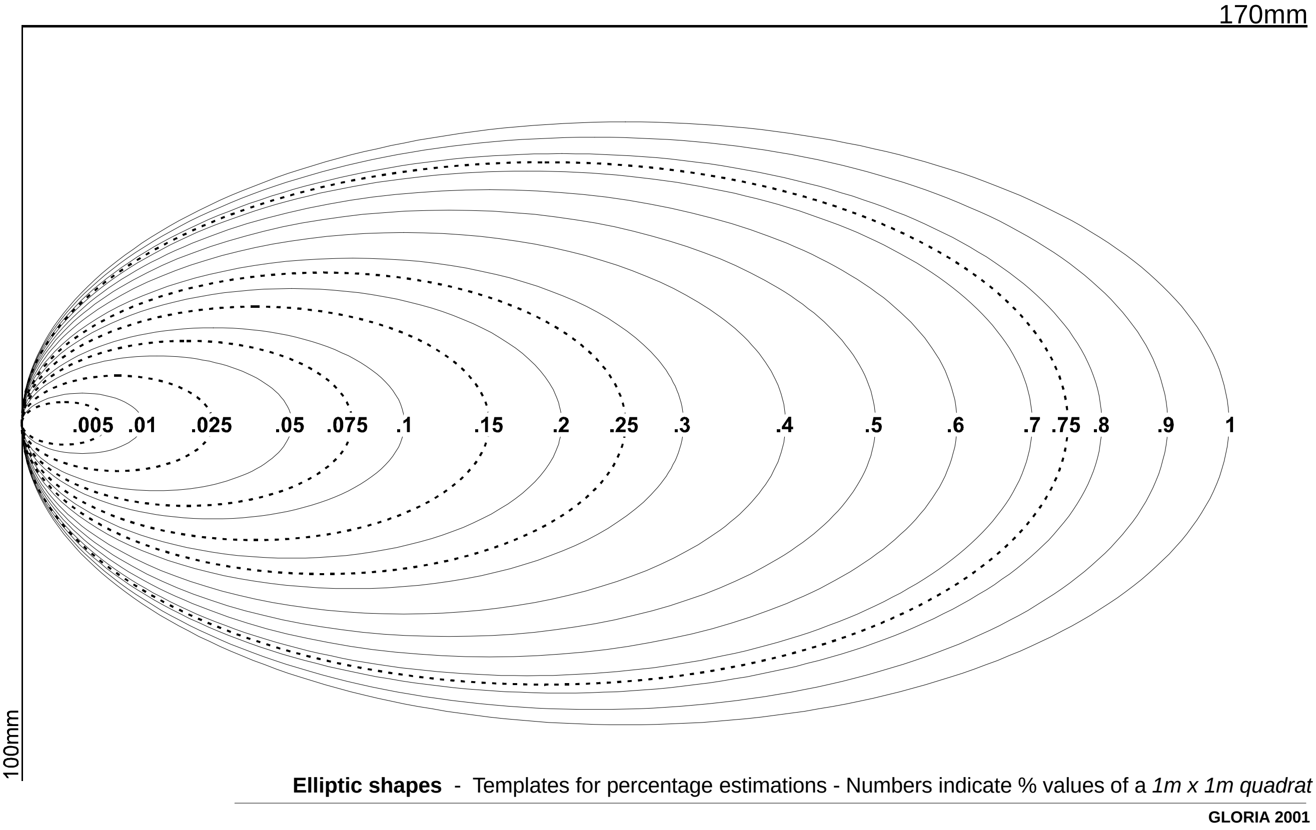


Fig. AI.3a. Templates for percentage cover estimations: rectangular shapes. These templates may be copied to a transparency and prepared for the field work. Make sure that the original size is maintained (i.e. when photocopying).



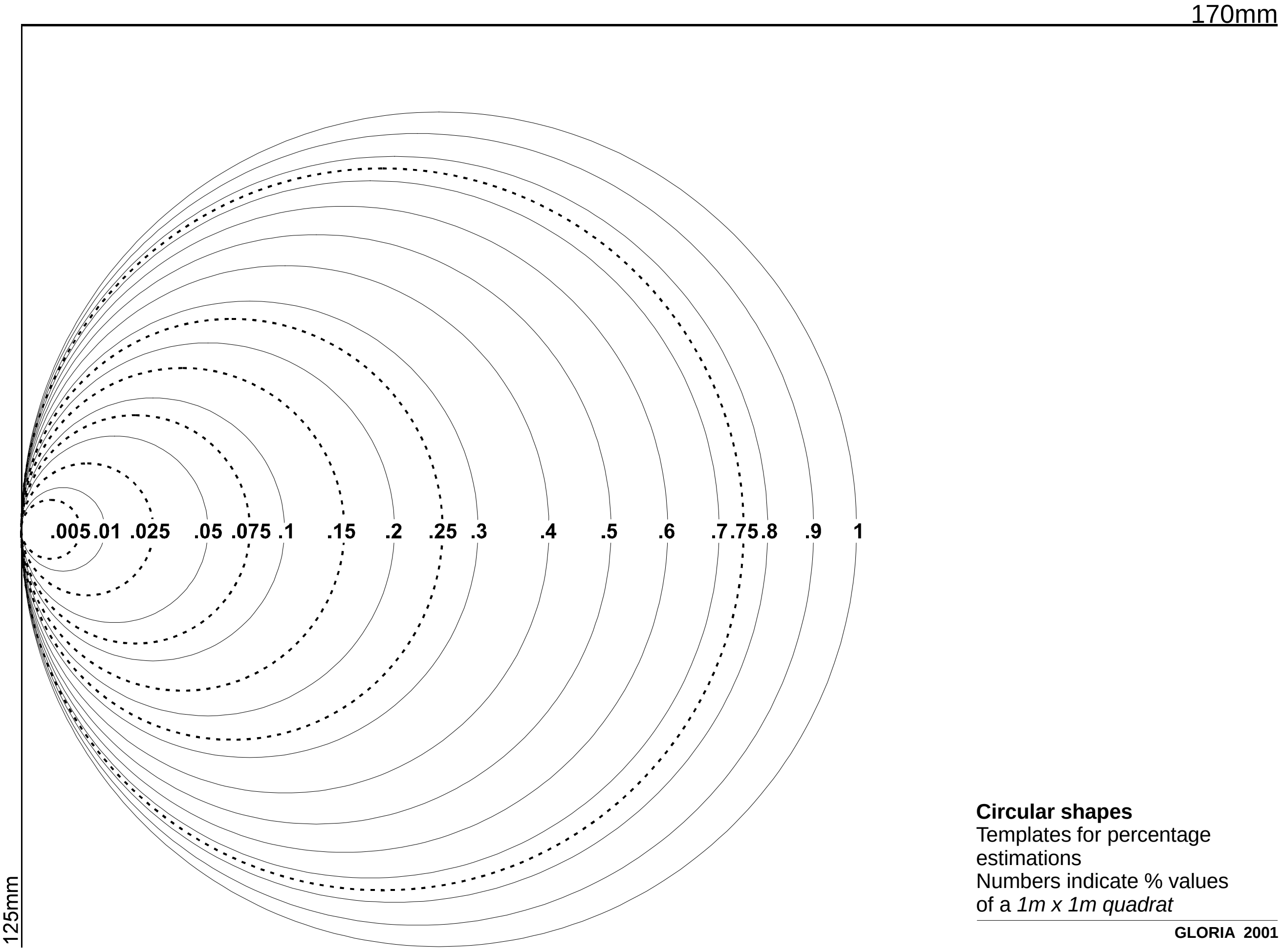


Fig. AI.3b. Templates for percentage cover estimations: circular and elliptic shapes. These templates may be copied to a transparency and prepared for the field work. Make sure that the original size is maintained (i.e. when photocopying).

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Multi-Summit Approach

ANNEX II: Data sampling forms

PART 1: Sampling forms

Form AII.0 Target Region Form

Form AII.1.1 Measurement protocol
Form AII.1.2 Summit selection

Form AII.2 Temperature loggers

Form AII.3a 1m x 1m Quadrat
Form AII.3b 1m x 1m Quadrat – continued

Form AII.4a Frequency counts in the 1m x 1m quadrat
Form AII.4b Frequency counts in the 1m x 1m quadrat – continued

Form AII.5a Summit area section
Form AII.5b Summit area section – continued

Form AII.0 Target Region

Country code[1]:		Date:	Researcher(s):
Target region code[1]:			

Comments on vegetation boundary lines [3]:

Altitude of major vegetation boundary lines (in metres):

Potential natural forestline [2]:		Potential natural treeline [2]:		Alpine-nival ecotone [2]:	
Current forestline[2]:		Current treeline[2]:			

Predominant bedrock material and approximate soil pH at the summit sites of the target region [4]:	Short description of the target region, particularly regarding land use history and the current land use situation [5]:

SUMMITS	Summit code[1]	Altitude (m)	Vegetation zone or ecotone [6]	Comments on the summit selection [7] (this refers to Form AII.1.2: SUMMIT SELECTION: comments are obligatory only if a checkbox of the column "not recommended" was marked in this form
HIGH ↑				
Altitude				
↓ LOW				

1) See Box 9.2 for coding; **2)** Enter an approximative value for each vegetation boundary line which indicates its average altitude in the *target region;* the forestline (or timberline) is defined as the line where closed forests end; the treeline is defined as the line where groups of trees taller than 3 m end; the alpine-nival ecotone is the transition zone between the upper alpine belt and the nival belt - make an estimation of the altitude of the upper boundary line of the alpine zone, where closed vegetation ends (this line may coincide with the permafrost limit in many mountain regions); **3)** Comments on the indicated altitudinal positions of boundary lines; e.g., deviations from the average altitude; mention if a boundary line does not exist in the *target region* and comment on the reasons for its absence;
4) Bedrock material of the summit sites of the target region, which should be consistent troughout the 4 summits (consistent regarding the influence of the bedrock on the species composition); in addition, make a rough estimate on the average soil pH (e.g. acid: <4.5, intermediate, neutral/alkaline: >6.5); **5)** If the situation is not pristine, indicate what kind of human land use have or had an impact on the present vegetation ?; wherever possible, comment on the extent of land use impacts and provide information about the long-term and recent land use history. **6)** i.e. treeline ecotone, lower alpine, lower/upper alpine, upper alpine, upper alpine/nival, or nival (compare Box 7.1 in the manual); use alternative terms only if the suggested vegetation zones are absolutely not appropriate. **7)** Indicate if this summit was included despite of the case that a criterium for summit selection was evaluated as *"not recommended"* (indicate which criterium, and the reason why it was evaluated as *"not recommended");* see chapter 7.2 of the manual).

Use extra blank sheets, if necessary - indicate the number of extra sheets in this box: ☐

Form AII.1.1 Measurement protocol

GLORIA - Multi-Summit approach

Country code[1]:	
Target region code[1]:	
Summit code[1]:	
Summit name[2]:	

Date:
Researcher(s):

Highest summit point (HSP)[3] Photo check[8] ☐	Altitude (m):	Geographic co-ordinates (deg/min/sec) long.: lat.:

Magnetic declination (°) for compass measurements[4]:

QUADRAT CLUSTERS & 10-m POINTS

	Point number[5]		Distance (m)[6]	Compass direction (°)[7]	Photo check[8]	
NORTH	**p5m-N11**	☐			☐ m² ☐ m²+Freq.frame	☐ 3x3m plot cluster overview
	p5m-N31	☐			☐ m² ☐ m²+Freq.frame	
	p-N33				☐ m² ☐ m²+Freq.frame	
	p-N13				☐ m² ☐ m²+Freq.frame	
	p10m-N				☐ 10-m-point doc.	
EAST	**p5m-E11**	☐			☐ m² ☐ m²+Freq.frame	☐ 3x3m plot cluster overview
	p5m-E31	☐			☐ m² ☐ m²+Freq.frame	
	p-E33				☐ m² ☐ m²+Freq.frame	
	p-E13				☐ m² ☐ m²+Freq.frame	
	p10m-E				☐ 10-m-point doc.	
SOUTH	**p5m-S11**	☐			☐ m² ☐ m²+Freq.frame	☐ 3x3m plot cluster overview
	p5m-S31	☐			☐ m² ☐ m²+Freq.frame	
	p-S33				☐ m² ☐ m²+Freq.frame	
	p-S13				☐ m² ☐ m²+Freq.frame	
	p10m-S				☐ 10-m-point doc.	
WEST	**p5m-W11**	☐			☐ m² ☐ m²+Freq.frame	☐ 3x3m plot cluster overview
	p5m-W31	☐			☐ m² ☐ m²+Freq.frame	
	p-W33				☐ m² ☐ m²+Freq.frame	
	p-W13				☐ m² ☐ m²+Freq.frame	
	p10m-W				☐ 10-m-point doc.	

INTERSECTION LINES

Point num.	Dist. (m)[6]	Comp. dir. (°)[7]	Photo check[8]	Point num.	Dist. (m)[6]	Comp. dir. (°)[7]	Photo check[8]
pNE-5			☐	**pSW-5**			☐
pNE-10			☐	**pSW-10**			☐
pSE-5			☐	**pNW-5**			☐
pSE-10			☐	**pNW-10**			☐

COMMENTS:

Entire summit: Photo check[8] ☐

Use extra blank sheets for further remarks, if necessary

Indicate the number of extra sheets in this box: ☐

1) See Box 9.2 for coding;
2) Full name of summit (from topographic maps, or a working name where no official name is available);
3) The highest summit point: the culmination point +/- in the middle of the summit area (rocky outcrops, which may be higher but are not centred in the summit area, should be ignored;
4) The angle (with its correct sign) between the direction of the geographic North Pole and of the magnetic North Pole (e.g. -6 for a magnetic declination of 6° W; +10 for 10° E; see Box 8.1);
5) Mark those checkbox where the point lies on the *principal measurement line* (e.g., *p5m-N11* or *p5m-N31* , but not both; compare Fig. 8.2);
6) The length of a straight surface line between the *HSP* and the measurement point (in metres, with two decimal places); keep the measurement tape tightened for all distance measurements! (see Box 8.3);
7) The compass direction from the HSP to the measurement point in degrees (360° scale; see Box 8.1); please note: always write the magnetic compass directions (i.e. degrees as indicated on the compass);
8) Photo check: Check the box after photos are taken to be sure that the photo documentation is complete (see under 8.4.4 for details; ?m² = without frequency grid frame, ?m²+Freq.frame = with the frequency grid frame mounted).

Form AII.1.2 SUMMIT SELECTION

GLORIA - Multi-Summit approach

Country code [1]**:**		**Date:**	
Target region code [1]**:**		**Researcher(s):**	
Summit code [1]**:**			

CATEGORY FOR EVALUATION [2]

CRITERIUM [2]	RECOMMENDED – Best case	RECOMMENDED	RECOMMENDED – "at least" case	NOT RECOMMENDED	MUST BE AVOIDED
1. Volcanism	The summit is **not** an **active** or **dormant volcano** and no such volcano is in the close vicinity ☐				**Active** (including **dormant**) **volcanism** present ☐
2. Consistent climate	The summit is exposed to the same local climate as the other summits of the target region; differences are **only** caused by the altitudinal climatic gradient ☐		The local climate on the summit does not obvoiusly deviate from the other summits; the differences are **mainly** caused by the altitudinal climatic gradient ☐	Summit lies within the area of the same local climate as the other summit sites, but local effects lead to a significant deviation, e.g., owing to a pronounced overshadow by neighbouring land features ☐	The local climate on the summit is different from the other summits; e.g. the summit lies beyond a main climatic shed (for example, in mountain systems with pronounced windward/ leeward differences) ☐
3. Geo-morphologic summit shape	Perfect moderately **cone-shaped summit** (the same slope situation towards all directions) ☐	Summit with **irregular cone shape**, where *3m x 3m quadrat clusters* can be positioned **without any deviations** from the standard design ☐	Summit with **irregular cone shape**, where all four *3m x 3m quadrat clusters* can be positioned with **minor**, but acceptable, horizontal **deviations** from the stand.design (comp. 8.3.2) ☐	**1)** The summit slopes are too **steep**, too **rugged** or their surface is too **unstable** for establishing plots on all sides of the summit or for applying all sampling methods; or **2)** the summit is so **flat** that the 5-m level lies beyond 50m surface distance from the *HSP*, respectively the 10m-level lies beyond 100 surface distance (compare also Box 8.4) ☐	**1)** Summit where work cannot be carried out without climbing equipment owing to steepness or substrate instability (dangerous sites must be avoided); **2)** Very flat plateau shaped summit areas where the sampling design cannot be applied ☐
4. Habitat situation (representativity of the vegetation for the respective ecotone or elevation zone)	The vegetation within the summit area represents the characteristic patterns of zonal plant communities of the respective ecotone or elevation zone ☐		The vegetation within the summit area shows at least the main characteristics of the respective ecotone or elevation zone (in cases, where vegetation is generally very scattered, potential habitats, appropriate for vascular plants to establish, must be available) ☐		Summit habitat is hostile to plant growth owing to its geomorphology (e.g., summit is composed of boulders, screes or plain rocks lacking potential habitats for vascular plants) ☐
5. Bedrock material	The same bedrock as on the other summits of the target region ☐		Bedrock deviating, but no obvious substrate-related influence on the species composition ☐	Deviating bedrock material has an obvious, but minor influence on the substrate-related species composition ☐	Bedrock is contrasting to the other summits regarding the influence on the species composition (e.g., a summit with siliceous substrate such as gneiss in a series of calcareous limestone summits) ☐
6. Land use and land use history	Pristine (no land use impact) ☐	No present land use, and the influence from historic land use is negligible ☐	Low to moderate impact from land use, but without remarkable changes over a long period (e.g. for > than a century) ☐	**1)** Remarkable land use change within the last 100 years from **high to low** impact, where former impacts on the vegetation are still visible; or **2)** moderate to high impacts over a long period, causing obviously altered vegetation, but plant communities are not substantially changed due to land use impacts, or **3)** the summit is not recommended owing to any other reason related to land use ☐	**1)** Remarkable land use change within the last 100 years from **low to high** pressure, where the impacts on the vegetation are clearly visible; or **2)** generally strong land use impacts causing substantially changed plant communities (e.g. nitrophilous vegetation), or **3)** the summit must be avoided owing to any other reason related to land use ☐
	SUMMIT ACCEPTED				**SUMMIT AVOIDED**

1) See Box 9.2 for coding; 2) For definitions of the criteria and evaluation categories compare chapter 7.2.2 of this manual. Please mark only one checkbox for each criterium; checkboxes for the evaluation category *"must be avoided"* are not of relevance, because summits which are accepted for the *Multi-Summit approach* cannot have a mark within this category.

Form AII. 2 Temperature Loggers

GLORIA - Multi-Summit approach

Country code[1]:		Summit code[1]:	
Target region code[1]:		Summit name[2]:	

Level A[3]	Logger code[4] (country / TR / summit / HSP / year)	Serial number[5]	Start date[6]	Start time[6] (local time)	UTC diff.[7]	Dist-HSP[8]	Cd-HSP[9]	Photo check open[12]	Photo check closed[12]	Researcher(s)	Comments:
Logger 1	__ __/__ __ __/__ __ __/ H S P /__ __ __ __							☐	☐		

Level B[3]	Logger code[4] (country / TR / summit / quadrat)	Serial number[5]	Start date[6]	Start time[6] (local time)	UTC diff.[7]	Dist-11[10]	Dist-31[11]	Photo check open[12]	Photo check closed[12]	Researcher(s)	Comments:
Logger 1	__ __/__ __ __/__ __ __/__ __ __/__ __ __ __							☐	☐		
Logger 2	__ __/__ __ __/__ __ __/__ __ __/__ __ __ __							☐	☐		

Level C[3]	Logger code[4] (country / TR / summit / quadrat / year)	Serial number[5]	Start date[6]	Start time[6] (local time)	UTC diff.[7]	Dist-11[10]	Dist-31[11]	Photo check open[12]	Photo check closed[12]	Researcher(s)	Comments:
Logger 1	__ __/__ __ __/__ __ __/__ __ __/__ __ __ __							☐	☐		
Logger 2	__ __/__ __ __/__ __ __/__ __ __/__ __ __ __							☐	☐		
Logger 3	__ __/__ __ __/__ __ __/__ __ __/__ __ __ __							☐	☐		
Logger 4	__ __/__ __ __/__ __ __/__ __ __/__ __ __ __							☐	☐		

1) See Box 9.2 for coding; **2)** Full name of the summit; **3)** Level A: 1 logger per summit near the HSP, Level B: 2 loggers per summit, Level C: 4 loggers per summit (only level C is relevant for GLORIA-EUROPE; see chapter 8.4.3); **4)** Please indicate the GLORIA-wide logger code on the form as well as on the back side of the logger itself (with permanent marker) before burying in the substrate (see Box 9.2 for coding); **5)** The logger serial number is usually indicated somewhere on the logger (if Stowaway Tidbit is used, this number is indicated on the left side of the logger body; e.g. 420309/9-00); **6)** Indicate the date and the time of logger installation in the field (use your local time). **7)** Indicate the value (hours) which has to be added or subtracted from your local time to correct it to the UTC/GCT (Coordinated Universal Time/Greenwich Mean Time); for example, if the local time is 14:00 and UTC 12:00, the value to be entered is **-2**. **8)** The length of a straight surface line between the *HSP* and the logger position (in metres with two decimal places; see Box 8.12); **9)** The magnetic compass direction from the HSP to the logger in degrees (360° scale; see Box 8.12); **10)** Distance (in m with two decimal places) from the logger to the left lower cluster corner (i.e. p5m-_11; see Box 8.12); **11)** Distance (in m with two decimal places) from the logger to the right lower cluster corner (i.e. p5m-_31; see Box 8.12); **12)** Photo check: Check the box after photos are taken to be sure that the photo documentation is complete (documentation of the logger position with the hole open and documentation after the hole is closed with soil material; see Fig. 8.12 and Box 8.12).

Form AII.3a 1m x 1m Quadrat

GLORIA - Multi-Summit approach

Country code[1]**:**		Aspect [2]:	Date**:**	
Target region code[1]**:**			Time: from	to
Summit code[1]**:**		Slope (°) [3]:	Researcher(s)**:**	
Quadrat code[1]**:**				

Top cover surface types (%) [4]

Vascular plants	
Solid rock	
Scree	
Lichens on soil not covered by vasc. plants	
Bryophytes on soil not covered by vasc. plants	
Bare ground	
Litter	
	Sum: 100%

Subtypes in % of the top cover type [5]

Lichens below vasc. plants		Bryophytes below vasc. plants	
Lichens on rock		Bryophytes on rock	
Lichens on scree		Bryophytes on scree	

Comments on top cover estimations**:**

Plant species cover (%) [6]

Species/(subspecies)	cf. [7]	%-cover

Species/(subspecies)	cf. [7]	%-cover

Cover sum [8]:

Number of vascular plant species:

General comments**:**

If you have used extra sheets (From AII.3b), indicate its number (excluding this first page):

1) See Box 9.2 for coding; **2)** Average aspect of the quadrat surface (N, NE, E, SE, S, SW, W, or NW); **3)** Average slope angle of the quadrat surface (in degrees, 360° scale); **4)** The vertical projection of cover (perpendicular to the slope angle), all types together add up to 100% (for definitions of surface types see under 8.4.1.1); **5)** The top cover as percentage of the respective top cover surface type (see under 8.4.1.1); **6)** Percentage cover of each species (see 8.4.1.1); the full set of vascular plants must be recorded; bryophytes and lichens are **optional** (see Box 8.6); indicate species either by using species names or by (provisional) codes; see also Box 9.2; **7)** Use the cf. column if the identification of the taxon is doubtful (use **g** if this is the case for the genus level, **s** for the species level, **t** for a lower taxonomic level. **8)** Check the cover sum (the cover of all species together) against the top cover surface type "vascular plants": the cover sum can be higher but not lower than this top cover surface type - the cover sum can exceed 100% in dense vegetation due to overlapping layers (see under 8.4.1.1).

Form AII.3b 1m x 1m Quadrat

CONTINUED *GLORIA - Multi-Summit approach*

Country code[1]:		Aspect[2]:	Date:
Target region code[1]:			Time: from to
Summit code[1]:		Slope (°)[3]:	Researcher(s):
Quadrat code[1]:			

Top cover surface types (%)[4]		Subtypes in % of the top cover type[5]			
Vascular plants		Lichens below vasc. plants		Bryophytes below vasc. plants	
Solid rock		Lichens on rock		Bryophytes on rock	
Scree		Lichens on scree		Bryophytes on scree	
Lichens on soil not covered by vasc. plants					
Bryophytes on soil not covered by vasc. plants		Comments on top cover estimations:			
Bare ground					
Litter					
	Sum: 100%				

Plant species cover (%)[6]

Species/(subspecies)	cf.[7]	%-cover	Species/(subspecies)	cf.[7]	%-cover
			Cover sum[8]:		
			Number of vascular plant species:		
			General comments:		
			Extra sheet number:		

1) See Box 9.2 for coding; ~~**2)** Average aspect of the quadrat surface (N, NE, E, SE, S, SW, W, or NW); **3)** Average slope angle of the quadrat surface (in degrees, 360° scale); **4)** The vertical projection of cover (perpendicular to the slope angle), all types together add up to 100% (for definitions of surface types see under 8.4.1.1); **5)** The top cover as percentage of the respective top cover surface type (see under 8.4.1.1);~~ **6)** Percentage cover of each species (see 8.4.1.1); the full set of vascular plants must be recorded; bryophytes and lichens are **optional** (see Box 8.6); indicate species either by using species names or by (provisional) codes; see also Box 9.2; **7)** Use the cf. column if the identification of the taxon is doubtful (use **g** if this is the case for the genus level, **s** for the species level, **t** for a lower taxonomic level. ~~**8)** Check the cover sum (the cover of all species together) against the top cover surface type "vascular plants": the cover sum can be higher but not lower than this top cover surface type - the cover sum can exceed 100% in dense vegetation due to overlapping layers (see under 8.4.1.1).~~

Form AII.4a **Frequency counts** in the 1m x 1m quadrats (100 cells of 0.1m x 0.1m)

GLORIA - Multi-Summit approach

Codes of [1)]	Country:	Target Region:	Summit:	Date:	Time: from to	General comments:

Rows no. 1 to 0 (numbered from top to bottom); column no. 1 to 0 (numbered from left to right when looking towards the summit) [2)]

Quadrat code[1)]:

Researcher(s):

Grazing impact [3)]		row 1 1 2 3 4 5 6 7 8 9 0	row 2 1 2 3 4 5 6 7 8 9 0	row 3 1 2 3 4 5 6 7 8 9 0	row 4 1 2 3 4 5 6 7 8 9 0	row 5 1 2 3 4 5 6 7 8 9 0	row 6 1 2 3 4 5 6 7 8 9 0	row 7 1 2 3 4 5 6 7 8 9 0	row 8 1 2 3 4 5 6 7 8 9 0	row 9 1 2 3 4 5 6 7 8 9 0	row 0 1 2 3 4 5 6 7 8 9 0
H.i. 1: faeces/droppings											
H.i. 2: browsing damage											
H.i. 3: trampling											
Species [4)]	**cf.**[4)]	row 1 1 2 3 4 5 6 7 8 9 0	row 2 1 2 3 4 5 6 7 8 9 0	row 3 1 2 3 4 5 6 7 8 9 0	row 4 1 2 3 4 5 6 7 8 9 0	row 5 1 2 3 4 5 6 7 8 9 0	row 6 1 2 3 4 5 6 7 8 9 0	row 7 1 2 3 4 5 6 7 8 9 0	row 8 1 2 3 4 5 6 7 8 9 0	row 9 1 2 3 4 5 6 7 8 9 0	row 0 1 2 3 4 5 6 7 8 9 0

If you have used extra sheets (Form AII.4b), indicate its number (excluding this first page):

1) See box 9.2 for coding; **2)** Each cell in this form represents a *0.1m x 0.1m cell* of the grid frame = 100 cells for each species where presence of the species will be indicated with an **X** (see Fig. 8.8); **3) Grazing** impact: frequency of impacts caused by livestock grazing (impacts caused by wild-living mammals are also included, because the latter may hardly be distinguishable from livestock impacts); **4)** Species (all vascular plants; bryophytes and lichens are **optional**); indicate species either by using species names or by (provisional) codes; use the *"cf."* column if the identification of the taxon is doubtful (use **g** if this is the case for the genus level, **s** for the species level, **t** for a lower taxonomic level); see also Box 9.2; A species is considered as present when showing plant parts within the boundary strings of a 0.1 x 0.1m grid cell (always in view perpendicular to the grid frame plane), regardless of where it is are rooted see also under 8.4.1.2).

Form AII.4b Frequency counts in the 1m x 1m quadrats (100 cells of 0.1m x 0.1m)

CONTINUED

GLORIA - Multi-Summit approach

Codes of [1]	Country:	Target Region:	Summit:	~~Date:~~	~~Time: from to~~	General comments:
Rows no. 1 to 0 (numbered from top to bottom); column no. 1 to 0 (numbered from left to right when looking towards the summit) [2]			**Quadrat code** [1]**:**	~~Researcher(s):~~		

~~**Grazing impact** [3]~~		row 1	row 2	row 3	row 4	row 5	row 6	row 7	row 8	row 9	row 0
		1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0
~~**H.i. 1:** faeces/droppings~~											
~~**H.i. 2:** browsing damage~~											
~~**H.i. 3:** trampling~~											
Species [4]	**cf.** [4]	row 1	row 2	row 3	row 4	row 5	row 6	row 7	row 8	row 9	row 0
		1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0

Extra sheet number:

1) See box 9.2 for coding; **2)** Each cell in this form represents a *0.1m x 0.1m cell* of the grid frame = 100 cells for each species where presence of the species will be indicated with an **X** (see Fig. 8.8); ~~**3) Grazing** impact: frequency of impacts caused by livestock grazing (impacts caused by wild-living mammals are also included, because the latter may hardly be distinguishable from livestock impacts);~~ **4)** Species (all vascular plants; bryophytes and lichens are **optional**); indicate species either by using species names or by (provisional) codes; use the *"cf."* column if the identification of the taxon is doubtful (use **g** if this is the case for the genus level, **s** for the species level, **t** for a lower taxonomic level); see also Box 9.2; A species is considered as present when showing plant parts within the boundary strings of a 0.1 x 0.1m grid cell (always in view perpendicular to the grid frame plane), regardless of where it is are rooted see also under 8.4.1.2).

Form AII.5a Summit area section

GLORIA - Multi-Summit approach

Codes of [1]		Top Cover Surface Types (%)[2]		Researcher(s):
Country:		Vascular plants		
Target region:		Solid rock		
Summit:		Scree		
Summit Area Section:		Lichens (excl. epilithic)		Comments on grazing impacts[3]:
Date:		Bryophytes		
		Bare ground		
Time: from to		Litter		
		SUM	100%	

Species[4]	cf.[5]	% cover[6]	locally? [7]	locally where? [8]

Sum of cover values of all species in this summit area section:
(must exceed the percentage of the surface type "vascular plants") [ ]

Total number of vascular plant species in this *summit area section:* [ ]

General comments:

1) See Box 9.2 for coding; for the *summit area section* : e.g. N05, N10, E05; **2** Visual cover estimation of the surface types (top cover) within the *summit area section* , indicated as percentage value; see chapter 8.4. **3)** Comment on impacts of grazing such as faeces, browsing damage, trampling; see Box 8.8; **4)** All vascular plant species; bryophytes and lichens on the species level are **optional**; indicate species either by using species names or by (provisional) codes; **5)** Use the cf. column if the indentification of the taxon is doubtful (use **g** if this is the case for the genus level, **s** for the species level, **t** for a lower taxonomic level); see also Box 9.2; **6)** Percentage cover estimation for each species; **avoid** indcations such as: less than (<) or more than (>); see Box 8.9;
7) Mark in this columns only those species which are found only locally, e.g. centred only at one or two locations with the *summit area section* (irrespectively from their cover); **8)** Obligatory for species marked as locally in the previous column: indicate briefly the circa location of the species, e.g. upper N part of the SAsection; central part of the SAsection; 2 m SSE of the *HSP* ; near p10m-W; at the lower boundary appr. 2 m from pNE-10; if possible, provide information about the absolute total cover or about the abundance of these locally distributed species (e.g. appr. 1/2 m², 3 individuals, 2 seedlings).

If you have used extrasheets (Form AII.5b), indicate its number (excluding this first page): [ ]

Form AII.5b Summit area section

CONTINUED *GLORIA - Multi-Summit approach*

Codes of [1]	
Country:	
Target region:	
Summit:	
Summit Area Section:	
Date**:**	
Time: from to	

~~**Top Cover Surface Types (%)** [2]~~	
~~Vascular plants~~	
~~Solid rock~~	
~~Scree~~	
~~Lichens (excl. epilithic)~~	
~~Bryophytes~~	
~~Bare ground~~	
~~Litter~~	
~~SUM~~	~~100%~~

~~Researcher(s)**:**~~
~~Comments on grazing impacts [3]:~~

Species [4]	cf. [5]	% cover [6]	locally? [7]	locally where? [8]

~~**Sum of cover values of all species in this summit area section:** (must exceed the percentage of the surface type "vascular plants")~~		~~**Total number of vascular plant species in this *summit area section*:**~~	

General comments:

1) See Box 9.2 for coding; for the *summit area section* : e.g. N05, N10, E05; ~~**2** Visual cover estimation of the surface types (top cover) within the *summit area section* , indicated as percentage value; see chapter 8.4.~~ ~~**3)** Comment on impacts of grazing such as faeces, browsing damage, trampling; see Box 8.8;~~ **4)** All vascular plant species; bryophytes and lichens on the species level are **optional**; indicate species either by using species names or by (provisional) codes; **5)** Use the cf. column if the indentification of the taxon is doubtful (use **g** if this is the case for the genus level, **s** for the species level, **t** for a lower taxonomic level); see also Box 9.2; **6)** Percentage cover estimation for each species; **avoid** indcations such as: less than (<) or more than (>); see Box 8.9;

7) Mark in this columns only those species which are found only locally, e.g. centred only at one or two locations with the *summit area section* (irrespectively from their cover); **8)** Obligatory for species marked as locally in the previous column: indicate briefly the circa location of the species, e.g. upper N part of the SAsection; central part of the SAsection; 2 m SSE of the *HSP* ; near p10m-W; at the lower boundary appr. 2 m from pNE-10; if possible, provide information about the absolute total cover or about the abundance of these locally distributed species (e.g. appr. 1/2 m², 3 individuals, 2 seedlings).

Extra sheet number:

The *GLORIA* Field Manual

Multi-Summit Approach

ANNEX II:

PART 2: Example sheets for the sampling forms

Form AII.0 Target Region

EXAMPLE

Country code[1]:	AT	Date: 6 August 2001	Researcher(s):
Target region code[1]:	HSW		M. Montealto, Y. Serov

Altitude of major vegetation boundary lines (in metres):

Potential natural forestline[2]:	1700	Potential natural treeline[2]:	1900	Alpine-nival ecotone[2]:	
Current forestline[2]:	1600	Current treeline[2]:	1850		

Comments on vegetation boundary lines[3]:

The target region extends only to the upper alpine zone; no alpine-nival ecotone present;
Forestline and treeline were slightly lowered due to historic land use (pasturing, logging);

Predominant bedrock material and approximate soil pH at the summit sites of the target region[4]:

Limestone
pH +/- neutral

Short description of the target region, particularly regarding land use history and the current land use situation[5]:

No significant human land use; mountain pasturing has never been important within the alpine zone of the target region;
only in some areas, timber logging at the forest line and life stock grazing in the lower treeline ecotone - but only before around 1920; none of the summits show obvious impacts caused by these activities; pasturing is restricted now, because area is protected as a fresh water reserve;

SUMMITS	Summit code[1]	Altitude (m)	Vegetation zone or ecotone[6]	Comments on the summit selection[7] (this refers to Form AII.1.2: SUMMIT SELECTION: comments are obligatory only if a checkbox of the column "not recommended" was marked in this form
HIGH	ZIR	1920	treeline ecotone	
Altitude	LAE	2045	lower alpine zone	
	MEX	2214	ecotone between lower and upper alpine zone	The selection criterium "geomorphological summit shape" was evaluated as "not recommended"; reason: the western side is so flat that the 5-m level lies not within 50-m surface distance (from HSP) - but all other sides are ok; no alternative summit could be found;
LOW	VUM	2373	upper alpine zone	

1) See Box 9.2 for coding; **2)** Enter an approximative value for each vegetation boundary line which indicates its average altitude in the *target region;* the forestline (or timberline) is defined as the line where closed forests end; the treeline is defined as the line where groups of trees taller than 3 m end; the alpine-nival ecotone is the transition zone between the upper alpine belt and the nival belt - make an estimation of the altitude of the upper boundary line of the alpine zone, where closed vegetation ends (this line may coincide with the permafrost limit in many mountain regions); **3)** Comments on the indicated altitudinal positions of boundary lines; e.g., deviations from the average altitude; mention if a boundary line does not exist in the *target region* and comment on the reasons for its absence;
4) Bedrock material of the summit sites of the target region, which should be consistent troughout the 4 summits (consistent regarding the influence of the bedrock on the species composition); in addition, make a rough estimate on the average soil pH (e.g. acid: <4.5, intermediate, neutral/alkaline: >6.5); **5)** If the situation is not pristine, indicate what kind of human land use have or had an impact on the present vegetation ?; wherever possible, comment on the extent of land use impacts and provide information about the long-term and recent land use history. **6)** i.e. treeline ecotone, lower alpine, lower/upper alpine, upper alpine, upper alpine/nival, or nival (compare Box 7.1 in the manual); use alternative terms only if the suggested vegetation zones are absolutely not appropriate. **7)** Indicate if this summit was included despite of the case that a criterium for summit selection was evaluated as *"not recommended"* (indicate which criterium, and the reason why it was evaluated as *"not recommended");* see chapter 7.2 of the manual).

Use extra blank sheets, if necessary - indicate the number of extra sheets in this box:

Form AII.1.1 Measurement protocol

EXAMPLE

GLORIA - Multi-Summit approach

Country code 1):	AT
Target region code 1):	HSW
Summit code 1):	MEX
Summit name 2):	Monte Exemplario

Date:	10 August 2001
Researcher(s):	Maria Montealto Yuri Serov

Highest summit point (HSP) 3)	Altitude (m):	Geographic co-ordinates (deg/min/sec)
Photo check 8) [X]	2214	long.: 15° 08' 01" E lat.: 47° 36' 53" N

Magnetic declination (°) for compass measurements 4): **+2**

QUADRAT CLUSTERS & 10-m POINTS

	Point number 5)		Distance (m) 6)	Compass direction (°) 7)	Photo check 8)	
NORTH	p5m-N11	☒	32.00	347	☒ m² ☒ m²+Freq.frame	[X] 3x3m plot cluster overview
	p5m-N31	☐	30.54	344	☒ m² ☒ m²+Freq.frame	
	p-N33		27.91	346	☒ m² ☒ m²+Freq.frame	
	p-N13		29.53	349	☒ m² ☒ m²+Freq.frame	
	p10m-N		44.47	347	☒ 10-m-point doc.	
EAST	p5m-E11	☐	18.17	082	☒ m² ☒ m²+Freq.frame	[X] 3x3m plot cluster overview
	p5m-E31	☒	17.75	077	☒ m² ☒ m²+Freq.frame	
	p-E33		14.78	077	☒ m² ☒ m²+Freq.frame	
	p-E13		15.26	084	☒ m² ☒ m²+Freq.frame	
	p10m-E		27.55	077	☒ 10-m-point doc.	
SOUTH	p5m-S11	☐	24.33	168	☒ m² ☒ m²+Freq.frame	[X] 3x3m plot cluster overview
	p5m-S31	☒	24.08	161	☒ m² ☒ m²+Freq.frame	
	p-S33		21.10	161	☒ m² ☒ m²+Freq.frame	
	p-S13		21.40	169	☒ m² ☒ m²+Freq.frame	
	p10m-S		40.85	161	☒ 10-m-point doc.	
WEST	p5m-W11	☐	23.04	261	☒ m² ☒ m²+Freq.frame	[X] 3x3m plot cluster overview
	p5m-W31	☒	23.17	257	☒ m² ☒ m²+Freq.frame	
	p-W33		20.20	256	☒ m² ☒ m²+Freq.frame	
	p-W13		20.07	263	☒ m² ☒ m²+Freq.frame	
	p10m-W		39.50	257	☒ 10-m-point doc.	

INTERSECTION LINES

Point num.	Dist. (m) 6)	Comp. dir. (°) 7)	Photo check 8)	Point num.	Dist. (m) 6)	Comp. dir. (°) 7)	Photo check 8)
pNE-5	20.35	032	X	pSW-5	14.35	212	X
pNE-10	29.24	032	X	pSW-10	26.50	212	X
pSE-5	16.50	122	X	pNW-5	21.35	302	X
pSE-10	29.20	122	X	pNW-10	38.44	302	X

COMMENTS:

The principal measurement line of the S-direction (determined by HSP, p5m-S31 and p10m-S) deviates 6° E from the exact geogr. S (because terrain was not appropriate for the cluster at exactly geogr. S)

Entire summit: Photo check 8) [X]

Use extra blank sheets for further remarks, if necessary

Indicate the number of extra sheets in this box: **0**

1) See Box 9.2 for coding;
2) Full name of summit (from topographic maps, or a working name where no official name is available);
3) The highest summit point: the culmination point +/- in the middle of the summit area (rocky outcrops, which may be higher but are not centred in the summit area, should be ignored;
4) The angle (with its correct sign) between the direction of the geographic North Pole and of the magnetic North Pole (e.g. -6 for a magnetic declination of 6° W; +10 for 10° E; see Box 8.1);
5) Check the box if the point lies on the principal measurement line (e.g., *p5m-N11* or *p5m-N31*, but not both; compare Fig. 8.2);
6) The length of a straight surface line between the HSP and the measurement point (in metres, with two decimal places); keep the measurement tape tightened for all distance measurements! (see Box 8.3);
7) The compass direction from the HSP to the measurement point in degrees (360° scale; see Box 8.1); please note: <u>always</u> write the magnetic compass directions (i.e. degrees as indicated on the compass);
8) Photo check: Check the box after photos are taken to be sure that the photo documentation is complete (see under 8.4.4 for details; ?m² = without frequency grid frame, ?m²+Freq.frame = with the frequency grid frame mounted).

Form AII.1.2 SUMMIT SELECTION

EXAMPLE GLORIA - *Multi-Summit approach*

Country code [1]**:**	AT
Target region code [1]**:**	HSW
Summit code [1]**:**	MEX

Date:	6 August 2001
Researcher(s):	M. Montealto, Y. Serov

CRITERIUM [2]	CATEGORY FOR EVALUATION [2]: RECOMMENDED — Best case	RECOMMENDED	RECOMMENDED — "at least" case	NOT RECOMMENDED	MUST BE AVOIDED
1. Volcanism	The summit is **not** an **active** or **dormant volcano** and no such volcano is in the close vicinity [x]				**Active** (including **dormant**) **volcanism** present [ ]
2. Consistent climate	The summit is exposed to the same local climate as the other summits of the target region; differences are **only** caused by the altitudinal climatic gradient [x]	The local climate on the summit does not obvoiusly deviate from the other summits; the differences are **mainly** caused by the altitudinal climatic gradient [ ]		Summit lies within the area of the same local climate as the other summit sites, but local effects lead to a significant deviation, e.g., owing to a pronounced overshadow by neighbouring land features [ ]	The local climate on the summit is different from the other summits; e.g. the summit lies beyond a main climatic shed (for example, in mountain systems with pronounced windward/leeward differences) [ ]
3. Geo-morphologic summit shape	Perfect moderately **cone-shaped summit** (the same slope situation towards all directions) [ ]	Summit with **irregular cone shape**, where *3m x 3m quadrat clusters* can be positioned **without any deviations** from the standard design [ ]	Summit with **irregular cone shape**, where all four *3m x 3m quadrat clusters* can be positioned with **minor**, but acceptable, horizontal **deviations** from the stand.design (comp. 8.3.2) [ ]	**1)** The summit slopes are too **steep**, too **rugged** or their surface is too **unstable** for establishing plots on all sides of the summit or for applying all sampling methods; or **2)** the summit is so **flat** that the 5-m level lies beyond 50m surface distance from the *HSP*, respectively the 10m-level lies beyond 100 surface distance (compare also Box 8.4) [x]	**1)** Summit where work cannot be carried out without climbing equipment owing to steepness or substrate instability (dangerous sites must be avoided); **2)** Very flat plateau shaped summit areas where the sampling design cannot be applied [ ]
4. Habitat situation (representativity of the vegetation for the respective ecotone or elevation zone)	The vegetation within the summit area represents the characteristic patterns of zonal plant communities of the respective ecotone or elevation zone [x]	The vegetation within the summit area shows at least the main characteristics of the respective ecotone or elevation zone (in cases, where vegetation is generally very scattered, potential habitiats, appropriate for vascular plants to establish, must be available) [ ]			Summit habitat is hostile to plant growth owing to its geomorphology (e.g., summit is composed of boulders, screes or plain rocks lacking potential habitats for vascular plants) [ ]
5. Bedrock material	The same bedrock as on the other summits of the target region [x]	Bedrock deviating, but no obvious substrate-related influence on the species composition [ ]		Deviating bedrock material has an obvious, but minor influence on the substrate-related species composition [ ]	Bedrock is contrasting to the other summits regarding the influence on the species composition (e.g., a summit with siliceous substrate such as gneiss in a series of calcareous limestone summits) [ ]
6. Land use and land use history	Pristine (no land use impact) [ ]	No present land use, and the influence from historic land use is negligible [x]	Low to moderate impact from land use, but without remarkable changes over a long period (e.g. for > than a century) [ ]	**1)** Remarkable land use change within the last 100 years from **high to low** impact, where former impacts on the vegetation are still visible; or **2)** moderate to high impacts over a long period, causing obviously altered vegetation, but plant communities are not substantially changed due to land use impacts, or **3)** the summit is not recommended owing to any other reason related to land use [ ]	**1)** Remarkable land use change within the last 100 years from **low to high** pressure, where the impacts on the vegetation are clearly visible; or **2)** generally strong land use impacts causing substantially changed plant communities (e.g. nitrophilous vegetation), or **3)** the summit must be avoided owing to any other reason related to land use [ ]
	SUMMIT ACCEPTED				**SUMMIT AVOIDED**

1) See Box 9.2 for coding; 2) For definitions of the criteria and evaluation categories compare chapter 7.2.2 of this manual. Please mark only one checkbox for each criterium; checkboxes for the evaluation category *"must be avoided"* are not of relevance, because summits which are accepted for the *Multi-Summit approach* cannot have a mark within this category.

Form AII. 2 Temperature Loggers

EXAMPLE

GLORIA - Multi-Summit approach

Country code 1):	**AT**	Summit code 1):	**MEX**
Target region code 1):	**HSW**	Summit name 2):	Monte Exemplario

Level A 3)	Logger code 4) (country / TR / summit / HSP / year)	Serial number 5)	Start date 6)	Start time 6) (local time)	UTC diff. 7)	Dist-HSP 8)	Cd-HSP 9)	Photo check open 12)	Photo check closed 12)	Researcher(s)	Comments:
Logger 1	__/___/___/ H S P /____										

Level B 3)	Logger code 4) (country / TR / summit / quadrat)	Serial number 5)	Start date 6)	Start time 6) (local time)	UTC diff. 7)	Dist-11 10)	Dist-31 11)	Photo check open 12)	Photo check closed 12)	Researcher(s)	Comments:
Logger 1	__/___/___/___/____										
Logger 2	__/___/___/___/____										

Level C 3)	Logger code 4) (country / TR / summit / quadrat)	Serial number 5)	Start date 6)	Start time 6) (local time)	UTC diff. 7)	Dist-11 10)	Dist-31 11)	Photo check open 12)	Photo check closed 12)	Researcher(s)	Comments:
Logger 1	A T / H S W / M E X / N 2 2 / 2 0 0 1	377618/5-00	14-08-2001	09:45	-1	2.07	2.10	X	X	M. Montealto	
Logger 2	A T / H S W / M E X / E 2 2 / 2 0 0 1	377614/5-00	14-08-2001	11:30	-1	1.86	1.85	X	X	M. Montealto	
Logger 3	A T / H S W / M E X / S 2 2 / 2 0 0 1	377602/5-00	14-08-2001	14:24	-1	2.13	2.57	X	X	Y. Serov	
Logger 4	A T / H S W / M E X / W 3 2 / 2 0 0 1	378302/7-00	14-08-2001	15:10	-1	3.06	1.37	X	X	M. Montealto	No substrate in quadrat W22; therefore logger mounted in W32

1) See Box 9.2 for coding; **2)** Full name of the summit; **3)** Level A: 1 logger per summit near the HSP, Level B: 2 loggers per summit, Level C: 4 loggers per summit (only level C is relevant for GLORIA-EUROPE; see chapter 8.4.3); **4)** Please indicate the GLORIA-wide logger code on the form as well as on the back side of the logger itself (with permanent marker) before burying in the substrate (see Box 9.2 for coding); **5)** The logger serial number is usually indicated somewhere on the logger (if Stowaway Tidbit is used, this number is indicated on the left side of the logger body; e.g. 420309/9-00); **6)** Indicate the date and the time of logger installation in the field (use your local time). **7)** Indicate the value (hours) which has to be added or subtracted from your local time to correct it to the UTC/GCT (Coordinated Universal Time/Greenwich Mean Time); for example, if the local time is 14:00 and UTC 12:00, the value to be entered is **-2**. **8)** The length of a straight surface line between the *HSP* and the logger position (in metres with two decimal places; see Box 8.12); **9)** The magnetic compass direction from the HSP to the logger in degrees (360° scale; see Box 8.12); **10)** Distance (in m with two decimal places) from the logger to the left lower cluster corner (i.e. p5m-_11; see Box 8.12); **11)** Distance (in m with two decimal places) from the logger to the right lower cluster corner (i.e. p5m-_31; see Box 8.12); **12)** Photo check: Check the box after photos are taken to be sure that the photo documentation is complete (documentation of the logger position with the hole open and documentation after the hole is closed with soil material; see Fig. 8.12 and Box 8.12).

Form AII.3a 1m x 1m Quadrat

EXAMPLE *GLORIA - Multi-Summit approach*

Country code[1]:	AT	Aspect [2]: SE	Date: 11 August 2001
Target region code[1]:	HSW		Time: from 14:40 to 15:10
Summit code[1]:	MEX	Slope (°) [3]: 15°	Researcher(s): Maria Montealto, Yuri Serov
Quadrat code[1]:	**E31**		

Top cover surface types (%) [4]

Vascular plants	32
Solid rock	44
Scree	8
Lichens on soil not covered by vasc. plants	2.5
Bryophytes on soil not covered by vasc. plants	3
Bare ground	10
Litter	0.5
	Sum: 100%

Subtypes in % of the top cover type [5]

Lichens below vasc. plants	1.5	Bryophytes below vasc. plants	2
Lichens on rock	35	Bryophytes on rock	0
Lichens on scree	20	Bryophytes on scree	0

Comments on top cover estimations:

The surface type scree is composed of scattered stones; but no scree field

Plant species cover (%) [6]

Species/(subspecies)	cf. [7]	%-cover	Species/(subspecies)	cf. [7]	%-cover
Carex firma		16			
Festuca quadriflora		4			
Dryas octopetala		9			
Arenaria ciliata		2.5			
Helianthemum oelan.ssp.alpestre		2.3			
Carex fuliginosa		1.5			
Salix retusa		1			
Draba sauteri		0.8			
Salix reticulata		0.1			
Poa alpina		0.2			
Silene acaulis s.str.		0.1			
Draba aizoides		1.2			
Polygonum viviparum		0.05			
Campanula alpina s.str.		0.04			
Myosotis alpestris		0.03			
Pritzelago alpina		0.005			
Saxifraga exarata ssp. moschata		0.01			

Cover sum [8]: **38.8**

Number of vascular plant species: **17**

General comments:

No particular difficulties;

perfect weather conditions for recording

If you have used extra sheets (From AII.3b), indicate its number (excluding this first page):

1) See Box 9.2 for coding; **2)** Average aspect of the quadrat surface (N, NE, E, SE, S, SW, W, or NW); **3)** Average slope angle of the quadrat surface (in degrees, 360° scale); **4)** The vertical projection of cover (perpendicular to the slope angle), all types together add up to 100% (for definitions of surface types see under 8.4.1.1); **5)** The top cover as percentage of the respective top cover surface type (see under 8.4.1.1); **6)** Percentage cover of each species (see 8.4.1.1); the full set of vascular plants must be recorded; bryophytes and lichens are **optional** (see Box 8.6); indicate species either by using species names or by (provisional) codes; see also Box 9.2; **7)** Use the cf. column if the identification of the taxon is doubtful (use **g** if this is the case for the genus level, **s** for the species level, **t** for a lower taxonomic level. **8)** Check the cover sum (the cover of all species together) against the top cover surface type "vascular plants": the cover sum can be higher but not lower than this top cover surface type - the cover sum can exceed 100% in dense vegetation due to overlapping layers (see under 8.4.1.1).

Form AII.4a **Frequency counts** in the 1m x 1m quadrats (100 cells of 0.1m x 0.1m)

EXAMPLE

GLORIA - Multi-Summit approach

Codes of 1)	Country: **AT**	Target Region: **HSW**	Summit: **MEX**	Date: 11 Aug. 2001	Time: from 15:30 to 16:25

Rows no. 1 to 0 (numbered from top to bottom); column no. 1 to 0 (numbered from left to right when looking towards the summit) 2)

Quadrat code1)**: E31**

Researcher(s): Maria Montealto, Yuri Serov

General comments: Grid frame difficult to fix flat on the surface at the lower right corner (at p5m-E31), but recording was possible;

Grazing impact 3) / **Species** 4) — row 1

row 1	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings											
H.i. 2: browsing damage											
H.i. 3: trampling											
Carex firma		X	X								
Festuca quadriflora						X		X		X	
Dryas octopetala				X	X	X					
Arenaria ciliata							X	X			X
Helianthemum oelan.ssp.alpestre			X	X				X			
Carex fuliginosa											
Salix retusa											
Draba sauteri										X	
Salix reticulata											
Poa alpina											
Silene acaulis s.str.											
Draba aizoides			X			X					X
Polygonum viviparum											
Campanula alpina s.str.											
Myosotis alpestris											
Pritzelago alpina											
Saxifraga exarata ssp. moschata											

row 2	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings											
H.i. 2: browsing damage											
H.i. 3: trampling											
Carex firma		X	X	X	X			X			
Festuca quadriflora						X			X	X	
Dryas octopetala					X	X	X				
Arenaria ciliata											X
Helianthemum oelan.ssp.alpestre				X							
Carex fuliginosa											
Salix retusa											
Draba sauteri											
Salix reticulata		X									
Poa alpina											
Silene acaulis s.str.											
Draba aizoides			X								
Polygonum viviparum											X
Campanula alpina s.str.											
Myosotis alpestris							X				
Pritzelago alpina											
Saxifraga exarata ssp. moschata											

row 3	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings											
H.i. 2: browsing damage											
H.i. 3: trampling					X						
Carex firma		X	X	X				X	X		
Festuca quadriflora											
Dryas octopetala						X	X				
Arenaria ciliata											
Helianthemum oelan.ssp.alpestre					X						
Carex fuliginosa											
Salix retusa					X	X				X	
Draba sauteri											
Salix reticulata		X	X								
Poa alpina											
Silene acaulis s.str.											
Draba aizoides		X									
Polygonum viviparum											
Campanula alpina s.str.											
Myosotis alpestris											
Pritzelago alpina											
Saxifraga exarata ssp. moschata											X

row 4	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings							X	X			
H.i. 2: browsing damage											
H.i. 3: trampling											
Carex firma			X	X	X				X		
Festuca quadriflora								X		X	X
Dryas octopetala						X	X	X	X		
Arenaria ciliata		X									
Helianthemum oelan.ssp.alpestre					X	X					
Carex fuliginosa											
Salix retusa					X				X	X	X
Draba sauteri											
Salix reticulata											
Poa alpina											
Silene acaulis s.str.											
Draba aizoides			X	X				X	X		
Polygonum viviparum		X									
Campanula alpina s.str.											
Myosotis alpestris											
Pritzelago alpina											
Saxifraga exarata ssp. moschata											

row 5	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings							X				
H.i. 2: browsing damage											
H.i. 3: trampling											
Carex firma		X	X	X	X		X	X	X		
Festuca quadriflora											
Dryas octopetala										X	X
Arenaria ciliata											
Helianthemum oelan.ssp.alpestre						X	X				
Carex fuliginosa											
Salix retusa											
Draba sauteri										X	X
Salix reticulata											
Poa alpina											
Silene acaulis s.str.											
Draba aizoides				X	X						
Polygonum viviparum											
Campanula alpina s.str.						X					
Myosotis alpestris											
Pritzelago alpina											
Saxifraga exarata ssp. moschata											

row 6	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings											
H.i. 2: browsing damage											
H.i. 3: trampling											
Carex firma											
Festuca quadriflora											
Dryas octopetala											
Arenaria ciliata											
Helianthemum oelan.ssp.alpestre							X				
Carex fuliginosa											
Salix retusa										X	X
Draba sauteri			X		X	X					
Salix reticulata									X		
Poa alpina								X		X	
Silene acaulis s.str.											
Draba aizoides				X							X
Polygonum viviparum											
Campanula alpina s.str.		X									
Myosotis alpestris											
Pritzelago alpina											
Saxifraga exarata ssp. moschata											

row 7	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings											
H.i. 2: browsing damage											
H.i. 3: trampling											
Carex firma											
Festuca quadriflora									X		
Dryas octopetala											
Arenaria ciliata											
Helianthemum oelan.ssp.alpestre											
Carex fuliginosa										X	X
Salix retusa											X
Draba sauteri					X	X		X			
Salix reticulata											
Poa alpina				X							
Silene acaulis s.str.											
Draba aizoides		X									
Polygonum viviparum											
Campanula alpina s.str.		X									
Myosotis alpestris											
Pritzelago alpina											
Saxifraga exarata ssp. moschata											

row 8	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings											
H.i. 2: browsing damage											
H.i. 3: trampling											
Carex firma							X	X	X		
Festuca quadriflora									X		
Dryas octopetala										X	X
Arenaria ciliata											
Helianthemum oelan.ssp.alpestre											
Carex fuliginosa									X	X	
Salix retusa											
Draba sauteri			X		X						
Salix reticulata											
Poa alpina											
Silene acaulis s.str.		X	X								
Draba aizoides								X			
Polygonum viviparum											
Campanula alpina s.str.											
Myosotis alpestris											
Pritzelago alpina											
Saxifraga exarata ssp. moschata											

row 9	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings											
H.i. 2: browsing damage											
H.i. 3: trampling											
Carex firma							X	X	X		
Festuca quadriflora					X	X					
Dryas octopetala										X	
Arenaria ciliata											
Helianthemum oelan.ssp.alpestre									X	X	
Carex fuliginosa				X							X
Salix retusa											
Draba sauteri											
Salix reticulata											
Poa alpina											
Silene acaulis s.str.			X								
Draba aizoides											
Polygonum viviparum											
Campanula alpina s.str.											
Myosotis alpestris											
Pritzelago alpina		X									
Saxifraga exarata ssp. moschata											

row 0	cf.4)	1	2	3	4	5	6	7	8	9	0
H.i. 1: faeces/droppings											
H.i. 2: browsing damage											
H.i. 3: trampling											
Carex firma						X	X				
Festuca quadriflora											
Dryas octopetala									X	X	
Arenaria ciliata		X		X							
Helianthemum oelan.ssp.alpestre									X		
Carex fuliginosa								X		X	X
Salix retusa				X	X		X	X			
Draba sauteri											
Salix reticulata											
Poa alpina											
Silene acaulis s.str.											
Draba aizoides									X	X	
Polygonum viviparum											
Campanula alpina s.str.											
Myosotis alpestris			X								
Pritzelago alpina											
Saxifraga exarata ssp. moschata											

If you have used extra sheets (Form AII.4b), indicate its number (excluding this first page):

1) See box 9.2 for coding; **2)** Each cell in this form represents a *0.1m x 0.1m cell* of the grid frame = 100 cells for each species where presence of the species will be indicated with an **X** (see Fig. 8.8); **3) Grazing** impact: frequency of impacts caused by livestock grazing (impacts caused by wild-living mammals are also included, because the latter may hardly be distinguishable from livestock impacts); **4)** Species (all vascular plants; bryophytes and lichens are **optional**); indicate species either by using species names or by (provisional) codes; use the *"cf."* column if the identification of the taxon is doubtful (use **g** if this is the case for the genus level, **s** for the species level, **t** for a lower taxonomic level); see also Box 9.2; A species is considered as present when showing plant parts within the boundary strings of a 0.1 x 0.1m grid cell (always in view perpendicular to the grid frame plane), regardless of where it is are rooted see also under 8.4.1.2).

Form AII.5a Summit area section

EXAMPLE *GLORIA - Multi-Summit approach*

Codes of [1)]

Country:	AT
Target region:	HSW
Summit:	MEX
Summit Area Section:	**E05**

Date: **12 August 2001**

Time: from 10:15 to 12:00

Top Cover Surface Types (%)[2)]

Vascular plants	50
Solid rock	25
Scree	15
Lichens (excl. epilithi	0.5
Bryophytes	0.4
Bare ground	9
Litter	0.1
SUM	100%

Researcher(s):

Maria Montealto

Yuri Serov

Comments on grazing impacts[3)]:

Some feaces from chamois, but no obvious grazing impact

Species[4)]	cf.[5)]	% cover[6)]	locally? [7)]	locally where? [8)]
Carex firma		15		
Dryas octopetala		8		
Festuca quadriflora		5		
Silene acaulis s.str.		3		
Saxifraga paniculata		2.5		
Carex fuliginosa		2.5		
Minuartia sedoides		2		
Helianthemum oeland.ssp.alpestre		1.8		
Salix retusa		1.8		
Arenaria ciliata		1.6		
Draba aizoides		1.5		
Salix reticulata		1.5		
Primula clusiana		1.2		
Doronicum glaciale		1.1		
Crepis terglouensis		1		
Sesleria albicans		1	X	near pSE-5, about 5m²
Campanula alpina s.str.		0.8		
Polygonum viviparum		0.5		
Poa alpina		0.5		
Draba sauteri		0.3		
Saxifraga exarata ssp.moschata		0.1		
Pritzelago alpina		0.1		
Saxifraga aizoides		0.05		
Petrocallis pyrenaica		0.03	x	ca. 3m E of HSP, 20-30 individuals within 4m²
Myosotis alpestris		0.01		
Pedicularis rosea		0.01		
Draba stellata		0.01	x	near boundary between HSP and pNE-5, 10 indiv.
Bartsia alpina		0.005	x	3m above quadrat cluster, patch of 20x20cm
Potentilla crantzii	S	0.005	x	central part of section, few not well devel. indiv.
Gentiana pumila		0.001	x	in quadrat E22, 4 indiv. und 5 seedlings
Agrostis alpina		0.001	x	0.1m from boundary betw.pNE-5 and p5m-E31, 5x5cm
Androsace chamaejasme		0.0005	x	0.5m N of pSE-5, 3 individuals

Sum of cover values of all species in this summit area section: (must exceed the percentage of the surface type "vascular plants") **53**

Total number of vascular plant species in this *summit area section*: **32**

General comments:

Upper third of the summit area section mostly rock and scree; the rest of the area a mosaic of Carex firma and Dryas vegetation, scree, rocks and bare ground;
Coverage of Poa alpina and Polygonum difficult to estimate because of scattered distribution.

1) See Box 9.2 for coding; for the *summit area section*: e.g. N05, N10, E05; **2** Visual cover estimation of the surface types (top cover) within the *summit area section*, indicated as percentage value; see chapter 8.4. **3)** Comment on impacts of grazing such as faeces, browsing damage, trampling; see Box 8.8; **4)** All vascular plant species; bryophytes and lichens on the species level are **optional**; indicate species either by using species names or by (provisional) codes; **5)** Use the cf. column if the indentification of the taxon is doubtful (use **g** if this is the case for the genus level, **s** for the species level, **t** for a lower taxonomic level); see also Box 9.2; **6)** Percentage cover estimation for each species; **avoid** indcations such as: less than (<) or more than (>); see Box 8.9;
7) Mark in this columns only those species which are found only locally, e.g. centred only at one or two locations with the *summit area section* (irrespectively from their cover); **8)** Obligatory for species marked as locally in the previous column: indicate briefly the circa location of the species, e.g. upper N part of the SAsection; central part of the SAsection; 2 m SSE of the *HSP*; near p10m-W; at the lower boundary appr. 2 m from pNE-10; if possible, provide information about the absolute total cover or about the abundance of these locally distributed

If you have used extrasheets (Form AII.5b), indicate its number (excluding this first page):

The *GLORIA* Field Manual

Multi-Summit Approach

ANNEX III:

GLORIA PHOTO DOCUMENTATION CODING

Any item which is included into the *GLORIA* photo documentation must have a *GLORIA*-wide unique code. This code has to be indicated on the blackboard included in the photo view, wherever applicable. Moreover, digitised photos which are to be sent to the *Central GLORIA Database* must have its filenames coded accordingly.

The software for maintaining your digital photo *documentation (GPDM, Gloria Photo Data Management*) as provided by the *GLORIA* co-ordination is designed to compose these filenames automatically for you, preventing you from typing errors as much as possible. Moreover, it is the basis for including your photos in the logical structure of the *Central GLORIA Database* and of the *GLORIA* web site. Therefore, it is highly recommended that you use this software. See the explanations included in the software package on how to use it. Please contact www.gloria.ac.at for downloading this software.

Photo file format and size

Exclusively JPEG files (*.jpg) are accepted to be included into the *Central GLORIA Database* and website. The pixel resolution and JPEG-compression factor of any digitised photos is up to you. But take in mind, that with low resolutions and high compressions, you may loose some valuable visual information of the photo. On the other hand, you can help us to save storage space in the *Central GLORIA Database* by sending not too huge files. A good compromise could be to prepare files of about 2000 by 1500 pixels with a jpeg compression of 20 (on a compression scale of [high quality 2 - 255 low quality]; 20 means relatively high quality due to low compression). This produces files of about 1.5 MB. However, there is no reason not to keep the original files in your office in the best digital quality which you can obtain from your original material.

Coding structure

The codes are composed of several elements. These elements are defined below. Some of them are required, while others are not required. While some elements are of fixed character length, others are not, due to already established coding conventions according to the MS manual.

Writing codes on the blackboard

Variable element lengths have no consequences for the code-writing on the blackboard. **On the blackboard, write the code elements in the sequence as given in the table below, separated by a small space, or dot (˙), or hyphen (ˉ) for better reading on the photo.**

Digital photo file names

However, variable element lengths do have consequences for the digital file naming: **All digital photo files should serve the opportunity to be ordered logically by there filenames.** Therefore, any element must have a constant length in the filenames. **If a code is shorter than the required element length, one or more underscores (_) have to be appended.** The code elements themselves have also to be separated by underscores in the filename (and **not** blanks, or dots, or hyphens, as opposed to the writing on the blackboard).

In many cases, more than one photo exists for the same item. Therefore, the rightmost fixed-length code element in the filename (i.e., element 7, see below) is defined as ordering number. Each photo file of your personal Target Region must have a unique ordering number. The software *GPDM* creates this automatically for you. If you want certain photos (of the same item) to appear in a certain order at the *GLORIA* website (e.g., for decreasing importance or quality), reflect this order in the numbering of this code element.

Definition of code elements

Element	Category	required on blackboard	required in filenames	Element length	Remark
Element1	Monitoring cycle	no	yes	fixed length: 2	the monitoring cycle of your *target region* in *GLORIA*; defaults to 01 at the current state of the project (December 2002);
Element2	Country code	yes	yes	fixed length: 2	constant for the whole *target region*
Element3	Target region code	yes	yes	fixed length: 3	constant for the whole *target region*
Element4	Summit code	yes	yes	fixed length: 3	if the photo cannot be related to a distinct summit, use 3 underscores (___) (this is the case only for the element5-categories PLANT___, LANDSC__, OTHER___)
Element5	Item code **(see in tables below)**	yes	yes	fixed length: 8	for shorter codes, append underscores (_) to reach a total length of 8 characters in the filename; avoid these underscores on the blackboard to save space;
Element6	Date of photo	yes	yes	fixed length: 8	in file names: use the format yyyymmdd; indicate 00 for any unknown day or month; on the blackboard, you may use the format yyyy/mm/dd and write this element in the upper left corner of the blackboard, for better reading;
Element7*****	Ordering number	no (**not applicable**)	yes	fixed length: 5	use 5-digit numbers in ascending order, unique within your target region (starting with 00000, 00001, etc.); if you use *GPDM*, this number is calculated automatically;
Element8******	Indication, or plant species name	no	no (**with exceptions**)	variable length, limited to 150 characters	short description of photo item; limited to 150 characters; use a hyphen (-) as word separator; • not required in most cases; • **required in the following cases:** **Indication:** description of item, if LANDSC__, or OTHER___ is used for element5; description of viewpoint, if SU-OV___ is used for element5; **or:** Plant species name if PLANT___ is used for element5; in this case, separate the genus and species name by a hyphen (-);

***** not applicable on the blackboard in the field; use only for digital photo files;
****** not required (optional) on blackboards in all cases; required (obligatory) for digital photo filenames only, if the element5- categories PLANT___, LANDSC__, SU-OV___ or OTHER___ are used;

List of applicable codes and filename examples

In the following, all applicable codes are listed together with examples for resulting filenames.
Placeholders are written in italics.

This list includes all items of which photos are **obligatory**, and others for which photos are **optional**. But making these photos as well may enhance the value of you photo documentation remarkably. See the entry in the list column "obligatory". For more information see the chapter 'Photo documentation' in the manual.

In any digital filename, only the following keys are accepted: characters from A-Z, numbers from 0-9, and two special characters, the hyphen (-) and the underscore (_). Any other keys including blanks are denied !!!

Ele.1	Ele.2	Ele.3	Ele.4	Ele.5	Ele.6	Ele.7	Ele.8 ***	photo obligatory or optional	Explanation
Monitoring cycle	Country code	Target region code	Summit code	Item code	Date	Ordering number	Indication,or plant species name	photo is obligatory/optional for the photo documentation	
no (due to limited space on the	**yes**	**yes**	**yes**	**yes**	**yes**	**no** (not applicable)	**no**		**<--- required on the blackboard in the field**
yes (due to compatibilty with the *GLORIA*	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**no** (with exceptions; see table above, and footnote ***)		**<--- required in digital photo filename**

*** element8: this column lists whether the element is required in the filename or not (n. r.); if required, it lists what object has to be described;

CORNER POINTS AND BOUNDARY LINES

Highest summit point:

Ele.1	Ele.2	Ele.3	Ele.4	Ele.5	Ele.6	Ele.7	Ele.8 ***	photo obligatory or optional	Explanation
00	*CC*	*TTT*	*SSS*	HSP_____	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	Highest summit point

3m x 3m quadrat cluster corner points:

00	*CC*	*TTT*	*SSS*	p5m-E11_	*yyyymmdd*	*00000*	*n.r.*	optional	lower left corner point of 3mx3m-quadrat-cluster east (and, eventually, cross point of 5m-summit-area boundary with principal measurement line east)
00	*CC*	*TTT*	*SSS*	p5m-E31_	*yyyymmdd*	*00000*	*n.r.*	optional	lower right corner point of 3mx3m-quadrat-cluster east (and, eventually, cross point of 5m-summit-area boundary with principal measurement line east)
00	*CC*	*TTT*	*SSS*	p-E33___	*yyyymmdd*	*00000*	*n.r.*	optional	upper right corner point of 3mx3m-quadrat cluster east
00	*CC*	*TTT*	*SSS*	p-E13___	*yyyymmdd*	*00000*	*n.r.*	optional	upper right corner point of 3mx3m-quadrat cluster east
00	*CC*	*TTT*	*SSS*	p5m-S11_	*yyyymmdd*	*00000*	*n.r.*	optional	lower left corner point of 3mx3m-quadrat-cluster south (and, eventually, cross point of 5m-summit-area boundary with principal measurement line south)
00	*CC*	*TTT*	*SSS*	p5m-S31_	*yyyymmdd*	*00000*	*n.r.*	optional	lower right corner point of 3mx3m-quadrat-cluster south (and, eventually, cross point of 5m-summit-area boundary with principal measurement line south)
00	*CC*	*TTT*	*SSS*	p-S33___	*yyyymmdd*	*00000*	*n.r.*	optional	upper right corner point of 3mx3m-quadrat cluster south
00	*CC*	*TTT*	*SSS*	p-S13___	*yyyymmdd*	*00000*	*n.r.*	optional	upper right corner point of 3mx3m-quadrat cluster south
00	*CC*	*TTT*	*SSS*	p5m-W11_	*yyyymmdd*	*00000*	*n.r.*	optional	lower left corner point of 3mx3m-quadrat-cluster west (and, eventually, cross point of 5m-summit-area boundary with principal measurement line west)
00	*CC*	*TTT*	*SSS*	p5m-W31_	*yyyymmdd*	*00000*	*n.r.*	optional	lower right corner point of 3mx3m-quadrat-cluster west (and, eventually, cross point of 5m-summit-area boundary with principal measurement line west)
00	*CC*	*TTT*	*SSS*	p-W33___	*yyyymmdd*	*00000*	*n.r.*	optional	upper right corner point of 3mx3m-quadrat cluster west
00	*CC*	*TTT*	*SSS*	p-W13___	*yyyymmdd*	*00000*	*n.r.*	optional	upper right corner point of 3mx3m-quadrat cluster west
00	*CC*	*TTT*	*SSS*	p5m-N11_	*yyyymmdd*	*00000*	*n.r.*	optional	lower left corner point of 3mx3m-quadrat-cluster north (and, eventually, cross point of 5m-summit-area boundary with principal measurement line north)
00	*CC*	*TTT*	*SSS*	p5m-N31_	*yyyymmdd*	*00000*	*n.r.*	optional	lower right corner point of 3mx3m-quadrat-cluster north (and, eventually, cross point of 5m-summit-area boundary with principal measurement line north)
00	*CC*	*TTT*	*SSS*	p-N33___	*yyyymmdd*	*00000*	*n.r.*	optional	upper right corner point of 3mx3m-quadrat cluster north
00	*CC*	*TTT*	*SSS*	p-N13___	*yyyymmdd*	*00000*	*n.r.*	optional	upper right corner point of 3mx3m-quadrat cluster north

5m-summit area boundary points (in addition to lower *3m x 3m quadrat cluster* corner points):

00	*CC*	*TTT*	*SSS*	pNE-5___	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 5m-summit-area boundary with intersection line Northeast
00	*CC*	*TTT*	*SSS*	pSE-5___	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 5m-summit area boundary with intersection line Southeast

00	*CC*	*TTT*	*SSS*	pSW-5___	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 5m-summit-area boundary with intersection line Southwest
00	*CC*	*TTT*	*SSS*	pNW-5___	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 5m-summit-area boundary with intersection line Northwest

10m-summit area **boundary points:**

00	*CC*	*TTT*	*SSS*	pNE-10__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 10m-summit-area boundary with intersection line Northeast
00	*CC*	*TTT*	*SSS*	p10m-E__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 10m-summit-area boundary with principal measurement line east
00	*CC*	*TTT*	*SSS*	pSE-10__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 10m-summit-area boundary with intersection line Southeast
00	*CC*	*TTT*	*SSS*	p10m-S__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 10m-summit-area boundary with principal measurement line south
00	*CC*	*TTT*	*SSS*	pSW-10__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 10m-summit-area boundary with intersection line Southwest
00	*CC*	*TTT*	*SSS*	p10m-W__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 10m-summit-area boundary with principal measurement line west
00	*CC*	*TTT*	*SSS*	pNW-10__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 10m-summit-area boundary with intersection line Northwest
00	*CC*	*TTT*	*SSS*	p10m-N__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	cross point of 10m-summit-area boundary with principal measurement line north

Filename examples:
01_AT_HSW_ZAK_HSP______20010726_00001.jpg
01_AT_HSW_ZAK_HSP______20010727_00002.jpg
01_AT_HSW_ZAK_p5m-S31__20010726_00003.jpg
01_AT_HSW_ZAK_pNW-10___20010726_00004.jpg
01_AT_HSW_ZAK_p-E33____20010726_00005.jpg
01_AT_HSW_ZAK_p-E33____20010726_00006.jpg
01_AT_HSW_ZAK_p-E33____20010726_00007.jpg

Measurement lines (*principal measurement lines, intersection lines* , summit-area boundary lines):

Remark: Making photos of measurement lines is not obligatory, but enhances the value of your photo documentation.

Use the closest measurement point as indication both on the blackboard and in the filename.

For the blackboard: If this point is seen on the photo, write the same code as for the point, but don't forget to draw also a north arrow onto the blackboard.
If this point is not seen on the photo, write the same code as for the point and draw an arrow pointing to the direction of the point; but don't forget to draw also a north arrow.

For the filename: Use the point code of the closest measurement point **AND** write the indication LINE to element8.

Filename examples:
01_AT_HSW_ZAK_pNW-10___20010726_00008_LINE.jpg
01_AT_HSW_ZAK_p5m-S31__20010726_00009_LINE.jpg

SAMPLING PLOTS

***1m x 1m quadrats* and frequency quadrats**

NOTE: on the blackboard, avoid the suffixes -QU and -FR in the item code (element5) to save space.

Ele.1	Ele.2	Ele.3	Ele.4	Ele.5	Ele.6	Ele.7	Ele.8	photo obligatory or optional	Explanation
00	*CC*	*TTT*	*SSS*	E11-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 11 of east quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	E11-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 11 of east quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	E31-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 31 of east quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	E31-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 31 of east quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	E33-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 33 of east quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	E33-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 33 of east quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	E13-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 13 of east quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	E13-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 13 of east quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	S11-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 11 of south quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	S11-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 11 of south quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	S31-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 31 of south quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	S31-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 31 of south quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	S33-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 33 of south quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	S33-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 33 of south quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	S13-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 13 of south quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	S13-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 13 of south quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	W11-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 11 of west quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	W11-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 11 of west quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	W31-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 31 of west quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	W31-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 31 of west quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	W33-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 33 of west quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	W33-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 33 of west quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	W13-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 13 of west quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	W13-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 13 of west quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	N11-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 11 of north quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	N11-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 11 of north quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	N31-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 31 of north quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	N31-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 31 of north quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	N33-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 33 of north quadrat cluster (without frequency frame)

00	*CC*	*TTT*	*SSS*	N33-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 33 of north quadrat cluster (with freq. frame as mounted for sampling)
00	*CC*	*TTT*	*SSS*	N13-QU__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 13 of north quadrat cluster (without frequency frame)
00	*CC*	*TTT*	*SSS*	N13-FR__	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	1x1m quadrat 13 of north quadrat cluster (with freq. frame as mounted for sampling)

***3m x 3m quadrat cluster* overviews**

00	*CC*	*TTT*	*SSS*	CL-E____	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	overview of 3mx3m-quadrat-cluster east
00	*CC*	*TTT*	*SSS*	CL-S____	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	overview of 3mx3m-quadrat-cluster south
00	*CC*	*TTT*	*SSS*	CL-W____	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	overview of 3mx3m-quadrat-cluster west
00	*CC*	*TTT*	*SSS*	CL-N____	*yyyymmdd*	*00000*	*n.r.*	**obligatory**	overview of 3mx3m-quadrat-cluster north

Summit areas (any overview or detail)

5m-summit areas

00	*CC*	*TTT*	*SSS*	5m-SA-E_	*yyyymmdd*	*00000*	*n.r.*	optional	overview or detail of 5m-summit-area east
00	*CC*	*TTT*	*SSS*	5m-SA-S_	*yyyymmdd*	*00000*	*n.r.*	optional	overview or detail of 5m-summit-area south
00	*CC*	*TTT*	*SSS*	5m-SA-W_	*yyyymmdd*	*00000*	*n.r.*	optional	overview or detail of 5m-summit-area west
00	*CC*	*TTT*	*SSS*	5m-SA-N_	*yyyymmdd*	*00000*	*n.r.*	optional	overview or detail of 5m-summit-area north

10m-summit areas

00	*CC*	*TTT*	*SSS*	10m-SA-E	*yyyymmdd*	*00000*	*n.r.*	optional	overview or detail of 10m-summit-area east
00	*CC*	*TTT*	*SSS*	10m-SA-S	*yyyymmdd*	*00000*	*n.r.*	optional	overview or detail of 10m-summit-area south
00	*CC*	*TTT*	*SSS*	10m-SA-W	*yyyymmdd*	*00000*	*n.r.*	optional	overview or detail of 10m-summit-area west
00	*CC*	*TTT*	*SSS*	10m-SA-N	*yyyymmdd*	*00000*	*n.r.*	optional	overview or detail of 10m-summit-area north

Filename examples:
01_AT_HSW_ZAK_E11-QU___20010726_00010.jpg
01_AT_HSW_ZAK_E11-QU___20010726_00011.jpg
01_AT_HSW_ZAK_E11-FR___20010726_00012.jpg
01_AT_HSW_ZAK_CL-N_____20010726_00013.jpg
01_AT_HSW_ZAK_CL-W_____20010726_00014.jpg
01_AT_HSW_ZAK_5m-SA-E__20010726_00015.jpg
01_AT_HSW_ZAK_10m-SA-W_20010726_00016.jpg

TEMPERATURE DATA LOGGERS

Remark: Photos of any mounted datalogger are obligatory, but it depends on how much loggers you have used (therefore obligatory/optional is indicated in column 'obligatory').
It is vital that you make from each logger position at least four photos, to ensure that the logger can be found again:
a1) whole quadrat with logger hole open; a2) zoom close to the logger with logger hole open; b1) whole quadrat with logger hole closed;
b2) zoom close to the logger position with logger hole closed. Use element7 to enumerate the photos.
On any photo, put a marker (e.g., the tip of a knife or a pencil) to the exact logger position.
In the case that you could not mount the logger in the 22-quadrat but have mounted it in another quadrat of the cluster, write the code of the respective quadrat (e.g., E21-LOGO).

Ele.1	Ele.2	Ele.3	Ele.4	Ele.5	Ele.6	Ele.7	Ele.8	photo obligatory or optional	Explanation
00	*CC*	*TTT*	*SSS*	HSP-LOGO	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview or detail of highest summit point datalogger (open)
00	*CC*	*TTT*	*SSS*	HSP-LOGC	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview or detail of highest summit point datalogger (closed)

00	*CC*	*TTT*	*SSS*	E22-LOGO	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview (including quadrat boundary) or detail of east quadrat cluster datalogger (open)
00	*CC*	*TTT*	*SSS*	E22-LOGC	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview (including quadrat boundary) or detail of east quadrat cluster datalogger (closed)
00	*CC*	*TTT*	*SSS*	S22-LOGO	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview (including quadrat boundary) or detail of south quadrat cluster datalogger (open)
00	*CC*	*TTT*	*SSS*	S22-LOGC	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview (including quadrat boundary) or detail of south quadrat cluster datalogger (closed)
00	*CC*	*TTT*	*SSS*	W22-LOGO	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview (including quadrat boundary) or detail of west quadrat cluster datalogger (open)
00	*CC*	*TTT*	*SSS*	W22-LOGC	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview (including quadrat boundary) or detail of west quadrat cluster datalogger (closed)
00	*CC*	*TTT*	*SSS*	N22-LOGO	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview (including quadrat boundary) or detail of north quadrat cluster datalogger (open)
00	*CC*	*TTT*	*SSS*	N22-LOGC	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview (including quadrat boundary) or detail of north quadrat cluster datalogger (closed)
00	*CC*	*TTT*	*SSS*	Nxy-LOGO	*yyyymmdd*	*00000*	*n.r.*	**obligatory** /optional	overview (including quadrat boundary) or detail of north quadrat cluster datalogger; if the logger cannot be installed in the centre cluster quadrat, use another quadrat and it's respective code; this scheme applies similarly to the E, W, and S clusters;
00	*CC*	*TTT*	*SSS*	Nxy-LOGC	*yyyymmdd*	*00000*	*n.r.*		
00	*CC*	*TTT*	*SSS*	etc. etc.	*yyyymmdd*	*00000*	*n.r.*		

Filename examples:
01_AT_HSW_ZAK_E22-LOGO_20010726_00017.jpg
01_AT_HSW_ZAK_E22-LOGO_20010726_00018.jpg
01_AT_HSW_ZAK_E22-LOGC_20010726_00019.jpg
01_AT_HSW_ZAK_E22-LOGC_20010726_00020.jpg

The following part of this table lists photo items where element8 must be used in the digital filename

SUMMIT OVERVIEW

Ele.1	Ele.2	Ele.3	Ele.4	Ele.5	Ele.6	Ele.7	Ele.8	photo obligatory or optional	Explanation
00	*CC*	*TTT*	*SSS*	SU-OV___	*yyyymmdd*	*00000*	*viewpoint*	optional	overview of summit (e.g., from another point in the landscape); indicate the point from where the photo is made in element8;

Filename example:
01_AT_HSW_WEK_SU-OV____20010726_00021_from-Ochsenboden.jpg

PLANTS

Ele.1	Ele.2	Ele.3	Ele.4	Ele.5	Ele.6	Ele.7	Ele.8	photo obligatory or optional	Explanation
00	*CC*	*TTT*	*SSS*	PLANT___	*yyyymmdd*	*00000*	*Gen-spec*	optional	plant photo; use the same genus and species names as in your field database

Remark: If any of such photos cannot be related to a distint summit, use 3 underscores (___) for element4 (summit code).

Filename example:
01_AT_HSW_WEK_PLANT____20010726_00022_Saxifraga-caesia.jpg

LANDSCAPES

Ele.1	Ele.2	Ele.3	Ele.4	Ele.5	Ele.6	Ele.7	Ele.8	photo obligatory or optional	Explanation
00	*CC*	*TTT*	*SSS*	LANDSC__	*yyyymmdd*	*00000*	*indication*	optional	e.g., a panorama from a part of the target region; in element8, define shortly what is seen on the photo; use the hyphen (-.) as word separator; limited to 150 characters;

Remark: If any of such photos cannot be related to a distint summit, use 3 underscores (___) for element4 (summit code).

Filename example:
01_AT_HSW_____LANDSC__20010726_00023_main-ridge-of-TR-as-seen-from-East.jpg

OTHER

Ele.1	Ele.2	Ele.3	Ele.4	Ele.5	Ele.6	Ele.7	Ele.8	photo obligatory or optional	Explanation
00	*CC*	*TTT*	*SSS*	OTHER___	*yyyymmdd*	*00000*	*indication*	optional	e.g. a person at fieldwork, or a field-camp photo; in element8, define shortly who and/or what is seen on the photo; use the hyphen (-.) as word separator; limited to 150 characters;

Remark: If any of such photos cannot be related to a distint summit, use 3 underscores (___) for element4 (summit code).

Filename examples:
01_AT_HSW_____OTHER___20010000_00024_fieldwork2001.jpg in this example the month and day of photo is not known

01_AT_HSW_ZIK_OTHER___20010726_00025_fieldwork2001-at-Zinken.jpg
01_AT_HSW_GHK_OTHER___20010726_00029_Gerhard-Gruber-working-on-Ghacktkogel.jpg

European Commission

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