

# Assessment of topsoil evolution associated with land use change in Val Camonica subalpine grasslands

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## Introduction

Alpine pastures and meadows are agroecosystems with biological and landscape importance, protected by the European Union. Grassland areas had a rapid decline in the last decades due to changes in management and/or abandonment of traditional mountain farming in the Alps.

The aim of our study is the characterization of the relationship between historical and present-day subalpine grassland management, their plant diversity, soil properties and humus forms. Humus forms are important indicators of biological functioning of soils and of organic matter degradation pathways, easily affected by land use change.

## Study area

The study area of about 35 km<sup>2</sup>, is Mortirolo grassland plateau (Monno, BS), in Alta Valle Camonica, Rhaetian Alps, Lombardy, Italy (46°26'25.00"N, 10°32'62.50"E), between 1800-2000 m a.s.l., on sialic glacial till, characterized by strong land use changes, as visible in historical aerial photographs (Fig. 1).

The Mortirolo plateau belongs to the High Camuno Geobotanical District (Andreis 2002) of the North-eastern Alpine Ecoregional Subsection (Blasi et al. 2014). It is part of the *Calamagrostio arundinaceae-Piceo excelsae sigmetum* (Verde et al. 2010).

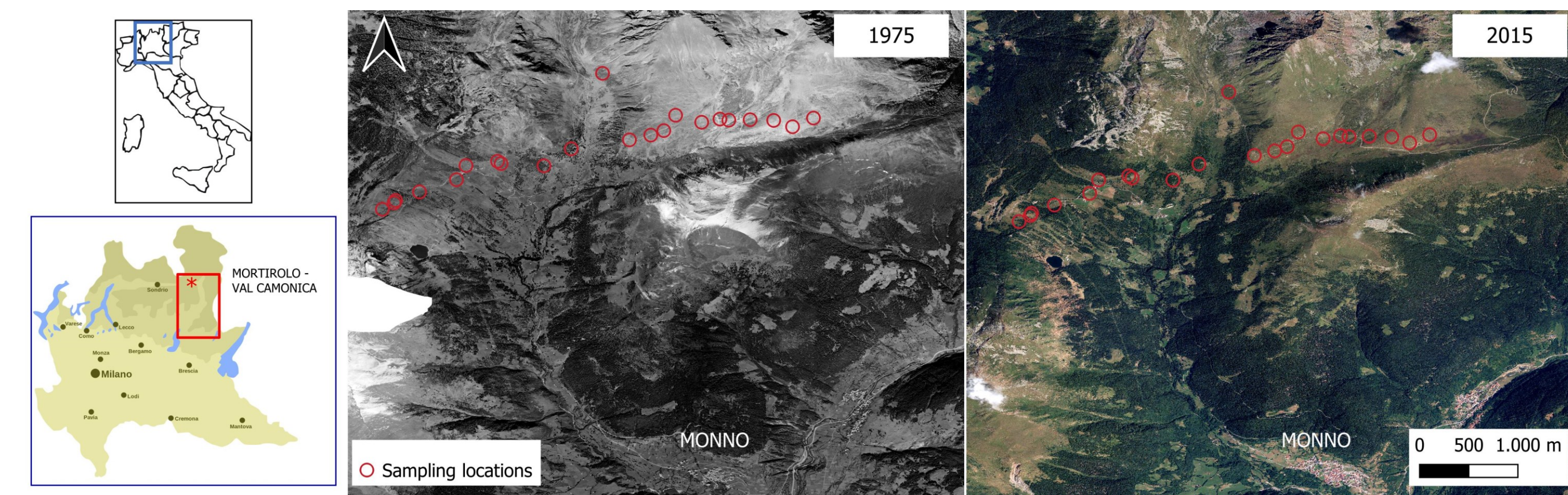


Fig. 1 Location and changes on land use from 1975 to 2015.

## Method

Observing orthophotos from 1975 to today we selected 22 sites across six dynamic phases from grazed grassland to forest, in which we performed phytosociological surveys (10 m x 10 m) according to the Braun-Blanquet method (1964), a soil profile and a characterization of topsoil and organic horizons to detect humus forms and properties. The relevés, georeferenced using GPS device, were performed during summer months of 2023. Standard physico-chemical soil properties (texture, pH, total organic C and N) were analyzed in the lab. In order to detect the dominant soil forming processes, the soils were described and classified according to the World Reference Base (2022). Humus was described and classified using the morpho-genetic approach (Zanella et al., 2018). Statistical analyses were performed on floristic-vegetational, morphological and pedological data collected using R software (R Development Core Team, 2024).

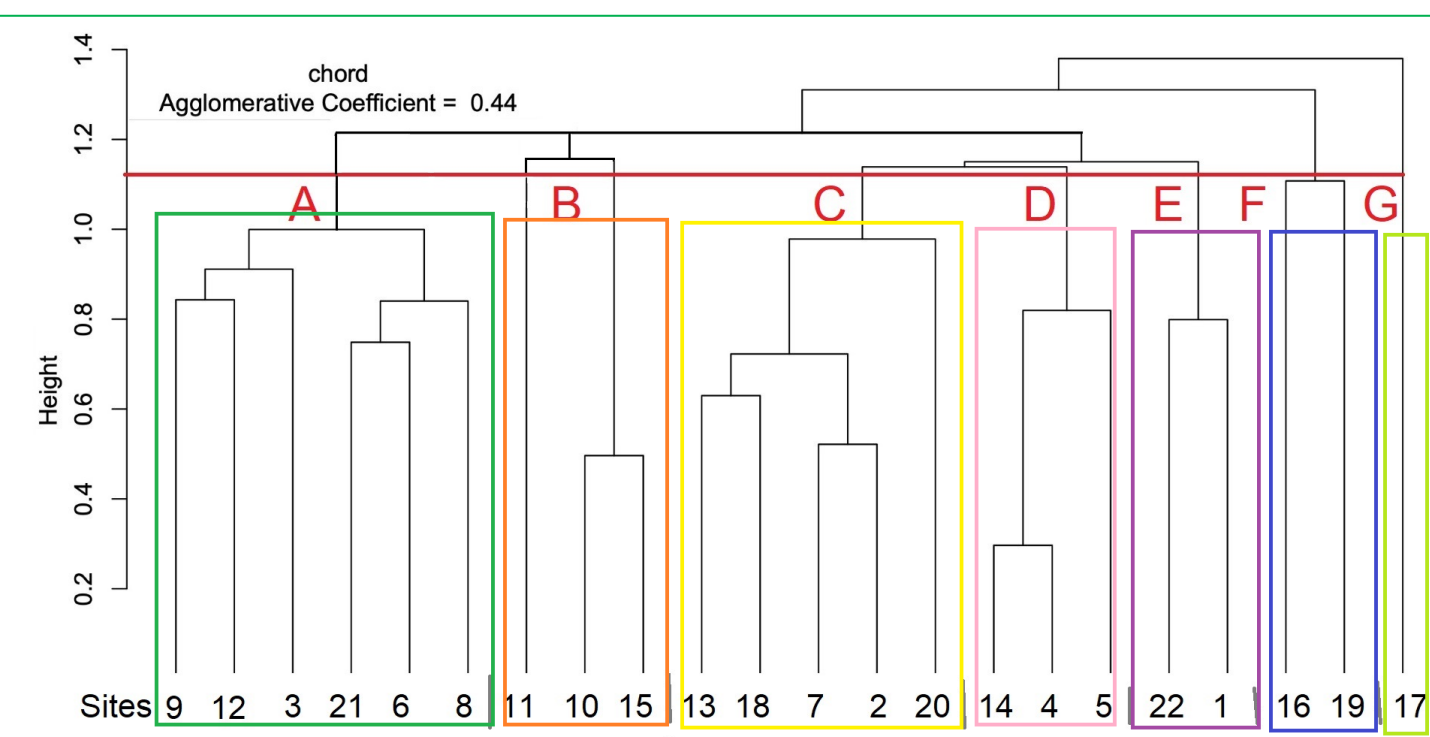
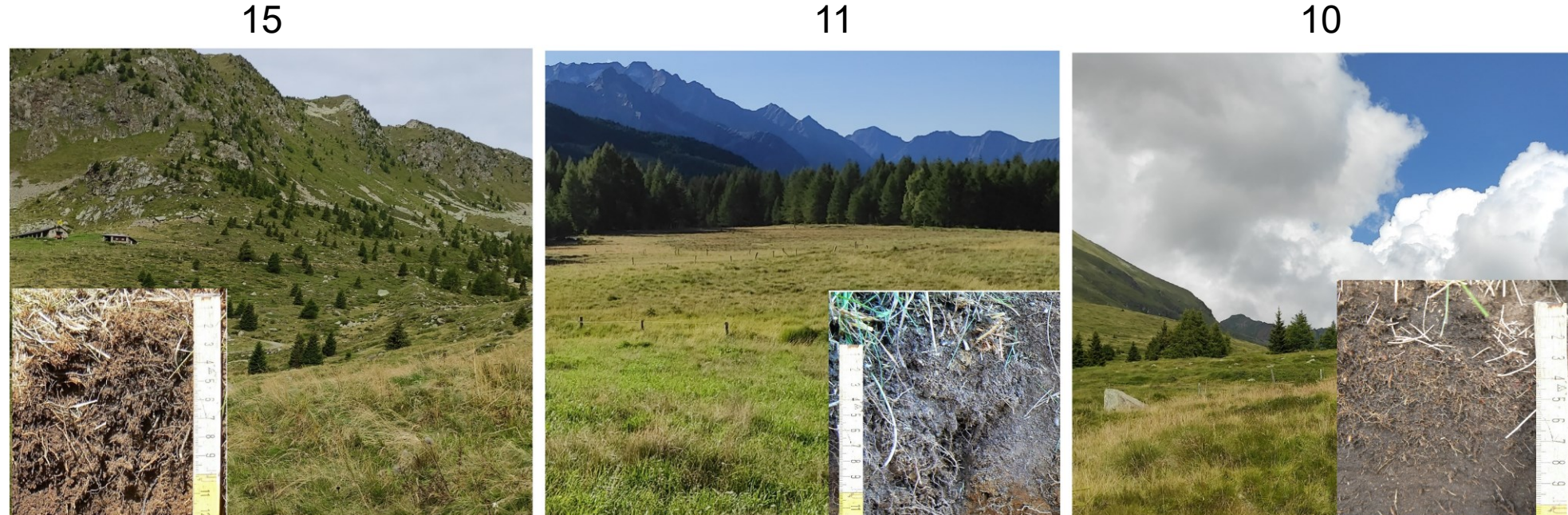


Fig. 2. Dendrogram of floristic relevés

## Results

According to the cluster analysis dendrogram (Fig.2), there are seven main vegetation types which represent a gradient of shrub and tree encroachment into subalpine grasslands.



### 1- *Festuca nigricans* grasslands (cluster B)

Grasslands with *Festuca nigricans* with some encroaching shrubs are good pastures, currently seasonally grazed. Their soils have a mean C stock of 7.4 Kg/m<sup>2</sup>.

The Para humus forms are dominant with a thick root mat and an A horizon with C/N mean value of 13 and pH of 4.3. Rhizo Dysmull are developed on Dystric Episkeletic Regosol (Loamic, Humic) (15), Rhizo Eumacroamphi on Hyperdystric Skeletic Leptosol (Loamic, Hyperhumic, Protosodic) (11), Rhizo Pachiamphi on Episkeletic Umbrisol (Loamic, Hyperhumic) (10) with the sporadic presence of *Vaccinium myrtillus*.



### 2- Peat bog community (cluster G)

The vegetation is dominated by *Sphagnum sp.* with hygrophilic grasses (*Molinia caerulea*, *Carex nigra*); Anmoor humus forms are observed on Sapric Dystric Histosol (17) with H horizons with C/N value of 17, 3% of N, 46% of C, pH of 4. They have a big importance for C stock with a value of 60.6 kg/m<sup>2</sup>.

### 4- *Festuca luedii* grassland (cluster F)

It is most common on steep slopes. It is an acidophilic grassland and has fewer herbaceous species typical of pastures. Its mean C stock is the smallest of all the observed grasslands: 4.8 Kg/m<sup>2</sup>. There is a predominance of Hemimoder humus form on Episkeletic Albic Podzol (Loamic) (19), where *Festuca luedii* is dominant (60%), and in site (16) where *Pinus mugo* is dominant (50%), on Dystric Episkeletic Cambisol (Loamic, Humic).

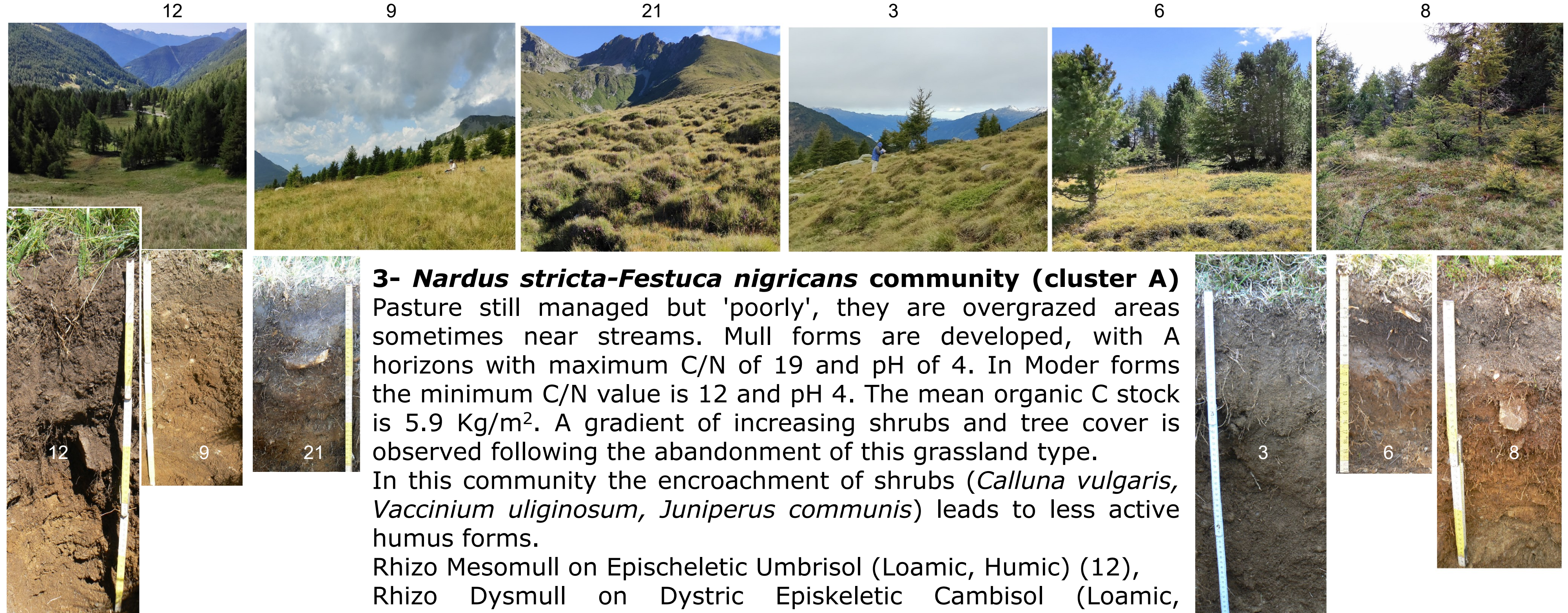
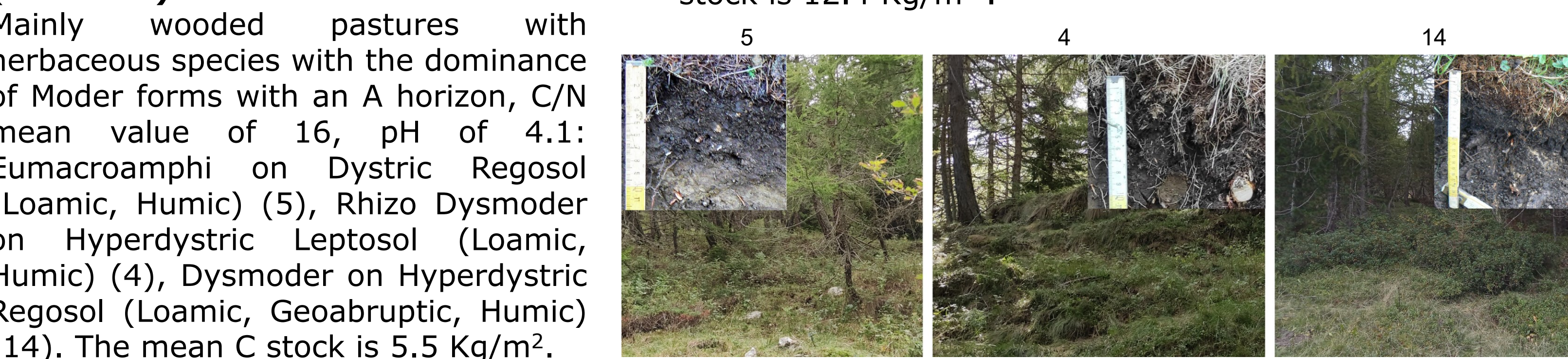


### 6- Grassland with *Rhododendron ferrugineum* (cluster E)

They are abandoned pastures in cool environments in a moderate state of tree and shrub colonization (*Rhododendron ferrugineum* and *Vaccinium uliginosum*), with the dominance of Para humus forms. Moder forms on Albic and Entic Podzol (Loamic) with an A horizon with C/N mean value of 17, a pH of 4.2: Rhizo Eumoder (22) and Rhizo Dysmoder (1). The mean C stock is 12.4 Kg/m<sup>2</sup>.

### 7- *Larix decidua* open forest (cluster D)

Mainly wooded pastures with herbaceous species with the dominance of Moder forms with an A horizon, C/N mean value of 16, pH of 4.1: Eumacroamphi on Dystric Regosol (Loamic, Humic) (5), Rhizo Dysmoder on Hyperdystric Leptosol (Loamic, Humic) (4), Dysmoder on Hyperdystric Regosol (Loamic, Geoabruptic, Humic) (14). The mean C stock is 5.5 Kg/m<sup>2</sup>.



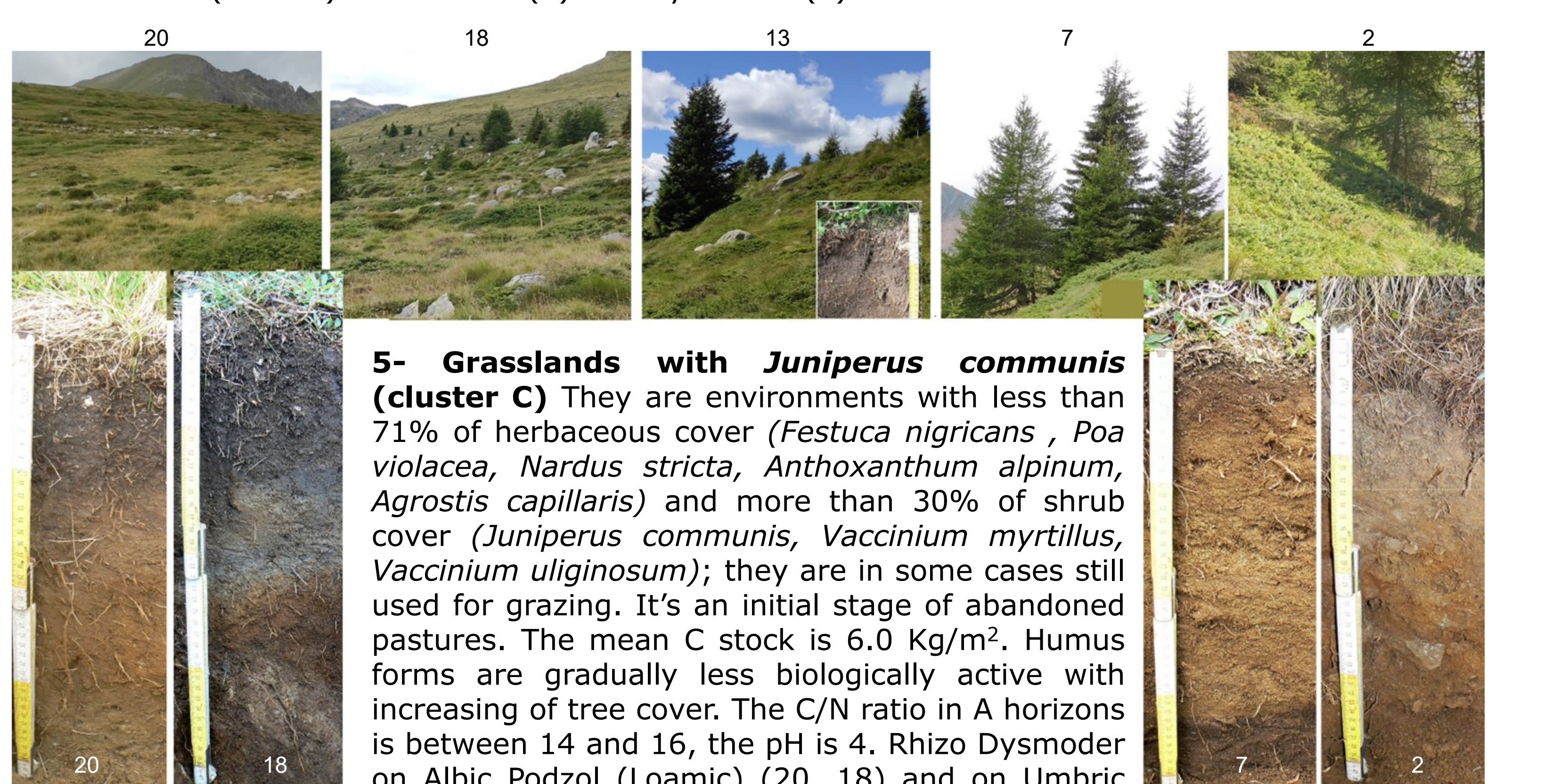
### 3- *Nardus stricta-Festuca nigricans* community (cluster A)

Pasture still managed but 'poorly', they are overgrazed areas sometimes near streams. Mull forms are developed, with A horizons with maximum C/N of 19 and pH of 4. In Moder forms the minimum C/N value is 12 and pH 4. The mean organic C stock is 5.9 Kg/m<sup>2</sup>. A gradient of increasing shrubs and tree cover is observed following the abandonment of this grassland type.

In this community the encroachment of shrubs (*Calluna vulgaris*, *Vaccinium uliginosum*, *Juniperus communis*) leads to less active humus forms.

Rhizo Mesomull on Episkeletic Umbrisol (Loamic, Humic) (12), Rhizo Dysmull on Dystric Episkeletic Cambisol (Loamic, Hyperhumic) (9) in an overgrazed meadow, near a stream.

Rhizo Eumoder on Albic Podzol (Loamic) (21), Rhizo Dysmoder on Hyperdystric Skeletic Leptosol (Loamic, Humic) (3), on Albic Podzol (Loamic) Hemimoder (6) and Dysmoder (8).



### 5- Grasslands with *Juniperus communis* (cluster C)

They are environments with less than 71% of herbaceous cover (*Festuca nigricans*, *Poa violacea*, *Nardus stricta*, *Anthoxanthum alpinum*, *Agrostis capillaris*) and more than 30% of shrub cover (*Juniperus communis*, *Vaccinium myrtillus*, *Vaccinium uliginosum*); they are in some cases still used for grazing. It's an initial stage of abandoned pastures. The mean C stock is 6.0 Kg/m<sup>2</sup>. Humus forms are gradually less biologically active with increasing of tree cover. The C/N ratio in A horizons is between 14 and 16, the pH is 4. Rhizo Dysmoder on Albic Podzol (Loamic) (20, 18) and on Umbric Podzol (Loamic) (13), Hemimoder on Dystric Regosol (Loamic, Humic) (7, 2).

## Conclusion

The widespread decrease in grazing intensity led to an expansion of less palatable grasses (e.g., *Nardus stricta*). These processes are associated to changes in plant diversity and vegetation structure and humus forms as well. In the wooded pasture with more than 50% of tree cover, the soils are usually shallow (Leptosols and Regosols), with a thin OH horizon on Amphi and Moder forms. This may be caused by the shallowness of the soils associated to less rich pastures also in the past. Umbrisols, Podzols and Cambisols are common in the other vegetation communities. Podzols under Moder forms are more frequent where the shrub cover is widespread. Soils are mostly Sapric Dystric Histosols under Anmoor in bogs. Mull and Amphi are the main forms in grazed areas with the better vegetational pasture composition. In the whole study area, we observed Rhizo humus systems where grass roots are the main source of organic matter in soils.